Research on technical standard of Marine corrosion protection for electronic equipment

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Abstract. Electronic equipment is an important part of military weapons, and it is often stored in complex and harsh Marine environment. Corrosion problem will become one of the urgent problems to be overcome. By analyzing the regional division and influencing factors of Marine corrosion, investigating the current status of relevant standards for Marine corrosion protection technology in China, and comprehensively considering the Marine environmental service platform of electronic equipment, this paper proposes the idea of building technical standards for corrosion protection of Marine environmental electronic equipment from two aspects of technology and management, and quantifies the corrosion of electronic equipment during the construction process. Evaluate the use of restrictions and other important and difficult problems for research and exploration.

Keywords: The Marine environment, Electronic equipment, Standard study.

1 Introduction

Since entering the 21st century, with the proposal and implementation of China's "Marine power" strategy, the application of China's electronic equipment has been moving from the near sea to the far sea, from light blue to dark blue, and providing global service has become an inevitable trend for the purpose of supporting cover, normal patrol, deterrence and pressure, and coping with serious situations [1]. As an important part of modern weapons and equipment and the center of information weapon system, electronic equipment has an increasingly prominent demand for anti-corrosion reliability under Marine corrosive environment. In particular, with the continuous advancement of operational preparations in the east and South seas, the adaptability of multi-platform and multi-mission electronic equipment to typical Marine environments such as the South China Sea has become the focus of equipment corrosion protection technology, and the need to comprehensively improve and guarantee the reliability of equipment and environmental adaptability has become increasingly urgent.

At present, China's research on the equipment corrosion protection technology of military electronic equipment in Marine environment only stays at the specific protec

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tion technology level. The most common anti-corrosion technology of electronic equipment in Marine environment includes temperature and humidity environmental control technology, corrosion potential monitoring, separation and desalination technology, salt spray filtration technology, etc [2]. Domestic military enterprises have not yet unified corrosion protection technology standards for military electronic equipment, resulting in uneven life of electronic equipment, the reliability of the entire life cycle of electronic equipment is not high, limiting the pace of China's independent research and development of weapons and equipment to the international high-tech industry. In order to improve the overall performance of weapons and equipment, it is urgent to carry out corrosion protection technology for electronic equipment in the Marine environment, and form a set of systematic, comprehensive, standardized and standardized top-level standards, which provide strong theoretical and reference support for the research of corrosion protection technical standards for electronic equipment [3].

2 Marine corrosion

2.1 Overview of Marine corrosion

At the 2016 Corrosion Conference, NACE initially announced the results of the global corrosion research project. The average economic loss caused by corrosion damage in the world accounts for about 3.4% of the global gross national product (GNP), of which Marine corrosion loss accounts for about 1/3 [4]. Marine corrosion is mainly due to the chemical reaction between equipment materials and the Marine environment in which they are located, leading to the degradation of their material properties, which may cause corrosion damage to various types of military electronic equipment at sea at different levels, delay the aircraft and thus produce hidden dangers of war loss, and can not adapt to the actual combat service environment. In 1960, under the influence of ocean corrosion, the non-regenerative heat exchanger of the United States nuclear submarine Nautilus broke through stress corrosion, resulting in an accident [5].

China has a total sea area of about 4.93 million square kilometers, of which the territorial sea (jurisdiction area) is about 299.7 square kilometers. Facing the security of national territory and rich natural resources in the boundless ocean, the sea has become the focus of current development in our country, and some experiences at home and abroad point out that, Through the regulatory control of the development and production of electronic equipment with reference to the corresponding standards, 25%-40% of corrosion losses can be avoided [6].

2.2 Marine corrosion regionalization

Usually in Marine environment service, the corrosion of electronic equipment can be divided by referring to the altitude and sea water depth of the actual service area. It is divided into the following five areas:

(1)Marine atmosphere: refers to the space area where the sea level is above the mean value of the high water line, and this area is in the Marine environment all the year round, and different seawater is in direct contact with. In the Marine atmosphere, electronic equipment is exposed to the Marine atmosphere, and the Marine atmosphere will be attached to the surface of electronic products, thus causing corrosion [7].

(2)Splash zone: The area above the mean high tide line of sea level where sea spray can splash but not be submerged. In the spray splash zone, electronic equipment will be subjected to the splash of seawater for a long time, in the dry and wet alternating environment, and the Marine atmosphere is rich in oxygen, oxygen is conducive to the life of oxygen-loving Marine organisms, increasing the possibility of Marine organisms fouling corrosion, so the corrosion of electronic equipment in this area has the greatest impact.

(3)Tidal range: The area of the sea level in the space between the mean of the high and low tide lines, which is flooded at high tide and exposed to the Marine atmosphere again at low tide. In the tidal range of seawater, the electronic equipment will be in an alternating dry and wet environment from time to time, because the oxygen content is lower than the splash zone, the oxygen concentration difference produces cathodic protection, which makes the corrosion rate of the electronic equipment in the tidal range of seawater slow.

(4)Sea water immersion area: refers to the space area below the tide line value, which is soaked by sea water all year round. In the seawater immersion area, the electronic equipment and the Marine atmosphere can not be directly in contact, mainly controlled by the oxygen concentration, salt content, pH value in the seawater, among which the oxygen concentration is the main factor affecting the corrosion rate, and the oxygen concentration decreases with the increase of depth, and the influence is gradually weakened.

(5) Seabed soil area: refers to the bottom of the sea silt area, this area is in the sea water, seabed sediment and soil.There are abundant Marine microorganisms in the seabed soil area, whose living activities will produce a large number of corrosive gases (such as ammonia, hydrogen sulfide, etc.), making corrosion behavior more complex and variable, which is the dilemma of current Marine corrosion research [8].

According to the above classification, combined with the service environment of electronic equipment in the Marine environment, the Marine corrosion of electronic equipment mainly occurs in the space area of Marine atmosphere, spray splash, sea water tidal range and sea water immersion. Therefore, in the construction of corrosion protection technical standards for electronic equipment in the Marine environment, it is necessary to propose corresponding protection control methods for different service environments to ensure that the standard covers the whole elements and the whole process of Marine corrosion protection technology research.

2.3 Factors affecting Marine corrosion

Marine corrosion is the result of different complex factors under the Marine environment. In different Marine corrosion areas, the factors affecting the corrosion of electronic equipment are not the same, including temperature, humidity, salinity, radiation, vibration and microorganisms, etc. In the Marine environment, the following are the main influencing factors:

(1) Temperature: temperature is one of the most important factors affecting the results of all chemical reactions, and the general temperature rises by 10°, the chemical reaction rate will be increased by about 2 times. Temperature is greatly affected by the season and ocean area, and its change will not only lead to changes in the performance and geometric size of electronic equipment, but also indirectly affect the corrosion of the ocean by affecting other factors.

(2) Humidity: High humidity is one of the factors unique to the Marine environment, the humidity of the Marine atmosphere is about large, its ability to absorb sea salt is about strong, if the surface of electronic equipment is attached with a corrosive film, it becomes the main way of electrical leakage, the dielectric strength and insulation performance of electronic equipment are reduced, which greatly strengthens the corrosion effect. The general rule is that the higher the humidity, the more severe the corrosion.

(3) Salinity: The biggest feature of seawater is that it contains a large amount of sea salt. In the Marine atmosphere environment, salt particles combine with the Marine atmosphere to form salt spray, which is one of the main affecting conditions in the Marine atmospheric environment. In the seawater environment, salt particles dissolve in the seawater, which makes the seawater have a strong corrosive electrolyte [9].

Table 1. Comparison of corrosion characteristics in different oceans.

Corrosion characteristics of environmental conditions in Marine areas	Corrosion characteristics of environmental conditions in Marine areas	Corrosion characteristics of environmental conditions in Marine areas
Ocean atmosphere salt spray, humidity	Ocean atmosphere salt spray, humidity,	Ocean atmosphere salt spray, humidity,
Temperature, solar corrosion and other corrosion, aging,	Temperature, solar corrosion and other corrosion, aging,	Temperature, solar corrosion and other corrosion, aging,
Partial presence of mold	Partial presence of mold	Partial presence of mold
Splash zone oxygen content, seawater,	Splash zone oxygen content, seawater,	Splash zone oxygen content, seawater,
Solar corrosion, Marine life and other corrosion is serious	Solar corrosion, Marine life and other corrosion is serious	Solar corrosion, Marine life and other corrosion is serious

The occurrence of Marine corrosion is not influenced by a certain environmental factor, but the corrosion failure process is actually formed by various different conditions and factors. Table 1 shows the comparison of corrosion characteristics in different Marine environmental regions. For example, appropriate humidity and temperature will enhance the performance of mold, plus the corrosion of the Marine atmosphere, salt spray, high temperature and alternating humid heat will strengthen the role of each other in the tidal range of sea water. Therefore, it is necessary to consider the influence of many factors in the research process of corrosion protection technical standard of electronic equipment in Marine environment.

3 Current situation of corrosion protection standards at home and abroad

3.1 Current situation abroad

International organizations in the field of Marine corrosion protection mainly include NACE (American Society of Corrosion Protection Engineers), ISO, SSPC (American Society for Protective Coatings), ASTM (American Society for Materials and Testing), and so on. NACE, as the world's largest professional organization for corrosion protection technology, A large number of existing standards are developed by its Technical Coordinating Committee (TCC) [10]. NACE standards are divided into three categories: operation Standard [SP (RP), Standard practice], Test method standard (TM), and Material requirement (MR) [11]. It has laid a cornerstone for the development of international Marine corrosion protection technology.

In recent years, countries have begun to attach great importance to the corrosion problem of weapons and equipment, and Gome has implemented the corrosion protection and Control Project plan (CAPP) within the army, intending to establish the status of interdisciplinary comprehensive system engineering of corrosion protection and control from the system, and change the concept of subsidiary disciplines on the edge of corrosion protection technology. In order to ensure the comprehensive and smooth development of the corrosion prevention and control project plan, the United States has formulated a series of supporting measures, including standard formulation, personnel training, supervision mechanism, etc., and as a long-term strategy, has gradually established a complete set of corrosion protection to effectively mitigate the impact of various types of corrosion on U.S. military weapons and equipment [12]. In the meantime, Some of the U.S. military standards and Department of Defense manuals related to corrosion protection have been formed successively, including MIL-F-7179 "General Specification for Aircraft Structural Protection", MIL-HDBK-5 "Aircraft Metal Materials and Components Protection Manual", MIL-S-5002 "Surface Treatment of Weapon System Technical Materials", and MIL-STD-1568B "Aviation Weapons" Device System Materials and Corrosion Protection and Control Processes, MIL-STD-1587C, Air Force Requirements for Materials and Processes for Weapon Systems, MIL-HDBK-1250, Corrosion Prevention and Deterioration Control of Electronic Components and Assemblies, AR 750-59 Army Corrosion Protection and Control Program, AFR-400-44 Corrosion Protection and Control Program, NAS-SD-24 Navy General Code for Structural Design of Weapons, NAVMATP-4855 Design Guide for Corrosion Prevention and Control of Avionics, etc [13].

3.2 Domestic situation

At present, China has not implemented the top-level system of corrosion protection technology related projects, but has recognized the harm of corrosion to weapons and equipment and the importance of corrosion protection, has invested more energy in the field of corrosion protection technology. However, compared with the current project standards of the US Army, there are still many problems, such as the lack of systematic corrosion protection projects, lack of top-level design and standards, narrow project coverage, unscientific protection methods, lack of professional personnel, etc., and it needs to be constantly improved on the basis of learning from the experience of the US army.

Compared with the relatively perfect corrosion protection and control standards of the US army, the existing standards in the field of equipment corrosion protection in China are few in number, and most of them are concentrated in the application of platforms. Some standards related to corrosion protection mainly include GJB 2635A-2015 "Requirements for Corrosion Protection Design and Control of Military Aircraft", GJB 8400-2015 "General requirements for Corrosion Protection and Control of Shipborne Helicopter Structures", GJB 9674-2020 "Requirements for Corrosion Protection Design and Control of shipborne aircraft Engines" and GJB 150.1~11A-2009 "Military equipment laboratory Environmental test Method". There are fewer standards for electronic equipment, The main ones are GJB/Z 80-1996 "Electronic Equipment biological, Stress corrosion protection structure Design Guide", SJ 20890-2003 "Electronic Equipment treatment and coating", GJB 8893.1~6-2017 "Military Equipment natural environment Test Method", SJ 20812-2002 "Regulations on the Design and Management of Three Defenses for Military Electronic Equipment", SJ 20509-1995 "Technical Manual on the Causes and Control of Microbial Degradation of Electronic Equipment", QJ 2188-91 "Corrosion Design Code for Electronic Equipment", etc [14]. These standards have not yet formed a complete set of standards, especially the standards of electronic equipment are too old, and can no longer be used as the basis for guiding and maintaining the full-cycle corrosion protection and control of China's weapons and equipment [15]. We should refer to the mature corrosion control standards of foreign countries, gradually improve the standards and requirements according to the characteristics of our military equipment, and do a good job in the security of our military equipment.

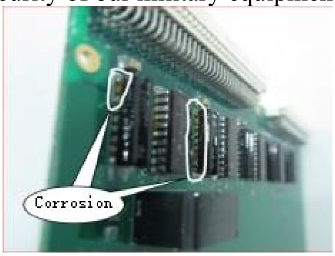


Fig. 1. Corrosion of electronic equipment.

In summary, the corrosion research on ships and aircraft at home and abroad has been relatively complete. However, in terms of the corrosion failure mechanism and protection control research on electronic equipment in Marine environment, the theoretical research support is insufficient, and systematic standard documents are lacking. In particular, the army does not know how to protect and control the corrosion of electronic equipment. The working environment and material types of electronic equipment and its components are different. In addition to bearing mechanical stress, electronic equipment also bears the influence of Marine environment, current, magnetic field, stress, etc., which makes its corrosion condition and corrosion law show complexity, diversity and particularity. The corrosion of electronic equipment is shown in Figure 1. Domestic military enterprises do not have a unified top level standard of electronic equipment corrosion protection technology, resulting in the current service life of electronic equipment is uneven, reliability is not strong. Therefore, according to the characteristics of Marine environment, the research on corrosion protection technical standards of electronic equipment is of great significance to avoid major corrosion problems of weapons and equipment.

4 Standard construction

4.1 Basic idea

The construction of the standard is a systematic and complex project, which requires the cooperation and joint efforts of all major electronic equipment design, manufacturing and use units [16]. At present, the National Standardization Administration approved the establishment of the National Corrosion Prevention Standardization Technical Committee (SAC/TC381) in 2007, trying to truly establish corrosion protection technical standards. And in the international ISO led by the development of GB/T33314-2016 "Corrosion control engineering life cycle general requirements", "Corrosion control engineering life cycle risk assessment", "Pipeline corrosion control engineering life cycle general requirements" and other standards. This lays a solid foundation for the construction of corrosion protection technical standards for Marine environmental electronic equipment [17].

The construction of corrosion protection technology standards for Marine environmental electronic equipment should be based on China's existing military standards and electronic equipment industry standards, and extensively absorb the advantages of existing domestic and foreign military and industry standards, with electronic equipment corrosion protection technology as the core, electronic equipment application platform environment as the object, and systematic and professional development as the guide. Facing the development needs of weapons and equipment in the Marine environment in the new era, taking into account the needs of current scientific research projects, and taking improving China's "military standards and electronic industry standards" as the core task, it adopts the dual main line matrix thinking of standardized technical indicators and optimized management measures to build standards. It provides a reference basis for the "unified specifications, unified criteria and unified requirements" of corrosion protection technology for Marine environmental electronic equipment [18]. The application platform environment of electronic equipment is complex and diverse, from deep sea to space, almost all kinds of military equipment, such as shipboard sea warning radar, VHF/UHF communication antenna, vehicle tracker, shipboard integrated sonar, infrared warning system, photoelectric active jamming equipment, missile fire control, etc. At present, The more common platform environments are mainly airborne, ship-borne and vehicle-borne, as shown in Figure 2.

a) Airborne electronic equipment

b) Shipborne electronic equipment

c) Automotive electronic equipment

Fig. 2. Electronic equipment common platform environment.

4.2 Architecture

Corrosion protection technology of Marine environmental electronic equipment is a systematic project, which runs through the whole process of design, development, production and in-service use. In order to effectively control corrosion protection of electronic equipment during the whole service cycle, factors such as service environment and equipment type of electronic equipment in Marine environment should be comprehensively considered when constructing standards. Conduct a comprehensive analysis of corrosion protection technologies in electronic equipment design, manufacturing, assembly, protection, detection, use, maintenance and other processes, investigate their corrosion failure modes and environmental impact factors, divide electronic equipment application platforms, and determine the main use environment of each application platform from two aspects of technology and management. To formulate corrosion protection standards for electronic equipment at all stages of the whole cycle from design to service maintenance. The detailed standard architecture is shown in Figure 3.

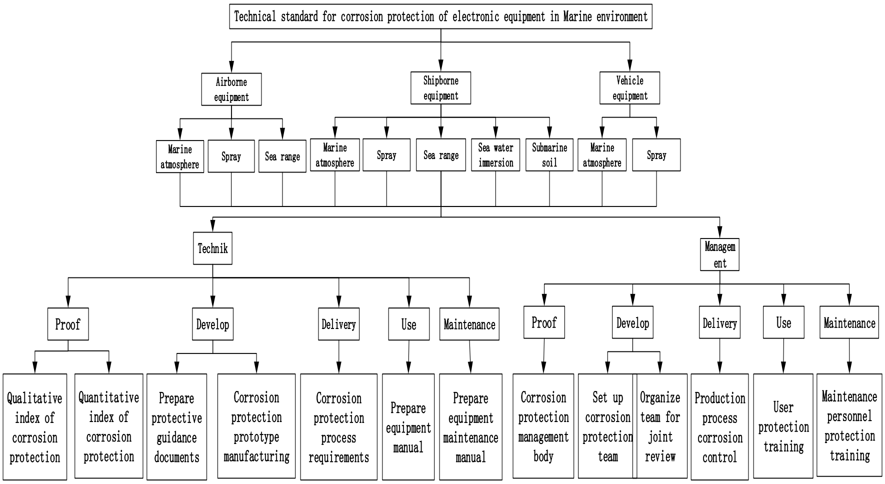


Fig. 3. Standard architecture.

4.3 Key and difficult points of construction

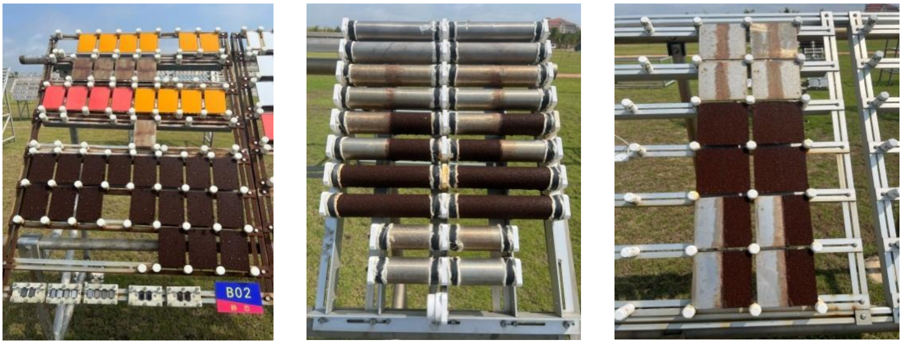
Corrosion protection technology is an important link to ensure the integrity of electronic products, an important condition for product corrosion resistance and durability design, and an important guarantee for realizing long life, high reliability and low maintenance costs of structures. It involves materials, structure, process, surface treatment and protection technology, stress and deformation control, etc. It is a comprehensive technology involving many fields and disciplines such as machinery, electrochemistry and biology [19]. Although there are relevant corrosion control verification methods, they can not completely cover the corrosion protection assessment requirements of electronic equipment. The important and difficult point of constructing the corrosion protection technical standard of Marine environmental electronic equipment is how to quantify its evaluation.

At present, most standard assessment and evaluation methods are mainly established through the following forms.

(1) By referring to the relevant foreign standards, the localization of the revision, the preparation of a series of standard documents;

(2) Formulate serialized standard documents based on actual verified military (civilian) product design schemes, process documents, management requirements and service data;

(3) Through natural environment test, accelerated laboratory test (salt spray method, wet heat method and electrochemical corrosion method, etc.), simulation software (BEASY, CorrosionMaster, Beijing Orbel and Grebe, etc.) analysis and other methods (as shown in Figure 4) [20], the corrosion resistance of the equipment was comprehensively evaluated and analyzed according to the test results. Build serialized standard files.



a. Natural environment test.

b. Accelerated laboratory test.

c. Simulation software test.

Fig. 4. Corrosion analysis method.

With comprehensive reference to the above assessment and evaluation methods, according to the needs of corrosion protection of electronic equipment at different stages, the appropriate methods are selected for assessment and evaluation, and the framework structure of the standard file is determined by referring to the series standards of corrosion protection technology, so as to complete the construction of corrosion protection technical standards for Marine environmental electronic equipment.

5 Conclusion

Standards are an important "bridge" for the transformation of scientific research achievements into equipment performance assurance, and the two complement each other and promote each other. The construction of corrosion protection technical standards for Marine environmental electronic equipment not only ensures that electronic equipment meets the requirements of the service environment, but also aims to improve the optimization of assessment and evaluation in the standards, considers the coordination and unification of various elements, and forms a top-level standard document for corrosion technology of Marine environmental electronic equipment in view of the weak links in Marine corrosion technology research. To provide high quality and high performance electronic equipment for China's electronic equipment to serve in the Marine environment will have a far-reaching impact on the development and production of electronic equipment.

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