Guidance For Classification And Construction

Part 1 Seagoing Ship

Volume G

GUIDANCE FOR THE CORROSION PROTECTION AND COATING SYSTEMS

2019

Biro Klasifikasi Indonesia

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GUIDANCE FOR THE CORROSION PROTECTION

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The following Guidance come into force on 1st July 2019

Amendments to the preceding Edition are marked by red color and expanded text. However, if the changes involes a whole section or sub section, normally only the title will be in red colour.

Foreword

This 2019 Edition of the Guidance for the Corrosion Protection (Pt.1, Vol.G) supersedes the 2004 Edition of the Guidance for the Corrosion Protection and Coating Systems (Pt.1, Vol.G). In this 2019 Edition new amendements are introduced which are derived from IMO Resolution and inputs from Research and Development Division.

The summary of current amandmets are indicated on the page of Guidance Amendment Notice.

Further query and information regarding approval of manufacturer can be addressed to BKI Head office.

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Guidance Amendment Notice

These pages contain amendments within the following section of the Guidance for Corrosion Protection, 2019 Edition.

These amendments will come into force on 1st July 2019 unless speciefied otherwise in the table

Paragraph	Title/Subject	Status/Remark
Chapter 1 – Corrosion Protection and Coating Systems		
Chapter 1, Section 3 – Materials		
C	**Cast Iron**	
1.	Scope of Application	To synchronize the term of applied materials among BKI Rules
D	**Stainless Steels and Stainless Steel Castings**	
Table 3.1	Required pitting resistance equivalent for seawater impingement	To change the value of PRE 30 instead of 20
D.2.1	PRE formula	To use symbol of N instead of Ni
Chapter 1, Section 4 – Coating		
A	**General**	
	Alternative requirements	To add requirement for coating specification
B	**Preparation of Surface**	
	Means of removing oil and grease residues	To add alternative method for preparation surface
1.	Surface Preparation of Unalloyed and Low-Alloy Steels	To direct the requirements for surface preparation of Ballast Water Tank to Chapter 3
Table 4.1	Preparation of edges	To add table footer as explanation of Table 4.1
Table 4.2	Preparation of welding seams	To add table footer as explanation of Table 4.2
1.2	Mechanical Grinding	To use term of grinding instead of blasting
1.3	Pressurized Water Blasting with Solid Blasting Agents	To change the reference paragraph from 4.2.1 to B.1.1
3.1	Cleaning	To use term of shall instead of must
6.	Surface preparation of wood	Renumbering from 4.B.5.3
7.	Surface Preparation of Fibre-Reinforced Plastics (FRP)	Renumbering from 4.B.5.4
C	**Selection of Coating Material**	
		Renumbering subsection 4.B.6. to 4.C
1.	Shop Primers	Renumbering from 4.B.6.1
1.	Shop Primers	To add requirements according to Chapter 3 for Ballast Water Tanks corrosion protection system
2.	Corrosion Protection Systems	Renumbering from 4.B.6.2
2.	Corrosion Protection Systems	To change the reference Table 4.3 instead of Table 4.1
3.	Special Coating	Renumbering its subparagraph B.7.1-B.7.6 to C.3.1-C.3.6
3.6	Linings	To direct the requirement for organic linings and metallic structural elements to Recognized Standard
4.	Approval of Coatings	Renumbering from 4.B.8
D	**Application of Coating Systems**	
		Renumbering subsection C. to D.
		To add requirements according to Rules for Hull Pt.2, Vol.II) Sec.2 for Ballast Water Tanks corrosion protection system
1. – 5.	Sub paragraph D.1 – D.5	Renumbering its subparagraph C.1-C.5 to D.1-D.5

Paragraph	Title/Subject	Status/Remark
E	**Competent Repair of Damage and Defects in Coating Systems during the Construction Period**	
		Renumbering subsection D. to E.
1. – 5.	Sub paragraph E.1 – E.5	Renumbering its subparagraph D.1-D.5 to E.1 – E.5
6.	Repair of defective areas in sea water ballast tanks according to IMO Resolution MSC.215 (82)	To add requirement for repair of defectives area in sea water ballast tanks according to IMO Resolution MSC.215(82)
F.	**Testing, Acceptance and Documentation of the Coating Systems**	
		Renumbering subsection E. to F.
	Subparagraph F.1 – F.2	Renumbering its subparagraph E.1-E.2 to F.1-F.2
Chapter 1, Section 5 – Metallic Coating on Steel		
B.	**Thermal Spraying**	
1.	Surface Preparation	To change the reference standard from DIN 8567 to EN 13507
2.	Materials for Metallic coatings	To change the reference standard from DIN 8566 to ISO 14919
5.	Quality Assurance for Spraying	To add reference standard as requirement for responsible personal
Chapter 1, Section 6– Antifouling Systems		
	Deleted	To be removed considering the different purposes of antifouling and corrosion protection
Chapter 1, Section 7– Certification of Coating Work		
A.	**General**	To be moved to Guidance for The Approval and Type Approval of Materials and Equipment for Marine Use (Pt.1, Vol. W)
Chapter 1, Section 8– Cathodic Corrosion Protection		
B.	**External Protection through Sacrificial Anodes**	
Table 8.4	Sacrificial anodes of aluminium alloys for applications in seawater	To use the terms remainder instead of residues
B.4.5	Part Protection (Stern Protection)	To add provision about anodes of class notation IW
D.	**External Protection through Impressed Current**	
		Renumbering subsection 8.C.5 to 8.D
1.	Field of Application	Renumbering its subparagraph 8.C.5.1 to 8.D.1
2.	Design Fundamentals	Renumbering its subparagraph 8.C.6 to 8.D.2
3.	Arrangement of Anodes and Reference Electrodes	Renumbering its subparagraph 8.C.7 to 8.D.3
3.	Arrangement of Anodes and Reference Electrodes	To add application of requirements to specific ship
4.	Monitoring and Control	Renumbering subparagraph 8.C.8 to 8.D.4
E.	**Maintenance of the Cathodic Protection System**	
		Renumbering subsection 8.D to 8.E
F.	**Documentation of the Cathodic Protection System**	
		Renumbering subsection 8.D.1 to 8.F
Chapter 2 – Corrossion Protection of Crude Oil Cargo Tanks		
Chapter 2, Section 1– General Fundamentals		
A.	Scope of Application	Has been added as new requirements
B.	Limitation	Has been added as new requirements
C.	Definition	Has been added as new requirements
Chapter 2, Section 2– General Requirements		
A.	Newbuilding	Has been added as new requirements

Paragraph	Title/Subject	Status/Remark
B.	Ship in Service	Has been added as new requirements
Chapter 2, Section 3 – Corrosion protection of Cargo Tanks of Crude Oil Tankers		
A.	Design Considerations	Has been added as new requirements
B.	Coating	Has been added as new requirements
C.	Cathodic Protection	Has been added as new requirements
Chapter 2, Section 4 – Certification and Supervision of Corrosion Protection Works		
A.	Documentation	Has been added as new requirements
B.	Supervision according to BKI Inspection Plan	Has been added as new requirements
Chapter 2, Annex A – Coating Performance Standard		
A.	Area to be Protected	Has been added as new requirements
B.	Specification of Coating System	Has been added as new requirements
Chapter 2, Annex B – Form for Final Report on Corrosion Protection Work		
A.	Final Report on Corrosion Protection Work	Has been added as new requirements
Chapter 3 – Coating of Ballast Water Tanks		
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A.	Certification of Ballast Water Tank Coating according to IMO Resolution MSC.215(82)	Has been added as new requirements
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B.	Ballast Water Tanks coated to other than IMO Resolution MSC.215(82)	Has been added as new requirements
Chapter 3, Annex A – BKI attachment to ISO 15711 – Testing requirements and Criteria		
A.	General	Has been added as new requirements
B.	Test Plate Preparation	Has been added as new requirements
C.	Test Conditions and Criteria	Has been added as new requirements
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Chapter 3, Annex B – Content of the Coating Technical		
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B.	New Construction Stage	Has been added as new requirements
C.	In Service Maintenance, Repair and Partial Re-Coating	Has been added as new requirements
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Chapter 3, Annex C – Examples for Documentation Records		
	Table C.1 and Table C.2	Has been added as new requirements

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Section 1 General Fundamentals

A. Scope of Application

This Chapter contains technical fundamentals on corrosion and the rules applying to corrosion protection on ships, structural parts, components and structures under maritime environmental and application conditions.

Under the condition that the corresponding boundary conditions are observed, it can also be applied to other systems, structural parts and components.

This Chapter is intended to supplement Rules for Hull (Pt.1, Vol. II), Sec.38 "Corrosion Protection", Chapter 2 and 3 of this Guidance which are limited to only those aspects which are imperative from the classificatory point of view and which must always be complied with for the construction of ships with BKI class.

National or international provisions and rules are to be observed in addition.

B. Limitations

Corrosion as a mechanism cannot be prevented entirely as such; it is merely possible to minimize the corrosion rates and the effects of the corrosion.

The aim should be to reduce the corrosion rate to an acceptable level for a certain system by means of corrosion protection measure, e.g. an appropriate selection of materials, application of the corresponding design principles, suitable coating systems or through cathodic protection. The result is that, with a high degree of probability, the specified lifetime of the structures is ensured and no corrosion damage will occur.

The corrosion and the corrosion rate depend on many different parameters. Application and environmental conditions, material properties, stress and strain states, as well as the effectiveness and efficiency of protective measures all have an influence on corrosion.

Damage by corrosion can certainly be prevented. The principles and information given in this Chapter are based on normative standards and values from experience which, applied correctly, will guarantee an adequate degree of corrosion protection for ships and components subjected to seawater and a marine atmosphere.

However, this does not release the operators and designers from the obligation to assess properly the special features of each particular system, structural part or component and to consider the relevant corrosion hazard. In particular, the corrosion protection measures which are applied, their maintenance and the servicing activities must be coordinated to suit the component or the structure and also the specified lifetime.

In designing the corrosion protection, the specific contractual conditions and agreements between the purchaser and the manufactures must always be taken into account.

For the design of the corrosion protection, the relevant normative references must also be considered. Upon request, BKI can act in an advisory capacity.

C. Definitions

Terms and their explanations in respect of corrosion and corrosion protection are defined in ISO 8044, EN 971, ISO 12944, EN 12473, DIN 81249 and DIN 81250.

For the terms “seawater” and “sea atmosphere”, the terms “salt water” and “marine atmosphere” are also in common use.

D. Symbols and Abbreviations Used

A_G = total area to be protected

A_{KSZ} = area of a cathodic protection zone

AY = acrylic resin

DTZ = Immersed Zone

EP = epoxy resin

FB = shop primer

f_B = loading factor

FRP = fibre-reinforced plastic

I_G = total protective current

IC = intercrystalline corrosion

I_{CPZ} = requirement in protective current for a CPZ

i_{CPZ} = protective current density for a CPZ

i_s = protective current density

CCP = cathodic corrosion protection

CPZ = cathodic protection zone

MCU = synthetic mineral blasting medium, made of copper works’ slag

m_G = total anode weight

m_{CPZ} = anode weight of a CPZ

MQS = natural mineral blasting medium, made of silica sand

PMMA = polymethyl methacrylate

PUR = polyurethane

Q_s = electrochemical efficiency of the anode alloy

R_z, R_{y5} = average surface roughness

CFC = corrosion fatigue cracking

SCC = stress corrosion cracking

SWZ = splash zone

TBT = tributyltin

t_s = protection period

U_H = potential against standard hydrogen electrode

UP = unsaturated polyester

PRE = pitting resistance equivalent

WTZ = tidal zone

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Section 2 Structural Design

Ships, systems and components should be designed with the aim of ensuring optimum corrosion protection through the application of suitable structural measures.

Amongst others, the following measures have proven their worth in practice:

- Points at which moisture tends to collect, thus facilitating the origination and propagation of corrosion, e.g. gaps and sumps, must be avoided as far as possible.
- The structural design should be such that subsequent activities for the passive and active corrosion protection, such as surface pre-treatments, coating work, inspections and maintenance, can be performed in an optimum manner, e.g. by ensuring good accessibility.
- So-called “shadows effects”, which impede the coating work (such as open, deep gaps) must be avoided.
- Accumulations of condensed water in steel structural elements can be avoided by providing sufficient venting possibilities.
- The surface must be designed to be as flat as possible. Any stiffeners, internal parts and piping etc. should, wherever possible, be arranged in area less at risk from corrosion.
- The possibility of performing a proper cleaning and pickling, especially in the case of pass vatable materials, e.g. austenitic steels, must be provided after the welding process
- Corrosion by impingement of drops can be avoided by using baffle plates.
- Interrupted welds, such as “chain intermittent welds”, are only permissible in zones which are heat-insulated and free of condensed water (see also Rules for Hull (Pt.1, Vol.II) Sec.19)
- Burrs and sharp edges should be round off, in order to facilitate the coating work and to increase the durability of the coating. The minimum radius should be 2,0 mm.
- Hollow components which are not accessible shall be sealed off completely and permanently, e.g. by welding them closed; in doing so, any applicable safety measures must be taken into consideration.
- Mixed construction using different materials should, if possible, be avoided; otherwise suitable insulating measures shall be applied

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Section 3 Materials

A. General

1 Field of Application

The statements in this section shall be considered for the selection of materials and in the design of ship components and units, if the corrosion behaviour of the material in seawater or sea atmosphere represents a major criterion.

2 Material Selection

The material shall be selected both according to design-related aspects and under consideration of the expected corrosive stress. The number of different materials within one structure shall, in consideration of the statements given in this Chapter, be limited as far as possible and the materials shall be matched accordingly.

3 Residues and Contamination

Cinders annealing colour, welding spatter, rust, remnants from machining, residues of coating and dirt shall be removed if their presence is likely to impair the corrosion resistance or the corrosion protection.

4. Welded Joints

The welding consumables shall be selected so that the free corrosion potential of the weld material is the same or a little positive in relation to the free corrosion potential of the materials to be joined. Rules for Welding (Pt.1, Vol. VI) are to be observed.

5 Maintenance

During cleaning, it shall be ensured that the Metallic coatings or covering layers are not damaged or destroyed.

B. Unalloyed and Low-Alloy Steels and Steel Castings

1. Scope of Application

This Chapter applies for unalloyed and low-alloy steels and steel castings, as mentioned in the Rules for Material (Pt.1, Vol.V) Sec.4 to Sec.7

2 Protective Measures

2.1 Corrosion Allowance

If only uniform surface corrosion is to be expected, or for sea atmospheres also shallow pit formation, a corrosion allowance can be provided in the component design. According to the literature, the corrosion allowance per year of planned service time should be:

- 0,21 mm for wetter surfaces and
- 0,10 mm for components and structures which are exposed only to the sea atmosphere

For ships and equipment with the BKI Class, the corrosion allowance according to Rules for Hull (Pt.1, Vol.II) Sec.3.K are to be observed.

A prerequisite for uniform surface corrosion is a uniformly descaled and cleaned surface without fouling. Furthermore, no erosion corrosion must occur as a result of local flow conditions.

2.2 Passive or Active Corrosion Protection

This refers to coatings and Metallic coating (passive) as well as a CCP (active) in the sense of this Chapter, such additional protective measures shall be used wherever selective corrosion can be expected, e.g. because of structural details.

C. Cast Iron

1. Scope of Application

This Chapter applies for cast iron types with Nodular cast iron and Grey cast iron, as mentioned in the Rules for Materials (Pt.1, Vol.V) Sec.8.

2. Protective Measures

2.1 Corrosion Allowance

If only uniform surface corrosion is to be expected, or for sea atmospheres also shallow pit formation, a corrosion allowance can be used in the calculations for the component design. According to the literature, the corrosion allowance per year of planned service time should be:

- 0,12 mm for wetted surfaces and
- 0,06 mm for components and structures which are only exposed to the sea atmosphere.

For ships and equipment with the BKI Class, the corrosion allowances according to the Rules for Classification and Construction shall be observed in all cases.

A prerequisite for uniform area corrosion is a uniform, cleaned surface with an intact and undamaged casting skin without fouling. Furthermore, no erosion corrosion must occur as a result of local flow conditions.

2.2 Passive or Active Corrosion Protection

This refers to coatings and linings (passive) as well as a CCP (active) in the sense of this Chapter. Such additional protective measures should be used wherever selective corrosion can be expected, e.g. because of structural details or irregularities in the casting surface.

D. Stainless Steels and Stainless Steel Castings

1. Scope of Application

This Chapter applies for stainless steels and stainless steel castings of the types mentioned in Rules for Materials (Pt.1, Vol.V) Sec.4.G, Sec.5.E and Sec.7.F.

2. Protective Measures

Stainless steels and stainless steel castings exhibit a passive surface state in seawater, as is the case in all media which are not too acidic. Accordingly, coating these types of steel is only recommended under special conditions. Depending on the composition and grain structure, stainless steels are sensitive to local corrosion, such as pitting and crevice corrosion.

2.1 Pitting and Crevice Corrosion

2.1.1 Alloy Composition

Depending on the temperatures to be expected, steels with the following pitting resistance equivalent in seawater are regarded as being resistant to pitting and crevice corrosion.

Table 3.1 Required pitting resistance equivalent for seawater impingement

Limiting temperatures for pitting resistance in seawater [° C]	Pitting resistance equivalent PRE (min.)
40	35
25	30
10	25

The pitting resistance equivalent (PRE) is calculated as follows:

a) For austenitic stainless steels alloy with more than 3 % molybdenum as well as nickel base alloys:

PRE = %Cr + 3,3 - %Mo + 30 - %N

b) For the austenitic-ferritic stainless steels X2CrNiMoN22-5-3 (1,4462):

PRE = %Cr + 3,3 - %Mo + 16 - %N

c) For austenitic stainless steels alloy with less than 3 % molybdenum as well as for the austenitic-ferritic steel X3CrNiMoN27-5-2 (1,4460):

PRE = %Cr + 3,3 - %Mo

2.1.2 Cathodic Corrosion Protection

Through cathodic corrosion protection, pitting and crevice corrosion can be prevented, whereby in the case of crevice corrosion, the effect of the CCP is limited, depending on the crevice geometry. For the case of pitting corrosion, a reduction in potential to $U_H = -0,1 \cdot V$ is sufficient for the austenitic and austenitic-ferritic steels, and $U_H = -0,3 \cdot V$ for the martensitic or nickel-martensitic CrNi, CrMo and CrNiMo steels.

Note:

Uncoated stainless steels are not protected cathodically if they are suitable for withstanding the corrosion stress. Coated stainless steels must be cathodically protected in the submerged zone.

2.1.3 Design and Workmanship

The following fundamental principles shall be observed:

- Crevices shall be avoided as far as possible. If this is not feasible, the crevice should be made as large as possible i.e. the gap should be wider than it is deep and the width should be larger than 1,0 mm.
- Flanges shall, if applicable, be made of materials with a greater corrosion resistance.
- Heat transmission paths should be avoided.
- Welds shall be executed in a technically competent manner, e.g. root imperfections and a material sensitivization through incorrect temperature control must be avoided.
- Weld joints must be post-treated in a technically competent manner, e.g. through the removal of annealing colours, scale layers etc.
- Coarse mechanical grinding is not permissible
- The surface should be as smooth as possible
- Only suitable processing tools should be used (e.g. “Stainless steel brush”).

2.2 Intercrystalline Corrosion (IC)

Steels that are not resistant to IC shall only be used in the solution-annealed state. Steels with a reduced carbon content (C = 0,03 %) as well as steels stabilized with titanium or niobium exhibit sufficient resistance against IC.

2.3 Stress Corrosion Cracking (SCC)

In seawater at temperatures above about 50 °C, chlorine-induced corrosion cracking can occur at austenitic stainless steels. At higher temperatures, steels with high contents of molybdenum and especially nickel shall be selected; their suitability shall be checked in each individual case. A high corrosion resistance is exhibited by austenitic-ferritic steels, e.g. the material X2CrNiMoN22-5-3 (1,4462), because of their grain structure.

Martensitic steels tempered for high tenacity require a CCP. However, the protective potential should lie below – 0,5 V (U_H) for hardness increases above 350 HV (e.g. through welding) or tenacities above 1000 MPa, otherwise there is a risk of hydrogen embrittlement.

2.4 Corrosion Fatigue Cracking (CFC)

In the case of a vibration stress, steps must be taken to exclude local corrosion attack. On the one hand, molybdenum-containing steels must be selected by preference and, on the other, a CCP should be installed. Here too, the protective potential should not lie below -0,5 V (U_H) in the case of the higher strength martensitic steels (R_M > 1000 MPa).

E. Copper and Copper Alloys

1. Scope of Application

This Chapter applies for copper, for wrought copper alloys and for cast copper alloys, as mentioned in Rules for Materials (Pt.1, Vol. V) Sec.11. Oxygenic and oxygen-free types of copper as well as copper-zinc wrought

and cast alloys with and without further alloying elements (except for CuZn20Al2 (2,0460)) are generally unsuitable for direct use in seawater.

2. Protective Measures

The following aspects should be observed:

- There must be a uniform surface condition without e.g. edges of cuts, surface damages or local fouling.
- For the formation of favourable protective coating, commissioning with clean and well-aerated water is necessary
- Care shall be taken to ensure that the protective layers cannot dry out and become brittle, e.g. during plant outages.
- In the area of application, there should be sufficient convection with flow rates exceeding 0,1 m/s.
- Regarding structural design in Section 2 is to be observed
- In the vicinity of the tidal zone, red bronze and tin bronze should not be used if possible, since there is a risk of pitting corrosion.
- The use of copper-aluminium alloys at temperatures above 60 °C is unfavourable. However, this does not apply, for alloys with a nickel admixture if an Al content > (8.5 + Ni/2)% is observed.
- Pipework should be designed for a flow rate of at least 0,8 m/s. The upper limit for the flow rate depends on the material and piping diameter. The following values shall not be exceeded:

Table 3.2 Maximum flow rates for pipes made of seawater-resistant copper alloys

Material		Max. calculated flow rate [m/s]	
Brief designation	Number	DN ≤ 40	DN ≥ 50
CuZn20Al2	2.0460	2,8	3,0
CuNi10Fe1,6Mn	2.1972	2,5	3,5
CuNi10Fe1Mn	2.0872		
CuNi30Mn1Fe	2.0882	3,1	4,5
CuNi30Fe2Mn2	2.0883	4,5	6,0
DN = Nominal Diameter (mm)			

F. Aluminium Alloys

1. Scope of Application

This Chapter applies for wrought and cast aluminium alloys, as mentioned in the Rules for Materials (Pt.1, Vol.V) Sec.10.

2. Protective Measures

For hull structures or components of zinc-free aluminium materials which are continuously submerged in seawater, cathodic protection with a protective potential less than – 0,55 V (U_H) by sacrificial anodes is required. For zink-containing aluminium materials, the necessary protective potential must be determined in each individual case.

Cathodic protection is also recommended for materials which are subjected to the corrosion stress of the tidal zone.

For aluminium materials which are only exposed to spray water, corrosion protection is not necessary. As a possible corrosion protection measure, the electrolytic anodizing of the aluminium surface has proven its worth for this area.

With aluminium materials, the danger of contact corrosion should always be considered

In many cases, a coating is selected for aesthetic reasons or possibly as the basis for an antifouling system. The requirements for corrosion protection shall be observed with such application.

For the underwater parts of ships and other structures made of aluminium alloys, anti foulings based on copper oxide as the effective constituent shall not be used, since this can lead to corrosion damage of the substrate metal.

G. Contact Corrosion

The table 3.3 provides information on the hazard of contact corrosion for various metallic materials with the same kind or different counterpart materials in seawater. Using the information given therein, it is possible e.g. to estimate the suitability or corrosion behaviour of bolted or riveted connections, whereby the area of the material to be assessed, in this case the bolt for example, must be viewed as small in relation to that of the base material.

Table 3.3 Influence of contact corrosion, based on DIN 81249

In contact with material of the subgroup	Material to be assessed, subgroup																	
	Unalloyed and Low Alloy Steel and Steel Castings and Cast Iron			Stainless Steels and Stainless Steel Castings			Copper and Copper Alloys			Aluminium Alloys			Nickel Alloy			Titanium and Titanium Alloys		
	>	=	<	>	=	<	>	=	<	>	=	<	>	=	<	>	=	<
Unalloyed and Low Alloy Steel and Steel Castings and Cast Iron	0	0	0	+	+	++	+	+	+	X	X	X	0	0	0	0	0	0
Stainless Steels and Stainless Steel Castings	x	X	XX	0	0	0			X	0	X	X	0	0	0	0	0	0
Copper and Copper Alloys	x	XX	XX	+	0	0	0	0	0	XX	XX	XX	0	0	0	0	0	0
Aluminium Alloys	+	+	+	0	0	+	+	+	++	0	0	0	+	+	+	0	0	0
Nickel Alloy	x	X	XX	0	0	0	0	0	X	X	X	XX	0	0	0	0	0	0
Titanium and Titanium Alloys	0	X	XX	0	0	0	0	X	XX	X	X	XX	0	0	0	0	0	0

> The exposed surface area of the material to be assessed is large in comparison to that of the material with which it is paired.

= The exposed surface area of the material to be assessed is about the same as that of the material with which it is paired.

< The exposed surface area of the material to be assessed is small in comparison to tat of the material with which it is paired.

++ The corrosion of the material to be assessed is reduced strongly.

+ The corrosion of the material to be assessed is reduced.

0 The corrosion of the material to be assessed is influenced to a negligible extent.

X The corrosion of the material to be assessed is increased.

XX The corrosion of the material to be assessed is increased to an appreciable extent.

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Section 4 Coatings

A. General

The coatings must be suitable for the corresponding application, according to the specifications of the manufacturer. For the maritime sector, this necessitates a resistance against seawater, brackish water and harbour water and against the impurities they contain. The properties, structures and application of a coating system shall be documented and specified by the coating manufacturer. Information on the coating material, its processing and its suitability within the coating system shall be included in the product data sheets. The selection, surface pre-treatment and application shall be carried out in accordance with the specifications and the instructions of the coating manufacturer.

In case, that not more stringent requirements are specified by the coating manufacturer, the following provisions shall be used as minimum standard, if not otherwise agreed separately.

B. Preparation of the Surface

In the following, the essential requirements for the surface pre-treatment of

- Unalloyed and low-alloy steels
- Cast iron
- Stainless steels
- Aluminium alloys
- Copper alloys
- Materials with metallic coatings of zinc or aluminium
- Wood
- Fibre-reinforced plastics (FRP)

are stated.

Before abrasive-blasting or mechanical grinding and before coating takes place, all oil and grease residues shall be removed from surfaces contaminated in this way. All other surfaces for which no abrasive-blasting or mechanical grinding is necessary should always be freed from oil, grease, dirt and other contaminants by means of a high-pressure cleaning unit or through dry-ice blasting.

Solid blasting media shall conform with the requirements set out in ISO 11124 or ISO 11126, respectively.

1. Surface Preparation of Unalloyed and Low-Alloy Steels

For the surface preparation of ballast water tanks Chapter 3 are to be observed.

1.1 Abrasive-Blasting

1.1.1 Purity

Within the scope of application of this Guidance, all steel surfaces shall always be descaled in the pre-production phase (through blasting to surface quality grade "Sa2$^1/_2$" or, for smaller areas, mechanical grinding) and provided with a suitable shop primer, unless otherwise agreed by contract.

Before further coating, renewed surface preparation is needed. The surface quality grades specified in the corresponding coating material/system documentation of the manufacturer shall be complied with. The blasting shall extend at least 25 mm into the adjacent coated surfaces.

A dry blasting process should be used.

1.1.2 Blasting Agent

As the blasting agents, copper works' slag (MCU), fused corundum (MKE) as well as iron or steel blasting agents can be considered. The use of silica and sand (MQS) shall be avoided.

The blasting agents shall be free of dust, salts or other impurities.

1.1.3 Roughness

The surface roughness R_z should lie between 40 and 100 µm (roughness grade "medium" according to ISO 8503-1).

1.1.4 Repairing of Surface Defects

Welding spatter, rough-rolled ends, laminations, rolling flaws, etc. which have only become apparent immediately before or during the blasting work shall be remedied. Edges and welding seams shall be treated according to Table 4.1 and 4.2 and transitions shall be gradual. Further specifications are given in the Shipbuilding and Repair Quality Standard of the IACS.

At point at which extensive repair work must be carried out after blasting, the blasting must be repeated after the repair. At components or structural units which concern the classification sector, the Rules for Materials (Pt.1, Vol.V) shall be observed in addition.

Table 4.1 Preparation of edges

	WORK COMPLETION / DESIGNATED AREA	THERMAL CUTTING EDGES				SAWCUT OR SHERCUT EDGES		
		1	2	3	4	5	6	7
		Slag removal	Burr removal (from below)	Chamfer edges (top and below)	Smooth face of manual cut	No dressing	Flash removal (from below)	Chamfer edges (top and below)
A	Shell	X				X		
B	Exposed deck inc. deck outfits, superstructure outside	X	X		X[1]		X	
C	Visibles areas within engine rooms, store rooms, serice rooms, living rooms	X				X		
D	Behind ceilings, underneath insulation and cladding	X				X		
E	Within service routes, e.g. alleyways, pipe tunnels	X	X				X	
F	Cargo Holds (dry)	X				X		
G	Cargo Holds (wet/dry)	X			X[1]			
H	Voids, cofferdams	X				X		
I	Ballast water tanks [4]	X		X[3]	X[1]	X		
K	Crude oil tanks [2]	X				X		
L	Changeable, stop and dirt water tanks	X			X[1]	X		
M	Chemical tanks	X		X	X			X
N	Tanks for fresh water, drinking water	X	X		X		X	
O	Boiler water tanks, distillate tanks	X	X		X		X	
P	Tanks for fuel oil, heavy oil	X				X		
Q	Tanks for lubricating oil, hydraulic oil incl. service tanks	X				X		
R	Circulation oil tanks	X				X		

1) Provided the score depth exceeded 0,5 mm for strength relevant parts or 1,0 mm for other parts
2) In case the Class Notation CTC is requested the rules according to chapter 2- Corrosion Protection of Crude Oil Cargo Tanks have to be observed
3) Departures have to be agreed between owner and yard
4) Ballast water tanks on vessels built according to IMO Resolution MSC.215 (82) has to be prepared according to Chapter 3

Table 4.2 Preparation of welding seams

DESIGNATED AREA \ WORK COMPLETION		WELDING SEAMS							
		1	2	3	4	5	6	7	8
		Slag removal	Removal of visible pores	Removal of undercut [1]	Removal of visible slag inclusion	Removal of loose spatters	Removal of loose spatters	Smoothing of seam surfaces	Grinding plane
A	Shell	X	X	X	X		X		
B	Exposed deck inc. deck outfits, superstructure outside	X	X	X	X		X		
C	Visibles areas within engine rooms, store rooms, service rooms, living rooms	X				X			
D	Behind ceilings, underneath insulation and cladding	X				X			
E	Within service routes, e.g. alleyways, pipe tunnels	X				X			
F	Cargo Holds (dry)	X				X			
G	Cargo Holds (wet/dry)	X				X			
H	Voids, cofferdams	X				X			
I	Ballast water tanks [4]	X				X	X[2]		
K	Crude oil tanks [3]	X				X			
L	Changeable, stop and dirt water tanks	X				X			
M	Chemical tanks	X	X	X	X		X		
N	Tanks for fresh water, drinking water	X	X	X	X		X		
O	Boiler water tanks, distillate tanks	X	X			X			
P	Tanks for fuel oil, heavy oil	X				X			
Q	Tanks for lubricating oil, hydraulic oil incl. service tanks	X					X		
R	Circulation oil tanks	X					X		

[1] Refer also to ISO 5817

[2] Departures have to be agreed between owner and yard

[3] In case the Class notation CTC is requested the Rules according to Chapter 2 – Corrosion Protection of Crude Oil Cargo Tanks have to be observed

[4] Ballast water tanks on vessels built according to IMO Resolution MSC.215 (82) shall be prepared according to Chapter 3

1.1.5 Environmental Conditions

For blasting purposes, the surface temperature must lie at least 3°C above the dewpoint and the relative atmospheric humidity should be a maximum of 90%. To prevent impairments by dust or blasting agents, the blasting activities should not be performed at places near which coating work is being done or near which coatings have not yet dried properly.

1.2 Mechanical Grinding

Mechanical grinding is limited to smaller areas, at which coating damage has to be remedied or where, because of the local conditions, no blasting can be performed. A surface condition as per "St3, "Sa2$^{1}/_{2}$" or one that is in accordance with the specifications of the coating manufacturer, should be achieved.

The mechanical treatment must not cause any excessive polishing or roughening of the surface. The grinding shall extend at least 25 mm into the adjacent coated surfaces if not otherwise specified.

1.3 Pressurized Water Blasting with Solid Blasting Agents

Pressurized water blasting with solid blasting agents should be limited to the areas that cannot be processed according to B.1.1. This work shall be performed according to an approved specification, which must be matched to the coating system by the coating manufacturer.

2. Surface Preparation of Cast Iron

For cast iron as a coating substrate, the same prerequisites as for steel apply in principle. However, in contrast to rolling scale, the relatively thin casting skin need not be removed. The surface roughness is greater than for steel.

3. Surface Preparation of Stainless Steels

3.1 Cleaning

Blasting shall be performed with ferrite-free blasting agents (proportion of metallic iron: max. 0,1%). The blasting agents shall not have been used on ferritic materials beforehand. All adherent welding spatter, welding beads and welding cinders must be removed. Brushes, pick hammers, spatulas and scrapers shall be made of stainless austenitic steel. Non-metallic brushes are permissible.

Abrasive media must be ferrite-free and must not contain an insert of steel wire.

Abrasive disks or belts must not have been used on ferritic components beforehand. For the purity not achieved by blasting, a metallic smooth surface on the basis of surface quality grade "St3" or "P St3" is required.

Annealing colours shall generally be removed by pickling or blasting. Grinding is permissible in exceptional cases. The pickling solution shall not contain any hydrochloric acid. After pickling, the surface shall be neutralized by thorough washing with fresh water, especially in crevices. As a matter of principle, it shall be ensured that components that are no longer to be subjected to surface treatment are protected against ferritic abrasion, e.g. during storage: rust films, sparks from flame-cutting, welding or grinding.

If foreign contamination cannot be removed by the above-mentioned procedures and agents, suitable measures shall be taken after agreement has been reached.

3.2 Roughness

For the primer, the average surface roughness R_Z, shall be 30 – 45 μm. In confined spaces for which this surface roughness can only be achieved with difficulty , owing to the polishing effect of the blasting agent, metal sheets with a defined surface roughness of 50 μm can also be used. This parts must be cleaned thoroughly before the coating is applied.

For surface which are to remain uncoated, the roughness should be as low as possible.

The blasting agent grain size and shape shall be selected so that sharp-edged surface is attained for the components to be coated, and a smooth, fine surface for components which are to remain uncoated.

4. Surface Preparation of Copper Alloys and of Materials with Metallic Coatings of Zinc or Aluminium Materials

The components shall be thoroughly cleaned and degreased. The cleaning procedure shall be coordinated with the coating manufacturer.

The following procedures are permissible:

- Cleaning with cold detergent and subsequent washing with fresh water
- Steam jet cleaning with dosing of chemicals
- High-pressure cleaning with closing of chemicals
- Light blasting

Immediately after cleaning/degreasing and drying, the components shall be treated with a wash primer or with a suitable coating material which acts as an adhesion promoter and finish coat at the same time.

5. Surface Preparation of Aluminium Alloys

5.1 Degreasing

All surface must be thoroughly degreased. For this purpose, chlorine-containing detergents shall be avoided, as they can lead to corrosion problems.

5.2 Cleaning

The cleaning procedure must be compatible with the corresponding coating material.

5.2.1 Pickling

An acidic pickling solution must be applied uniformly to all surfaces to be treated. After application, the detergent must be left to act on the material surface for the reaction time specified by the manufacturer, which is usually 20 – 30 minutes. Then the surfaces must be washed thoroughly with fresh water, until the pH value of the washing water corresponds to that of the fresh water.

5.2.2 Grit-Blasting

Only ferrite-free special fused alumina shall be used as the blasting agent. Blasting agents which have already been used for metals other than aluminium shall be avoided, owing to the risk of putting corrosion. The surface roughness R_z should lie between 25 and 50 μm. The prepared surfaces should be thoroughly freed from dust and coated as soon as possible, since the newly formed oxide layer tends to generate a porous hydrous covering layer under the influence of the weather.

5.2.3 Mechanical Grinding

Mechanical grinding is limited to smaller areas at which coating damage has to be remedied or where, because of the local conditions, no blasting or pickling can be performed. A coarse-grained grinding disc should be used, in order to achieve a suitable surface condition in accordance with the specification of the coating manufacturer. The blasting should extend at least 25 mm into the adjacent coated surfaces.

6. Surface Preparation of Wood

The surface of wooden parts shall be freed from all contaminants and, if applicable, from foreign layers, e.g. through:

- Sanding
- Vacuum-cleaning
- Brushing off

The surface shall be treated with a suitable sealing primer. When applying the sealing primer and subsequent coatings, the moisture content of the solid wood shall not amount to more than 15 %.

7. Surface Preparation of Fibre-Reinforced Plastics (FRP)

The following requirements apply only for surfaces which are to be treated with a coating after the component has been fully fabricated.

The surfaces shall be freed from all contaminants, especially release agents. The surface must not be etched. Brief high-pressure washing with hot water and with/without dosing of chemicals is permissible to remove grease. The water temperature shall not exceed 80 °C.

Prior to application of a coating, the surface shall be roughened by sanding (with sandpaper of grain 100 or finer). The gelcoat shall not be sanded off.

It is possible that the sanding dust adheres to the surfaces, for instance through electrostatic forces, and so it must be removed by suitable means (e.g. blowing it off with ionized air). If necessary, a wash primer shall be applied after the roughening.

C. Selection of the Coating Materials B-C

1. Shop Primers

The requirements for shop primers in respect of corrosion protection are set out in Rules for Hull (Pt.1, Vol.II) Sec.38.

The shop primers used particularly in shipbuilding (for BKI class) shall be of a type approved by BKI or recognized body. For these shop primers, the requirements set out in Rules for Welding (Pt.1, Vol.VI) Sec.6 shall apply in addition.

If a shop primer shall be used in combination with a corrosion protection coating for sea water ballast tanks, Chapter 3 for Coating of Ballast Water Tanks are to be observed.

2. Corrosion Protection Systems

Coating materials and coating systems shall be selected and applied according to the prevailing environmental and application-related conditions. Suitable coating systems for the use in seawater ballast tanks, cargo tans on bulk carriers and for the outer shell of steel ships are set out in Table 4.3. Their

suitability shall in each case be guaranteed by the coating manufactures, and evidence thereof shall be provided on request. The most important data of a coating material shall be documented according to STG Guideline No.22161[1]. For the selection the applicable statutory conditions and technical rules concerning work, fire and environmental protection shall be observed by the user.

The selection of a coating system for a certain case should preferably be based on practical experience with similar cases. Coating systems which are subject to strong dynamic or elongations stresses, as can occur particularly on ships of higher-strength fine-grained structural steels, or which have to withstand high temperature stresses, shall be especially suitable for withstanding such stresses.

In addition to the necessary practical tests, the corrosion protection effectiveness of coatings can be assessed on the basis of tests performed as ISO 12944-6. Moreover, in the case of underwater coatings, the compatibility with the cathodic corrosion protection procedure as per STG Guideline No.2220 or an equivalent procedure should be verified.

The following diagram shows two typical coating systems for aluminium structures, see Fig. 4.1.

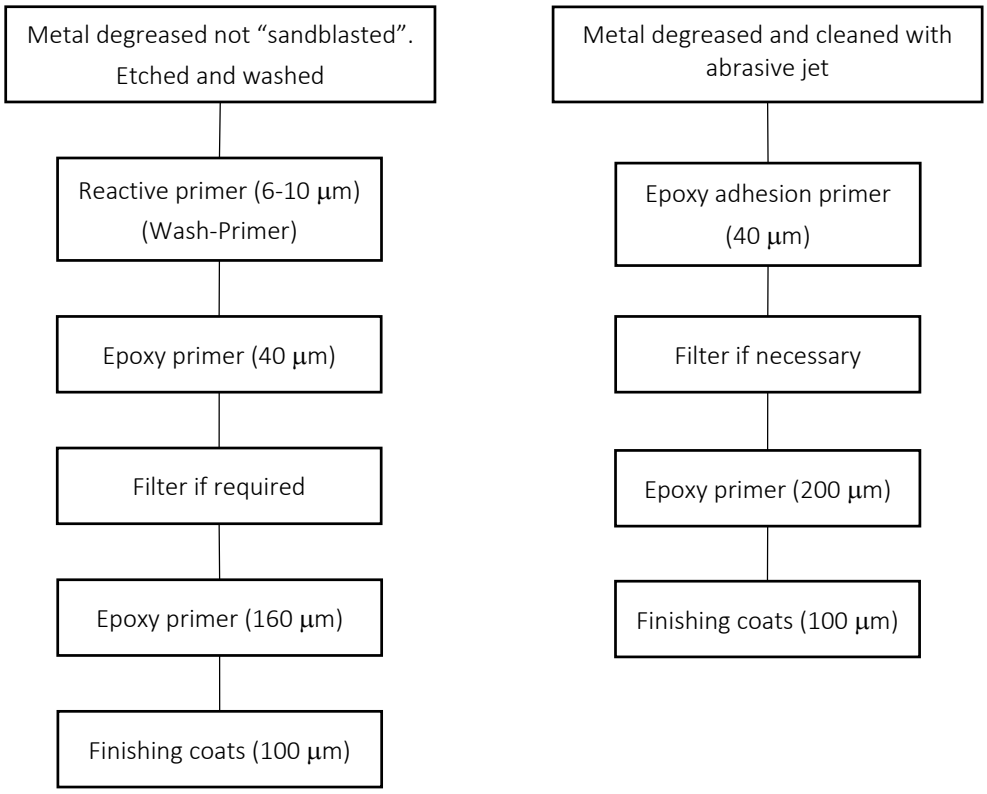

Fig.4.1 Typical coating systems for aluminium structures

[1] In case of documentation of data of coatings for ballast water tanks the Rules for Hull (Pt.1, Vol.II) Sec.38 apply

Table 4.3 Examples for suitable coating systems, based on STG-Guideline-No.2215

Areas	Type of binder	Standard Preparation grade (before coating)	Minimum film thickness (µm)			Remarks
			Undercoat	Topcoat	Total dry film thickness	
Underwater shell plating/ Sea water ballast tanks	Epoxy (resin) (EP)	Sa2½	1 x 500		500	Solvent-free, ice-going ships
		PSa2½	1 x 125	1 x 125	250	
	Epoxy (resin) tar combination (TE)	PSa2½	1 – 2 x 125	1 x 125	250 -375	Solvent-free
			1 x 300		300	
	Polyurethane (PUR)		2 x 100	1 x 100	300	
	Polyurethane tar combination (PUR-T)		1 x 125	1 x 125	250	
	Polyvinylchloride (PVC)		3 x 100		300	
	Polyvinylchloride tar combination (PVC-T)		2 x 100	1 x 100	300	
	Chlorinated rubber (RUC)		2 x 90	1 x 90	270	
	Tar (T)	PSa2½ / St3	1 x 125	1 x 125	250	
Shell plating above water	Alkyd (resin) (AK)	PSa2	3 x 40	1 x 40	120 -160	Undercoat 1 with anticorrosive pigment
		PSa2½	1 x 60 (Zinksilikat) +1 x 40 (Sperrgrund) + 1 x 40	1 x 40	170	Increased corrosion protection
	Acryl (resin) (AY)	PSa2	2 x 60	1 x 40	160	
	EP	St3/PSa2½	2 x 40	2 x 40	160	
			1 x 100	1 x 40	140	
	Epoxy (resin) ester (EPE)	St2	1 x 90	2 x 40	170	
	PUR	PSa2½	1 x 100	2 x 40	180	
	PVC		1 x 100	2 x 40	180	
	RUC		1 x 80	2 x 40	160	
Cargo holds dry (bulk cargo)	EP	St3	1 x 150		150	
	PUR		1 x 100	1 x 100	200	
The complete list is given in STG Guideline No.2215						

3. Special Coatings

3.1 General

The coatings and coating materials mentioned in this section go beyond the scope of normal coating systems for corrosion protection. With regard to application method, application case or suitability, they can only be used in a very specialized manner or only for certain areas.

3.2 Soft Coatings

These solvent-free coating materials are based on wool fats, greases, mineral oils and/or waxes. They are used for corrosion protection coatings, for example in water ballast tanks[2], by spraying in film thicknesses up to 2,0 mm. Because in such areas it is often only possible to remove the loose rust, these types are especially suitable for cases of repair. However, where strong water movements can be expected, e.g. owing to the size of the tank (fore peak), other coatings should be given preference.

Since they do not contain any solvents, these coatings can be exposed to water immediately after their application. The disadvantage of these products is that the coating remain relatively soft. To permit a proper walk-in inspection, all the necessary measures and safety precautions shall be taken. When flooding and freeing the tanks, it shall be ensured that no constituents of the soft coating pass out of the ship into the sea. Soft coatings are not approved for ballast water tanks in ship new buildings, and in the case of repair they are not considered when determining the survey intervals.

3.3 Repair Coatings

Repair coatings are understood as being coatings which are preferred for the repair/renewal of the internal protection, e.g. of seawater ballast tanks on older ships. They are semi-hard coatings with a strong inhibiting effect. It should be possible to achieve a surface preparation which suffices for the application e.g. through pressurized water blasting based on STG Guideline No.2222 or by mechanical surface preparation with cleaning.

Such coatings can be examined by BKI with regard to their special suitability for the case in question. Following a successful practical test of such a system, a product approval is issued. When repair coating with a product approval are used in areas of interest for the class, e.g. in the ballast water tanks, Rules for Classification and Surveys (Pt.1, Vol.I) shall be observed in addition.

3.4 Fibre-Reinforced Plastics (FRP)

Solvent-free plastics which are reinforced with glass flakes, fibres, mats, fabrics and fleeces and made on the basis of unsaturated polyester (UP), epoxy resin (EP) and polyurethane (PUR) provide very abrasion-resistant high-build coatings of high density. Applications by spraying or using a spatula and inserting glass mats, fabrics or fleeces. Depending on the stress to be withstood, the number and thickness of insert layers can vary. The film thickness of the coating can range up to several millimetres.

For the surface preparation, grit-blasting with the surface quality grade " Sa2½ " is required. Shop primers are not suitable as the substrate.

The special areas which are coated with these system include e.g. the alternating submersion zones of offshore structures as well as the protective shields of electrical corrosion protection equipment or hull parts of ice-going ships.

3.5 Deck Coverings

Deck coverings in the sense of this Regulation are coatings which are distinguished by very good corrosion protection as well as high abrasion resistance and anti-skid effect. They are mainly applied to the strongly frequented work surfaces in outside areas. The coatings have a total dry film thickness of 2-20 mm. The binding agent is based on solvent-free polyurethane (PUR), epoxy resin (EP), acrylic resin (AY) or polymethyl methacrylate (PMMA).

The surface preparation shall be undertaken by grit-blasting to surface quality grade " Sa2½ ". To protect the grit-blasted steel and to improve the adhesion of the coatings, a primer shall be applied. The heavily

[2] Use of soft coatings in ballast water tanks may be restricted. Reference is made to the Rules for Hull (Pt.1, Vol.II) Sec.38

loaded coating material is applied in one or more layers, mainly by using a spatula. The anti-skid effect of the coating is achieved by scatting or working mineral materials of varying grain sizes and shapes into the wet layer.

At a concluding step, the surface is sealed.

To a certain degree, specially modified asphalt/bitumen combinations are also used as deck coverings. In film thicknesses ranging between 25 and 50 mm, the coverings are armoured with expanded metal or gratings to improve the load-bearing capacity. Such coverings offer good corrosion protection, but exhibit the disadvantages of having thermoplastic properties and excessive weight.

3.6 Linings

Organic linings for cargo tanks system of product carriers shall be in accordance with DIN EN 14879-4.

The constructive design of metallic structural elements shall be in accordance with DIN EN 14879-1 or DIN 2874, respectively.

Linings with laminates of hard or soft rubber are used for the cargo tanks of product tankers for special cargoes, such as phosphoric acid. The surface shall be prepared by abrasive – blasting to surface quality grade "" Sa2½ ". This is followed by the application of a special primer for the temporary protection of the steel surface. After the preparation work in the tank has been completed, the lining is applied under a controlled climate by bonding and welding the laminate strips. The self-vulcanization of the linings occurs, depending on the type of rubber, within a few weeks or months at temperatures of 20 – 250 °C.

The fittings, valves and piping belonging to the cargo loading/unloading system arc vulcanized at the workshop in closed autoclaves under pressure and at increased temperatures.

Furthermore, there are also solvent-free rubber-modified urethane coatings which are applied with special high-pressure spraying equipment in thicknesses of 1-5 mm.

4. Approval of Coatings

For all coating systems, it is possible to apply to BKI for an approval. Here it is necessary to provide sufficient evidence to BKI that the coating material is suitable for the intended purpose. A written application must be submitted to BKI. After successful examination of the product data sheets, coating, specifications and suitability documentation appended to the application, e.g. references and relevant test results etc., a certificate issued by BKI.

Coating materials for seawater ballast tanks as per Rules for Hull (Pt.1, Vol.II) Sec.38 shall be approved.

D. Application of Coating Systems

Special attention has to be paid if application shall be carried out for ballast water tanks. The relevant requirements are set out in the Rules for Hull (Pt.1, Vol.II), Sec.38.

1. General Requirements

- Before coating work commences, all surfaces shall be kept dust-free
- Any scaffolding or stages which may be necessary must, as far as possible, be arranged so that the surfaces to be coated can be processed continuously (e.g. free-standing, scaffold). If heating units are used, the exhaust fumes of the power generators shall be vented to the outside air; they shall not be allowed to mix with the heating air and precipitate on the surfaces to be coated.

- Unless otherwise agreed, the coating work shall commence on the prepared surfaces within four hours of the abrasive-blasting or mechanical grinding.
- The corresponding drying or curing times between the individual layers must comply with the manufacturer's instructions, with due consideration of the environmental conditions.
- During the application of the various layers, all critical areas such as edges, comers, welds, brackets, bolts and nuts must be stripe-coated, in order to ensure compliance with the minimum film thickness and a proper sequence of layers.
- The surface temperature should be less than 30°C, but at least 3°C above dewpoint, and the air temperature should, unless otherwise permitted by the coating manufacturer, be higher than 5 °C.
- The relative atmospheric humidity shall attain a maximum of 90% for systems on epoxy resin basis and a maximum of 95% for moisture-curing polyurethane systems. In practice, the following rules has proven its worth:
  - If surface temperature and dewpoint are not measured at prescribed intervals, application shall only take place up to a relative atmospheric humidity of max. 85 % if both parameters are measured at intervals to be laid down, application may also take place at a higher relative atmospheric humidity.
  - The first measurement shall be carried out before application commences. The intervals for further measurements shall be varied depending on the climatic conditions and their changes.
- No coating should be applied if a change of weather is to be expected such that the specified environmental parameters cannot be complied with over the next 2 hours after completion of the coating work.

As a matter of principle the requirements as per ISO 12944-7 should be observed for this area.

2. Spraying

Each layer shall be applied to the entire surface so that a uniform and closed coating is achieved. Defects in the coating which impair the corrosion protection effect shall be repaired before the next layer is applied.

3. Painting with Brush or Roller

At points where, because of the local condition, no spraying is possible, the coating shall be applied by painting with a brush or roller. The tool and the coating material (for roller application) shall be suitable for the intended purpose.

4. Storage of Coating Materials

If no other requirements are stipulated by the manufacturer of the coating materials, storage temperatures between 5°C and 30°C shall be observed for the materials. The materials shall not be stored for longer than permissible; the manufacturer's instructions shall be observed.

5. Approval of Coating Shops

Coating shops can receive BKI-approval. As a prerequisite, the coating shop must ensure, through personnel with suitable training and equipment that is in good working condition, that the demands set for the processing of the coating materials are satisfied. An existing quality management system with defined working sequences and the envisaged company-internal quality checks shall be verified. The examination of the conditions existing on site, with a positive result, must be viewed as a fundamental requirement. This examination must be carried out before work starts; spot checks should also be made during the application process, to confirm the initial conditions. If all requirements are met and if the examinations yield a positive result, a certificate is issued by BKI.

E. Competent Repair of Damage and Defects in Coating Systems during the Construction Period

1. General

A classification of coating damage can take place according to STG-Guideline No.2221, for example. The repair work shall always be suitable for the coating system intended for the corresponding area, including the surface preparation.

2. Insufficient Film thickness

Surfaces at which the film thickness is insufficient shall be cleaned thoroughly and, of necessary, sanded down. Then a compatible coating shall be applied until the required film thickness is attained. The transitions to the original coating shall be gradual.

3. Contaminated Surfaces

Contaminated surfaces which are to be coated further, should be prepared anew as per B.

4. Coating Damage without Exposed Metal Surface

The affected areas of the surface shall first be cleaned and degreased as per B. In addition, it is necessary to attain smooth transitions by sanding the edge zones, in order to achieve as uniform a surface as possible. Many two-component coatings have a retouching interval; for this reason, if this interval has elapsed, additional edge zones must be sanded or roughened in the intact area, to achieve perfect adhesion in the transition zone.

5. Coating Damage with Exposed Metal Surface

The condition of the material or the systems in respect of surface preparation, the application data for each individual layer etc. shall be observed as per specification. For the adjacent coating areas, the required procedure is set out in E.4.

6. Repair of defective areas in sea water ballast tanks according to IMO Resolution MSC.215 (82)

If defective areas in sea water ballast tanks occur, special measures are to be observed as set out in the Rules for Hull (Pt.1, Vol.II) Sec.38.

F. Testing, Acceptance and Documentation of the Coating Systems

For Coating Systems applied according to IMO Resolution MSC.215(82) special measures for the testing, inspection and documentation apply as set out in the Rules for Hull (Pt.1, Vol.II) Sec.38.

1. Testing

The surface preparation of a component or a structure should be checked as follows before the coating work commences:

- Check of the required roughness profile (visual inspection or contact stylus method)
- Testing for soluble salts and other non-visible impurities (see ISO 8502) for high-quality coating systems, e.g. for cargo tanks and seawater ballast tanks.

Within the scope of the application process, each individual coating that is applied, and subsequently the entire coating system, shall be tested as follows:

- Visual inspection for uniformity, colour, covering power, curing and possible defects (e.g. cracks, flaking, craters etc.)
- Coating thickness measurement for compliance with the required target film thickness or minimum film thickness
- Coating systems for cargo tanks of chemical and product tankers shall be tested additionally with low-voltage or high-voltage units to ensure that they are free of pores
- In special cases, a tests of adhesive strength (see ISO 2409 or ISO 4624) is also possible.

There is the possibility, that control areas as per ISO 12944-7 will be provided at the object in questions.

The scope, number and position of these control areas shall be agreed upon by the parties involved before the coating work commences.

2. Acceptance and Documentation

For the acceptance (see STG Acceptance Protocol) of prepared surfaces and coating systems in all outside areas, water-containing tanks and cargo spaces, the applicator shall invite representatives of not only the shipyard but also of the coating material supplier and the ship owner to attend. In case of seawater ballast tanks, and for IW ships also the underwater part of the ship's outer shell, an acceptance inspection has to be carried out by the BKI Surveyor.

The applicator shall compile the documentation and shall deliver this to the yard and if applicable, to the other participants. The documentation shall provide evidence of the checks and acceptance tests as well as the conditions prevailing during the processing, including data on the coating materials which were used:

STG-Acceptance-Protocol for Applicator		
Perusahaan: Company	**Inspektor:** Inspector	**Tanggal:** Date
Obyek: Object **Galangan:** Yard	**Daerah:** Area	

Persiapan permukaan sesuai rencana pelapisan:
Surface preparation acc. to coating plan:

Penerimaan Acceptance	**ya** yes	☐	**tidak** no	☐

Sistem pelapisan sesuai rencana pelapisan :
Coating System acc. coating plan:

Ketebalan film: Film thickness:	**dari** from	**mikron** micron	**sampai** to	**mikron** micron	**rata-rata** average	**mikron** micron

Kondisi Permukaan:
Surface condition

Penerimaan Acceptance	**ya** yes	☐	**tidak** no	☐

Catatan:
Remarks

Tanda tangan peserta
Signatures of participants

Pemohon Applicator	**Galangan** Yard	**Pemilik** Owner	**Pemasok bahan pelapisan** Coating material supplier

Distirbusi Distirbution	: :	**Galangan/Pemasok bahan pelapisan/Pemilik** Yard/Coating material supplier/Owner

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Section 5 Metallic Coatings on Steel

A. Hot Galvanizing

Metallic coatings by hot galvanizing shall comply with the requirements set out in ISO 1461. Hot-galvanized components should always be protected additionally by a coating (duplex coating)

B. Thermal Spraying

1. Surface Preparation and Application Conditions

The surface preparation of the steel surfaces shall comply with the requirements set out in Section 4, B.1.

Further notes and recommendations are given in EN 13507 “Pretreatment of surfaces for thermal spraying”.

With regard to the application conditions, the following points shall be observed:

- The interval between preparation and spraying shall be selected so that the surface to be coated remains clean and dry and does not visibly oxidize. This interval should be less than 4 hours.
- The steel temperature shall lie at least 3 °C above dewpoint.

2. Materials for Metallic coatings

As suitable materials for metal spraying.

Aluminium : A199,5 and

Al-Mg alloy : AlMg5

As per ISO 14919 or an equivalent quality grade can be considered.

The following information shall be available with regard to the filler metal that is used:

- Material data sheet
- Material test certificate
- Manufacturer’s designation
- Standard used
- Production or batch number
- Chemical analysis
- Wire diameter
- Net weight
- Production date

3. Spraying Technique

- Each layer shall be applied uniformly to the entire surface. The metallic coatings shall be applied in several crossed layers.
- Equipment and units for thermal spraying shall comply with the requirements set out in EN 1395.
- For parts which are to be welded after spraying, an area 5-10 cm around the welding groove shall remain uncoated.
- The protective film shall adhere properly. Spraying layers shall exhibit a uniform surface appearance that is not too coarse. They shall be free from bubbles, voids, loosely adherent spray metal, discolourations, damages and uncoated spots.
- Before a subsequent laver is applied, any damage that may have occurred to the previous layer shall first be repaired.
- Sealing can be achieved either by a chemical transformation (through phosphatizing, reactive compacting agents etc.) or through the use of a suitable painting system which covers up the pores.

4. Minimum Film Thickness

The minimum thickness of the metallic coatings shall not be less than the following values:

Table 5.1 Minimum thicknesses of sprayed metallic coatings

Spraying Material		Minimum film thickness [µm]	
		Without painting	With painting
Aluminium	Al99,5	200	150
AlMg alloy	AlMg5	250	200

5. Quality Assurance for Spraying

The testing of thermal spraying layers should be performed on the basis of DVS Work Sheet 2301 and 2304.

The responsible personnel should be checked according to ISO 14918.

Spraying shops in the sense of this Guidance can apply for approval by BKI. Through personnel with suitable training and equipment that is in good working condition, the ship shall ensure that the requirements for the processing of the thermal spray materials are met. An existing quality management system with defined working sequences and the envisaged company-internal quality checks shall be verified. The examination of the conditions existing on site, with a positive results shall be viewed as a fundamental requirement. This examination shall be carried out before work start; spot checks should also be made during the application process, to confirm the initial conditions. If all requirements are met and if examination yield a positive result, a certificate is issued by BKI.

Spraying shops which produce thermally sprayed layers for improving the workpiece properties (for example, in respect of wear, corrosion, heat transmission, electrical conductivity or similar) or for reinstating the operational readiness of components as per the Rules for Classification and Construction of BKI shall have been approved in accordance with the welding regulations issued by BKI.

Section 6 Antifouling Systems

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Section 7 Certification of Coating System

A. General A

For the requirements Certification of Coating System, see Guidance for The Approval and Type Approval of Materials and Equipment for Marine Use (Pt.1, Vol. W) Sec.3.

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Section 8 Cathodic Corrosion Protection

A. General

The design and arrangement of the cathodic protection systems shall take into account the specific requirements of the structure or the component. These protection systems must ensure the corrosion protection for the specified protection duration.

To be able to guarantee sufficient protection, the structure must be adequately polarized. The protective potentials specified in Table 8.1 shall be observed.

The cathodic protection systems must be compatible with the coating that is applied, i.e. their use must not lead to an impairment of the quality and functionality of the coating. Evidence of the durability should be provided in accordance with the requirements of STG Guideline No. 2220 or an equivalent standard.

The ship or the structure to be protected must be subdivided into a suitable and expedient number of cathodic protection zones (CPZs). These are surfaces of varying corrosive stress or different areas of action as a result of geometric conditions. The areas of the corresponding CPZs must be determined or estimated as precisely as possible. The necessary protective current density for a CPZ should be chosen in accordance with the recommendation of Table 8.2, and those of the corresponding protective potential in accordance with Table 8.1.

Table 8.1 Protective potentials for the CCP of various metals in seawater

Material of the structure to be protected	Range of the protective potential (Ag/AgCl/seawater)	
	Negative minimum potential	Negative maximum potential
AlMg and AlMgSi alloys	-0,80 V	-1,10 V[1)]
Steel/cast iron Aerobic conditions Anaerobic conditions	 -0,80 V -0,90 V	 -1,10 V -1,10 V
High-strength steels ($Rp_{0.2} \geq 700MPa$)[2)]	-0,80 V	-0,95 V
Stainless steel [2), 3)] Pitting resistance equivalent ≥ $PRE_{min.}$[4)] Pitting resistance equivalent < $PRE_{min.}$[4)]	 -0,30 V -0,60 V	 -1,05 V -1,05 V

[1)] A possible cancellation through over-protection and also the risk of hydrogen embrittlement with higher-strength alloys must be considered.

[2)] With steel types that are sensitive to hydrogen embrittlement and crack initiation and with duplex steels which exhibit an unfavourable grain structure (e.g. because of incorrect application of heat), a protective potential of no less than -0,83 V must be maintained.

[3)] Martensitic steels tempered for high tenacity (Rm > 1000 MPa) should have a protective potential between -0,5 and -0,7 V.

[4)] See Section 3.D.2.1.1

The required consumption of protective current for CPZ (I_{CPZ}) is obtained from the product of the CPZ area (A_{CPZ}) and the corresponding protective current density (i_{CPZ}):

Equation I : $I_{CPZ} = A_{CPZ} \cdot i_{CPZ}$

For the outer shell of ships with the character of class IW and for seawater ballast tanks, Rules for Hull (Pt.1, Vol.II) Sec.38 "Corrosion Protection" shall be observed.

B. External Protection through Sacrificial Anodes

1. Field of Application

This section applies for the cathodic corrosion protection of the underwater surfaces of ships and floating units through sacrificial (galvanic) anodes (also termed "anodes" in the following) in seawater and brackish water.

2. Design Fundamentals

The protection period should be designed for one drydocking interval, but at least for 2 years (17.520 h).

Table 8.2 Protective current densities for various cathodic protection zones

Typical CPZ			Protective current density (i_s) (minimum value) [mA/m²]
Coated out shell of steel ships with speeds [1]	up 20 kn		15
	20 – 25 kn		30
	Over 25 kn		40
Coated outer shell of steel ships used for voyages in ice			60 [2]
Outer shell of ships made of aluminium alloys	Coated		4
	Uncoated		20
Outer shell of ships made of austenitic alloys	Coated		2
	Uncoated		20
Other uncoated underwater surfaces			200
Propeller surfaces			≥ 500
Trim, ballast water, slop and sludge tanks or similar	Coated surfaces		10
	Uncoated surfaces		120
Tank tops (inner bottoms), bilges or similar			20-100 (depending on loading, coating and accessibility)
Underwater zone of stationary steel structures (depending on the environmental conditions)	Uncoated	DTZ	80-130
		WTZ	Current density of the uncoated sustained submersion zone + 20 %
	Coated	DTZ	1-2% of the uncoated sustained submersion zone + 1 – 1,5% per year
		WTZ	2 – 5 % of the uncoated sustained submersion zone + 1 – 1,5% per year

[1] For service in primarily tropical waters, higher protective current densities can become necessary.

[2] In the case, that BKI approved ice-coatings have been applicated there could be a reduction on to 1,5 times of the normal protective current density.

2.1 Protective Current Density

Reference values for the required protective current densities are given in Table 8.2. Protective current densities for non-specific areas or for CPZs which represent special areas from a corrosion protection viewpoint (bow thrusters, water-jet drivers etc.) shall be determined individually in each case.

The calculated underwater area applies only for the hull; for the determination of the overall area A_G to be protected, the additional cathodic protection zones (such as the appendages, propeller and shafts) are calculated separately according to drawings and then added.

The protection of openings, e.g. sea chests, and other CPZs lying outside the region of action must be calculated in addition.

2.2 Calculation of the Protective Current

The required total protective current is:

Equation II: $I_G = A_G \cdot i_s$

where :

I_G = total protective current

A_G = total area to be protected

i_s = protective current density

The protective current for cathodic protection zones to be handles separately must be determined by Equation I.

2.3 Calculation of the Required Anode Weight

The required total anode weight is:

Equation III: $$m_G = \frac{I_G \cdot t_S}{Q_g}$$

where:

m_G = required total anode weight

I_G = total protective current

t_S = Protective period

Q_g = electrochemical efficiency of the anode alloy

The required anode weight of a CPZ to be handles separately is:

Equation IV: $$m_{CPZ} = \frac{I_{CPZ} \cdot t_S}{Q_g}$$

If an area which has to be considered separately, such as a bow thruster, consists of several cathodic protection zones (impeller, bracket, tunnel), the required total mass must be calculated by addition of the individual values.

3. Anode Selection

3.1 Anode Materials

For the materials for galvanic anodes, aluminium or zinc alloys as per the requirements set out in Tables 8.3 and 8.4: Sacrificial anodes of aluminium alloys for applications in seawater or as per EN 12496, VG 81255 or equivalent standards must be applied.

The manufacture and acceptance of the sacrificial anodes should be carried out in accordance with the recommendations of EN 12496.

Other material combinations, as specified in Tables 8.3 and 8.4: Sacrificial anodes of aluminium alloys for applications in seawater, are only permissible for sacrificial anodes if their suitability and protective effect can be verified, either through successful and documented service over many years or through suitable testing methods.

Table 8.3 Sacrificial anodes of zinc alloys for applications in seawater

Element	KI-Zn1	KI-Zn2
Al	0,10 – 0,50	≤ 0,10
Cd	0,025 – 0,07	≤ 0,004
Cu	≤ 0,005	≤ 0,005
Fe	≤ 0,005	≤ 0,0014
Pb	≤ 0,006	≤ 0,006
Zn	> 99,22	≥ 99,88
Potential (T = 20 °C)	-1,03 V Ag/AgCl/See	-1,03 V Ag/AgCl/See
Q_g (T = 20 °C)	780 Ah/kg	780 Ah/kg
Efficiency (T = 20 °C)	95%	

Table 8.4 Sacrificial anodes of aluminium alloys for applications in seawater

Element	KI-Al1	KI-Al2	KI-Al3
Si	≤ 0,10	≤ 0,10	
Fe	≤ 0,10	≤ 0,13	
Cu	≤ 0,005	≤ 0,005	≤ 0,02
Mn	N/A	N/A	0,15 – 0,50
Zn	2,0-6,0	4,0-6,0	2,0-5,0
Ti	-	-	0,01-0,05
In	0,01-0,03	-	0,01-0,05

Table 8.4 Sacrificial anodes of aluminium alloys for applications in seawater (continued)

Sn	-	0,05-0,15	-
Other El.	≤ 0,1	≤ 0,1	≤ 0,1
Al	Remainder	Remainder	Remainder
Potential (T = 20 °C)	-1,05 V Ag/AgCl/See	-1,05 V Ag/AgCl/See	-1,05 V Ag/AgCl/See
Q_g (T = 20 °C)	2000 Ah/kg	2000 Ah/kg	2700 Ah/kg
Efficiency (T = 20 °C)	95%		

Anodes of magnesium alloys are not permissible in ship and offshore technology, neither for cargo tanks and ballast water tanks nor for the protection of the ship's outer shell nor as a temporary protection. An exception here is presented by application solely in fresh water.

In the case of ambient temperatures exceeding 25 °C, the reduced capacity and effectiveness of the sacrificial anodes must be taken into account for the design and arrangement. This is especially applicable to hot transverse bulkheads (e.g. walls adjoining fuel tanks). Conventional sacrificial anodes of zinc must only be used up to an ambient temperature of 50 °C for the protection of steel. If special alloys are to be used at temperatures exceeding 50 °C, their electrochemical characteristic and protective effect must be verified separately. The capacity of aluminium anodes is also reduced. In the case of high temperatures, it can be calculated as an approximation within the temperature range from T = 20 to 80 °C using the following equation:

Equation V: $Q_g\,(t) = 2000 - 27 \cdot (T - 20\,°C)$ [Ah/kg]

Experience shows that there are also special alloy for aluminium anodes which possess greater current capacities at high temperatures than the values calculated according to Equation V. The manufactures must then verify and guarantee these values.

3.2 Shape and mounting

The shape and size of the anodes must be suitable for the intended purpose. For the ship's outer shell, flat anodes must be specified, to keep the flow resistance to a minimum. Applicable instructions are given in VG 81257.

Here it must be ensured that the selected anodes provide the required protective currents and the calculated anode weight through their number and shapes.

Depending on the material to which the anodes are affixed, mountings of hull structural steel (H), stainless steel (SS), non-magnetic austenitic steel (NM) or aluminium (Al) must be used.

H = KI-B or equivalent type of steel with regard to strength and weldability

SS = X6CrNiMoTi17-12-2 (1.4571) according to DIN EN 10088-2 or equivalent type of steel with regard to strength, weldability and corrosion resistance

NM = X2CrNiMoN18-14-3 (1.3952.9) according to WL 1.3952-1 or at least equivalent type of steel with regard to strength, weldability, corrosion resistance and non-magnetic properties

Al = AlMg4,5Mn (3.3547) or other type according to EN 573 that can be agreed upon when the order is placed

The mounting bracket of ship structural steel, zinc-plated with a thickness > 25 μm, must be free of cracks and impurities. Zinc coatings are not suitable for aluminium anodes.

The mounting of stainless steel or non-magnetic steel must be pickled.

Mounting of aluminium must be free of impurities.

4. Arrangement of the Anodes

4.1 Fastening the Anodes

The connection between the anode and the area to be protected must be metallically conductive. For this reason, the anodes must be welded on.

In the case of low shell thicknesses, sensitive materials or platforms, mounted plates (doubling) of sufficient thickness must be welded on, with an extra border of 20 mm, on all sides around the welding points of the anode.

If bolted connections cannot be avoided in exceptional cases – which must be agreed upon with the client – a metallically conducting connection, e.g. through welding points, must be provided.

4.2 Shadow Effect and Openings

The anodes must be arranged so that a shadow effect is largely avoided.

Opening in the outer shell, e.g. for sea chest, lateral thrust propellers or similar, must be protected in addition. It must be taken into account that openings are protected by externally placed anodes only up to a depth of one to two times the opening diameter.

4.3 Anode-free Areas

In order not to impair the inflow of water to the propeller, an area depending on the diameter of the propeller, according to Fig. 8.1, should be kept free of anodes.

The dimension given are reference values which depend on the shape of the hull and the speed.

Areas in which the flow conditions must not be impaired (e.g. in the vicinity of sonar domes or openings for pitot heads) must be kept free of anodes according to the corresponding instructions of the manufacturer.

In the tunnel of bow thrusters, the anodes should be arranged by agreement with the manufacturer of the thruster unit.

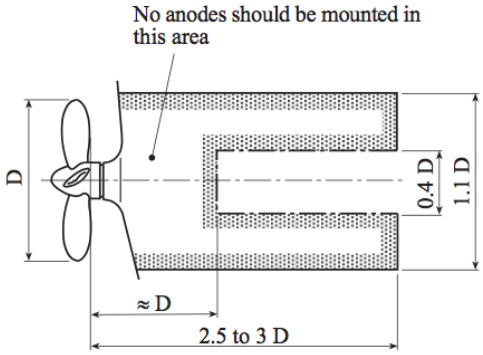

Fig. 8.1 Anode-free zone in way of the propeller (example) as per VG 81256-2

4.4 Complete Protection

The anodes required according to B. serve to protect the entire ship and must be distributed over the entire underwater area of the vessel. For the stem area, about 25% of total anode weight must be used for single-propeller ships, and about 30% for multi-propeller ships; for the arrangement, see B.4.6.

The remaining anode weight must be distributed over the midbody and the forebody.

In way of the bilge, the anodes must be arranged so that they cannot be damaged when the ship is berthed in berthed. In the case of bilge keels, the anodes must be arranged in alternation on their upper and lower sides; if the bilge keel heights is not sufficient for this, the anodes must be arranged on the hull near the bilge keel in alternation above and below the bilge keel.

The anodes near the bows must be arranged in the direction of water flow and placed so that they cannot be damaged by the anchor chain.

4.5 Part Protection (Stern Protection)

For ships where only the aft ship is protected, about 25% or 30% of the total anode weight must be applied within the scope of the complete protection according to B.4.6. With this partial protection of the ship, at least 2 anodes of the same shape, or 10% of the actual stern protection must be applied in addition. These additional anodes shall be fixed 3,0 to 8,0 m in front of the front anode of the actual stern protection. In case of the Class Notation IW the complete underwater hull has to be protected in any case.

4.6 Arrangement at the Stern

When determining the anode arrangement in the stern area, the local flow conditions must be considered and the folloulwing points must be taken into account:

- Above the propeller well and the heel piece just before the propeller well, at least one anode must be mounted on each side.
- In way of the stern tube exit, the necessary anodes must be arranged (at least one on each side), whereby special attention must be paid to the anode-free area according to B.4.3 and Fig. 8.1.
- To protect the shaft brackets, anodes must be applied near their mountings on both sides of the hull; size and material of the shaft brackets must be taken into account for the number of anodes.
- As a rule, propellers and shafts should be included in the cathodic corrosion protection of the outer shell. These parts must be connected conductively with the hull by means of sliprings on the propeller shafts and brushes. To achieve a low-impedance connection, the split bronze or copper ring must have a rolled-in silver layer, on which the brushes of metallic graphite run. The transfer

voltages should lie under 40 mV. For monitoring purposes, a measuring instrument must be installed permanently via a separate carbon brush.

- It is possible to cathodically protect the propeller and shaft solely through a zinc ring mounted on the propeller hub or on the shaft.
- The rudders of fast ships (speed over 30 knots) should as a rule only be protected by anodes adapted to the rudder profile. If this is not possible, the rudder must be included in the complete protection scheme by cable or copper-band connections to the hull.
- Rudder heels must be given one anode on either side. The width of the anode should be smaller than the height of the rudder heel.

4.7 Special Aspects

4.7.1 Metal Ships with Special Features

For ships with special propulsion systems (e.g. Voith-Schneider drive) and for ships with special rudder shapes (e.g. Kort nozzle or rudder propellers), certain measures that must be agreed upon with the corresponding manufacturer and BKI are necessary.

For special hull type (e.g hydrofoils, ships with water-jet drivevs, catamarans), the structural design and the flow rate must be considered for the arrangement of the external protection.

4.7.2 Ships with a Non-Metallic Hull

For the protection of the metallic appendages, anodes applied to the hull must be conductively connected (using either welding straps or cables) with the parts to be protected, whereby in each case care must be taken to ensure a metallically conducting connection.

If there is no central cathodic protection system, rudders must be cathodically protected by anodes, and propellers and shafts by zinc rings affixed to the propeller hubs or shafts.

C. Internal Protection through Sacrificial Anodes

1. Field of Application

This section applies for the cathodic corrosion protection of the internal areas of ships and floating units by means of sacrificial anodes.

The standard applies only for surfaces which have been exposed to an electrolytic solution of sufficient conductivity-at least brackish water- for a sufficient length of time-at least 50% of the service time. The effect of the anodes is limited in fresh water and river water.

2. Design Fundamentals

2.1 Protective Current Requirement

2.1.1 Protective Current Density

Reference values for the required protective current densities are given in Table 8.2.

2.1.2 Protective Duration

The protective duration should be set to 5 years (43800 h) or defined by agreement with the client.

2.1.3 Loading Factor

The size of the loading factor (f_B) depends on the period in which the surface is covered with the electrolytic solution.

In the case of constant loading (filled tanks/cells), the factor must be set to 1.

2.1.4 Total Area to be Protected

The maximum surface area covered by the electrolytic solution is used for the calculation.

2.2 Anode Weight

The required anode weight per CPZ is obtained by

Equation VI:

$$m_{CPZ} = \frac{I_{CPZ} \cdot t_S \cdot f_B}{Q_g}$$

f_B = loading factor

3. Anode Selection

With regard to the anode materials, the notes under item B.3 must be observed.

4. Arrangement of the Anodes

4.1 General

The anodes must be arranged so that a shadow effect is avoided to a large degree, even in areas with a complex structure.

Because of the unknown filling level, the anodes must be assigned primarily to the lower parts, i.e. the areas most likely to be wetted.

It must be noted that several smaller anodes provide a better current distribution than one large anode of same weight.

In addition to the notes given in B., it must be noted that there may be a necessity to increase the number of anodes assigned to the internal spaces, for the following reasons:

- The effective zone of the anodes may be limited due to low water levels.
- Internal structures can cause a shadow effect.
- The effect of noble materials (formation of galvanic cells) must be compensated locally.

In extreme cases, it may even be necessary to apply extra anodes in addition to the total anode weight calculated according to C.2.2, in order to achieve the required number of anodes needed for a uniform distribution of the protective current.

4.2 Fastening the Anodes

The connection between the anode and the area to be protected must be metallically conductive. For this reason, the anodes must be welded on.

In the case of low material thicknesses, sensitive materials or platforms, mounted plates (doubling) of sufficient thickness must be welded on, with an extra border of 20 mm on all sides around the welding points of the anode.

If bolted connections cannot be avoided in exceptional cases – which must be agreed upon with the client- a metallically conducting connection must be provided, e.g. through welding points.

4.3 Aluminium Anodes

Aluminium anodes must only be affixed so that they do not exceed a drop energy of 275 J, i.e. to take an example, an aluminium anode with a weight of 10 kg must not be mounted any higher than 2,75 m over the bottom.

The limitation does not apply for ballast water tanks.

D External Protection through Impressed Current

1. Field of Application

This section applies for the cathodic corrosion protection of the underwater surfaces of ships and floating units through impressed current in seawater and brackish water.

2. Design Fundamentals

The same design fundamentals apply as set out in B.2.

Opening in the outer shell-e.g. sea chests, overboard discharges, stabilizer boxes, thrusters, scoops, parts not conductively linked, Voith-Schneider propellers, shaft penetrations, and other cathodic protection zones which lie outside of the zone of action – must be protected additionally with sacrificial anodes.

3. Arrangement of Anodes and Reference Electrodes

- The impressed-current cathodic protection system is designed for a specific ship or structure. In general, the following design criteria must be observed:
- The impressed-current system must be symmetrical, i.e. for the port and starboard sides, the same number of impressed-current anodes and reference electrodes must be arranged at the same positions. Damage to the ship must be expected for an asymmetrical arrangement.
- At least one anode each much be arranged to port and starboard in the stern area of the ship preferably in way of the engine room
  - At both sides, at least one reference electrode must be arranged for either side; this electrode must be located between the anode and the propeller and be as far away a possible from the associated anode (minimum distance approx. 10% of the ship's length).
  - Vessels with a length (L_{pp}) of more than 175 m must be equipped with a second impressed-current system in the bow area.
  - If there are two impressed-current systems, the systems for the bow area must be arranged so that the control electrode is located between the anode and the bows.
- The structural inclusion (cofferdam) of the anodes in the outer shell must be carried out in a technically competent manner. In case of ships with BKI Class, this is object of the drawing examination.

- The anodes exhibit a relatively high current delivery which could lead to damage to the coating if no suitable countermeasures are taken. For this reason, a protective shield of adequate coating thickness and size must be built up around the anodes to ensure a favourable distribution of current.
  - At a distance of at least 0,8 m from the anode edge, an FRP coating or a filler compound or an equivalent coating with a dry film thickness of at least 3,0 mm at the anode and 2,0 mm at the outer border of this area shall be applied. For the remaining area of the protective shield, a coating with a dry film thickness (without antifouling) of at least 500 µm can be used.
  - The protective shields of FRP coatings, filler compounds and/or coating systems must be resistant to the loads occurring in the "potential funnels" (e.g. elementary chlorine), must not become brittle, must exhibit adequate ductility and must not change even after lengthy docking periods.
  - The protective shields must have a target lifetime of 10 years
- The Rudder must be included in the cathodic protection scheme with an appropriate cable connection, and the propeller with a shaft slipring. (see also item B.4.6.)
- The capacity of the rectifier must be designed so that the required protective current requirement is ensured in all cases and so that a reserve capacity at least 1,5 times of the normal service value is available to accommodate the coating damage which is to be expected

In Fig. 8.2, Fig. 8.3, Fig. 8.4 the impressed-current protection for a ship is shown in schematic form.

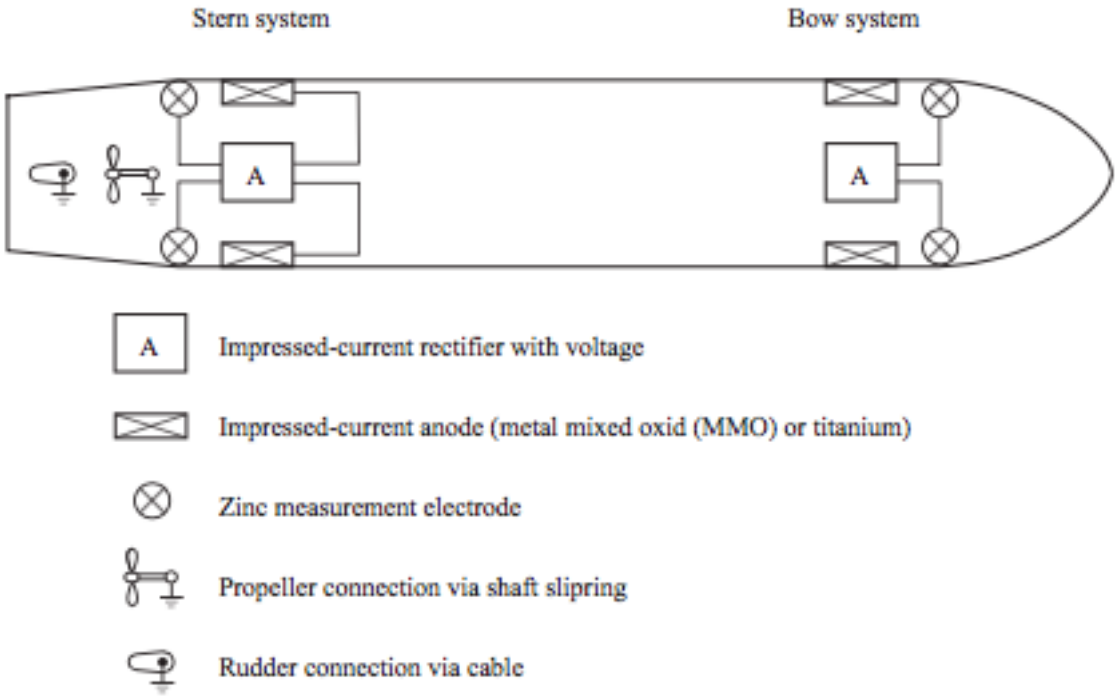

Fig.8.2 Schematic arrangement of an impressed-current system

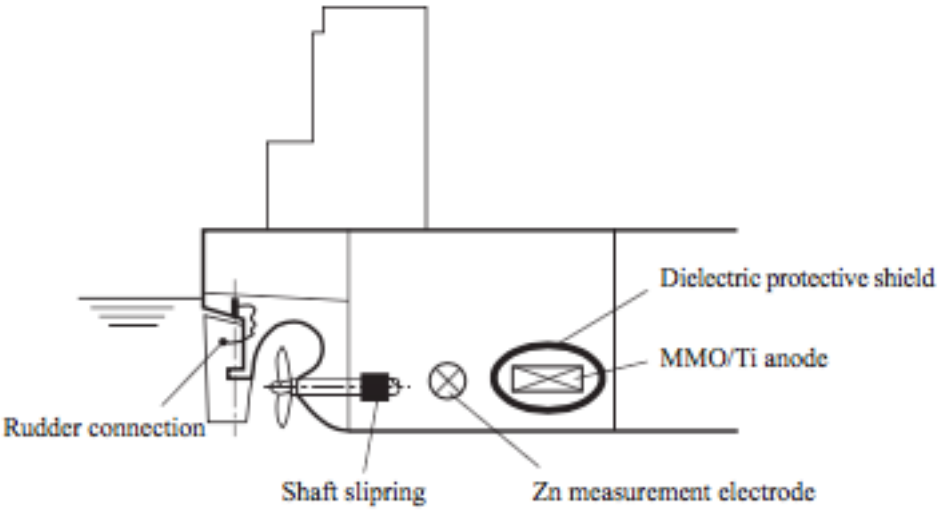

Fig.8.3 Schematic arrangement of an impressed-current system (stern area)

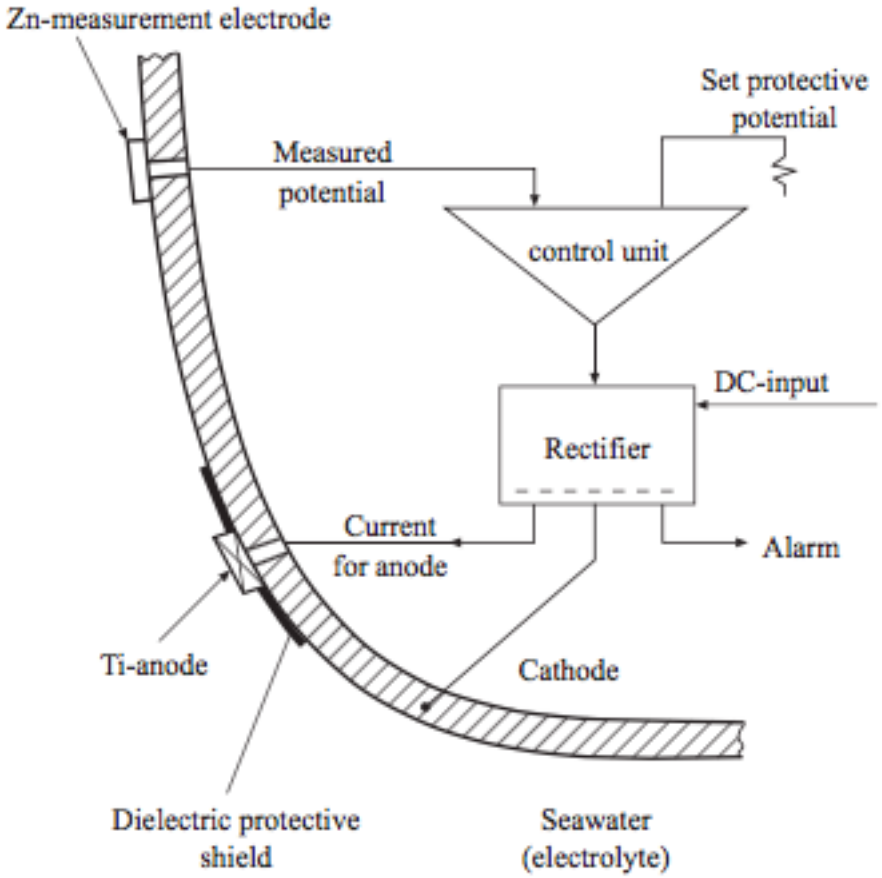

Fig.8.4 Schematic circuit diagram for an impressed-current system

4. Monitoring and Control

4.1 Impressed-current protection systems must be fitted with voltage-controlling power supply units which may exhibit a slow control characteristic. It must be possible to read the control electrodes individually, so that the protective current can be adjusted independent for port and starboard side.

4.2 The possibility of switching over from automatic to manual operation must be provided.

4.3 The following indicator must be provided as a minimum:

- Indicator light “On”
- Indicator light “Manual Operation”
- Common indicator light “Malfunction”
- Indicator “Anode failure or anode group failure”
- Measurement units for “Anode current”, “Anode voltage” and “Potential” (input impedance of the measurement circuit: ≥ 1 M Ω)

4.4 The target-value transmitter for setting the required potential must be fitted with a locking arrangement.

4.5 Automatic limiters for anode current and anode voltage must be provided.

4.6 In the event of wire break or short circuit at the control electrodes, the protective current must be switched off automatically or regulated down to zero when in automatic more.

4.7 For alerting purposes, each group alarm must be routed via a potential-free contact (change-over) to the terminal strip of the power supply unit.

4.8 The control precision of the set voltage for the control electrodes (target value) must be within ± 10 mV during automatic operation.

4.9 The measurement units must be arranged so that it is easy to read off the measurement values regularly.

4.10 The potential values, the voltage difference at the shaft slipring and, if applicable, the anode current and anode voltage must be recorded at regular intervals.

E. Maintenance of the Cathodic Protection System

During docking periods, the sacrificial anodes must be checked for excessive metal loss, damage and for possible passivation, and also for uniformity of the metal loss. Furthermore, the mountings of the sacrificial anodes must be checked for proper electrical contact.

In the case of impressed-current systems, the condition of the reference electrodes, the impressed-current anodes and the anodic protective shield must be checked for damage.

During abrasive-blasting and high-pressure washing work at the outer shell, the reference electrodes, the impressed-current anodes and the anodic protective shields must be protected against damage.

The voltage difference between the slipring of the propeller shaft and the brushes must not exceed 40 mV, in order to prevent damage to the propeller bearings and the propeller shaft. Any instructions issued by the manufacturer must be observed.

F. Documentation of the Cathodic Protection System

The installed cathodic corrosion protection system must be described by appropriate documentation and can be represented to BKI for examination. In the case of ships with the class of BKI that are to bear the character of class “IW”, the following documents shall be submitted (see Rules for Hull (Pt.1, Vol.II) Sec.38 “Corrosion Protection”). The documentation must, insofar applicable, cover the following points:

- Design data of the system (selected protective current densities and potential ranges for specific areas for the ship, for each CPZ)
- Arrangement of the sacrificial anodes on the ship
- Specification of the sacrificial anodes on the ship
- Specification of the sacrificial anodes, i.e. type or chemical composition, mass, capacity manufacturer, acceptance certificate
- Type and arrangement of the reference electrodes and the impressed-current anodes as well as the rudder and propeller connections
- Type and design data of the rectifier
- Specification of the anodic protective shield
- Specification of the control unit
- Design of the cofferdams

Section 1 General Fundamentals

A. Scope of Application

1 Field of Application

This Guidance applies to the corrosion protection of cargo tanks and slop tanks of crude oil tankers below 5000 tonnes deadweight. Tankers complying to this Guidance may be assigned, on request of the owner, either the Class Notation CTC (Cargo Tank Coating). This Guidance specifies the requirements for the corrosion protection system, the application during a newbuilding process and the supervision and certification conditions.

Cargo tanks of crude oil tankers of 5000 tonnes deadweight and above shall be coated during construction in compliance with Resolution MSC.288(87) or shall be protected by alternative means complying with Resolution MSC.289(87).

Crude oil tankers of 5000 tonnes deadweight and above may be exempted from these requirements if the ship is built to be engaged solely in the carriage of cargoes and cargo handling operations not causing corrosion according to Guidelines set out in MSC.1/Circ.1421.

B. Limitations

1. Scope of Application

Corrosion as a mechanism cannot be prevented entirely as such; it is merely possible to minimize the corrosion rates and the effects of the corrosion.

The corrosion rate can be reduced to an acceptable level for a certain system by means of corrosion protection measures, e.g. an appropriate selection of materials, application of the corresponding design principles, suitable coating systems or through cathodic protection. The result is that, with a high degree of probability, the specified lifetime of the structure is ensured and no corrosion damage will occur.

However, this does not release the shipyard and the ship operators from the obligation to assess properly the special features of each particular system, structural part or component and to consider the relevant corrosion hazard. In particular, the corrosion protection measures, which are applied, their maintenance and the servicing activities must be coordinated to suit the corrosion systems in the tank and also the specified lifetime.

C. Definitions

Terms and their explanations in respect of corrosion and corrosion protection are defined in ISO 8044, ISO 4618, ISO 12944, EN 12473 and DIN 81249.

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Section 2 General Requirements

A. Newbuilding

The corrosion specification of the newbuilding has to fulfil as a minimum the requirements of the following items:

- coating performance standard as described in Annex A
- cathodic protection in accordance with Section 3, C
- documentation and supervision during newbuilding according to Section 4, B

Where supervision of coating application/surface preparation is required to be performed by BKISurveyors, the yard and/or application contractor must ensure that:

- The Surveyor has unrestricted, unobstructed and safe access to all parts which have to be inspected.
- Detailed specifications and material data sheets (including material health and safety data) are timely submitted.
- The exact time schedules of inspections are submitted in advance (not later than one day before the inspection).
- Qualified and properly authorised yard and/or application contractor personnel accompany the Surveyor throughout the inspection.
- Confined spaces are adequately ventilated and lit during the inspection.

B. Ship in service

In order to maintain the Class Notation during ship operation, it is needed to implement a suitable maintenance system to provide that the coating of the respective tanks is in "good" condition according to IMO Res. A.744 (18), Table 2.1. During periodical class surveys, this coating condition has to be confirmed by the BKI Surveyor. Necessary repair works shall be in accordance with the paint manufacturer's specification.

Table 2.1 Requirements for the coating condition “good”

Coating condition	Allowable level	Explanation
General breakdown of coating or area rusted	< 3%	Percentage is related to the area under consideration or of the “critical structural areas”
Rust grade on plain areas	< Ri 3	According to ISO 4628-3
Area of hard rust scale	None	
Local breakdown of coating or rust on edges or weld seams	< 20%	Percentage is related to the edges or weld seams in the area under consideration or in the “critical structural area”

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Section 3 Corrosion Protection of Cargo Tanks of Crude Oil Tankers

A. Design Considerations

Special attention is to be paid to the design of cargo tanks and their equipment with the aim of ensuring optimum corrosion protection through the application of suitable structural measures.

The following measures shall be taken into consideration:

- Wherever possible stiffness shall be improved in areas especially subject to fatigue and high deflection rates.
- The structural design shall be such that subsequent activities for the passive and active corrosion protection, such as surface pre-treatment, coating work, inspections and maintenance, can be performed in an optimum manner, e.g. by ensuring good accessibility.
- The surfaces must be designed to be as smooth as possible. Any stiffeners, internal parts and piping etc. shall, wherever possible, be arranged in areas less at risk from corrosion.
- Obstruction of structure members by others (shadow effects), which impedes the coating work (such as open, deep gaps) must be avoided.
- The number of scallops in structural members, intended for coating, shall be limited, wherever possible, in order to facilitate the coating application.
- Points at which moisture tends to collect, thus facilitating the origination and propagation of corrosion must be avoided as far as possible.
- Effective and well placed drain holes shall be foreseen.
- Mixed construction using different materials shall, if possible, be avoided; otherwise suitable insulating measures shall be applied.

B. Coating

1. General

According to the specifications of the manufacturer, coatings must be suitable for the corresponding application. For cargo oil tanks, this necessitates resistance against crude oil, seawater, brackish water and corrosive gases and all relevant mixtures of it. The paint manufacturer shall assist the shipyard and owner in designing a coating system providing suitable properties and application under consideration of the planned building and operation conditions. Information on the coating material, its processing and its suitability within the coating system shall be included in the product data-sheets. The selection, surface pre-treatment and application shall be carried out in accordance with the specifications and the instructions of the paint manufacturer. Wherever there are no specific instructions by the manufacturers, the requirements described in this Section shall be followed.

2. Preparation of the surface

In the following, the essential requirements for the surface pre-treatment of unalloyed and low-alloy steels are stated.

For other materials, the requirements and recommendations as stated in the Chapter 1 are applicable.

Before surface preparation according to 2.1, 2.2 or 2.3 and before coating takes place, all oil and grease residues shall be removed from surfaces contaminated in this way. Surfaces for which no abrasive-blasting or mechanical grinding is necessary shall always be freed from oil, grease, dirt and other contaminants.

2.1 Abrasive blasting

2.1.1 Cleanliness

.1 Primary surface preparation

Within the scope of application of this Guidance, all steel surfaces shall always be descaled in the preproduction phase (through blasting to surface quality grade Sa 2½ according to ISO 8501-1 or, for smaller areas, mechanical grinding in accordance with St 3 according to ISO 8501-1) and provided with a suitable shop primer.

.2 Secondary surface preparation

The surface quality grades specified in the corresponding coating material/system documentation of the manufacturer shall be complied with.

2.1.2 Blasting agent

Solid blasting media shall conform with the requirements set out in ISO 11124 or ISO 11126, respectively. As the blasting agents, copper works' slag (MCU), fused corundum (MKE) as well as iron or steel blasting agents can be considered.

The blasting agents shall be free of dust, salts or other impurities.

2.1.3 Roughness

The surface roughness shall be of roughness grade "medium" according to ISO 8503-1.

2.1.4 Repairing of surface defects

Welding spatter, wormholes in fillet welds, rough-rolled ends, laminations, rolling flaws etc. which have only become apparent immediately before or during the blasting work, shall be remedied.

Edges and welding seams shall be in accordance with preparation grade P2 according to ISO 8501-3 and transitions shall be gradual. IACS Rec. 47 The Shipbuilding and Repair Quality Standard shall be observed in addition.

At points at which extensive repair work must be carried out after blasting, the blasting must be repeated after the repair. At components or structural units which are matter of Classification, Rules for Materials (Pt.1, Vol.V) shall be observed in addition.

2.1.5 Environmental conditions

For blasting purposes the minimum surface temperatures shall be 3°C above the dew point and the maximum relative atmospheric humidity shall be 90%. To prevent impairments by dust or blasting agents, the blasting activities should not be performed close to places where coating work is being done or where coatings have not yet dried properly.

2.2 Mechanical grinding

Mechanical grinding is limited to smaller areas, at which coating damage has to be remedied or where, because of the local conditions, no blasting can be performed. A surface condition as per PMa according to ISO 8501-2 or St 3 according to ISO 8501-1 respectively, or one that is in accordance with the specifications of the paint manufacturer shall be achieved.

The mechanical treatment must not cause any excessive polishing or roughening of the surface. The grinding shall extend at least 25 mm into the adjacent coated surfaces.

2.3 Pressurized water blasting with solid blasting agents

Pressurized water blasting with solid blasting agents shall be performed according to an approved specification, which must be matched to the coating system by the paint manufacturer.

3. Selection of the coating materials

3.1 Shop primers

The requirement for shop primers in respect of corrosion protection are set out in the Rules for Hull (Pt.1, Vol.II) Sec. 38.

The shop primers used shall be of a type approved by BKI. For these shop primers, the requirements set out in the Rules for Welding (Pt.1, Vol.VI) Sec. 6, shall apply in addition.

3.2 Corrosion protection systems

Coating materials and coating systems shall be selected and applied according to the prevailing environmental and application-related conditions. Their suitability shall in each case be guaranteed by the paint manufacturer, and evidence thereof shall be provided on request. The most important data of a coating material shall be documented according to STG Guideline No. 2216. For the selection, the applicable statutory conditions, safety requirements and technical rules concerning work, fire and environmental protection shall be observed by the user.

The selection of a coating system for cargo oil tanks should preferably be based on practical experience with similar cases. Coating systems which are subject to strong dynamic or elongation stresses, as can occur particularly on ships of higher-strength fine-grained structural steels, or which have to withstand high temperature stresses, shall be especially suitable for withstanding such stresses. The coating shall be in light colours.

4. Application of coating systems

4.1 General requirements

- Before coating work commences, all surfaces shall be kept dust-free in compliance with ISO 8502-3 Class (rating) 2.
- Any scaffolding or stages which may be necessary must, as far as possible, be arranged so that all surfaces to be coated can be processed continuously (e.g. free-standing scaffold). If heating units

are used, the exhaust fumes of the power generators shall be vented to the outside air; they shall not be allowed to mix with the heating air and precipitate on the surfaces to be coated.

- The corresponding drying or curing times between the individual layers must comply with the manufacturer's instructions, with due consideration to the environmental conditions.
- Before or during the application of the various layers, all critical areas – such as edges, corners, welds, brackets, bolts and nuts as well as areas of difficult access by spraying – shall be stripe-coated, in order to ensure compliance with the minimum film thickness and a proper sequence of layers.
- The maximum DFT (dry film thickness) of each layer and of the total thickness shall, if not otherwise stated by the paint manufacturer, not be higher than three times the NDFT (nominal dry film thickness).
- The surface temperature shall be less than 30°C, but at least 3°C above dew point, and the air temperature shall be higher than 5°C, unless otherwise permitted by the paint manufacturer.
- The relative atmospheric humidity shall attain a maximum of 90 % for systems on epoxy resin basis. In practice, the following rule has proven its worth:
  - If the surface temperature and the dew point are not measured at regular intervals, application shall only take place up to a relative atmospheric humidity of max. 85 %; if both parameters are measured at intervals to be laid down, application may also take place at a higher relative atmospheric humidity.
  - The first measurement shall be carried out before application commences. The intervals for further measurements shall be varied depending on the climatic conditions and their changes.
  - The relative atmospheric humidity needs to be considered with respect to the maximum admissible space of time between surface preparation and start of the coating works. In case, that the relative atmospheric humidity is 85 % or higher, it shall not be more than four hours.

4.2 Spraying

Each layer shall be applied to the entire surface so that a uniform and closed coating is achieved. Defects in the coating which impair the corrosion protection effect shall be repaired before the next layer is applied.

4.3 Coating with brusher or roller

At points where, because of the local conditions, no spraying is possible, the coating shall be applied by coating with a brush or roller whereby the first hand is to be applied by brush. The tool and the coating material (for roller application) shall be suitable for the intended purpose.

4.4 Storage of coating materials

Storage temperatures between 5° and 30°C shall be observed for the materials. The materials shall not be stored for longer than permissible.

5. Competent repair of damage and defects in coating systems during the construction period

5.1 General

Repair works shall be specified in the corrosion protection specification. A classification of coating damage can take place according to STG-Guideline No. 2221, for example. The repair work shall always be suitable for the coating system intended for the corresponding area, including the surface preparation.

5.2 Insufficient film thickness

Surfaces at which the film thickness is insufficient shall be cleaned thoroughly and, if necessary, sanded down. Then a compatible coating shall be applied until the required film thickness is attained. The transitions to the original coatings shall be gradual.

5.3 Contaminated surfaces

Contaminated surfaces, which are to be coated further, shall be prepared anew as per 2.

5.4 Coating damage without exposed metal surface

The affected areas of the surface shall first be cleaned and degreased. In addition, it is necessary to attain smooth transitions (feathering) by sanding the edge zones, in order to achieve as uniform a surface as possible. Many two-component coatings have a recoating period; for this reason, if this interval has elapsed, additional edge zones must be sanded or roughened in the intact area, to achieve perfect adhesion in the transition zone.

5.5 Coating damage with exposed metal surface

The conditions of the material or the systems in respect of surface preparation, the application data for each individual layer etc. shall be observed as per specification. For the adjacent coating areas, the required procedure is set out in 5.4.

6 Testing, acceptance and documentation of the coating systems

In the following general requirements for testing, acceptance and documentation of coating systems for cargo oil tanks are described. The requirements stated in Section 4 apply, in addition.

6.1 Testing

The surface preparation of the tanks shall be checked as follows before the coating work commences:

- check of steel work with respect to surface imperfections, welds and edges
- check of the required roughness profile (visual inspection or contact stylus method)
- testing for soluble salts, dust and other non-visible impurities following ISO 8502
- surface temperature and relative humidity

Within the scope of the application process, each individual layer of coating that is applied, and subsequently the entire coating system shall be tested as follows:

- Curing temperature and time, and in case of zinc silicate also relative atmospheric humidity shall be recorded.
- Visual inspection for uniformity, colour, covering power, curing and possible defects (e.g. cracks, flaking, craters etc.)
- Coating thickness measurement for compliance with the NDFT. The NDFT shall be seen as the minimum dry film thickness, which is required on the whole surface.
- In special cases, where clear indications are given, that a good adhesion is not achieved, a test of adhesive strength (see ISO 2409 or ISO 4624) is needed.

6.2 Reference areas

6.2.1 General

Reference areas are suitable areas on the structure used to establish a minimum acceptable standard for the work, to check that data provided by a manufacturer or contractor is correct and to enable the performance of the coating to be assessed at any time after completion.

Reference areas shall be prepared in locations in which the corrosive stresses are typical for the structure concerned. All surface preparation and coating application work on reference areas shall be carried out in the presence of BKI Surveyor as well as representatives of all parties concerned, who shall give their agreement in writing when the reference areas are in accordance with the specification. All reference areas shall be accurately documented and permanently marked on the structure itself.

The size and number of reference areas shall be in reasonable proportion, both practically and economically, to the area of the complete structure, see also Table 3.1.

6.2.2 Reference area records

The contractor shall keep records on the preparation of reference areas for each step of the work (for recommended form see Annex B). The records shall include all relevant data and shall be approved by Surveyor.

6.2.3 Damaged reference areas

If reference areas have been damaged, the defects shall be carefully repaired but these repaired parts are no longer valid as reference areas.

Table 3.1 Number of reference areas according to ISO 12944-7

Size of structure (coated area) [m^2]	Recommended maximum number of reference areas	Recommended maximum percentage of reference area relative to total area of structure [%]	Recommended maximum total area of reference areas [m^2]
Up to 2000	3	0,6	12
Above 2000 to 5000	5	0,5	25
Above 5000 to 10000	7	0,5	50
Above 10000 to 25000	7	0,3	75
Above 25000 to 50000	9	0,2	100
Above 50000	9	0,2	200

6.3 Acceptance and documentation

Within the corrosion protection, the way of acceptance and documentation shall be specified and agreed. If not otherwise defined, the acceptance (see Annex B) of prepared surfaces and coating systems in all cargo tanks, the applicator shall invite representatives of not only the shipyard but also of the coating material supplier and the ship owner to attend.

The applicator shall compile the documentation and shall deliver this to the yard and, if applicable, to the other participants. The documentation shall provide evidence of the checks and acceptance tests as well

as the conditions prevailing during the processing, including data on the coating materials which were used.

Curing temperature shall be recorded as per procedure to be agreed by the parties involved before the coating work commences.

C. Cathodic Protection

Sacrificial anodes shall be mandatory in all levels of slop tanks. If not otherwise agreed between owner and shipyard, Chapter 1 Section 7, applies for cathodic protection of tanks.

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Section 4 Certification and Supervision of Corrosion Protection Works

A. Documentation

1. The work processes involved in setting up a coating system as well as the coating materials to be used must be laid down in a coating plan.

2. The coating plan for tanks must be submitted to BKI for approval.

3. The coating protocol is to be compiled in such a way that all work steps executed, including surface preparation and coating materials used, are documented.

4. This documentation is to be compiled by the paint manufacturer and/or the contractor executing the work and/or the yard. An inspection plan must be agreed to between the parties involved. The papers pertaining to the documentation must be signed by these parties. On completion of the coating system, the signed papers constituting the documentation are to be handed to the Surveyor for acceptance. The documentation is to contain the following data:

- location and date
- ship and the tanks treated
- manufacturer's specifications for the coating system (number of coatings, total DFT, processing conditions)
- product data sheet for the coating
- contractors and persons carrying our the work
- surface preparation (procedure, working materials, ambient conditions)
- condition of surface prior to coating (cleanness, roughness, existing primer, surface quality grade achieved)
- application (procedure, number of coatings)
- application conditions (time, surface/ambient temperature, humidity, dew point, ventilation)
- report of DFT measurement and visual inspections
- signatures of involved parties (yard, paint manufacturer, work contractor)

5. Coating protocols already in existence and used by coating manufactures, work contractors, yards and ship owners will be accepted by BKI, provided they contain the above data and are signed by all parties involved. Any missing data are to be furnished.

B. Supervision according to BKI Inspection Plan

The inspection plan shows the supervision works performed by the Surveyor. The Surveyor needs to be informed in time about all relevant steps of the surface preparation and coating works as well as the tests to be performed, so that he has the possibility to prepare for the inspection works and supervise the testing. The consequences as given in Table 4.1 are applicable, if the acceptance criteria are not fulfilled.

The supervision works according to the inspection plan shall be confirmed by the Surveyor by counter signing the relevant test reports prepared by the paint manufacturer and/or the contractor executing the work and/or the yard.

For reference areas as described in Section 3, B.6.2 all surfaces preparation and coating application work shall be carried out under BKI supervision. The surface preparation and coating application shall be assessed by test types, methods and acceptance criteria as stated in the BKI acceptance plan and shall be documented by the Surveyor using Annex B.

Table 4.1 Inspection plan

Test Type	Method	Frequency[1]	Acceptance criteria[3]	Consequence
The surface preparation of the tanks shall be checked as follows before the coating work commences:				
Visual examination	Visual, for sharp edges, weld spatter slivers, etc.	Spot checks with special consideration of critical areas	P2 acc. to ISO 8501-3	Defects to be repaired
Cleanliness	ISO 8501-1	Spot checks with special consideration of critical areas	Sa 2 ½, St 3 for small areas	Reblasting or grinding for small areas
	ISO 8502-3	Spot checks	Max. quantity and size rating 2	Recleaning and retesting until acceptable
Salt test	ISO 8502-9 or equivalent	Spot checks	Max. conductivity corresponding to 30mg/m^2 NaCl	Recleaning and retesting until acceptable
Roughness	Comparator or Stylus Instrument (ISO 8503)	Each component or once per 10 m^2	Medium	Reblasting
Within the scope of the application process, each individual coating that is applied and subsequently the entire coating system, shall be tested as follows:				
Environmental Conditions	Ambient and steel temperature. Relative humidity. Dew point	Before start of coating works	In accordance with specified requirements (refer to Section 3.B.4)	No blasting or coating
Visual examination of coating	Visual, to determine: Curing, contamination, solvent retention, pinholes/popping, sagging, surface defects	Spot checks with special consideration of critical areas (after each layer)	According to specified requirements	Repair of defects
Film thickness	ISO 2178	Each component or once per 10 m^2 (10 mm from edges)	DFT ≥ 300 µm in total	Repair, additional coats or recoating as appropriate
Adhesion between steel and first coating layer (i.e. not required)	ISO 4624 using equipment with an automatic centred pulling force, and carried out when system are fully cured	Spot checks only, if there are clear indications that good adhesion is not given	According to ISO 12944-6	Coating to be rejected

[1] Scope of testing need to be extended if deviations from the requirements are found

[2] If the same blasting agent is used for all areas spot checks are sufficient

[3] Deviations from the stated acceptance shall be implemented, if deemed necessary due to the coating manufacturer's specification

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Annex A Coating Performance Standard

A. Areas to be Protected

- Deck head with complete internal structure including brackets connecting to longitudinal and transverse bulkheads, see Fig. A.1
- Vertical plating of surrounding bulkheads with attached structure extending 10 % of tank's height, but not more than 2,0 m, down from the deck with additional 100 mm around vertical brackets/stiffeners
- Inner bottom & vertically 1,5 m above bottom surface
- Slop tanks shall be coated on all surfaces

B. Specification of Coating Systems

The structure of the specification shall include at least the items shown in Table A.1:

Table A.1 Minimum requirements for coating specification

1.	**General Information**	**Remarks**
1.1	Area of use: Oil tanks and slop tanks	
2.	**Steel dressing**	Section 3, B.2 to be observed
2.1	Edges	P2 according to ISO 8501-3
2.2	Steel surface imperfections	
2.3	Irregularities in welds	
3.	**Surface preparation**	Section 3, B.2 to be observed
3.1	Sa 2 ½ on areas with damaged shop primer and weld seams. The shop primer shall be removed if good adhesion and compatibility is not confirmed by the paint manufacturer. St 3 for small damages (< 3 % of total area) or where no blasting can be performed because of the local conditions	ISO 8501
3.2	Surface roughness: medium	ISO 8503
3.3	Dust: dust grade "2"	ISO 8502-3
3.4	Water soluble salt: < 30 mg/m^2	ISO 8502-9
4.	**Coating system**	Section 3, B.3, B.4 and B.5 to be observed
4.1	Epoxy based (or other equivalent hard coating)	
4.2	NDFT shall be ≥ 300 µm in minimum two coats. Surface areas, which are obstructed and are thus inadequately exposed to the spraying, exposed edges and corners as well as weld seams must be stripe coated to achieve a sufficient coating thickness. DFT must not be more than 3 · NDFT. For areas below bell mouths (about 2 m · 2 m) and suction well inside special abrasive resistant coating with increased coating thickness (NDFT ≈ 600 µm) shall be used.	
Deviations from the above given specification shall be implemented if deemed necessary due to the paint manufacturer's specification or recommendation.		

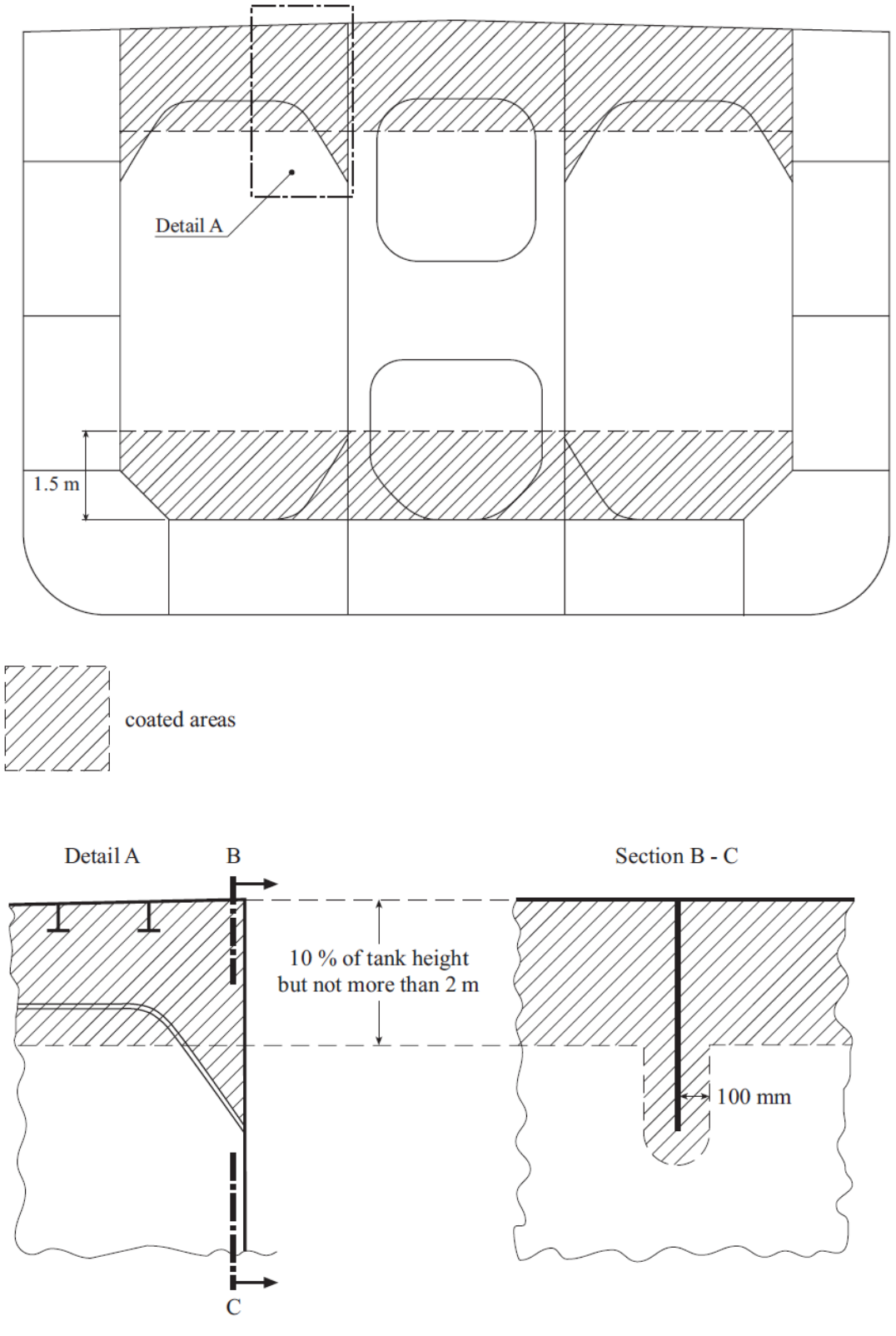

Fig.A.1 Areas to be protected

Annex B Form for Final Report on Corrosion Protection Work

A. Final Report on Corrosion Protection Work

Tank:	BKI Reg. No:				Drawing No:
	Coating system:				
	1st coat	2nd coat	3rd coat	4th coat	5th coat
Application contractor					

New work

Rust grade of steel surface (ISO 8501-1)

☐ A ☐ B ☐ C ☐ D

☐ Milling Imperfection found

☐ Sharp edges and burrs removed

☐ Welding residues, including weld spatter, not removed

Specified surface preparation grade (ISO 8501-1 or ISO 8501-2):

Blast-cleaning	☐ Sa 2	☐ Sa 2 ½	☐ Sa 3
	☐ PSa 2	☐ PSa 2 ½	☐ PSa 3
Flame cleaning	☐ FI		
Hand and power-tool cleaning	☐ St 2	☐ St 3	
	☐ PSt 2	☐ PSt 3	
Machine abrading	☐ PMa		

Specified surface profile (ISO 8503-1)

Comparator G ☐	Fine ☐	Medium ☐	Coarse ☐
Comparator S ☐	Fine ☐	Medium ☐	Coarse ☐

		Detail of surface preparation	Details of paint application				
			1st coat	2nd coat	3rd coat	4th coat	5th coat
Surface preparation grade achieved							
ISO 8501-1, ISO 8501-2							
ISO 8502-3							
Surface profile achieved (ISO 8503)							
Salt test (ISO 8502-6, ISO 8502-9)							
Brand name(s)/types of blast-cleaning abrasive (e.g. in accordance with ISO 11124/ISO 11126 series of standards)							
Manufacturer(s) of abrasive							
Date							
Air temperature, °C							
Relative humidity, %							
Dew point, °C							
Surface temperature, °C							
Designation of paint and type of coat, product No.							
Colour							
Batch No.							
Paint manufacturer(s)							
Method of application							
NDFT	µm						
DFT	min. µm						
	mean µm						
	max. µm						
Complies with specification?			Yes/no	Yes/no	Yes/no	Yes/no	Yes/no

Reference areas provided?	☐ Yes, indicate report No(s).	☐ No
Date of preparation:		
Remarks:		
Use additional sheet, if necessary.		
Date:	Name of Surveyor:	
Place:	Signature:	

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Section 1 Certification

A. Certification of Ballast Water Tank Coatings according to IMO Resolution MSC.215(82)

Refer to Guidance for Approval and Type approval Material and Equipment for Marine Use (Pt.1, Vol.W)

B. Certification of Ballast Water Tank Coatings other than IMO Resolution MSC.215(82)

1. General requirements

Applied coatings and coating systems for sea water ballast tanks of new buildings have to pass a prequalification test in a laboratory or in form of a field test and need to be type approved by Biro Klasifikasi Indonesia.

2. Procedures for coating system approvals

- Pre-qualification tests in a laboratory shall be in accordance with ISO 12944 – 6 with the corrosivity category C5-M (medium) and Im2 (medium).
- Cathodic disbondment according to ISO 15711 including the BKI attachment in Annex A.
- Equivalent tests may be acceptable upon review by BKI Head Office.
- The test plate preparation shall be according to the coating manufacturer's technical data sheets for the product or system to be tested.
- Systems tested and type approved in accordance with the procedures described under A. are accepted in any case.
- A type approval shall be obtained by the coating manufacturers from BKI Head Office.
- A list with type approved coatings and coating systems is obtainable from BKI Head Office.
- A type approval does not constitute confirmation of the suitability and compatibility of the coatings in the corrosion protection system. These points are to be ensured by either the yard or the manufacturer of the coating materials

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Section 2 Coating Application in Ballast Water Tanks

A. Ballast Water Tanks coated according to IMO Resolution MSC.215(82)

1. General requirements

Concerning the coating process of seawater ballast tanks during newbuilding requirements from the International Maritime Organisation (IMO) have to be observed (IMO Performance Standard for Protective Coatings – Resolution MSC.215(82)). With these regulations the coating process needs to be surveyed much more detailed and substantial. Since the IMO coating standard is made mandatory stepwise with different implementation dates the survey of the coating process of seawater ballast tanks on newbuildings needs to be distinguished in vessels where it is applicable and in vessels where it is not applicable.

1.1 Instructions for vessels built according to the IMO Resolution MSC.215(82)

Applicable to seawater ballast tanks on all types of vessels of not less than 500 gross tonnage and double-side skin spaces arranged in bulk carriers of 150 m in length and upwards for which at least one of the following items is applicable:

- for which the building contract is placed on or after 1 July 2008; or
- in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009; or
- the delivery of which is on or after 1 July 2012; or
- the building contract is placed on or after 8 December 2006 in case of being built according to the Common Structural Rules; or
- IMO Resolution MSC.215(82) is agreed on in the building contract.

2. Process

2.1 Process Flow

2.1.1 The general coating process typically follows a process flow as shown in Fig. 2.1. Each of the major coating steps is indicated, together with a cross reference to the applicable section within the IMO Resolution MSC.215(82). The various documentation and review steps are necessary to demonstrate compliance with the IMO Resolution MSC.215(82) and IACS UIs SC223 and SC227.

2.1.2 The IMO Resolution MSC.215(82) also includes requirements for pre-qualifying IMO PSPC coating systems. The general process flow for pre-qualifying coatings is shown in Fig. 2.2.

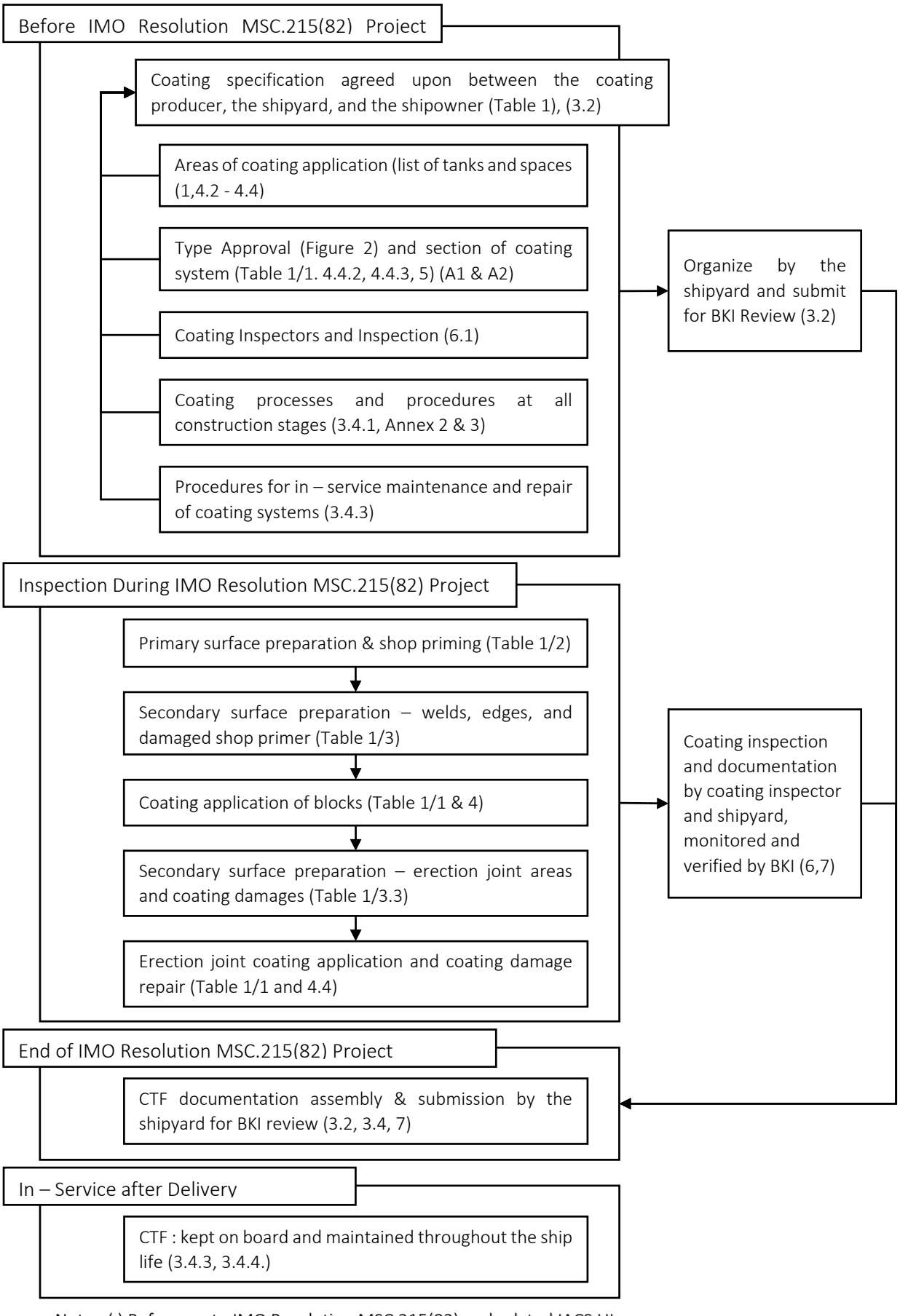
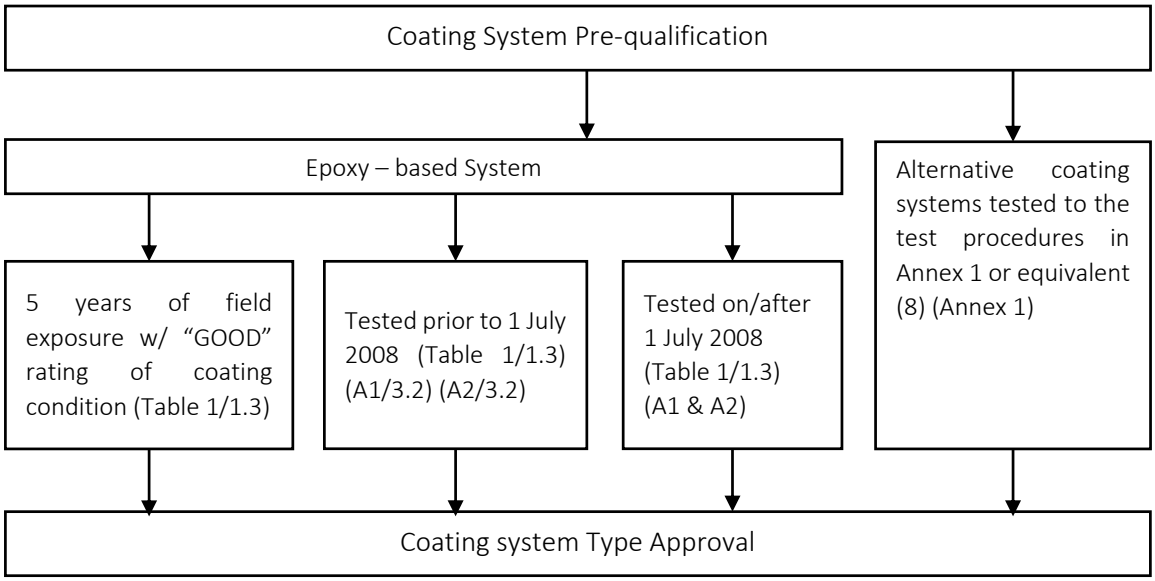


Fig.2.1 Coating Process Flow



Note : ( ) Reference to IMO Resolution MSC.215(82) and related IACS UIs

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Fig.2.2 Coating Pre-qualification Testing Flow (Referred to in Fig. 2.1)

3. Detail Instruction

3.1 Coating Process Detailed instructions for each of the major steps shown in Fig.2.1 and 2.2 are provided in this section.

3.1.1 Coating Inspection Agreement

.1 The inspection procedure of surface preparation and coating processes is to be agreed upon between the ship owner, shipyard, and coating manufacturer and shall be presented to an BKI Head Office for review prior to commencement of any coating work on any stage of a new building and, as a minimum, shall comply with the IMO Resolution MSC.215(82). BKI may, if it so determines, participate in the agreement process. The agreement, also called as Tripartite Agreement, is to be included in The Coating Technical File (CTF). See IMO Resolution MSC.215(82) paragraph 3.2.

.2 The specification is, as a minimum, to be in accordance with all the requirements of IMO Resolution MSC.215(82) Table 1. The specification, as defined in IMO Resolution MSC.215(82) paragraph 2 of Annex 1, is to contain the type of coating system, steel preparation, surface preparation, surface cleanliness, environmental conditions, application procedure, acceptance criteria and inspection criteria.

3.1.2 Selection of Areas to be Coated

.1 The IMO Resolution MSC.215(82) is applicable for protective coatings in dedicated seawater ballast tanks of all types of ships of not less than 500 gross tonnage and double-side skin spaces arranged in bulk carriers per 1.1 above.

.2 Together with the Tripartite Agreement submitted, the shipyard is to prepare and submit a list of all spaces to be coated in accordance with the IMO PSPC Sections 1, 4.2, and 4.3 to an BKI Head Office for review. The final list is to be included in the CTF per 4. below.

3.1.3 Qualifications of Coating Inspector(s)

.1 The qualifications of the coating inspector(s) are to comply with the requirements in the IMO Resolution MSC.215(82) paragraph 6.1.1. Coating inspector qualification, requirements for assistant inspectors, and equivalent qualification of coating inspectors are clarified in IACS UI SC 223.

3.1.4 Selection of Coatings

.1 The selection of coatings is to be made taking into account the expected service conditions and intended planned maintenance program that should provide a target useful coating life of 15 years in "GOOD" condition in accordance with IMO Resolution MSC.215(82) paragraph 4.1. The selected coatings are to be listed and cross referenced to the spaces to be coated as per 3.1.2 above. See IMO Resolution MSC.215(82) Table 1, 1.1.

.2 The selected coating system shall be Type Approved (per 3.1.5 below) for compliance with IMO Resolution MSC.215(82) paragraph 5, by a pre-qualification test as illustrated in Fig. 2.2. See IMO Resolution MSC.215(82) Table 1, 1.3,.

3.1.5 Type Approval Certificate

.1 A "Type Approval Certificate" which signifies that one of the options as illustrated in Fig. 2.2 has been satisfied is to be obtained for each coating system selected. See IMO Resolution MSC.215(82) paragraphs 4.4.3 and 5.

.2 The coating manufacturer is to provide copies of the Type Approval Certificate for each coating system to be used in accordance with the IMO Resolution MSC.215(82) to the shipyard for inclusion into the CTF per 4. below.

3.1.6 Technical Data Sheet

.1 Each selected coating is also to be documented by a "Technical Data Sheet" and its own verified application procedures which list technical information necessary to properly identify the coating product and application requirements. See IMO Resolution MSC.215(82) paragraphs 3.4.2.2, 4.4.4, and Table 1, 1.1.

.2 The coating manufacturer is to provide copies of the Technical Data Sheets for each coating system to be used to the shipyard for inclusion into the CTF per 4. below.

3.1.7 Primary Surface Preparation

.1 The primary surface preparation is to comply with IMO Resolution MSC.215(82) Table 1, 2.1 and 2.2.

.2 The yard is to carry out the primary surface preparation and retain work records or other documentation as confirmation of the preparation treatment. Coating inspector(s) shall carry out inspections and document their confirmation that the primary surface preparation is within the standard. The documents are to be included in the CTF per 4. below.

3.1.8 Shop Primer Application

.1 The shop primer is to be applied in compliance with the IMO PSPC Table 1, 2.3. See IACS UI SC 223 for review of Quality Control of Automated Shop Primer plants and paragraph 7.3 for common interpretations concerning shop primer.

.2 The yard is to apply the shop primer and retain work records or documentation. Coating inspector(s) shall carry out inspections and document that the shop primer application is within the

standard and compatible with the selected coating to be applied. The documents are to be included in the CTF per 4. below.

3.1.9 Secondary Surface Preparation

.1 The secondary surface preparation is to comply with IMO Resolution MSC.215(82) Table 1, 3.

.2 The yard is to carry out the secondary surface preparation and retain work records or other documentation as confirmation of the surface preparation. Coating inspector(s) shall carry out inspections and document their confirmation that the secondary surface preparation is within the standard. The documents are to be included in the CTF per 4. below.

3.1.10 Protective Coating Application

.1 The protective coating is to be applied in compliance with IMO Resolution MSC.215(82) Table 1, 1.4 and 1.5. The application conditions from IMO Resolution MSC.215(82)Table 1, 4.1 and 4.2 are to be followed. Inspection of the coating is to be performed as per 3.1.11 below.

.2 The yard is to apply the coatings and retain work records or documentation. Coating inspector(s) shall carry out inspections and document that the coating application is within the standard.

The documents are to be included in the CTF per 4. below.

3.1.11 Coating Inspection

.1 The coating is to be inspected at various stages of surface preparation and application to verify and document that the surface preparation and the coating application are within the standard as per IMO Resolution MSC.215(82) Paragraph 6.1.2.

.2 The coating inspectors are to document the results from the inspections per IMO Resolution MSC.215(82) Paragraph 6.1.3, Annex 2 and Annex 3. The documents are to be included in the CTF per 4. below.

.3 BKI is to monitor and verify (see 3.2) the implementation of IMO Resolution MSC.215(82) paragraph 7.

3.1.12 Coating Repair

.1 Any defective areas of the coatings are to be repaired per IMO Resolution MSC.215(82) Table 1, 4.4. The coating inspectors are to document the results from the inspections of the repaired areas per IMO Resolution MSC.215(82) Paragraph 6.1.3 and Annex 2. The documents are to be included in the CTF per 4. below.

3.1.13 CTF Documentation and Review

.1 The IMO Resolution MSC.215(82) mandates that each step in the coating process is performed strictly in accordance with the specifications and properly documented. The Coating Inspection Agreement, called the Tripartite Agreement, is to be documented and reviewed prior to the performance of the actual work. Daily log and non-conformity reports for the inspection items listed in IMO Resolution MSC.215(82) Paragraph 6.2 are required to illustrate the conditions and inspection results of the actual work carried out.

.2 The assembly and submission of all documents called the Coating Technical File (CTF) is the overall responsibility of the shipyard as per IMO Resolution MSC.215(82) Paragraph 3.4 and 4. of this Guidance. The final CTF file is to be submitted to the attending BKI surveyor for review.

3.2 Verification Procedure

The basic verification procedure is included in IMO Resolution MSC.215(82) Paragraph 7. The following information shall be verified by BKI prior to reviewing the CTF.

3.2.1 Technical Data Sheet, Type Approval Certificate

Verify the Technical Data Sheet and Type Approval Certificates for compliance with the IMO Resolution MSC.215(82) Paragraph 5.

3.2.2 Coating Identification

.1 The attending BKI Surveyor shall verify on sampling basis that the coating identification on representative containers is the same coating identified in the Technical Data Sheet and Type Approval Certificate.

3.2.3 Coating Inspector Qualification

.1 The attending BKI Surveyor shall verify that the coating inspector(s) and assistant inspector(s) are qualified in accordance with the qualification standards in IMO Resolution MSC.215(82) Paragraph 6.1.1 and IACS UI SC223.

3.2.4 Coating Inspector's Reports

.1 The attending BKI Surveyor shall verify that the coating inspector's reports of surface preparation and the coatings' application indicate compliance with the manufacturers' Technical Data Sheet, Type Approval Certificate and coating specification agreed in the tripartite agreement.

3.2.5 Implementation of Coating Inspection Requirements

.1 The attending BKI Surveyor shall monitor implementation of the coating inspection requirements, see IMO Resolution MSC.215(82) Paragraph 7.5 and IACS UI SC223.

3.3 Maintenance, Repair, and Partial Re-coating

3.3.1 The coatings are to be maintained in accordance with IMO Resolution MSC.215(82) Paragraph 3.4.3 and 3.4.4. The relevant sections of the Guidelines for Maintenance and Repair of Protective Coatings from IMO Circular MSC.1/Circ.1330 are to be applied.

3.3.2 Records of maintenance, repair, and partial re-coating are to be documented in the CTF, which is to be kept on board and maintained throughout the life of the ship in accordance with IMO Resolution MSC.215(82) Paragraph 3.4.5.

4. Documentation

4.1 Each single step of the coating process, including surface preparation shall be documented and filed.

4.2 The collection of the documentation is commonly called Coating Technical File (CTF).

4.3 The CTF will include, amongst others, the reports of the certified coating inspector, technical data sheets of the coating system, type approval certificates, procedures for in-service maintenance and repair of coating systems, etc.

4.4 The CTF remains on board of the vessel and shall be maintained throughout the life of the vessel. This means that inspection and maintenance of the coating process shall be continuously recorded including location and work specification.

4.5 The content of the Coating Technical File is listed in Annex B.

4.6 Examples for documentation records are shown in Annex C.

5. Survey After Construction

5.1 All annual, intermediate, and renewal or periodic survey, the attending Surveyor is to verify:

- That documentation is onboard as outlined in 4 above.
- That approved operational procedures as outlined in 3.3 above are maintained onboard.
- That at the time of the corresponding periodical survey (Annual, Intermediate, or Renewal), any maintenance or repair of coating that have been carried out are properly documented, as per 3.3.

B. Ballast Water Tanks coated according to other than IMO Resolution MSC.215(82)

1. General

- All seawater ballast tanks shall be provided with a corrosion protection system.
- The following corrosion protection systems are to be used:
- coating systems,
- coating systems in combination with a cathodic protection system.

2. Coating systems

2.1 General

- The coatings shall be, in accordance with the manufacturer's specifications, resistant against seawater, coastal water, harbour water and the substances they may contain.
- The characteristics, composition and field of application of a coating system shall be documented, i.e. prescribed by the manufacturer of the coating material.
- Details of the coating material, how it is to be processed and its suitability for the coating system shall be contained in the product data sheet.

2.2 Approvals

- For new buildings, the applied coatings and coating systems shall be approved by BKI. Refer to Section 1, B.

2.3 Surface preparation

- The surface shall be prepared according to the instructions of the manufacturer of the coating material.
- Surface preparation is subject to specifications in the product data sheet and shall correspond to a valid surface quality grade, e.g. SIS 055900, ISO 12944-4 or ISO 8501.
- Slag and loose weld spatters have to be removed before the coating is applied.

– Welded or otherwise attached accessory material (tack plates, lugs etc.) shall be completely integrated into the corrosion protection, or otherwise removed.

2.4 Application

– The process of application is to be carried out according to the coating manufacturer's instructions.

– During application the ambient conditions and procedural instructions are to be complied with, in accordance with the details specified in the manufacturer's instructions and in the approvals.

– Surface areas which are obstructed and are thus inadequately exposed to the spraying, exposed edges and corners, as well as weld seams, shall be stripe coated in advance to achieve a sufficient coating thickness.

2.5 Dry film thickness

– The dry film thickness of the coating systems shall be in accordance with the approvals and correspond to a minimum of 250 µm.

– The prescribed coating thickness is the minimum coating thickness which shall not be undercut at any spot of the coated surface.

2.6 Documentation

– The work processes involved in setting up a coating system as well as the coating materials to be used shall be laid down in a coating plan.

– The coating plan for ballast water tanks is to be submitted to BKI for approval.

– The coating protocol is to be compiled in such a way that all work steps executed, including surface preparation and coating materials used, are documented.

– This documentation is to be compiled by the coating manufacturer and/or the contractor executing the work and/or the yard. An inspection plan shall be agreed to between the parties involved.

– The papers pertaining to the documentation shall be signed by these parties. On completion of the coating system, the signed papers constituting the documentation are to be handed to the Surveyor for acceptance. The documentation is to contain the following data:

  – location and date,
  – ship and the tanks treated,
  – manufacturer's specifications for the coating system (number of coatings, total coating thickness, processing conditions),
  – product data sheet for the coating and BKI approval number,
  – contractors and persons carrying out the work,
  – surface preparation (procedure, working materials, ambient conditions),
  – condition of surface prior to coating (cleanness, roughness, existing primer, surface quality grade achieved),
  – application (procedure, number of coatings),
  – application conditions (time, surface/ambient temperature, humidity, dew point, ventilation),
  – the date the tanks were first ballasted is to be recorded,
  – report of coating thickness measurement and visual inspections,
  – signatures of involved parties (yard, coating manufacturer, work contractor).

– Coating protocols already in existence and used by coating manufacturers, work contractors, yards and ship owners will be accepted by BKI, provided they contain the above data and are signed by all parties involved. Any missing data is to be furnished.

3. Coatings combined with cathodic protection

3.1 Coating

- In the case of coatings used in combination with cathodic protection, the provisions under point 2 shall apply for the coatings.
- In addition, the coatings have to be resistant against the cathodic protection, i.e. the coatings shall not exhibit any impairment of their purpose up to a potential of – 1200 mV against the copper/copper-sulphate electrode. Proof of resistance against cathodic corrosion protection can be provided in accordance with recognized standards, e.g. ISO 15711. Refer also to Annex A.

3.2 Cathodic protection

- For the cathodic protection of ballast water tanks in combination with coatings, sacrificial anodes made of zinc or aluminium may be used.
- Tables 2.1 and 2.2 contain recommended alloy compositions for conventional aluminium and zinc anodes.
- Zinc and aluminium anodes of differing chemical composition may also be used, provided proof of the cathodic protection ability is provided.
- Zinc anodes may not be used in the event that operating temperatures in excess of 60 °C can be expected.
- Impressed current systems are not permitted in ballast water tanks.

Table 2.1 Sacrificial anodes of zinc alloys for applications in seawater

Element	KI-Zn1	KI-Zn2
Al	0,01 – 0,05	≤ 0,01
Cd	0,025 – 0,07	≤ 0,004
Cu	≤ 0,005	≤ 0,005
Fe	≤ 0,005	≤ 0,0014
Pb	≤ 0,006	≤ 0,006
Zn	≥ 99,22	≥ 99,88
Potential (T = 20 °C)	-1,03 V Ag/AgCl/Sea	-1,03 V Ag/AgCl/Sea
Qg (T = 20 °C)	780 Ah/kg	780 Ah/kg
Efficiency (T = 20 °C)	95 %	

Table 2.2 Sacrificial anodes of aluminium alloys for applications in seawater

Element	KI-Al1	KI-Al2	KI-Al3
Si	≤ 0,10	≤ 0,10	
Fe	≤ 0,10	≤ 0,13	≤ 0,10
Cu	≤ 0,005	≤ 0,005	≤ 0,02
Mn	N/A	N/A	0,15 – 0,5
Zn	2,0 – 6,0	4,0 – 6,0	2,0 – 5,0
Ti	-	-	0,01 – 0,05
In	0,01 – 0,03	-	0,01 – 0,05
Sn	-	0,05 – 0,15	-
Other El.	≤ 0,10	≤ 0,10	≤ 0,10
Al	Remainder	Remainder	Remainder
Potential (T = 20 °C)	-1,05 V Ag/AgCl/Sea	-1,05 V Ag/AgCl/Sea	-1,05 V Ag/AgCl/Sea
Q_g (T = 20 °C)	2000 Ah/kg	2000 Ah/kg	2000 Ah/kg
Efficiency (T = 20 °C)	95%		

Annex A BKI Attachment to ISO 15711 – Testing requirements and criteria

A. General

This annex is an attachment to ISO 15711, Paints andvarnishes – Determination of resistance to cathodic disbanding of coatins exposed to marine environments'.

This annex shall only be used in combination with ISO 15711.

B. Test Plate Preparation

In total five (+ two) sample plates of hull structural or unalloyed structural steel with the dimension 150 mm x 150 mm and a minimum thickness of 2 mm have to be prepared.

The sample plates shall be coated on both sides. The total dry film thickness shall be measured and documented (see Fig. A.1).

Five plates need to have brazed wire connections. The wire shall have a diameter of 5 mm and a length of 100 mm. The braze point and the edges of the plates shall be sealed additionally (see Fig. A.1).

Shortly before putting the plates into the test solution defined coating defects shall be placed on the side of the sample plate without braze point (see Fig. A.2).

The defined coating defect has to be down to bare steel.

The different sample plates will be tested as follows:

- Plate 1/2/3 with coating defects, with cathodic protection
- Plate 4 with coating defects, without cathodic protection
- Plate 5 without coating defects, with cathodic protection
- Plate 6/7 determination of the original data (recommended)

C. Test Conditions and Criteria

Test solution: artificial seawater acc. to ISO 15711

Test potential: - 930 mV Ag / AgCl / KCl ges.

Test duration / period: Plate 1 90 days

Plate 2 180 days

Plate 3/4/5 270 days

D. Acceptance Criteria (at End of the Period)

Blistering (ISO 4628-2:2003): 0(S0)

Disbondment from artificial holiday: ≤ 10 mm

Impact strength (ISO 6272-1:2002):

- Falling weight 1000g
- Falling height 1 m
- After impact 0(S0)a acc. to ISO 4628-4
- No pinholes shall be detected acc. to ASTM D 5162

Adhesion value (ISO 4624:2002):

- Adhesive failure > 3.5 MPa
  Adhesive failure between substrate and coating or between coats for 60 % or more of the areas.
- Cohesive failure ≥ 3 MPa
  Cohesive failure in coating for 40 % or more of the area.

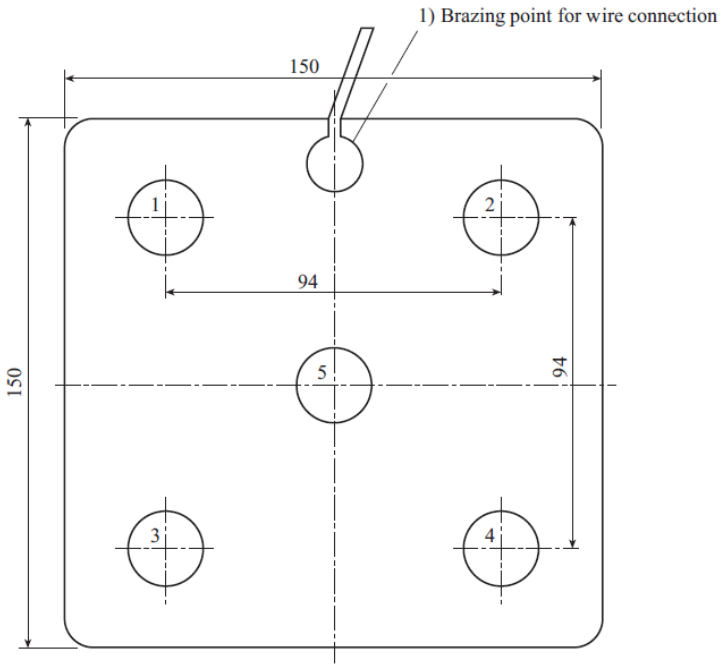

Fig.A.1 Measurement points for determination of dry film thickness

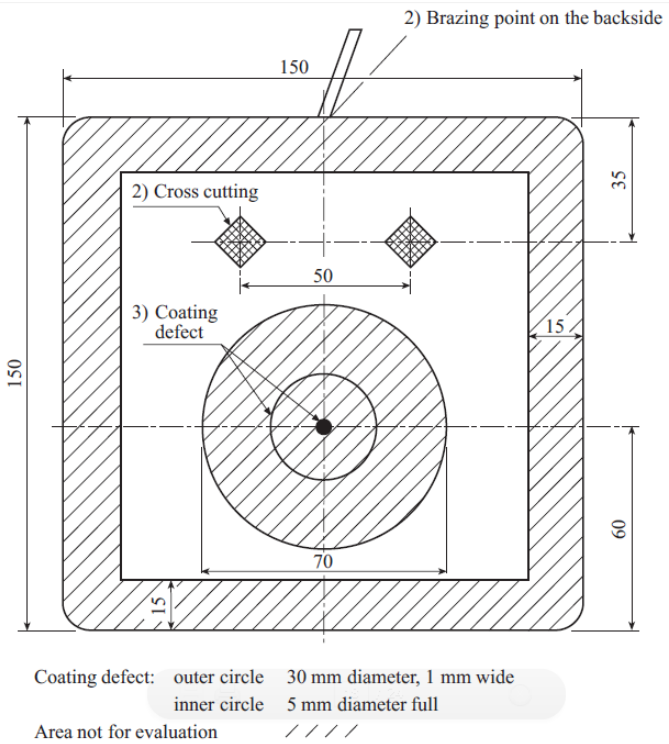

Fig.A.2 Dimensions of the sample plate and coating defects, location of cross cuttings and area, where blistering is allowed on the front side of the sample plate

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Annex B Content of the Coating Technical File (CTF)

A. General

- Specification of the coating system applied to the dedicated seawater ballast tanks and doubleside skin spaces.
- Record of the shipyard´s and shipowner´s coating work.
- Detailed criteria for coating selection.
- Job specifications.
- Inspection, maintenance and repair.

B. New Construction Stage

- Copy of Statement of compliance or Type Approval Certificate.
- Copy of Technical Data Sheet including
  - Product name and identification mark and/ or number,
  - Materials, components and composition of the coating system, colours,
  - Minimum and maximum dry film thickness,
  - Application methods, tools, and/or machines,
  - Condition of surface to be coated (derusting grade, cleanness, profile, etc.),
  - Environmental limitations (temperature and humidity).
- Shipyard work records of Coating application, including
  - Applied actual space and area (in square metres) of each component,
  - Applied coating system,
  - Time of coating, thickness, number of layers etc.,
  - Ambient condition during coating,
  - Method of surface preparation.
- Procedures for inspection and repair of coating system during ship construction.
- Procedures for inspection and repair of coating system during ship construction.
- Coating log issued by the coating inspector, stating that the coating was applied in accordance with the specifications of the coating supplier representative and specifying deviations from specifications (example of daily log and non-conformity report, Annex C).
- Shipyards verified inspection report, including
  - Completion date of inspection,
  - Result of inspection,

- Remarks (if given),
- Inspector signature.

- Procedures for in-service maintenance and repair of coating system.

C. In-Service Maintenance, Repair and Partial Re-Coating

In-service maintenance, repair and partial recoating activities shall be recorded in the Coating Technical File in accordance with the relevant section of the guidelines for coating maintenance and repair.

D. Re-Coating

- If a full re-coating is carried out, the items specified above shall be recorded in the CTF.
- The CTF shall be kept on board and maintained throughout the life of the ship.

E. Health and Safety

- The shipyard is responsible for implementation of national regulations to ensure the health and safety of individuals and to minimize the risk of fire and explosion.

Annex C Examples for Documentation Records

Table C.1 Form PSP

COATING LOG (PRIMARY SURFACE PREPARATION)			
			Sheet No.
Name/No. of ship Plate Numbers Inspection date			
ENVIRONMENT			
	Before	Weather changes	Remarks
Measured time Dry Temperature (°C) Relative humidity (%) Dew Point (°C) Surface Temperature (°C)			
SURFACE PREPARATION			
			Remarks
Surface profiles Water soluble salts (mg/m^2)			
SHOP PRIMER			
			Remarks
Manufacturer Product name Identification Mark/Number Manufacturer's Recommended DFT Measured DFT Curing			
COATING INSPECTOR'S	Name: Signature:		

Table C.2 Form SSP

COATING LOG (SECONDARY SURFACE PREPARATION)		
		Sheet No.
Name/No. of ship		
Part of structure (Block/Tank, No. etc.)		
Construction stage	Block assembly/erection	
STEEL CONDITION CONFIRM		
Type of defect	Repair method	Repair confirm/date
SURFACE TREATMENT		
Inspection date		Remarks
Method, grade		

Table C.3 Form CA

COATING LOG (COATING APPLICATION)				
			Sheet No.	
	First coat		Second coat	
	Before	After	Before	After
INSPECTION DATE				
Environment				
Dry Temperature (°C) Relative humidity (%) Dew Point (°C) Surface Temperature (°C)				
Water soluble salts (mg/m^2)				
Dust				
Oil contamination				
Abrasive inclusion				
Stripe coats				
Manufacturer				
Product name of coating				
Product identification mark/no.				
Remarks				
COATING INSPECTOR'S	Name: Signature:			

Table C.4 Form DFT

COATING LOG (DRY FILM THICKNESS MEASUREMENT)		
		Sheet No.
Name/No. of ship		
Part of structure (Block/Tank No. etc.)		
Construction stage	Block assembly/erection	
DRY FILM THCKNESS MEASUREMENT		
Dry film thickness (μm)	Number of points	Ratio
320		
288 – 320		
0 – 288		
Total		100%
Maximum thickness (μm)		
Minimum thickness (μm)		
Remarks		
FINAL COATING CONDITION CONFIRM		
Type of defect	Repair method	Repair confirm/date
COATING INSPECTOR'S	Name: Signature:	

Table C.5 Non-comformity report

		Sheet No.
Ship:	Tank/Hold No.:	Database:
Part of structure:		
DESCRIPTION OF THE INSPECTION FINDINGS TO BE CORRECTED		
Description of findings:		
Reference document (daily log)):		
Action taken:		
Job No:	Date:	Signature:

Table C.6 Daily Log

<table>
<tr><td colspan="2"></td><td>Sheet No.</td></tr>
<tr><td>Ship:</td><td>Tank/Hold No.:</td><td>Database:</td></tr>
<tr><td colspan="3">Part of structure:</td></tr>
<tr><td colspan="3">SURFACE PREPARATION</td></tr>
<tr><td>Method:</td><td colspan="2">Area (m^2):</td></tr>
<tr><td>Abrasive:</td><td colspan="2">Grain size:</td></tr>
<tr><td>Surface temperature:</td><td colspan="2">Air temperature:</td></tr>
<tr><td>Relative humidity (max):</td><td colspan="2">Dew point:</td></tr>
<tr><td colspan="3">Standard archieved:</td></tr>
<tr><td colspan="3">Rounding of edges:</td></tr>
<tr><td colspan="3">Comment:</td></tr>
<tr><td>Job No:</td><td>Date:</td><td>Signature:</td></tr>
<tr><td colspan="3">COATING APPLICATION</td></tr>
<tr><td colspan="3">Method :
<table>
<tr><th>Coat No.</th><th>System</th><th>Batch No.</th><th>Date</th><th>Air temp.</th><th>Surf temp.</th><th>RH %</th><th>Dew point</th><th>DFT Meas. *</th><th>Specified</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
*Measured minimum and maximum DFT, DFT readings to be attached to daily log</td></tr>
<tr><td colspan="3">Comment:</td></tr>
<tr><td>Job No:</td><td>Date:</td><td>Signature:</td></tr>
</table>