



**BUREAU
VERITAS**

**GUIDELINES
FOR
CORROSION PROTECTION
OF
SEAWATER BALLAST TANKS
AND
HOLD SPACES**

**NI 409 DNC R00E
September 1995**



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NI 409 DNC R00E

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MARINE BRANCH GENERAL CONDITIONS

ARTICLE 1

1.1. - BUREAU VERITAS is a Society, the purpose of whose Marine Division is the classification of vessels, sea and river units, offshore structures and craft of all kinds, collectively hereinafter referred to as "ships".

The Society :

- sets forth and develops Rules, Guidance Notes and other documents ;
- publishes Registers ;
- issues Certificates, Attestations and Reports following its interventions.

1.2. - BUREAU VERITAS also participates in the application of National or International Regulations or Standards, in particular, by delegation from different Governments.

1.3. - BUREAU VERITAS can also carry out Technical Assistance missions and provide special services exceeding the scope of classification, to which Particular Conditions will then apply.

1.4. - BUREAU VERITAS is neither, and may not be considered as, an Underwriter, Consulting Engineer, Naval Architect, Shipbuilder or a Shipowner, and cannot assume the obligations incumbent on such functions, even though its experience enables it to answer enquiries concerning matters not covered by its Rules, Guidance Notes or other documents.

ARTICLE 2

2.1. - Classification is the expression of confidence given by the Society to a ship, for a particular use or service and for a certain period of time, by reference to its Rules, Guidance Notes and other documents : this opinion expresses only the strict personal view of the Society. It is represented by a class published in the Register.

2.2. - The documents issued pursuant to surveys carried out by the Society's surveyors according to the methods and modalities mentioned in articles 3 and 4 reflect the condition of the ship at the time of the survey. It is the Owner's or his Agent's responsibility to maintain that condition until the next survey required by the Rules.

ARTICLE 3

BUREAU VERITAS

- appraises specifications and drawings for the construction of ships by reference to its Rules,
- inspects materials, machinery, equipment, fittings and other items used in the construction of ships, by reference to its Rules,
- surveys the construction of ships to ensure that they are built in accordance with approved drawings and the Society's published Rules,
- classes ships in accordance with its Rules and publishes the ships' names in its Register,
- carries out periodic surveys of ships in service in order to ensure that the requirements for the specified class are met. It is the owner's duty to report to the Society any incident or event affecting the condition of the ship or the need for repairs, whatever their nature or extent.

ARTICLE 4

4.1. - The Rules, Guidance Notes and other documents published by the Society endeavour to meet the state of the art and technology at the time they are published.

Committees, consisting of personalities from the International Maritime Industry, contribute to the development of these documents.

The Society is not responsible for any inadequacy or failure of such Rules, Guidance Notes or other documents as a result of future development of techniques which could not reasonably have been foreseen at the time of their publication.

4.2. - BUREAU VERITAS is sole qualified to decide upon the meaning, the interpretation and application of the documents mentioned above. Any reference to them is of no value if it does not involve, accompany or follow a Society's intervention.

4.3. - The Society exercises due care and skill and acts in a professional and workmanlike manner :

- in the selection of its surveyors,
- in the performance of its services, considering the state of the art and technology in existence at the time the services are being performed.

4.4. - Surveys conducted by the Society include, but are not limited to, visual inspection, non-destructive testing, laboratory testing and underwater inspection by divers. Survey practices and procedures are selected by the Society in its sole and absolute discretion based on its experience and knowledge and according to generally accepted professional standards in the Industry.

ARTICLE 5

5.1. - No report, statement, notation on a plan, review, certificate of class or any document or information issued or given as part of the services provided by the Society shall be given any legal effect or implication other than a representation that the ship, structure, item of material, equipment or machinery or any other item covered by such document or information has met one or more of the Society's Rules. Any such representation is issued solely for the use of the Society, its committees and clients or other duly authorized entities and for no other purpose.

5.2. - The classing of a ship, or the issuance of certificate with relation to, or in furtherance of the classification of a ship or the performance of services by the Society, is not a representation, statement or warranty of seaworthiness, structural integrity, quality or fitness for a particular purpose or

service of any ship, structure, material, equipment or machinery surveyed by the Society, beyond any representation set forth in the Rules of the Society.

5.3. - Nothing contained herein, or in any information, report, certificate or like document issued in connection with or pursuant to the performance by the Society of its services, shall be deemed to relieve any designer, naval architect or engineer, builder, manufacturer, shipyard, seller, supplier, contractor or subcontractor, repairer, or owner, operator or other entity from any warranty or other contractual obligations express or implied or from any fault whatsoever, nor to create any right, claim or benefit in any third party.

In particular, the Society does not declare the acceptance or commissioning of a ship, that being the exclusive responsibility of the owner.

The validity, application, meaning and interpretation of a Classification Certificate or any similar document or information issued by the Society in connection with, or in furtherance of the performance of its services, is governed by the Rules of the Society which shall be the sole judge thereon, in its absolute discretion.

ARTICLE 6

6.1. - In providing services, information or advice, neither the Society nor any of its servants or agents warrants the accuracy of any information or advice supplied. Furthermore, all express and implied warranties are specifically disclaimed. Except as set out herein, and also in the case of the surveys mentioned in Article 1.2., neither the Society, nor any of its servants or agents, shall be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, due to any act or omission or error of whatever nature, whether or not negligent, and howsoever caused in any information or advice given in any way whatsoever by or on behalf of the Society.

6.2. - Nevertheless, if any person uses the Society's services, and suffers loss, damage or expense thereby, which is proved to have been due to any negligent act, omission or error of the Society, its servants or agents, or any negligent inaccuracy in information or advice given by or on behalf of the Society, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fee - if any - charged by the Society for the particular service, information or advice and, if no fee is charged, FRF 50,000.

Where the fees are related to a number of services, the amount of fees shall be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of each service.

Any liability for consequential damages is specifically excluded.

In any case, whatever the amount of the fees, the maximum damages payable by the Society shall be not more than FRF 5,000,000.

6.3. - Any claim for damages of whatever nature by virtue of the provisions set forth herein must be made in writing, and notice must be provided to the Society within six months of the date the services were first supplied or the damages first discovered. Failure to provide such notice within the time set forth herein will constitute an absolute bar to the pursuit of such claim against the Society.

ARTICLE 7

Requests for interventions shall, in principle, be submitted in writing. They entail the acceptance without reservation, of the present General Conditions and of Particular Conditions which may be attached thereto.

ARTICLE 8

8.1. - Any intervention of BUREAU VERITAS, whatever its nature, whether completed or interrupted for any cause whatsoever, shall involve the payment of fees upon receipt of the invoice and the reimbursement of the expenses incurred. Interests may be demanded in case of late payment.

8.2. - The class of a ship may be withheld or, if granted, suspended or withdrawn, in the event of non-payment of fees.

ARTICLE 9

9.1. - All plans, drawings, specifications and information provided to the Society, or of which the Society may become reasonably aware in connection with the performance of its services, shall be treated as confidential by the Society and shall not, without the prior consent of the party furnishing such document, be used for any purpose other than that for which they are furnished.

9.2. - Records and other documents whatsoever relating to ships classed with the Society shall not be disclosed or communicated by the Society to any third party but with the prior approval of the owner, unless it is in pursuance of an order of the flag authorities or an injunction of a Court having jurisdiction.

ARTICLE 10

Should a technical disagreement arise between the requesting party and the BUREAU VERITAS surveyor, the Society may, at the request of that party, designate another of its surveyors.

ARTICLE 11

Any dispute over the interpretation, or the enforcement of these General Conditions of services, or the performance of BUREAU VERITAS's services, shall be submitted to arbitration in London. Arbitration proceedings will be conducted according to the English law on arbitration. The arbitrator shall be selected by the parties and, in case they could not reach an agreement, he would then be nominated by the President of the Law Society of England and Wales upon request of any party.

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FOREWORD

This guide is intended to provide shipyards and shipowners with information and recommendations concerning various systems of protection against corrosion, so that they can make the proper choice and draw up a contractual specification. The guide applies mainly to new buildings of ships, and also to ships in service.

The guide is concerned mainly with protection of seawater ballast tanks of all types of ships and hold spaces on bulk and ore carriers. It concerns only the protection of such structures made from carbon steel. Some chapters (in particular chapter 3) give general information on corrosion protection.

The recommendations set out in this guide to protect seawater ballast tanks assume a life expectancy of approximately twelve years in case of new buildings coated with hard coating.

The guide does not come within the framework of BUREAU VERITAS Classification Rules. As its name indicates, it is merely a guide for the use of shipyards and shipowners.

The Classification Society is concerned with corrosion protection from two standpoints:

- For new ships at the building stage, to check that zones requiring protection, as specified in the BUREAU VERITAS Rules, are protected.
- For ships in service at the maintenance stage, in relation to the frequency of surveys (Refer to 1.2.2. and Appendix 2).

The particular requirements of BUREAU VERITAS concerning corrosion protection are appended to this guide.

The guide has been drawn up following the work of the *ad hoc* workgroup "Coatings to protect seawater ballast tanks and hold spaces against corrosion". Shipyards, shipowners, painters, paint manufacturers and BUREAU VERITAS all took part in this workgroup.

Users of this guide are reminded of the fact that the subjects dealt with are not examined in detail. The guide is primarily a practical handbook for users.

A glossary of the main terms is given in Appendix 1, for the purpose that the same language is spoken by the users of this guide.

CHAPTER 1 - INTRODUCTION

1.1. General

Corrosion is one of the main causes of structural problems encountered on ships in service.

Large areas of ship structures can be subject to severe corrosion:

- seawater ballast tanks,
- bulk carrier holds, especially when carrying cargoes of corrosive nature of (e.g. coal with high sulphur content),
- cargo tanks, following washing operations.

Many factors contribute to the spread of corrosion, including:

- severe stress on certain zones,
- water retained on horizontal surfaces,
- condensation and streaming of water,
- corrosive cargoes,
- flexibility of sideplating
- inadequate cleaning of bulker holds.

Some of these factors can be taken into account at the design stage, by examining the behaviour of the structure in relation to corrosion.

However, such measures are not sufficient to prevent or reduce the effects of corrosion. The durability of a structure subject to corrosion depends mainly on corrosion protection applied to the new building.

1.2. Regulations

1.2.1. International Regulations

THE IMO will amend the chapter II-1 of the SOLAS 74 Convention by adding a new regulation 14.1. This new regulation will ask for an efficient system of corrosion protection in water ballast tanks of oil tankers and bulk carriers.

1.2.2. BUREAU VERITAS Rules for Classification of ships

Given these changes in International regulations, BUREAU VERITAS has introduced the following IACS Unified Rules and IMO Regulations into its own Rules:

- 1) In April 1992 (for ships more than 65 m in length) and in August 1991 (for ships less than 65 m in length):

Salt water ballast spaces having boundaries formed by the hull envelope shall have an efficient protection coating (BUREAU VERITAS Rules and IACS Unified Rule Z8).

2) In May 1993:

The frequency of inspections of ballast tanks on all ships and of holds in bulk carriers after the first five years depends on the condition of the protective coating (BUREAU VERITAS Rules, IACS Unified Rules Z7, Z10.1 and Z10.2, and IMO Resolution A744 (18)).

3) In September 1993:

Sensitive areas in holds of bulk carriers under construction must be protected by a suitable coating (BUREAU VERITAS Rules and IACS Unified Rule Z9).

Appendix 2 contains the parts of the BUREAU VERITAS Rules concerning the protection of seawater ballast tanks and holds (new buildings and maintenance).

1.3. Economic aspect

1.3.1. Extent of surface areas to be protected during construction

The new regulations (Rule 13F of 1992 amendments to Annex 1 of MARPOL Convention 73/78), requiring a double hull for oil tankers and product carriers, means that the surface areas of ballast tanks to be protected on such ships are now very large.

For information, table 1.I below shows the surface area of seawater ballast tanks on oil tankers and product carriers, in the case of a single hull and in the case of a double hull.

Table 1.I

Deadweight	Single hull	Double hull
40000 t	20000 m ²	70000 m ²
250000 t	50000 m ²	250000 m ²

The change from a single to a double hull means that the area of ballast tanks to be protected against corrosion is increased 3.5 to 5 times.

1.3.2. Cost of corrosion protection

In addition to the cost of applying protection to the new building, allowance must be made for the cost of maintenance and long-term repairs (immobilisation of the ship, painting, scaffolding, possible replacement of plates). This means that the cost of restoring the paint protection can be approximately eight to ten times the cost during building.

Therefore, it is preferable to invest at the construction stage in the best possible protection against corrosion.

CHAPTER 2 - CORROSION OF STEEL

2.1. General

Corrosion is the process of deterioration of metallic materials and their properties, following a reaction with the surrounding environment.

The metals tend to return to a more stable thermodynamic state: iron oxide (rust) for steel.

2.2. Unprotected steel

2.2.1. Types of corrosion

2.2.1.1 Galvanic corrosion

This type of corrosion occurs when two metals or alloys are electrically in contact in a corrosive environment (electrolyte). The less noble metal, in other words the one with the greater electronegative potential is attacked ; it is called anode. The most noble metal is protected ; it is called cathode. This process is known as galvanic corrosion. A more detailed explanation of the processes involved is given in Appendix 3.

This type of corrosion is affected by the following factors:

- difference in potential between the two metals or alloys,
- relative surface areas of anodic and cathodic zones,
- distance between anode and cathode,
- electrical resistance of the galvanic circuit (which depends, in particular, of the electrolytic conductivity and of the coating protection).

2.2.1.2 General corrosion

This involves an almost uniform attack over the surface of the material. In this type of corrosion, the galvanic process extends uniformly over the whole surface.

This form of corrosion is not particularly dangerous, because it can be predicted by tests, and wear on the material is proportional to time and easily measurable.

2.2.1.3 Pitting corrosion

This involves a localised attack, which can result in perforation of the metal or alloy. It is one of the most insidious forms of corrosion.

This form frequently occurs on damaged parts of non-conducting layers on the surface of the metal (oxide films).

In particular, pitting often occurs on stainless steels, and is usually caused by surface contamination.

2.2.1.4 Crevice corrosion

This is an intense localised form of corrosion, usually associated with small volumes of stagnant solution resulting from holes, masked surfaces or crevices.

The mechanism can be explained by the fact that the stagnant solution inside the crevice prevents the diffusion and migration of ions, and that access of oxygen to the metal surface area at corrosion bottom is inadequate to keep the protective oxide layer intact (case of stainless steels).

2.2.1.5 Stress corrosion

In this type of corrosion, fractures occur in the material exposed to a corrosive environment and subject to stresses, the levels of which would not be regarded as dangerous if they were applied outside the corrosive environment. For example these stresses can be residual stresses of welding or thermal stresses.

Such fractures are also not easily detectable.

2.2.1.6 Bacterial corrosion

This form of corrosion is caused by certain bacteria, particularly sulphate-reducing anaerobic bacteria. Such corrosion develops under corrosion deposit product, or in deaerated seawater circuits.

2.2.2. Principal corrosion factors

2.2.2.1 Electrolyte salinity

Seawater contains a high level of salinity (about 3,5 %) and therefore of conductivity. This encourages galvanic corrosion and localised attacks.

In addition, chlorides present in seawater produce breakings in the protective oxide films responsible for corrosion resistance of many materials.

Finally, as regards general corrosion, the rate of corrosion increases in proportion to the salt content.

2.2.2.2 Oxygen

Oxygen is one of the most important factors in corrosion. A decrease in oxygen concentration causes a rise in corrosion rates.

In addition, variations in oxygen concentration on the surface of the same material result in corrosion by differential aeration: surfaces with the lowest oxygen concentration undergo accelerated corrosion.

2.2.2.3 Electrolyte temperature

In general, and if there is no modification in the environment, corrosion increases with temperature. In the same way, it increases with the speed of circulation.

2.2.2.4 Bacteria

Bacteria present in seawater can cause local changes in corrosive conditions, and are therefore dangerous for most metallic materials. The mechanisms of bacterial attack are still unknown. However, efforts are made to combat it by trying to limit the deposits beneath which such bacteria develop, and by using bactericides.

2.2.3. Corrosion rates

For information, the following Table 2.1 gives some corrosion rates, in mm/year, on structures of oil tankers in service. These figures refers to uncoated platings.

Table 2.1

Plating	Segregated Ballast Tank	Cargo / Ballast Tank	Cargo Oil Tank
Deck	0,10 - 0,50	0,05 - 0,30	0,03 - 0,10
Side shell	0,05 - 0,10	0,05 - 0,10	-
Bottom	0,05 - 0,25	0,05 - 0,25	0,04 - 0,10
Longitudinal bulkhead	0,10 - 0,30	0,03 - 0,50	0,03 - 0,10
Transverse bulkhead	0,30 - 0,50	0,02 - 0,10	0,03 - 0,10

2.3. Steel protected by paint coating

In the case of surfaces protected by coats of paint, corrosion can develop in one of the following ways:

1) Local cracks in the paint film

In this case, corrosion is galvanic, and highly active.

These local cracks in the surface can result from mechanical wear or defects in the paint film which have not been checked and repaired on the new building stage (e.g. absence of grinding to smooth the sharp edges of cutouts).

Such cracks may also result from localised fatigue stresses, caused by design errors, or from plastic structural deformations, exceeding the elongation properties of the paint film.

2) Lack of thickness of paint film

A dry film of paint is never completely impermeable to liquid and gas, and full protection requires a certain thickness in order to provide a proper barrier against corrosion.

This type of corrosion is slower than in the case of a local crack in the paint film, but it is generally more extensive.

3) Premature ageing of paint film

Premature ageing of the paint film, particularly of the top coat, will mean less protection for lower layers, and consequently greater permeability to liquid and gas. For this purpose, the film should have a homogeneous thickness in any point.

Premature ageing of the top coat may result from the incorrect choice of type of the paint for its resistance to chemicals, UV or heat, for example.

CHAPTER 3 - CORROSION PROTECTIONS

3.1. General

3.1.1. Application

This chapter is devoted to protection of steel structures against corrosion. This chapter gives general information applying also to other structures than water ballast tanks and hold spaces.

3.1.2. Paint system

A good protection system by painting depends on the following parameters:

- the choice of types of paint, which is to be suitable for the surface to be protected, the environment and required useful life,
- the surface preparation, which is to be suitable for the paint,
- the thickness of the film,
- the conditions of application,
- the work planning,
- the conditions of survey and inspection.

Moreover, it should also be remembered that paint manufacturer's recommendations must be respected under all circumstances.

3.2. Hard coatings

3.2.1. Definition

Generally, a hard coating is a paint. This is in liquid form prior to application and dries after application. A dry, hard coat of paint then remains on the surface, hence the term "hard coating".

3.2.2. Types of paints

Before considering types of paints, the main components of any paint should be recalled:

- the binder, providing internal cohesion in the paint film and the bond with the substrate, and giving the chemical resistance,
- the pigments, which give the paint its colour, covering power, correct consistency and resistance to abrasion,
- the fillers, which allow the paint to be applied in thick layers, without the risk of breaking caused by cracking of the film,
- the additives which, for example, confer thixotropic or fungicidal properties to the paint,
- the solvents, in which the paint binder is diluted in the liquid state, and which evaporate as the paint dries.

Paints are classified in relation to their binders and the way in which they dry and harden.

There are three main ways in which paints cure:

- drying by oxidation,
- physical drying,
- chemical curing.

Paints which dry by oxidation, in addition to evaporation of solvents, require oxygen to provide a bond for the molecular chains which will form the continuous film of paint. Oil paints and alkyd paints form part of this group.

Physical drying paints are dissolved before application in very strong solvents, which prevent strong bonds in molecular chains. When these solvents have evaporated, bonds form and the paint cures.

In general, paints in this second group are based on the following binders:

- chlorinated rubber,
- vinyl,
- bitumen,
- tar.

Chemical curing paints contain two components: the base and the hardener. Curing is obtained by mixing the base and hardener in clearly defined proportions. A chemical reaction then occurs, causing crosslinking of the molecular chains. Once cure, these paints provide a very hard film.

In general, paints in this third group are based on the following binders:

- epoxy,
- tar epoxy,
- polyurethane,
- polyester,
- zinc silicate.

3.2.3. Criteria for the selection of paint systems

In order to select the paints for a particular application, it is important to know their main properties and the particular conditions for their application and maintenance.

They are given hereafter:

1) Surface preparation

The quality of the necessary surface preparation varies in degree. Requirements shall be respected, in order to ensure that the paint adheres properly to the material. This factor has a fairly high impact on the total application cost.

2) Two-components or one-component paint

There are obviously risks of mixing two-components paints incorrectly, or using the wrong proportions.

3) Percentage solvents

A paint containing a high percentage of solvent will be easy to apply, but solvent evaporation will be more intense, and precautions are needed to ensure replacement of air. Solvent free paints should preferably be used in confined spaces for safety reasons.

4) Temperature of application

Temperature limits should be respected in order to ensure satisfactory application and drying. This applies especially to chemical curing paints, as epoxy.

5) Recoating time

These are the minimum and maximum times between which a second coat of paint may be applied, to retain maximum adherence between the two coats.

6) Drying time

This is an important factor, particularly in case of repairs for which the available time is often short.

7) Colour

In order to check that one coat will cover the coat below, colour of paints can be alternated.

8) Maximum dry film thickness

When the paint film is thin, several coats can be needed to ensure the required protection. This implies a significant increase in the application cost.

9) Covering properties

Certain very hard paints, or paints which have a very smooth, high gloss finish, present poor adhesion qualities. It is advisable to use such paints only for the top coat.

10) Elongation

This property is to be taken into account when the paint is applied to a zone subject to stresses and/or to fatigue.

11) Resistance to water and chemicals (acids, solvents, etc)

This parameter is to be considered in relation to the environment in contact with the painted surface. The word "permeability" can also be used as equivalent to "waterproof".

12) Resistance to abrasion, impacts, heat and UV

These properties should be examined in relation to the surrounding environment.

13) Toxicity

For health and safety reasons, the painter must be informed of any dangers he may incur.

3.2.4. Surface preparation

1) Importance of surface preparation

The only way of ensuring the durability of a coat of paint is to ensure that it adheres properly to the underlying material.

Such adherence is possible only on a well cleaned surface.

The following substances are to be removed, according to relevant standards :

- metal oxides,
- scales,
- water soluble salts,
- old coatings,
- dust,
- grease and oil,
- foreign matters,
- humidity.

Moreover, the cutting sharp edges and angularities on welds are to be treated, in order to avoid local cracks in the paint film.

In order to ensure the good adherence of the coating, the so prepared surface is to present the specified roughness, adapted to the type and thickness of the coating.

2) Types of surface preparation

Degrees of rust and surface preparation are defined by reference to standard ISO 8501.1. Other standards may be used for reference, if they are recognised as equivalent to the ISO standard.

Surface roughness is defined by reference to standard ISO 8503.

Table 3.I below shows, in a general scope, the characteristics of the two main modes of cleaning: blastcleaning ("Sa" according to ISO 8501.1) and mechanical or manual cleaning ("St" according to ISO 8501.1).

Table 3.I

METHOD	CHARACTERISTICS
Blastcleaning (Sa)	- Excellent to remove metal oxides, scales and substances adhering to the surface, - Excellent to ensure surface roughness, - May be insufficient to remove grease, oil and water-soluble salts, - Work time much shorter than for other methods.
Mechanical or manual cleaning (St) : - Scraper, - Buffer, - Brush.	- Insufficient to ensure surface roughness : risk of polishing the surface, - Insufficient to remove grease, oil and water-soluble salts, - Costly methods.

Blast-cleaning usually provides an excellent result.

Mechanical means may be used in areas where blastcleaning is difficult to carry out.

Compared to blast-cleaning and mechanical cleaning, manual methods give less results and should consequently be avoided, if possible.

As a general rule, all steel structural components to be painted are blast-cleaned, in order to obtain at least grade Sa 2 1/2, according to ISO 8501.1.

3) Preparation of edges and welds

In general, surface defects, such as splashes of welding material, weld defects and irregular weld profiles, need to be removed before actual surface preparation takes place:

- sharp and acute cutting ridges must be chamfered or rounded,
- welds and burns must be blastcleaned,
- plate defects must be removed by grinding, brushing or blastcleaning.