

**BUREAU
VERITAS**

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Guidelines for Corrosion Protection Applicable to Inland Navigation Vessels

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MARINE & OFFSHORE DIVISION

GENERAL CONDITIONS

ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine & Offshore Division (the "Society") is the classification ("Classification") of any ship or vessel or offshore unit or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- "prepares and publishes Rules for classification, Guidance Notes and other documents ("Rules");
- "issues Certificates, Attestations and Reports following its interventions ("Certificates");
- "publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as "Certification".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as "Services". The party and/or its representative requesting the services is hereinafter referred to as the "Client". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Ship-builder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraisal given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisal is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - **It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisal or cause to modify its scope.**

2.4. - The Client is to give to the Society all access and information necessary for the safe and efficient performance of the requested Services. The Client is the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out.

ARTICLE 3

3.1. - **The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are a collection of minimum requirements but not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.**

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - **The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.**

3.3. - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

3.4. - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- "reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- "conducts surveys at the place of their construction;
- "classes Units and enters their class in its Register;
- "surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.

5.2. - The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for. In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

5.3. - **The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder.**

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - **If the Services of the Society or their omission cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee. These limits apply regardless of fault including breach of contract, breach of warranty, tort, strict liability, breach of statute, etc.**

The Society bears no liability for indirect or consequential loss whether arising naturally or not as a consequence of the Services or their omission such as loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred. Time is to be interrupted thereafter with the same periodicity.

ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - **Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.**

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

7.4. - The contract for classification and/or certification of a Unit cannot be transferred neither assigned.

ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve, for the part carried out, the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. - **Overdue amounts are increased as of right by interest in accordance with the applicable legislation.**

8.3. - **The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.**

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- "Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the **classification file** consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit ;
- "copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- "the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, may be passed on to IACS (International Association of Classification Societies) according to the association working rules;
- "the certificates, documents and information relative to the Units classed with the Society may be reviewed during certifying bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France, or to another Court as deemed fit by the Society.

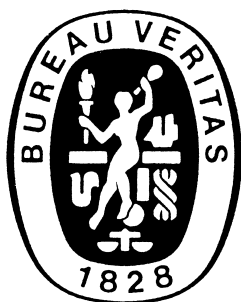
12.3. - **Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.**

ARTICLE 13

13.1. - These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement. They are not varied by any purchase order or other document of the Client serving similar purpose.

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.



GUIDANCE NOTE NI 607

NI 607

Guidelines for Corrosion Protection Applicable to Inland Navigation Vessels

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SECTION 1 GENERAL

1 General

1.1 Introduction

1.1.1 Corrosion is one of the main causes of structural problems encountered on vessels in service. Large areas of vessel structures can be subject to severe corrosion:

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

1.1.2 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
- 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 Scope

1.2.1 These guidelines are intended to provide Owners, building yards and the Society's Surveyors with information and recommendations aiming to fulfilling the requirements for hull structure preservation laid down in NR217, Pt B, Ch 8, Sec 2. In particular, they will enable all the above-mentioned parties to:

- make a proper choice and draw up specifications of the corrosion protection system
- assure a proper maintenance of the corrosion protection system
- carry out efficiently inspections required for the corrosion protection system within the scope of surveys for class assignment and maintenance.

SECTION 2 CORROSION OF STEEL

1 General

1.1 Definition

1.1.1 Corrosion is the degradation of metallic materials and their properties due to interaction with their environment. It is difficult to totally eliminate corrosion as most materials used for engineering applications, including steel and aluminium, are thermodynamically unstable, compared to the naturally occurring oxides and hydroxides.

1.2 Electrochemical nature of corrosion

1.2.1 Nearly all corrosion reactions in the marine environment are electrochemical in nature, i.e., electrical current is associated with the chemical reactions of corrosion. The driving force of corrosion can be considered the electrical potential difference between two states of matter. In most marine corrosion processes, electrical current passes between two sites (an anode and a cathode) through an electrolyte (water), with associated reactions at both the anode and cathode. The reaction at the anode is the corrosion reaction, called oxidation.

1.2.2 There are several requirements for electrochemical corrosion to take place:

- there must be an anode and cathode
- both must be in contact with a common electrolyte
- there must be an electrical connection between the anode and cathode, other than the electrolyte
- there must be a thermodynamic tendency for electrochemical reaction to occur.

Eliminate any one of these elements, and corrosion will not occur.

2 Unprotected steel

2.1 Types of corrosion

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 (anode). The most noble metal is protected (cathode). A more detailed explanation of the processes involved is given in App 1.

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 electrolyte conductivity and of the coating protection).

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.

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

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).

2.1.5 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 the residual stresses of welding or thermal stresses. Such fractures are also not easily detectable.

2.1.6 Bacterial corrosion

This form of corrosion is termed Microbiologically Influenced Corrosion (MIC) caused by certain bacteria, particularly sulphate-reducing anaerobic bacteria.

Such corrosion develops under corrosion deposit product, or in deaerated raw water circuits.

2.2 Main corrosion factors

2.2.1 Electrolyte salinity

Level of salinity gives the measurement of conductivity of the water. This encourages galvanic corrosion and localised attacks. Seawater contains high level of salinity (about 3,5%) compared to brackish water (1-2,5%) and fresh water (below 1%)

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 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.

2.2.3 Electrolyte temperature

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

2.2.4 Bacteria

Bacteria present in water 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.

Bacteria known to cause MIC are listed in Tab 1 together with environment conditions and metallic materials affected.

Table 1 : Bacteria known to cause MIC

Genus of Species	pH	Temperature range °C	Oxygen Requirement	Metals Affected
Desulfovibrio	4 - 8	10 - 40	Anaerobic	Iron, steel, stainless steels, aluminium, zinc and copper alloys
Desulfotomaculum	6 - 8	10 - 40 (Some 45 - 75)	Anaerobic	Iron and steel, stainless steels
Desulfomonas		10 - 40	Anaerobic	Iron and steel
Thiobacillus thiooxidans	0,5 - 8	10 - 40	Aerobic	Iron and steel, copper alloys
Thiobacillus ferrooxidans	1 - 7	10 - 40	Aerobic	Iron and steel
Gallionella	7 - 10	20 - 40	Aerobic	Iron and steel
Sphaerotilus	7 - 10	20 - 40	Aerobic	Iron and steel

Table 2 : Corrosion rates, in mm/year, for seagoing oil tankers

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 Corrosion rates

2.3.1 For information, Tab 1 gives some corrosion rates, in mm/year, on structures of seagoing oil tankers in service. These figures refer to uncoated platings.

3 Steel protected by paint coating

3.1 General

3.1.1 In the case of surfaces protected by coats of paint, corrosion can develop in one of the ways described in [3.1.2] to [3.1.4].

3.1.2 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.

3.1.3 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.

3.1.4 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 paint for its resistance to chemicals, UV or heat, for example.

SECTION 3 CORROSION PROTECTIONS

1 Corrosion control methodologies

1.1 General

1.1.1 Methods for controlling corrosion are grouped into five categories according to [1.2] to [1.6].

1.2 Material selection

1.2.1 Material selection is choosing a material for the specific environment and application so that the resultant corrosion, if any, is maintained within acceptable limits.

1.3 Design

1.3.1 Designing for corrosion control addresses factors that can lead to corrosion such as eliminating crevices, eliminating standing water, allowing for drainage, and also includes providing allowances for corrosion.

1.4 Coatings

1.4.1 Coatings act by physically separating the metal from the effects of environment (electrolyte) thus removing an essential factor for corrosion. There is type of coating which acts only as a barrier. Barrier coatings include greases and oils, as well as common organic coatings (paints).

1.5 Cathodic protection

1.5.1 General

Cathodic protection is an electrical technique recommended to be used together with coatings for corrosion protection of immersed components and structures, such as underwater hulls, external propulsion gear, and ballast tanks.

1.5.2 Sacrificial anode cathodic protection

Sacrificial anode cathodic protection is a natural method using a more active metal to protect the vessel's structure or component. The more active metal is placed in electrical contact and in the same electrolyte with the metal to be protected. The active metal becomes the anode of the electrochemical cell and corrodes, the site of the oxidation reaction, while the structure to be protected becomes the cathode. This natural form of cathodic protection is called sacrificial anode cathodic protection since the active metal sacrifices to protect the structure. The active, sacrificial metal may be provided in the form of a sacrificial anode, or may be incorporated into the chemistry of coating such as in zinc rich coatings.

1.5.3 Impressed current cathodic protection

In the impressed current cathodic protection, the active metal is replaced by a direct current power source that serves to make the structure the cathode.

1.6 Inhibitors

1.6.1 Inhibitors are substances that, when added in small quantities to the environment, inhibit one or more of the steps in the corrosion process. Inhibitors are commonly used in three ways:

- in closed loop fluid systems, such as boiler steam systems, where the concentration of inhibitor in the liquid can be maintained
- in the form of vapor phase inhibitors to reduce atmospheric corrosion in closed spaces
- in coatings.

2 Coatings

2.1 General

2.1.1 A coating is any material that will form a continuous film over a surface; whereas paint refers to a general type of coating in which a mixture of pigment and vehicle together form a liquid or paste that can be applied to a surface, and is organic in nature. Coating is broad category that includes paints (organic coatings), as well as inorganic metallic and non-metallic coatings.

2.1.2 Paint system

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

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

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

2.1.3 Types of paints

In the following, drying is the evaporation of the solvent, whereas curing is the ultimate reaction of the components. Curing may be by:

- atmospheric drying
- baking (temperature activated), or
- catalyst activated chemical reaction.

Organic coatings (paints) are most commonly categorised by binder type, cure mechanism or a combination of the two.

Organic coatings include asphalt, oil, alkyd, acrylic, vinyl, epoxy and urethane. Special purpose coatings include anti-fouling coatings and zinc-rich coatings. Non-organic coatings include inorganic non-metallic coatings, metal coatings and conversion coatings.

a) Asphalts

Asphalts are derived from petroleum and coal residues and include natural asphalts and coals tars. Asphalts may be used alone or mixed with other materials. These coatings are typically inexpensive, heavy, and do not require extensive surface preparation. They degrade in sunlight and may not dry hard.

b) Oils

Oils are based on naturally occurring oils such as linseed, tung, pine and fish oils and provide a stable film when oxygen from the air reacts with oil molecules to harden the film and produce limited cross-linking.

c) Alkyds

Alkyd resin (also called polyester) offers great versatility. Alkyds have good color stability and are suitable for use in most atmospheric and mildly industrial environments, but should not be used in strongly acidic or alkali conditions.

d) Acrylics

There are two major categories of use for the acrylic resin. First, acrylic resins are used in conjunction with other resins, for example, epoxies and vynils, to improve appearance in exterior applications, and second, acrylics are used in the preparation of latex water based paints. Latex paints are used extensively for interior applications where appearance considerations are equal to or exceed durability requirements.

e) Vinyl

Vinyl coatings are based on the same molecule as common PVC (poly-vinyl-chloride) piping and are extremely resistant to most organic substances such as acids, alkalis, oils and alcohols as well as water.

f) Epoxy

Although the epoxy resin may be combined with oils, epoxy coatings are most often two-component coatings, in which two liquids (generally called the base and the hardener, an oil fatty acid) are mixed and chemically react to form the epoxy ester, which is an extremely cross-linked film. The extensive cross-linking results in some of the most desirable coating properties. Epoxies must, however, be mixed and applied properly, and are somewhat sensitive to the surface preparation and cleanliness of the substrate.

g) Urethane

Urethanes are also formed by the reaction between a base (isocyanate) and a hardener (a hydroxyl compound). Although often used for a variety of exterior and immersed applications, the properties of urethane coatings, as a class, can be varied more widely than almost any other organic coating.

h) Anti-fouling

Anti-fouling paint is a classification by special property. Anti-fouling paints are designed to prevent the attachment and growth of biological matter on structures and hulls.

i) Zinc-rich coatings (inorganic non-metallic)

Inorganic non-metallic zinc coatings utilize zinc in the coating structure. These coatings are most often used as primers, either stand-alone or in conjunction with topcoats and provide cathodic protection to the substrate.

j) Metallic coatings

Metallic coatings provide a metallic layer over the substrate. The metal coating may be anodic (active) or cathodic (noble) to the substrate. In anodic metal coatings, the coating metal is less corrosion resistant (anodic) than the substrate and provides sacrificial cathodic protection, whereas in cathodic metal coatings (such as nickel plating), the coating is more corrosion resistant (cathodic) than the substrate.

k) Conversion coatings

These coatings convert the surface of the substrate to provide the desired affect. Processes include anodizing, phosphating, and the most common, chromating.

2.2 Hard coatings

2.2.1 Definition

Generally, 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".

2.2.2 Paint components

The main components of paints are the following:

- the binder (resin) is responsible for providing adhesion, binding the pigment, and also gives the paint resistance properties which make the final coating tough and durable
- the pigments play a large role in determining color and appearance. Some pigments also provide added bulk, helping to thicken a paint when needed
- the fillers increase the bulk of the coating, improve density and can improve abrasion resistance
- the additives, when certain properties need to be manipulated or enhanced, additives are often the solution. Thickeners, for example, are additives that help thicken the paint to make application easier
- the solvent is responsible for transporting the binder and other components to the substrate surface. The type of solvent depends upon the other components of the given paint. Oil-based paints, for example, can use a basic paint thinner as the solvent. Latex-based paints, on the other hand, tend to use water as their solvent.

2.2.3 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 specified herebelow:

a) 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.

b) Two-component and one-component paint

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

c) 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.

d) 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.

e) 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.

f) Drying time

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

g) Colour

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

h) 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.

i) 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.

j) Elongation

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

k) Resistance to water and chemicals

This parameter is to be considered in relation to the environment in contact with the painted surface.

l) Resistance to abrasion, impacts, heat and UV

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

m) Toxicity

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

Table 1 : Characteristics of cleaning methods

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"): <ul style="list-style-type: none">• Scraper• Buffer• Brush	Insufficient to ensure surface roughness: risk of polishing the surface
	Insufficient to remove grease, oil and water-soluble salts
	Costly methods

2.2.4 Surface preparation

a) 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.

b) Types of surface preparation

Degrees of rust and surface preparation are defined by reference to standard ISO 8501.1. Other equivalent standards may be used for reference.

Surface roughness is defined by reference to ISO 8503.

Tab 1 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).

Blastcleaning usually provides an excellent result.

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

Compared to blastcleaning 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 to be blastcleaned in order to obtain at least grade Sa 1/2, according to ISO 8501.1.

c) 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.

Applicable recognised steel plating preparation standards are to be complied with.

2.2.5 Application procedures

a) Ambient conditions

To prevent problems of adhesion and paint defects caused by condensation, the ambient conditions given by the paint manufacturer are to be complied with.

Except for particular case, the following conditions should be observed:

- relative humidity of air less than 85%
- surface temperature at least 3°C above dewpoint
- minimum and maximum temperatures of the surface are to be in accordance with the recommendations of the paint manufacturer.

b) Methods of application

There are many methods for applying paints. For steel constructions, only applications by brush, roller or airless spraygun are recommended. For characteristic features of these methods, see Tab 2.

In general, it is recommended to apply, after the surface preparation, stripe coats by brush on edges, welds, and areas difficult to reach with an airless spraygun.

Table 2 : Characteristic features of paint application methods

Application method	Characteristics
Brush	Very good paint penetration, even with high relative humidity
	Thickness of paint film two or three times less than with airless spraygun application
	Slow speed of application (10 to 20 m² per hour)
	Easy to apply in areas of difficult access
Roller	Very poor penetration of paint in first coat
	Inclusion of air in wet paint film
	Approximately same thickness of paint film as for brush application
	Medium speed of application (50 m² per hour)
	Not easy application for some types of paints
Airless spray gun	Very good paint penetration
	Thick film
	Absence of air in paint film
	High speed of application (250 m² per hour)
	Training needed for painter

2.2.6 Defects: causes, prevention and repairs

Tab 3 gives a list of common defects during application of paint on steel constructions, their cause, preventive methods and appropriate repair procedures.

Table 3 : Causes, prevention and repairs of paint defects

Defects	Causes	Prevention - repairs
Runs and sags	<ul style="list-style-type: none">• Too much paint per coat• Gun too close to the surface• Too much thinner• Too high paint temperature (in case of two-component paint)• Exceeded pot life	<ul style="list-style-type: none">• Hold the gun at the correct distance from the surface• Avoid excess thinning• Use a small brush to cancel runs and sags while the paint is still wet
Orange skin	<ul style="list-style-type: none">• Low air pressure implying bad atomisation• Gun too close to the surface• Solvent evaporation too rapid• Overthickness	<ul style="list-style-type: none">• Correct air pressure• Hold the gun at the correct distance from the surface• Use proper thinner• Sand down to smooth surface and repaint
Peeling / delamination	<ul style="list-style-type: none">• Unsatisfactory surface preparation• Incompatibility with undercoat• Contamination of intercoat• excessive curing time between coats	<ul style="list-style-type: none">• Peel off and recoat
Dry spray	<ul style="list-style-type: none">• Gun too far from the surface• Application angle too much open• Solvent evaporation too rapid• Too high temperature	<ul style="list-style-type: none">• Hold the gun at the correct distance from the surface• For zinc primers: reblasting and recoat• For oxidative curing paints: remove loose dust and apply a new coat
Bleeding	<ul style="list-style-type: none">• Diffusion of a coloured substance through the coat• In general, associated to epoxy coat covering a coal tar epoxy coat	<ul style="list-style-type: none">• Avoid such a paint system

Defects	Causes	Prevention - repairs
Lifting	<ul style="list-style-type: none">• Paint with strong solvents applied over incompatible paint• Excessive softening of base coat by top coat• Temperature too high or too low	<ul style="list-style-type: none">• Choose the right paint system• Adjust temperature• Sand down to smooth surface and recoat
Pinholes / holidays	<ul style="list-style-type: none">• Porosity in the undercoat or in the metal surface• Coating over hot steel surface• Incorrect spray viscosity	<ul style="list-style-type: none">• Adjust temperature• Use the correct gun technic• sand down to smooth surface and recoat
Blistering	<ul style="list-style-type: none">• Solvent retention• Improper coating application• Soluble salt contamination (non sufficient washing of the surface) under the paint film	<ul style="list-style-type: none">• Use proper thinner• Use correct application technic• Efficient washing of the surface• Reblasting and washing of the affected area and recoating
Fish eyes	<ul style="list-style-type: none">• Application over oil, moisture, dirt, other contamination or incompatible coating	<ul style="list-style-type: none">• Efficient washing of the surface• Choose a compatible system of coats• Sand down to smooth surface and recoat

2.2.7 Advantages and disadvantages

Tab 4 shows the main advantages and disadvantages of different types of paints.

Table 4 : Advantages and disadvantages of paint types

Type of paint	Advantages	Disadvantages
Pure epoxy	<ul style="list-style-type: none">• Good chemical resistance• Good adhesiveness• Very low permeability• High mechanical strength	<ul style="list-style-type: none">• Application temperature• Two components• Excellent surface preparation• Curing time• Behavior to UV• Difficulty of covering
Mastic epoxy	<ul style="list-style-type: none">• Curing temperature lower than for pure epoxy• Very low permeability• Good chemical resistance• High percentage of solids	<ul style="list-style-type: none">• UV behavior• Temperature for application• Two components
Zinc epoxy	<ul style="list-style-type: none">• Very short drying time• 85% of zinc (in dry film)• Good adhesion• High mechanical strength• Galvanic protection	<ul style="list-style-type: none">• Temperature for application• Two components• Low maximum film thickness (10 to 30µm)• Poor acid resistance• Low cohesion
Zinc silicate	<ul style="list-style-type: none">• Good solvent resistance• Good resistance to heat• Good mechanical strength• Ease of application	<ul style="list-style-type: none">• Excellent surface preparation• Curing with humidity• Temperature for application• Two components• Low maximum film thickness (risk of mud-cracking above 100 µm)
Alkyds	<ul style="list-style-type: none">• Ease of application• One component• Good weatherproof quality	<ul style="list-style-type: none">• Medium acid resistance• Medium water resistance• Low solvent resistance• Difficulty of covering with another type of paint

Type of paint	Advantages	Disadvantages
Chlorinated rubber	<ul style="list-style-type: none">• Application unaffected by temperature• Good water resistance• Ease of covering	<ul style="list-style-type: none">• Poor solvent resistance• Low solid content• Thermoplastic coating• Low maximum film thickness (75 to 100 µm)
Polyurethane	<ul style="list-style-type: none">• Good chemical resistance• Excellent weatherproof quality• Good solvent resistance• Possible application at low temperature	<ul style="list-style-type: none">• Two components• Difficulty of covering• Contact with skin to be avoided
Vinyl	<ul style="list-style-type: none">• Good mechanical resistance• Good weatherproof quality• Good water resistance• Flexible	<ul style="list-style-type: none">• Low solid content (35 to 40%)• Poor resistance to strong solvents• Low maximum film thickness
Vinyl tar	<ul style="list-style-type: none">• Good water resistance• Fast drying	<ul style="list-style-type: none">• Difficulty of covering with finishing paints other than antifouling paints• dark colour
Acrylic	<ul style="list-style-type: none">• Application unaffected by temperature• Ease of covering• Good resistance to weather and UV	<ul style="list-style-type: none">• Low resistance to solvents• Low solid content• Low maximum film thickness

2.3 Soft coats

2.3.1 Definition

At the opposite of the hard coatings (see [2.2]), these remain soft after being applied on the surface to protect.

2.3.2 Types of soft coats

The main soft coat types are the following:

- a) Petroleum and wool grease based soft coats
They normally are applied by spraying. However, they can be applied by floating. In such a case, some particular precautions are to be taken against the pollution of water.
- b) Rubber or PVC (or equivalent) tapes
These are applied either by pressing the tape to the surface, or by heating the surface after application (heat shrinkable tape).

2.3.3 Surface preparation

The surface preparation before application of the soft coat should be:

- removing grease, dirt, dust and loose rust
- cleaning of the surface using a high pressure water jet.

As a rule, the soft coats are to be applied on a surface as dry as possible.

Table 5 : Advantages and disadvantages of soft coats

Advantages	Disadvantages
<ul style="list-style-type: none">• Easy surface preparation• Quick to apply	<ul style="list-style-type: none">• Short life of the coat• Risks in survey due to soft and slippery coats• Dark colour coat• Frequent surveys with necessary recoating every one or two years• Fire and explosive risks in case of welding work (specially with wool grease based soft coat)• Risk of water pollution when applied with floating method• Difficulty for elimination before application of a hard coating

2.3.4 Advantages and disadvantages

Tab 5 lists the main advantages and disadvantages of soft coats.

In compliance with Tab 5, the soft coats can be used for temporarily coating, in case of repairs onboard vessels in service. In such a case, the same system of coating is to be continued, due to difficulties for elimination of soft coats

3 Cathodic protection

3.1 Principles

3.1.1 The cathodic protection is based on the principles of galvanic corrosion detailed in App 1. When two different metals joined by an external conductor are immersed in an electrolyte (water), electrons are going from the anode (less noble metal) to the cathode (more noble metal) through the electric conductor. Consequently, the anode is corroded and the cathode is protected.

For protection of a steel structure by this principle, the steel structure is considered as the cathode, and another metal is used as the anode.

This can be carried out in the following two ways.

a) Cathodic protection with sacrificial anodes

A sacrificial anode is a block of very pure metal, connected by welding to the structure. It is to be noted that a connection between the two metals is to be achieved. The protection by such anode is very efficient in areas close to the anode. Consequently, several anodes have to be fitted.

b) Impressed current system

In such a system, the structure to be protected is connected to the negative pole of a direct current power source. The anodes are connected to the positive pole. The current is then impressed in order to keep the potential difference as low as possible.

3.2 Advantages and disadvantages

3.2.1 Tab 6 lists the main advantages and disadvantages of the cathodic protection.

3.3 Sacrificial anodes

3.3.1 Sacrificial anodes are made in zinc or aluminium, in very pure metal. The composition of the anode alloy is very important for the proper working of the anode, in order to avoid the creation of an isolating coat on the anode surface.

The metallic connection of the anode with the surface to be protected is to be well ensured in order to have an electrical continuity. For this purpose, welding is recommended.

The amount of anodes necessary to protect a structure (excluding some particular local protection) can be obtained by the following formula:

$$P = \frac{IAH}{1000K}$$

Where:

P : Total mass of anodes, in kg

A : Area to be protected, in m²

I : Necessary current for, cathodic protection of submerged steel, in mA/m².

The following values are given for information:

- I = 1 mA/m², for painted steel, in case of no paint defects
- I = 2 - 10 mA/m², for painted water ballast tanks
- I = 10 - 20 mA/m², for underwater painted external hull
- I = 50 - 70 mA/m², for uncoated ballast tanks

H : Effective life of the anodes, in hour

K : Current capacity of anodes, in Ah/kg

- K = 760 Ah/kg for zinc anodes
- K = 2400 Ah/kg for aluminium anodes.

The anodes are to be distributed in order to ensure an efficient protection of all areas of the structure.

In cargo tanks of tankers, only aluminium anodes are permitted. In this case, the maximum height of the anode is to be determined in accordance with recognised standards.

Table 6 : Advantages and disadvantages of cathodic protection

Advantages	Disadvantages
<ul style="list-style-type: none">• Efficient system for corrosion protection• complementary protection in case of installation on painted structures	<ul style="list-style-type: none">a) Electrolyte (water) neededb) Sacrificial anodes<ul style="list-style-type: none">• Necessary installation of many anodes, well connected to the structure• Frequent replacement of anodesc) Impressed current<ul style="list-style-type: none">• Hydrogen (explosive gas) development, i.e. risks of explosion in closed structures without ventilation• Development of alkalinity on the steel surface: risks of damage for some types of paints.

SECTION 4 NEW BUILDINGS

1 General

1.1

1.1.1 The protection systems indicated in this Section are to be considered as examples of usually applied systems acting satisfactorily. However, some other recognised systems can be considered.

2 Choice of protection systems

2.1 General

2.1.1 The choice can be done between the following protection systems:

- Hard coatings
- Soft coats
- Cathodic protection.

2.2 Hard coatings

2.2.1 This type of system is very well adapted for the protection of holds in bulk carrier and of water ballast tanks.

The attention is drawn to the fact that the paint is to be compatible with the cargo or with the water, sometimes strongly polluted in water ballast tanks.

The epoxy based paints are a good choice for holds of bulk cargo vessels, due to their particular hardness.

2.3 Soft coats

2.3.1 This system does not give a sufficient lifetime protection of structure. Consequently, the soft coats are not recommended in case of new buildings.

2.4 Cathodic protection

2.4.1 This type of protection can only work on structures immersed in electrolyte, i.e. water. Moreover, the impressed current system implies a development of hydrogen and shall not be fitted in closed structures without ventilation. Consequently, only the sacrificial anodes system can be fitted in water ballast tanks, and in general, together with a protection by coating.

3 Water ballast tanks

3.1 Hard coatings

3.1.1 Paint specification

The paint specification, established jointly by the building yard, the owner and the paint manufacturer, defines the paint system. App 4 gives information of the content of a paint specification.

3.1.2 Surface preparation

a) Primary surface preparation

Referring to Sec 3, the minimum primary surface preparation consists in removing mill scale, oxidation and foreign matters by abrasive blast-cleaning treatment to grade Sa 2 1/2, according to the ISO 8501.1 and the surface roughness according to the manufacturer's specification. A possible application of a shop primer can follow this surface preparation.

b) Secondary surface preparation

It consists in removing oxidation and foreign matters after fabrication work and weather exposures, prior to application of the paint system. Secondary surface preparation grade is to comply with applicable recognised standards.

Table 1 : Characteristics of paint systems

Water ballast tanks		
Paint	Total DFT, in µm	Number of coats
Pure epoxy	350	2
Modified epoxy	350	2
Zinc silicate (1)	100 (2)	1
(1) Only for local application on warm bulkheads		
(2) It is recommended to apply this paint without over thickness		

3.1.3 Thickness

The total Dry Film Thickness (DFT) shall be applied as per the manufacturer’s recommendations.

3.1.4 Paint colour

It is recommended to select paints of light colour.

3.1.5 Compatibility

In the case of water ballast tanks, the paints used are to resist sea/river water, often polluted, and should also be compatible with the shop primer, if the case may be.

3.1.6 Choice of paint

Taking into account the recommendation [3.1.5], the following paint systems can be considered:

- Pure epoxy
- Modified epoxy
- Polyurethane
- Zinc silicate.

It is to be noted that:

- Polyurethane is to be selected for application at low temperature (down to –5°C)
- Zinc silicate paints are recommended for local application on warm bulkheads adjacent to heated compartments.

3.2 Hard coatings and sacrificial anodes

3.2.1 In the coatings, local defects always exist and are starting points of corrosion. This phenomenon occurs particularly on bottom plates of tanks, and pitting corrosion can be developed in these areas.

3.2.2 In order to have a complementary protection, it is recommended to provide a cathodic protection with sacrificial anodes, in addition to the hard coatings. This complementary cathodic protection can be dimensioned on the basis of half time ballasting and for 4 years.

3.2.3 The dimensions and distribution of anodes on the structure are to be established jointly by the building yard and the anodes supplier.

3.2.4 The protection due to anodes is efficient only on structures immersed in an electrolyte. Consequently, no efficiency is achieved in empty tanks or above the water level.

4 Holds in bulk cargo vessels

4.1 General

4.1.1 The recommendations given in [3.1.1] to [3.1.4] apply to paints for holds in bulk cargo vessels.

4.1.2 The paints are to be compatible with the cargo in holds, in particular, in case of alimentary products.

Table 2 : Characteristics of paint systems

Holds in bulk cargo		
Paint	Total DFT, in µm	Number of coats
Pure epoxy	350	2
Modified epoxy	350	2
Polyurethane	350	2

4.1.3 The selected paints are to be of a high hardness in order to withstand shocks and abrasion.

4.1.4 Considering the recommendations in [4.1.1] to [4.1.3], the following paint systems can be considered:

- Pure epoxy
- Modified epoxy
- Polyurethane.

It is to be noted that:

- Polyurethane is to be selected for application at low temperature (down to –5°C)
- Zinc silicate paints are recommended for local application on warm bulkheads adjacent to heated compartments.

SECTION 5 VESSELS IN SERVICE

1 General

1.1

1.1.1 A regular and periodical maintenance of the protection against corrosion is recommended in order to increase the life of the protection and consequently to maintain the steel structure in good condition.

For this purpose, it is strongly recommended to repair all defects detected during inspections, and especially localised corrosion on edges of stiffeners and openings.

2 Hard coatings

2.1 General

2.1.1 As a guidance for repair, it is recommended to repair defects as soon as rust extends on more than 5% of the surface area in order to maintain the coating in GOOD or FAIR condition as defined in App 2.

It is to be noted that if the coating is in POOR condition as defined in App 2, repairs are necessary, considering the coating as being no more efficient.

However, for localised corrosion on edges of stiffeners and openings particularly, it is preferable not to wait and to repair defects as soon as they are detected by inspection.

2.2 Types of paints

2.2.1 The paint to be used for repairs is preferably to be of the same paint type as the original. If not possible, the paint should be compatible with the paint system used during the construction of the vessel. The compatibility is to be agreed by the paint manufacturer, the building yard and the owner.

2.2.2 Considering that the conditions for repair, and specifically the surface preparation and the conditions for application, are not so easy to achieve as in the case of a new building, the paint manufacturers have developed special "tolerant" epoxy paints with the following advantages, compared with "standard" epoxy paints:

- the degree of surface preparation is lower
- the temperatures application are less compelling
- the time for recoating is longer.

2.3 Surface preparation

2.3.1 General

As for paint applied on new vessels, the surface preparation is of greater importance for the quality and the durability of the coating. The surface preparation can be achieved by one of the following methods:

- blast cleaning
- mechanical cleaning
- hydroblasting
- electrolytic descaling.

2.3.2 Blast cleaning

This method is the recommended one for having an efficient surface preparation (refer to Sec 3, [2.2.4]). It shall be applied after washing and degreasing of the surface area.

As a rule, the degree of preparation shall not be less than Sa 2 according to ISO 8501.1, and is also to be in accordance with the paint manufacturer requirements.

2.3.3 Hand and poor tool cleaning

The surface preparation can be achieved by using this method, only for local and limited repairs.

As for blast cleaning, a washing and degreasing are to be carried out before cleaning.

As a rule, the degree of preparation is to be at least St 2, according to ISO 8501.1, and preferably St 3.

2.3.4 Hydroblasting

In maintenance work, hydroblasting is more and more used for the cleaning of the surface to be repaired. Compared to blast cleaning, the following advantages and disadvantages can be noted:

- no abrasive is needed
- no dust is to be removed after cleaning
- hydroblasting leaves a very low salt content on the surface
- there is a quick oxidation of the surface area after cleaning
- no surface roughness is created.

The degree of cleaning depends on the pressure of the water jet. For achieving a complete cleaning, with removal of rust and all paint layers, a pressure greater than 1700 bar is recommended (Ultra High Pressure hydroblasting).

In the case of cleaning on local areas, it is recommended to remove old paints on the border of such areas, these paints being disbonded by hydroblasting.

The new paint to be applied must be well adapted to this type of surface preparation and the “tolerant” epoxy paints, as described in [2.2.2], are particularly suitable.

2.3.5 Electrolytic descaling

This method can be used for ballast tanks, before dry docking. It consists on a breakdown of the rust using a very strong electrical current. This current is produced by galvanic effect between steel and a large amount of magnesium anodes fitted for this purpose in the ballast tank, which is completely filled with water (electrolyte).

This process requires one or two weeks and is accompanied by heavy hydrogen gas emission, so an appropriate ventilation is to be fitted.

After descaling, an efficient washing of the ballast tank is to be carried out, for removal of rust and of calcareous deposit formed on the tank surfaces.

3 Soft coats

3.1 General

3.1.1 Soft coats can be considered as a convenient alternative to hard coatings in case of repairs, when the hard coatings are strongly damaged and cannot be quickly repaired by painting.

3.1.2 Due to their short life, soft coats are to be renewed regularly, as a rule annually or biannually. For this purpose, the yard is to comply with the recoating procedures established by the manufacturer and agreed by the owner within the maintenance specification.

3.1.3 Regarding surface preparation, care shall be taken when removing and applying such coats. Refer to Sec 3, [2.3], and particularly to Sec 3, Tab 5.

3.2 Soft coat systems

3.2.1 The systems are, in general, defined by the specification, including thicknesses and number of coats. As a rule, soft coats are to be applied in one coat. However, a new application is recommended after one year or more (but less than two years) depending on the results of the inspection of the soft coat.

4 Sacrificial anodes

4.1 General

4.1.1 In addition to coating and in order to decrease the corrosion rate, it is recommended to fit sacrificial anodes in ballast tanks.

In such a case, an efficient electrical continuity is to be ensured between the anode and the steel structure. The anodes shall be fitted by welding. The amount of sacrificial anodes is to be defined in accordance with Sec 3, [3.3].

SECTION 6 INSPECTIONS

1 General

1.1 General

1.1.1 In order to obtain a long coating life, it is also necessary to carry out inspections during the application.

1.1.2 Scope and relevant standards for such inspections are to be defined within the specification and agreed between the yard, the owner and the coating manufacturer. In particular, the following elements are to be considered:

- methods of inspection
- criteria of acceptance
- form of the reports
- authority of inspector
- knowledge of inspector.

It is to be noted that all inspections are to be reported by writing. Inspections carried out are to be in accordance with Society Rules NR217 and NR580 for classed vessels and floating establishments respectively.

Some standards that could be used for inspection are given in App 3.

1.2 Working conditions

1.2.1 It is to be checked that, in every step of the coating work, the working conditions (lighting, scaffoldings, ventilation, etc.) are satisfactory.

1.3 Coating products

1.3.1 Prior to any surface preparation and application, it is to be ensured that:

- the coating products to be used are in accordance with the specification
- the storage of the products (coatings, thinner, abrasives) is carried out in accordance with
- the batches see App 2, [5] for definition of products are well identified.

1.4 Surface preparation

1.4.1 Before cleaning the steel surface, it is to be checked that the ambient conditions are satisfactory for this work. It is also to be ensured that the equipment used for the surface preparation is well adapted to this work and is in good conditions.

1.4.2 After the surface has been prepared, the following inspections shall be carried out:

- checking that cutting sharp edges are effectively rounded, and that weld surfaces and other surface irregularities are well smoothed
- checking that the cleanliness of the surface is in accordance with the specification (Sa 2 1/2 or better)
- checking that the surface roughness is in accordance with the manufacturer's requirements
- checking that the surface is free from abrasives and dust.

1.5 Coatings

1.5.1 Ambient conditions

Before and during the application, it is to be ensured that the ambient conditions (hygrometry, air and steel temperature) are in accordance with the specified ones, and that the cleanliness of the surface is maintained.

1.5.2 Application equipment

It is to be ensured that the application equipment is well adapted to the product to be applied, and that this equipment is maintained in good condition. In the same way, the applicator is to be qualified for using this equipment.

1.5.3 Coating application

During and after the coating application, compliance of the following items with the specification is to be checked:

- a) Number of coats
- b) Wet film thickness

The wet film thickness is to be checked by the applicator for each coat.

- c) Dry film thickness (DFT)

The DFT is to be checked for each type of coat and for the total coating. For this purpose, a recommended practice is the 90/10 one: a minimum of 90% of all thickness measurements should be over the specified thickness and none of the remaining 10% measurements should be lower than 90% of the specified thickness. However, such a practice would have to be written within the specification.

- d) Adhesion

A minimum adhesion value can be specified within the specification. However, it is to be noted that the adhesion tests are destructive ones and consequently, repairs are to be provided in areas where these tests are carried out. Attention is drawn to difficulties of repairs of some paints.

- e) Defects

Defective areas are to be noted and consequently repaired. For this purpose, an appropriate procedure is to be agreed within the specification. The repaired areas are to be re-checked for acceptance.

1.6 Sacrificial anodes

1.6.1 It is to be checked that the sacrificial anodes are installed in accordance with the drawings and the specification. In particular, it is to be ensured that the anodes and their fittings are not damaged or coated.

1.7 Coating inspector

1.7.1 Coating inspector's duties

Within the specification, the responsibility of inspections is defined between the yard, the owner, the paint manufacturer and eventually a contractually agreed inspection organism.

A qualified coating inspector is appointed and is in charge of the following activities:

- tests and inspections as described in [1.2] to [1.6]
- reporting on the discrepancies between the specified requirements and the quality actually found.

Depending on the quantity of work, more than one coating inspector can be appointed, after agreement between the parties.

1.7.2 Inspection equipment

The coating inspector should have the minimum following documentation and equipment to carry out inspection:

- specifications
- surface preparation and roughness standards
- psychrometer or hygrometer
- dew point calculator
- dry film thickness measuring gauge.

In addition, the following equipment is also recommended:

- adhesion test equipment
- surface profile comparator, for measuring the roughness
- measuring device for soluble salts.

SECTION 7 YARD ORGANISATION

1 General

1.1 Planning of coating

1.1.1 It is recommended to establish a planning of the whole coating work in relation with the other building activities. Such a planning is to be so detailed and regularly updated according to Class requirements in order to permit an efficient following of the coating works by the owner, the coating manufacturer and the coating inspector.

1.2 Traceability

1.2.1 It is recommended that the yard draws up and keeps current procedures for applying suitable means to identify consignments of the batches of coating products. Such identification must enable tracing of the batches back to origin if clients so request, or in the case problems occur during the life of the coating.

1.3 Quality system

1.3.1 To ensure that the coating is in accordance with the specified requirements, it is recommended that the yard establishes and maintains a documented management system. The purpose of such a system is to describe the procedures for the following items:

- organisation
- document control
- purchasing
- product identification and traceability
- process control
- inspection and testing
- inspection, measuring and test equipment
- non-conformities
- corrective and preventive actions
- internal quality audits
- training.

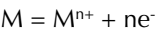
APPENDIX 1

GALVANIC CORROSION

1 General

1.1 Standard electrode potentials

1.1.1 When putting a metal M into an electrolyte, the metal corrods and the following reaction occurs:



The metal releases n electrons which remain on the metal bar, and ions M^{n+} are dissolved in the electrolyte. This process occurs until an equilibrium will arise. At this stage, the difference of potential between the metal and the electrolyte can be measured and is called the Standard Electrode Potential of the metal for the electrolyte used.

This potential can be measured for each type of metals and then, potentials can be classed from the most negative one to the most positive one, as given in Tab 1 (not for water) the reference potential being equal to zero for hydrogen.

The most negative potential means that the metal has a greater tendency to release electrons and so to be corroded.

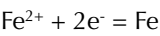
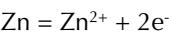
1.2 Galvanic serie for sea water

1.2.1 For information, Tab 2 gives the galvanic serie in sea water, i.e. the table where metals and alloys are listed according to their corrosion protection abilities in sea water. The top of the table corresponds to the anodic end of the serie and the bottom to the cathodic end.

1.3 Electrochemical nature of corrosion

1.3.1 The corrosion process can be illustrated by simple electrolytic cell: two different electrodes, immersed in an electrolyte and joined by an external conductor.

If a measuring device is fitted on this conductor, a current will be detected. For example, zinc and iron electrodes can be chosen and immersed in water. In such a case, the following reactions occur:



The zinc electrode being more negative than the iron one, the electrons are going from zinc to iron through the external conductor, and so create an electric current.

Table 1 : Standard Electrode Potential, E₀

Element	Symbol	E ₀ , in Volt
Potassium	K	– 2,92
Magnesium	Mg	– 2,36
Aluminium	Al	– 1,67
Zinc	Zn	– 0,77
Chrome	Cr	– 0,74
Iron	Fe	– 0,44
Hydrogen	H	0
Copper	Cu	+ 0,34
Silver	Ag	+ 0,80
Platinum	Pt	+ 1,20
Gold	Au	+ 1,69

Table 2 : Galvanic serie in sea water

Galvanic series in sea water
Magnesium
Aluminium
Zinc
Cadmium
Iron or Steel
Stainless Steels (active)
Tin
Lead
Nickel
Brass
Bronzes
Nickel-Copper Alloys
Copper
Stainless Steels (passive)
Silver Solder
Silver
Titanium
Platinum

1.3.2 The following reactions occur at that time:

- a) New zinc atoms are dissolved and leave electrons on the zinc electrode, in order to maintain the potential between the zinc electrode and the electrolyte. Consequently, the zinc electrode is corroded.
- b) the iron electrode takes up the iron ions which will be neutralised by consumption of electrons. Consequently, there is a precipitation of metallic iron, and so the iron will not be corroded.

This phenomena is called galvanic corrosion: the less noble metal (the anode) is corroded, the more noble metal (the cathode) does not corrode. Due to electrons supplied from the anode to the cathode through the electrical conductor, the cathode will be more negative and so will prevent it from corrosion.

APPENDIX 2

GUIDE TO EVALUATION OF COATING
CONDITION

1 General

1.1 Introduction

1.1.1 This Appendix is developed to assist the surveyor to evaluate the condition of vessel structure protective coatings when performing surveys.

1.1.2 This Appendix does not replace applicable rules, regulations, procedures and instructions. The contents of this Appendix is limited to referential information that surveyors may find useful in the course of their surveys, where access to more complete documents may be difficult.

2 Coating Condition

2.1 Definitions

2.1.1 The present definitions of coating conditions “GOOD”, “FAIR” and “POOR” are defined in Tab 1:

3 Types of Coating Failures

3.1 Cracking

3.1.1 Definition

Cracking of coating is defined as a break-down in which the cracks penetrate at least one layer and which may be expected to result ultimately in complete failure. Such cracks may result from:

- Over thicknesses of paint
- Plastic structure deformations exceeding the elongation properties of paint film
- Localised fatigue stress.

Fig 1 shows photographic evidence of coating cracking:

Table 1 : Coating Condition Rating Criteria

Description	Definition
GOOD	Condition with spot rusting is less than 3% of the area under consideration without visible failure of the coating. Rusting at edges or welds, must be less than 20% of edges or weld lines in the area under consideration.
FAIR	Condition with breakdown of coating or rust penetration is less than 20% of the area under consideration. Hard rust scale rust penetration must be less than 10% of the area under consideration. Rusting at edges or welds must be less than 50% of edges or weld lines in the area under consideration.
POOR	Condition with breakdown of coating or rust penetration is more than 20% or hard rust scale is more than 10% of the area under consideration or local breakdown concentrated at edges or welds is more than 50% of edges or weld lines in the area under consideration.
-	No protective coating fitted
-	Not applicable
<p>Note 1: Soft Coatings or Semi Hard Coatings are not rated in the scope of this document.</p> <p>Note 2: Spot rusting is rusting in spots without visible failure of coating.</p> <p>Note 3: Blistering of coatings is identified as coating failure. (See [4] and [5] for information on blistering and for assessment ratings for coating blistering).</p>	

Figure 1 : Example of coating cracking



3.2 Flaking

3.2.1 Definition

Flaking of coating is defined as the lifting of the paint from the underlying surface in the form of flakes or scales. The causes of a loss of adhesion may be the following ones:

- Unsatisfactory surface preparation
- Incompatibility with underlayer
- Contamination between layers
- Excessive curing time between layers.

Fig 2 shows photographic evidence of coating flaking.

Figure 2 : Example of coating flaking



3.3 Blistering

3.3.1 Definition

Blistering appears as a bubble formation scattered on the surface of a paint film with a diameter ranging from 3-4 mm to 20-30 mm. Blisters contain liquid, vapour or gas. Blistering is a localised loss of adhesion and lifting of the film, coming generally from osmosis due to one of the following causes:

- Solvent retention
- Improper coating application
- Soluble salt contamination under the paint film due to insufficient cleaning of the surface.

3.3.2 Examples

It is to be noted that in most cases there is no corrosion in an unbroken blister and many years of protection can be obtained if these blisters are left untouched.

Due to a heavy overlap coating and poor workmanship, blisters have often been observed.




Blisters have sometimes been observed on flat plates and often are observed on areas of structure where access causes difficulties for painters to work on, such as the back of face plates e.g. Longitudinals, webs, etc.

Blisters is designated as coating failure (although Tab 2 shows that the blistered coating is still protecting the steelwork after 20 years.) The coating condition in the photo is in the transition stage between FAIR/POOR, but could still be designated as fair condition.

Although blistering of coating implies a coating failure this may not mean that these coatings are failing to provide protection to the steel surface. Blistering may be a coating failure, but may not mean a complete coating breakdown.

However, where blisters are burst, (e.g. exposing shop primer or rusting of the substrate) then in these areas this is a coating breakdown.

Table 2 : Examples of coating blistering

<p>a) Coating blistering on flate plate after 5 years</p> 	<p>b) Coating blistering after 8 years</p> 
<p>c) Intact coating blistering after 20 years</p> 	

3.3.3 Guideline for Assessment of Blistering

Tab 3 takes into consideration actual breakdown of the coating which allows the formation of rust.

This guideline should be read in conjunction with the information and definitions tabulated in [2].

Table 3 : Coating Condition for Assessment of Blistering

Description	Definition
GOOD	Blistering is 20% or less in the area under consideration with spot rusting is less than 3% of the AUC and rusting at edges or welds must be less than 20% of edges or weld lines.
FAIR	Blistering is more than 20% of the AUC with rust penetration is less than 20% in the area under consideration. Hard rust scale rust penetration must be less than 10% of the AUC. Rusting at edges or welds must be less than 50% of edges or weld lines in the AUC.
POOR	Blistering is more than 20% of the AUC with rust penetration is more than 20% at the AUC, or hard rust scale is more than 10% of the AUC or, rusting at edges is more than 50% of edges or weld lines in the area under consideration.

4 Pictorial ISO Standards for Coatings

4.1 General Principles and Rating Schemes

4.1.1 The standards given in this article are ISO standards and are given for reference purposes only. The ratings given within these tables are NOT only CAP ratings but are ISO standard ratings (ISO 4628 Evaluation of degradation of paint coatings).

4.1.2 Tab 4, Tab 5 and Tab 6 show ISO rating scheme tables of coatings

4.2 Designation of Degree of Blistering

4.2.1 Size and density of blistering defined in Tab 7.

Table 4 : Intensity of deterioration rating criteria

Rating	Intensity of change
0	Unchanged, i.e. no perceptible change
1	Very Slight, i.e. just perceptible change
2	Slight, i.e. clearly perceptible change
3	Moderate, i.e. very clearly perceptible change
4	Considerable, i.e. pronounced change
5	Severe, i.e. intense change

Table 5 : Quantity of defects rating criteria

Rating	Quantity of Change (Relative to a test area of 1 to 2 dm ²)
0	None, i.e. no detectable defect
1	Very Few, i.e. some just significant defects
2	Few, i.e. small but significant amount of defects
3	Moderate, i.e. medium amount of defects
4	Considerable, i.e. serious amount of defects
5	Dense, i.e. dense pattern of defects

Table 6 : Size of defects rating criteria

Rating	Size of Defects
0	Not visible under x 10 magnification
1	Only visible under magnification up to x 10
2	Just visible with Normal Corrected Vision (NCV)
3	Clearly visible with NCV (up to 0,5 mm)
4	Clearly visible with NCV (0,5 to 5 mm)
5	Clearly visible with NCV (> 5 mm)

Table 7 : Degree of blistering

Size 2	<div><div>DENSITY 2</div><div>DENSITY 3</div><div>DENSITY 4</div><div>DENSITY 5</div></div>
Size 3	<div><div>DENSITY 2</div><div>DENSITY 3</div><div>DENSITY 4</div><div>DENSITY 5</div></div>
Size 4	<div><div>DENSITY 2</div><div>DENSITY 3</div><div>DENSITY 4</div><div>DENSITY 5</div></div>
Size 5	<div><div>DENSITY 2</div><div>DENSITY 3</div><div>DENSITY 4</div><div>DENSITY 5</div></div>

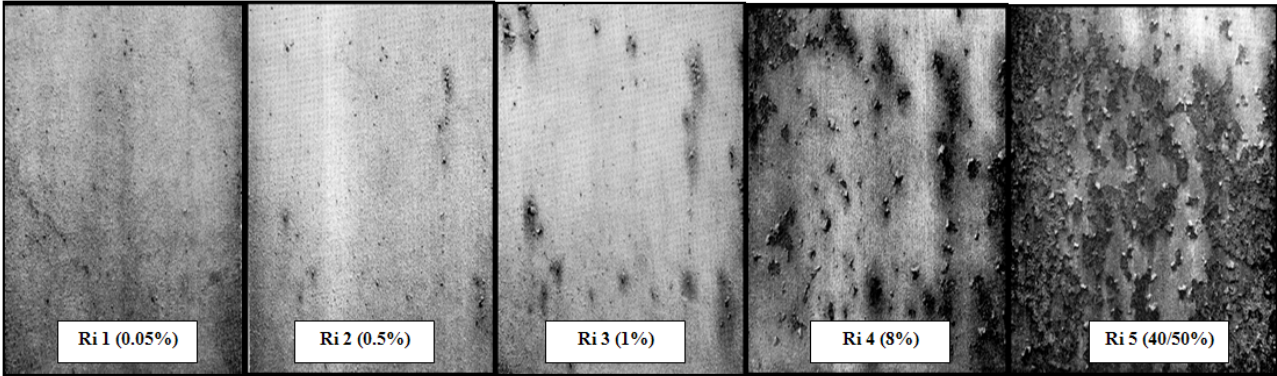
4.3 Designation of Degree of Rusting

4.3.1 Degree of rusting is determined by the percentage of the area affected (see Tab 8). Fig 3 shows pictorial examples of degree of rusting.

Table 8 : Rusting degree criteria

Degree	% Area
Ri 0	0
Ri 1	0,05
Ri 2	0,5
Ri 3	1
Ri 4	8
Ri 5	40/50

Figure 3 : Different density degree of rusting



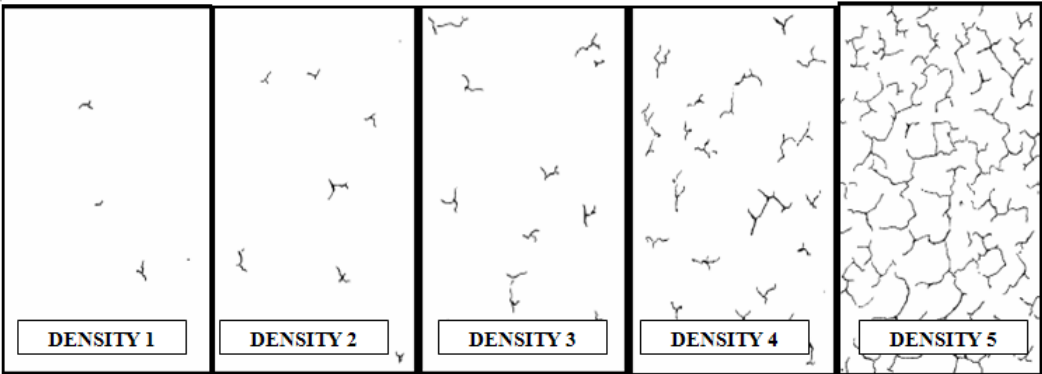
4.4 Designation of Degree for Cracking

4.4.1 Degree of cracking is designated by the percentage of the area affected (see Tab 9). Fig 4 shows the degree of cracking determined.

Table 9 : Cracking degree criteria

Degree	% Area
0	Not visible under x10 magnification
1	Only visible under magnification up to x 10
2	Just visible with normal corrected vision
3	Clearly visible with normal corrected vision
4	Large cracks generally up to 1 mm wide
5	Very large cracks greater than 1 mm wide

Figure 4 : Degree of cracking



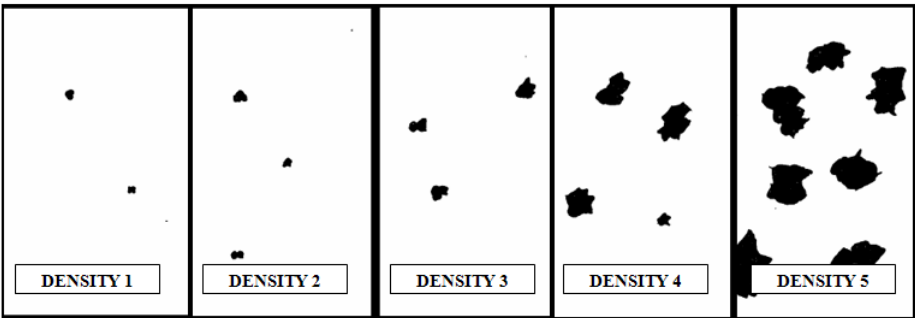
4.5 Designation of Degree of Flaking

4.5.1 Degree of flaking is designated by the percentage of area affected or the size of flakes (see Tab 10). Fig 5 shows different degree of flaked area according to flaking density.

Table 10 : Degree of flaking regarding percentage of area affected or size of flakes

Rating	% Area	Size of Flaking
0	0	Not visible under x 10 magnification
1	0,1	Up to 1 mm
2	0,3	Up to 3 mm
3	1	Up to 10 mm
4	3	Up to 30 mm
5	15	Larger than 30 mm

Figure 5 : Density degree of flaking



4.6 Coating breakdown assessment

4.6.1 Fig 6 give the general example on how to assess coating breakdown.

Figure 6 : Assessment of coating breakdown



5 Definitions of Standard Terms

5.1

5.1.1 Tab 11 lists definitions of standard terms.

Table 11 : Definitions of standard terms

Term	Definition
Abrasion	Frictional rubbing as distinct from knocks and impacts.
Abrasive	Agent used for blast cleaning before coating application.
Abrasive blasting	Abrasive cleaning or blast cleaning is cleaning of steel with abrasives propelled by compressed air jet.
Adhesion	The bonding strength; the attraction of a coating to the substrate.
Ageing	Progressive degradation of a coating in the long run.
Air Entrapment	The inclusion of air bubbles in liquid paint or a paint film.
Ambient temperature	The room temperature or temperature of surroundings.
Anode	The corroding part of an electrochemical corrosion cell such as sacrificial anode or impressed current anode. The positive electrode at which corrosion occurs.

Term	Definition
Anticorrosive	Generic term defining paint used to protect metals from corrosion.
Batch	The quantity of a paint manufactured at one time in a single vessel and identified by a batch number.
Binder	Non-volatile portion of the vehicle of a paint.
Bleeding	The appearance of a coloured substance on a newly painted surface from a previously painted substrate.
Blistering	Bubbling in coating films normally caused by osmosis.
Block Holding Primer (BHP)	Primer applied at block stage to reduce the amount of insitu secondary surface preparation. Not a pre-construction primer.
Blushing	Development of a milky appearance on a coating surface during drying process caused by humidity and/or from the precipitation of one or more solid components of the paint.
Breakdown of coating	Defects in the coatings like rust penetration, blistering, flaking and cracking.
Brittle failure	Cracking and/or other failure normally encountered with hard, low ductility glassy objects and films.
Brittleness	Degree of resistance to cracking or breaking by bending. Lack of resistance to cracking or breaking when bending
Bubbling	Coating defect, temporary or permanent, in which small bubbles of air or solvent or both are present in the applied film.
Cathode	The negative electrode at which corrosion does not usually occur.
Cathodic Protection	Corrosion prevention by sacrificial anodes or impressed current.
Chalking	The formation of a friable, powdery layer on the surface of a paint film caused by disintegration of one or more components of film due to action of the weather and sunlight (ultra-violet radiation).
Checking	Defect with surface cracking and crocodiling.
Coating Breakdown	Failure of the coatings due to defects or mechanical damage.
Coating system	A number of coats separately applied, in a predetermined order, at suitable intervals to allow for drying and curing, resulting in a completed job.
Coating, Lining	Terms used to define various products that are applied on steel to protect it from corrosion and/or to decorate it.
Coatings	Surface coverings; paints; barriers.
Cohesion	Property of holding together of a single material.
Compatibility	Attitude of a paint to be applied on another already dry coating.
Corrosion	Decay; oxidation; deterioration due to interaction with environment.
Corrosion prevention/protection system	A system designed to protect the substrate from corrosion.
Corrosion rate	Rate at which the corrosion proceeds. This rate is the thickness of metal lost during a year, considering one side of the surface. It is expressed in mm per year.
Cracking of coating	Defect with fracture in the coating in at least one coat, often down to the substrate. Related expression is checking, which is surface cracking and crocodilling.
Corrosion rate	The rate usually in mm/year, at which the corrosion process proceeds.
Curing	The hardening of a liquid paint by a chemical reaction or by admixing a cross-linking agent of hardener.
Curing time	Minimum time during which the paint achieves its properties and mechanical characteristics.
Curtaining	Special form of sagging by which the film appears locally with high thickness and with flakes similar to drape curtains.
Decohesion	Breaking within the thickness of a paint film.
Dew point	The temperature below which water vapour in the air will condense.
Discoloration	Colour change of a coating after application, normally caused by exposure to sunlight or chemical atmospheres.

Term	Definition
Discsanding	Mechanical surface preparation by using a sand disc.
Dry film thickness (DFT)	Thickness of the paint film, after drying or curing.
Dulling or Tarnishing	Loss of gloss of a coating.
Edging	Striping.
Enamel	A finish coat of paint that shows a smooth, gloss surface after drying.
Epoxy amine	Amine cured epoxy resin.
Epoxy resins	Film formers (binders) usually made from bisphenol-A and epichlorohydrin, resins containing the oxyrane ring.
Erosion	Gradual and irregular destruction of coating surface caused by a mechanical or also by a chemical-physical action.
Film integrity	Degree of continuity of film.
Film thickness	The thickness of a coating layer or a multilayer coating system. Minimum and maximum values are the only relevant numbers when dealing with corrosion protection.
Film	A layer of coating material applied on a surface. The film just applied, before evaporation of the solvents is called "wet film"; the dry paint film, after solvent evaporation, "dry film".
Finish	Term used to define indifferently the final coat in a paint system or the general aspect of a painted surface after drying.
Flaking	Detachment of a coating from the surface, in the form of flakes.
Flooding-Floating	Differentiated separation of pigments on a coating surface
Galvanic corrosion	Corrosion of dissimilar metals in electrical contact.
Galvanising	Anticorrosive system which consists in dipping a steel structure, into melted zinc at a temperature of approximately 450°C.
Galvanized steel	Zinc plated steel applied in a molten bath of zinc.
General corrosion	Evenly distributed corrosion attack on steel surface.
Glazing	Coat intentionally applied with a small thickness.
Gloss	Aptitude of a surface to reflect the light in certain conditions.
Hard coating	A coating which chemically converts during its curing process. Hard coating can be either inorganic or organic. All conventional paints are included in this definition, e.g. epoxy, polyurethane, zinc silicate, vinyl, etc.
Hardener	In two-components materials, the component which produces the chemical reaction linking the molecular chains of the binder together in more rigid structure.
Hardener	In two-components materials, the component which produces the chemical reaction linking the molecular chains of the binder together in more rigid structure.
Holidays	Defects due to the lack of the whole film or of one film layer.
Light colour	The light colour of the coating, specially of the top coat, allows to see any rust traces.
Localised corrosion	More or less localised corrosion attacks such as pitting corrosion, crevice corrosion, corrosion on welds and edges.
Mechanical wire brushing	Mechanical surface preparation by a wire brush.
Osmosis	Transfer of liquid through a paint film or other membrane as the result of a solute/solvent couple.
Osmotic blistering	Formation of blisters containing liquid through osmosis.
Product Data Sheet	Document published by paint manufacturer in which product characteristics, the method to use, instructions for application and storage are indicated.
Protective life	(also called useful life) Interval of time during which a paint system protects substrate from deterioration.
Paint system	The complete number and type of coats comprising a paint job. In a broader sense, surface preparation, pre-treatments, dry film thickness, and manner of application are included in the definition of a paint system.

Term	Definition
Peeling	Disbonding of particles of a coating from substrate in the form of strips, due to loss of adhesion.
Pigments	Insoluble coloured particles dispersed in a coating material in order to define appearance, structure and functionality of the final film.
Pinholes	Presence of small holes in a coating that are formed during application or drying.
Pitting	Cavity in a metallic surface, due to localised corrosion.
Pot life	The period after mixing the components of a two-components paint during which the paint remains usable.
Prime coat	First coat. preventive maintenance painting; Spot repair painting; touch-up or full coats of paint before rusting starts.
Primer	General term used to define the first coat of a paint system applied to provide adhesion and/or corrosion protection.
Repainting	Repetition of a complete painting operation including surface preparation.
Roller Application	Hand application of a coat of paint using an absorbing roller on a surface.
Sacrificial anode	Anode made from less noble metal than steel in the galvanic series, (usually zinc or aluminium). When immersed, the anode protects the steel by coming into solution.
Sags	Runs
Scattered breakdown of coating	Various kinds of evenly distributed defects in the coatings like rust penetration, blistering, flaking and cracking.
Semi-hard coating	Coating that, after drying, remain flexible and hard enough to be touched and walked upon without damaging them and that are not affected by water erosion during de-ballasting operations.
Service life	Interval of time during which a paint system protects substrate from deterioration.
Shop primer	An inexpensive, rust inhibiting primer designed to protect steel from general weathering immediately after plate fabrication and before final coating processes.
Soft coating	Defined as coatings that does not dry, but remain permanently soft.
Solids	The non-volatile matter in a paint composition, i.e. the ingredients which after drying are left behind and constitute the paint film.
Solvent	Liquids, usually volatile, which are used in the manufacture of paint to dissolve or disperse the binder-forming constituents, and which evaporate during drying and therefore do not become a part of the dried film.
Solvent entrapment	The encapsulation of solvent within a cured paint film.
Spontaneous degradation	Coating degradation that is controlled and directed internally: self-acting; developing without apparent external influence, force, cause, or treatment.
Spot repair	Preventive repainting of small areas.
Spot rusting	Rusting in spot without visible failure of coating.
Stripe Coating	Painting method used before a general coat on positions (weld, back, edge, corner etc.) where it is not easy to achieve the final thickness with the simple airless spray application.
Striping	Edge, weld, scallop painting prior to priming.
Substrate	Surface to be painted; in this context carbon steel, stainless steel, galvanized steel and all surfaces that can affect the corrosion rate or can corrode.
Thinner	Volatile liquids added to paints to facilitate application and to aid penetration by lowering the viscosity.
Touch-up painting	Spot repair painting usually conducted a few months after initial painting. Also, manual painting to correct thickness deficiencies.
Varnish, Lacquer	Non-pigmented coating material.
Wrinkling	Coating defect due to a non-homogeneous solidification of the paint film with wrinkling of the surface coat.
Zinc silicate	Inorganic zinc coating.

APPENDIX 3 STANDARDS FOR COATING

1 General

1.1 Standards applicable to surface preparation

1.1.1 ISO 8501

Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness.

- Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings (ISO 8501-1:2007)
- Part 2: Preparation grades of previously coated steel substrates after localized removal of previous coatings (ISO 8501-2:1994).

1.1.2 ISO 8502

Preparation of steel substrates before application of paints and related products. Tests for the assessment of surface cleanliness.

- Part 1: Field test for soluble iron corrosion products (ISO 8502-1:1991)
- Part 2: Laboratory determination of chloride on cleaned surfaces (ISO 8502-2:2005)
- Part 3: Assessment of dust on steel surfaces prepared for painting (pressure -sensitive tape method) (ISO 8502-3:1992)
- Part 4: Guidance on the estimation of the probability of condensation prior to paint application (ISO 8502-4:1993).

1.1.3 ISO 8503

Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates.

- Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast cleaned surfaces (ISO 8503-1:2012)
- Part 2: Method for the grading of surface profile of abrasive blast cleaned steel - Comparator procedure (ISO 8503-2:2012).

1.1.4 ISO 8504

Preparation of steel substrates before application of paints and related products - Surface preparation methods.

- Part 1: General principles (ISO 8504-1:2000)
- Part 2: Abrasive blast cleaning (ISO 8504-2:2000)
- Part 3: Hand- and power-tool cleaning (ISO 8504-3:1993).

1.2 Standards for testing of the dry film

1.2.1 ISO 2808

Paints and varnishes - Determination of film thickness (ISO 2808:2007).

1.2.2 ISO 2409

Paints and varnishes - Cross cut test (ISO 2409:2013)

1.2.3 ISO 4624

Paints and varnishes - Pull-off test for adhesion (ISO 4624:2002)

1.2.4 NACE SP0188-2006

Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

1.2.5 ISO 4628

Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and of intensity of uniform changes in appearance.

- Part 1: General introduction and designation system (ISO 4628-1:2003)
- Part 2: Assessment of degree of blistering (ISO 4628-2:2003)
- Part 3: Assessment of degree of rusting (ISO 4628-3:2003)
- Part 4: Assessment of degree of cracking (ISO 4628-4:2003)
- Part 5: Assessment of degree of flaking (ISO 4628-5:2003)
- Part 6: Assessment of degree of chalking by tape method (ISO 4628-6:2011).

APPENDIX 4 SPECIFICATIONS

1 General

1.1 Purpose of a specification

1.1.1 A specification is a reference and contractual document, agreed by the yard, the owner and the coating manufacturer. This document covers all information and technical aspects of the entire coating work.

1.2 Content of a specification

1.2.1 The specification should, at least, cover the items described in [1.2.2] to [1.2.9].

1.2.2 Paint systems

The exact references of the paints, including shopprimer, are to be indicated with data sheets from the manufacturers.

1.2.3 Surface preparation

The requirements for surface preparation, roughness, preparation of edges, etc., are to be detailed under this item.

1.2.4 Conditions of application

The following aspects for the application work are to be specified:

- the qualification of applicator
- the equipment to be used
- the needed ambient conditions (hygrometry, air and steel temperature, dew point)
- the minimum and maximum limits for the application of the over coat
- the drying time
- the necessity of stripe coats
- the demand in ventilation, lighting and scaffoldings
- the requirements for health and safety.

1.2.5 Coating

For each paint system, the following elements are to be indicated:

- number of layers and reference of the paints
- wet and dry thickness of each layer
- Total dry film thickness.

Great attention is to be paid to the definition of the thickness: minimum values or average values.

1.2.6 Procedures for repairs

A repair procedure is to be developed for each type of defect.

1.2.7 Sacrificial anodes

The requirements for the quality of anodes and procedure for the installation are to be indicated.

1.2.8 Inspections

For the inspection work, the following points are to be developed:

- extent of inspection
- methods of inspection, including the criteria for acceptance
- treatment of non-conformity
- content of reports
- qualification of the paint inspector.

1.2.9 Planning

All the steps of paint and coating works are to be described in details.