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To relevant business departments of CCS Headquarters, Ship Surveyors of branches (offices)

Notice on the implementation of Guidelines for Surveys and Repairs to Ship Structure Pitting Corrosions

Pitting corrosion is a conventional corrosion type of ship structures, and IACS (International Association of Classification Societies), TSCF (Tanker Structure Cooperation Forum), OCIMF(Oil Companies International Marine Forum) released relevant guidelines for inspections and repairs of ship structure pitting corrosions, CCS Instructions to Surveyors also provide some guidelines on it.

For strengthening the instructions on surveys to ship structure pitting corrosions, Classed Ships in Service Dept. of CCS Head Office prepared Guidelines for Surveys and Repairs to Ship Structure Pitting Corrosions, with the references to the relevant contents of CCS Instructions to Surveyors and the guidelines of IACS, TSCF and OCIMF, which is to supersede the relevant contents of the current Instructions to Surveyors.

Please implement the Guidelines during the surveys.

Annex:

"Guidelines for Surveys and Repairs to Ship Structure Pitting Corrosions"

Guidelines for Surveys and Repairs to Ship Structure Pitting Corrosions

1. Technical requirements for ship pitting corrosions by this society and related organizations/institutions

Currently survey requirements related to ship pitting corrosions by this society are as follows:

No.	Reference	Chapter	Applicable vessels
1)	Instructions to surveyors II-C3-4-15	Appendix 1: Repair of hull structure	All vessels
2)	Instructions to surveyors II-C3-9	9.12.4.5A Repair of pitting on frames of cargo holds in accordance with URS 31 9.12.4.5B Repair of grooving of frames of cargo holds in accordance with URS 31	Bulk Carriers
3)	Instructions to surveyors II-C3-17	Criteria for the strength of the Hull of Ships in Service-17.3.2 pitting corrosion	All vessels
4)	Instructions to surveyors II-C3-19	Guidelines for thickness measurement of hull-Chap.III Criteria for Hull Strength 2. Other than general corrosion	All vessels

For the above items, except item 2) is applicable to side shell frames of bulk carriers(refer to IACS URS31), the remaining survey requirements related to ship pitting corrosion are applicable to all vessels. Considering the positions of different types of ships prone to pitting corrosions vary and suggestions/experiences vary accordingly, it is imprecise to use one criteria of one ship type to cover all vessels. Therefore technologies related to pitting corrosion are divided into liquid cargo carrier technologies and bulk carrier technologies by its ship structure, cargos carried, tank washing characteristics etc. Other ships may refer to bulk carriers' criteria according to its structure and pitting corrosion forming characteristics.

Different requirements for tankers' pitting corrosion by IACS/TSCF/OCIMF have been given. For easy understanding, we've made the comparison among different

survey requirements by IACS/TSCF/OCIMF, for which refer to Annex 1. Besides, pitting corrosion requirements for dry cargo ships/bulk carriers/container ships by IACS have been summarized. Please refer to Annex 2 for details. With regard to ship pitting corrosion technical requirements from related organizations/institutions, and combined with corresponding contents from the current Instructions to Surveyors by CCS, we hereby provide further Guidelines for Surveys and Repairs to Ship Structure Pitting Corrosions as criterion for solving problems. This Guideline supersedes the relevant contents in Instructions to Surveyors.

2. Allowable pitting corrosion limit for tankers

2.1 Maximum Allowable pitting corrosion limit for non-CSR tankers

1) Structure of Cargo oil tank

The reference area for pitting corrosion density is single panel area. Refer to figure 1-Pitting intensity diagrams.

- ✧ For structural members, which the general corrosion limit is 20%: If the pitting corrosion intensity is no less than 20%, general corrosion criteria is to be adopted; If corrosion intensity is less than 20%, the minimum allowable remaining thickness is 70% of the as-built thickness, and the remaining thickness of any pits is no less than 6mm.
- ✧ For structural members, which the general corrosion limit is 25%: If the pitting corrosion intensity is no less than 20%, general corrosion criteria is to be adopted; If corrosion intensity is less than 20%, the minimum allowable remaining thickness is 65% of the as-built thickness, and the remaining thickness of any pits is no less than 6mm.
- ✧ Allowable pitting corrosion limit for tankers using special corrosion criteria (not 20% or 25%)
- ✧ For structural members, the general corrosion limit of which is less than 25%: If the pitting corrosion intensity is no less than 20%, general corrosion criteria is to be adopted; If corrosion intensity is less than 20%, the minimum allowable remaining thickness is 70% of the as-built thickness, and the remaining thickness of any pits is no less than 6mm.
- ✧ For structural members, the general corrosion limit of which is not less than 25%: If the pitting corrosion intensity is no less than 20%, general corrosion criteria is to be adopted; If corrosion intensity is less than 20%, the minimum allowable remaining thickness is 65% of the as-built thickness, and the remaining thickness of any pits is no less than 6mm.

2) Structures other than cargo oil tank

Refer to pitting corrosion criteria of structure of cargo oil tank.

2.2 Allowable pitting corrosion limit for CSR tankers

For plates with pitting intensity less than 20% (see figure 1), the measured thickness, t_{tm}, of any individual measurement is to meet the lesser of the following criteria:

$t_{tm} \geqslant 0.7(t_{as\text{-}built}-t_{own})$ mm

$t_{tm} \geqslant t_{ren}-1$ mm

Where:

$t_{as\text{-}built}$---as built thickness of the member, in mm

t_{own}---owner/builder specified additional wastage allowance, if applicable, in mm

t_{ren}---renewal criteria for general corrosion as defined in 1.4.2.1

The average thickness across any cross section in the plating is not to be less than the renewal criteria for general corrosion. For plates with pitting intensity less than 20%, general corrosion criterion are to be adopted.

3. Maximum allowable pitting corrosion limit for bulks carriers

3.1 Maximum allowable pitting corrosion limit for non-CSR bulks carriers

1) Side structure in accordance with URS31 requirement

If pitting intensity is higher than 15% in area (A, B, C, D), thickness measurement is to be taken to check pitting corrosion. The 15% is based on pitting on only one side of a plate.

In cases where pitting is exceeding 15%, , an area of 300 mm or more, at the most pitted part of the plate (or, where this is impracticable on the frame flange or the side shell, hopper tank plating or topside tank plating attached to the side frame, an equivalent rectangular area） is to be cleaned to bare metal and the thickness is to be measured in way of the five deepest pits within the cleaned area. The least thickness measured in way of any of these pits is to be taken as the thickness to be recorded.

The minimum remaining thickness in pits is to be greater than:

- 75% of the as-built thickness, in the frame, webs and flanges of cargo holds.
- 70% of the as-built thickness, in the side shell, hopper tank and topside tank plating attached to the each side frame, over a width up to 30 mm from each side of it.

If pitting intensity is lower than 15% in area, it is acceptable to have scattered pitting

greater than 1/4 of the original thickness to be building up welded. If the remaining thickness is less than 6 mm, the plate should be renewed.

2) Structures other than above 1) mentioned structure
Refer to pitting corrosion criteria of side structure in above 1).

3.2 Allowable pitting corrosion limit for CSR bulks carriers
If pitting intensity in an area where coating is required by CSR is higher than 15% (see Fig 1), thickness measurements are to be performed to check the extent of pitting corrosion. The 15% is based on pitting on only one side of a plate.
In cases where pitting is exceeding 15%, an area of 300 mm or more, at the most pitted part of the plate, is to be cleaned to bare metal and the thickness is to be measured in way of the five deepest pits within the cleaned area. The least thickness measured in way of any of these pits is to be taken as the thickness to be recorded.
The minimum remaining thickness in pits as defined in Ch 13, Sec1, [1.2.1] of CSR is to be greater than:

- 75% of the as-built thickness, in the frame and end brackets webs and flanges
- 70% of the as-built thickness, in the side shell, hopper tank and topside tank plating attached to the each side frame, over a width up to 30 mm from each side of it, without being greater than $t_{renewal}$.

$t_{renewal}$: Renewal thickness as well as the minimum allowable thickness, mm. If the remaining thickness is lower than $t_{renewal}$, structure is to be renewed.

4. Maximum allowable pitting corrosion limit for ships other than tankers and bulk carriers
Refer to pitting corrosion criteria of side structure of non-CSR bulk carriers.

5. Guidelines for pitting repair
The following alternatives can be adopted for treatment of pitting corrosion areas: no repairs, filling with coatings or fillers, welding (building up welding for pitting corrosion) , renewal etc. Appropriate methods are to be used according to pitting corrosion intensity, corrosion depth and corrosion position with reference to foresaid corrosion limits of different types of ships.

The following survey guidelines can only be used as the guide for solving problems. Specific analysis is to be made on a case-by-case basis on site. Methods

exceeding this guideline are to be under the consent of the CCS headquarters.

5.1 Filling

When pits depth is less than 1/4 of the original thickness can be defined as shallow pits. These pits can be filled with coatings or fillers. Prior to filling, adopted materials and procedures should be approved by the society. Besides, appropriate dry and surface treatment measures should be done according to manufacturer's instructions. Pitting may accelerate corrosion process, especially at areas with coatings. In order to control pitting corrosion, it is necessary to take actions at the beginning of corrosion. Please note: coatings or fillers used for pitting can only be used as methods to deter or deplete pitting, not as repair alternatives when exceeds the maximum allowable corrosion limit.

5.2 Welding

1) Pits greater than 1/4 of the original thickness and with remaining thickness is less than 6.0 mm can be welded, if the thickness is not exceeds the maximum allowable corrosion limit.
2) General principles for pitting corrosion welding

✧ In highly stressed areas and main structures withstanding main strength, pitting corrosion welding should be strictly controlled. Only under special circumstances and with careful consideration can welding be adopted, and it should be approved by CCS headquarters.

✧ For HTS, welding should not be adopted generally. Only under special circumstances it can be done. Survey branches should apply to CCS headquarters with photos and specific reports for approval.

✧ Considering operability of on-site welding repair and welding quality etc, it is only acceptable to have individual pits or pitting in a small area to be welded. In principle it is disagreed to have large area to be welded except some special circumstances. Survey branches should apply to CCS headquarters with photos and specific reports for approval.

✧ Where welding position is overhead (such as lower edge of bottom plate), welder's qualification and welding procedures adopted should be strictly controlled.

3) Welding material and procedures must correspond to the base material.

Cleaning： Heavy rust to be removed.

Drying：	Proper drying of pits by torch heating or equivalent.
Pre-Heating:	Required when ambient.
Welding:	Low hydrogen electrode Preferable. Reverse.
NDT：	Min. 10% extent, Preferably MPI so to inspect cracks in sub-surface.

5.3 Renewal

Steels, types and welding material should be in compliance with the related requirements of Materials and Welding Specifications by this society. Welding material and procedures must correspond to the base material. After the watertight repair of hull structure, tightness test should be done afterwards.

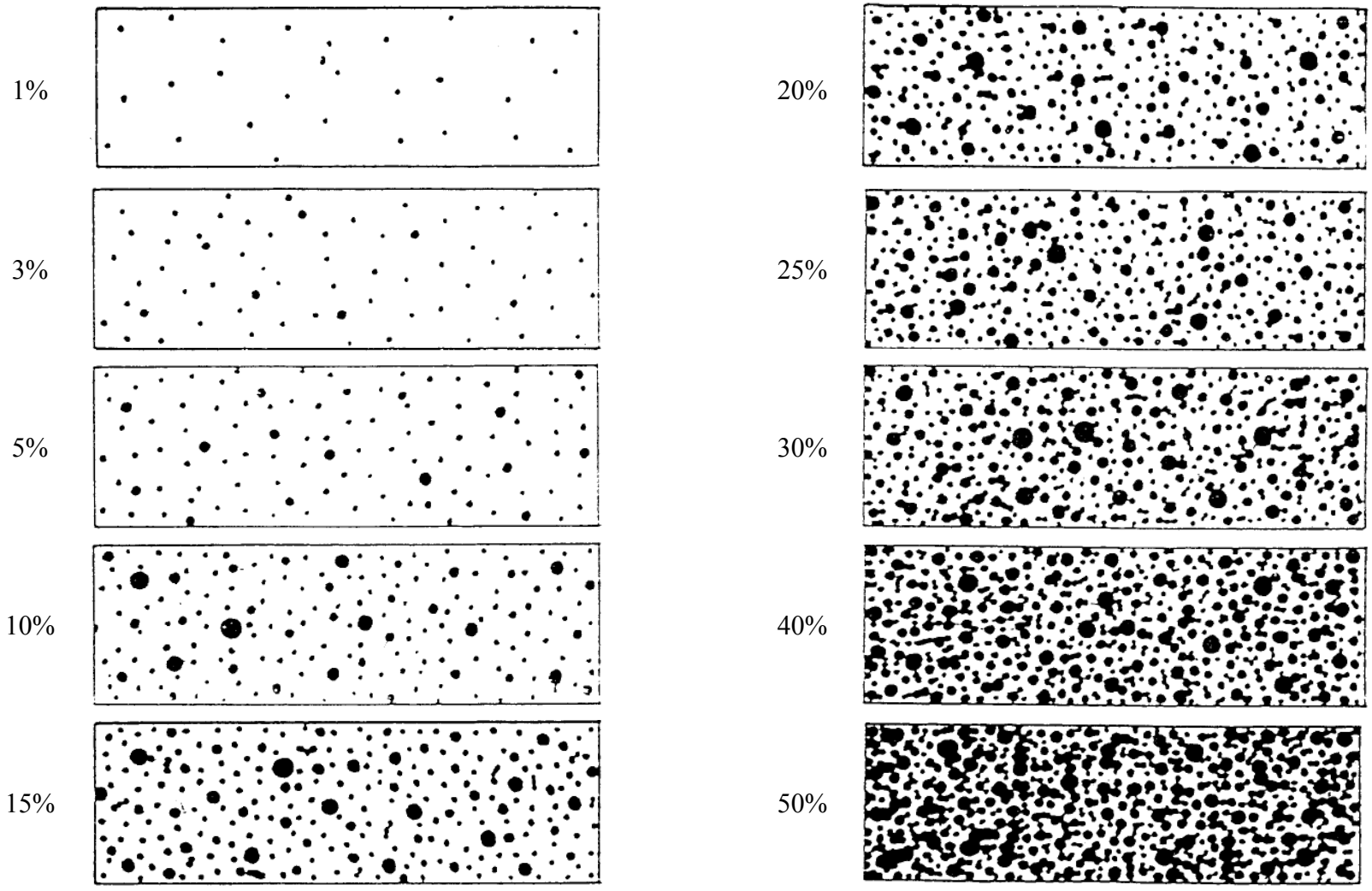
Deep pits with pitting corrosion exceeds maximum allowable corrosion limits as required or with remaining thickness less than 6mm, should not be welded, but be repaired by renewal plates.

Figure 1:Pitting Intensity Diagrams

Annex 1: List of pitting requirements for tankers by IACS/TSCF/OCIMF

Annex 2: List of pitting requirements for dry cargo ships/bulk carriers/container ships by IACS

Figure 1:Pitting Intensity Diagrams



Annex 1: List of pitting requirements for tankers by IACS/TSCF/OCIMF

<table>
<tr><th>No.</th><th>Organization</th><th>Applicable vessels</th><th>Original texts</th><th>Reference</th></tr>
<tr><td>1.</td><td>TSCF</td><td>tankers</td><td>Table 3.2 Guidelines for pitting repair
The following Table provides guidance for the assessment of wastage data for local strength and leakage potential for structural components.
<table>
<tr><td colspan="2">Guidance on Min. Remaining Plate Thickness in Pits for Pitting Intensity < 20% (1)</td></tr>
<tr><td>Structural component</td><td>Normally no action is required when the following conditions are fulfilled:</td></tr>
<tr><td>Bottom plating</td><td>Tmin=~2/3*to (2)(3)</td></tr>
<tr><td>Webs of horizontal members (Stringers, longitudinals etc.)</td><td>Tmin=~1/2*to (4)</td></tr>
</table>
Definitions:
Tmin = Minimum acceptable remaining thickness.
To = Original thickness or Rule thickness.
Notes
(1) For pitting intensity refer to Appendix VIII, Fig. VIII.5.2</td><td>TSCF-Guidance Tanker Structure</td></tr>
</table>

			and 3. For higher intensities the average corrosion loss should also be considered. (2) The limit differs between the Classification Societies, guidance should be obtained in each case. (3) Min. remaining thickness t min = 6.0 mm in bottom plating pits when welding afloat. (4) In highly stressed areas, e.g. at supports, the remaining cross-sectional area should be checked in separate cross-sections and related to actual stress condition, (shear and/or axial stress) and acceptable general corrosion, see Table 3.1. General guidance on pit repair: The advice and approval of the procedures and materials must be obtained from the Classification Society before pit filling/welding repairs are carried out. Welding material and procedures must correspond to the base material. Pitting corrosion can develop very rapidly, especially in coated areas, and early corrective action is essential to control it. Proper drying of pits by torch heating or equivalent, and cleaning before welding is essential and required for a satisfactory result and avoidance of hydrogen cracking.	

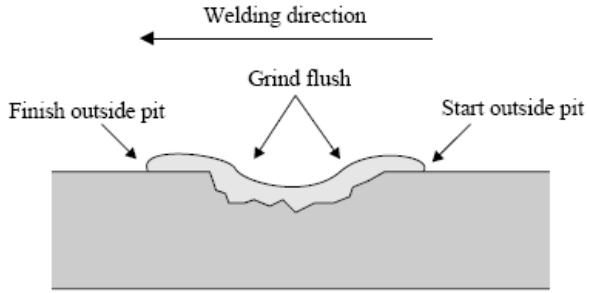
			Isolated pits in bottom plating down to 3.0 mm remaining plate should only be welded upon advice from the Classified Society and only when the vessel is in dry dock. Pits with remaining thickness min. 6.0 mm may normally be filled with a suitable filler material. Spot NDT checking of welded pits should be carried out, both surface and sub-surface cracks to be checked for. Proper drying and surface preparation prior to pit filling is to be carried out in accordance with the filler manufacturer recommendations. For bottom plating pitting maintenance and repair, refer to 4.3.3 for guidance.	
2.	TSCF	tankers	3.3 Acceptance criteria Table 3.2 indicates the normally acceptable pitting corrosion depths for scattered pitting, usually considered to be a pitting intensity up to 20% of the area in question. Scattered pitting can normally be considered a potential pollution or leakage problem, not a structural strength problem. If more extensive pitting is found, the corrosion loss should also be considered according to Table 3.1.	TSCF-Guidance Tanker Structure
3.	TSCF	tankers	4.3.3 Pitting and Grooving Repair	TSCF-Guidance Tanker Structure

			The following guidelines apply mainly to the bottom plating. Pitting on other structures have to be considered on basis of actual stress patterns, refer to Table 3.2. 1) Coat shallow pits by applying coating or pit filler. Shallow pits can be defined to be less than about 1/3 of the original thickness. 2) Deep pits and grooves greater than about 1/3 of the original thickness can be welded flush with the original surface. For HTS special welding procedures are required. If deep pits/grooves are clustered together the plate should be renewed by plate inserting instead of repairing by welding repairs. 3) Weld the deep pits plus apply coating or pit filler.	
4.	TSCF	tankers	8.3.3 Pitting and Grooving Repair 1) Coat shallow pits by applying coating or pit filler. Shallow pits can be defined to be less than about 1/3 of the original thickness. 2) Deep pits/grooves greater than about 1/3 of the original thickness can be welded flush with the original surface. If deep pits/grooves are clustered together or remaining thickness is less than 6 mm, the plate should be renewed by	TSCF-Guidelines for inspection of Double hull tankers

			plate inserting instead of repairing by welding repairs. 3) Weld the deep pits, plus apply coating or pit filler.	
5.	OCIMF	tankers	2.2 Pitting Corrosion OCIMF recommends that pitting corrosion is specifically examined and reported as part of the Enhanced Survey. The Survey Report File should include records of any bottom plating with a pitting intensity of 20% or more with wastage in the substantial corrosion range, or where the average depth of pitting is 1/3 or more of the plate thickness. …….. For pitting assessment, reference should be made to the "Guidance Manual for Tanker Structures" issued by Tanker Structure Cooperative Forum.	An Extended Scope For The Enhanced Survey Programme (ESP)
6.	OCIMF	tankers	7.2 Pit filling A common repair method for pitting is to thoroughly clean or blast the surrounding area and fill the pits either by welding or with epoxy filler or by welding and over-coating with an epoxy paint or filler. It should always be borne in mind that localised damage to a coating can cause accelerated pitting corrosion to occur.	Factors Influencing Accelerated Corrosion of Cargo Oil Tanks

7.	IACS	tankers	5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit. When scattered deep pitting is found, it may be repaired by welding.	IACS Rec.96 Double Hull Oil Tankers-Guidelines for Surveys, Assessment and Repair of Hull Structures
8.	IACS	tankers	Pitting corrosion is a localized corrosion often found in the inner bottom plating or on horizontal surfaces in cargo oil tanks and in the bottom plating of ballast tanks. Pitting corrosion is normally initiated due to local breakdown of coating. For coated surfaces the attack produces deep and relatively small diameter pits that can lead to hull penetration in isolated random places in the tank. Pitting of uncoated tanks, as it progresses, forms shallow but very wide scabby patches (e.g. 300 mm diameter); the appearance resembles a condition of general corrosion. Severe pitting of uncoated tanks can affect the strength of the structure and lead to extensive steel renewals. Once pitting corrosion starts, it is exacerbated by the galvanic current between the pit and other metal.	IACS Rec.96
9.	IACS	tankers	Composition and Properties of Cargo Carriage of crude oil that has high sulphur content can lead to	IACS Rec.96

			high rates for general corrosion and tank bottom pitting corrosion. By reacting with water many sulphur compounds can form acids, which are very corrosive. This will often mean that water bottom dropping out of the cargo will be acidic and corrosive.	
10.	IACS	tankers	2.1.3 Pitting corrosion may occur throughout the deck plating. The combination of accumulated water with scattered residue of certain cargoes may create a corrosive reaction.	IACS Rec.96
11.	IACS	tankers	2.1.2 Pitting corrosion may be found under coating blisters, which need to be removed before inspection. Pitting may also occur on horizontal structures, in way of sediments and in way of impingement from tank cleaning machines.	IACS Rec.96
12.	IACS	CSR tankers	1.6.2 Pitting 1.6.2.1 For plates with pitting intensity less than 20%, see Figure 12.1.1, the measured thickness, t_{tm}, of any individual measurement is to meet the lesser of the following criteria: $t_{tm} \geq 0.7(t_{as\ built} - t_{own})$ mm $t_{tm} \geq t_{ren} - 1$ mm Where: $t_{as\text{-}built}$ as built thickness of the member, in mm t_{own} owner/builder specified additional wastage allowance, if	DOUBLE-HULL OIL TANKERS STRUCTURE(CSR)

			applicable, in mm t_{ren} renewal criteria for general corrosion as defined in 1.4.2.1. 1.6.2.2 The average thickness across any cross section in the plating is not to be less than the renewal criteria for general corrosion given in 1.4.2.1.	
13.	IACS	all vessels	6.7 Welding of pitting corrosion NOTES: Shallow pits may be filled by applying coating or pit filler. Pits can be defined as shallow when their depth is less than 1/3 of the original plate thickness.  Fig. 6.7 Welding of pits Extent/depth: Pits/grooves are to be welded flush with the original surface. If deep pits or grooves are clustered together or	IACS Rec.47

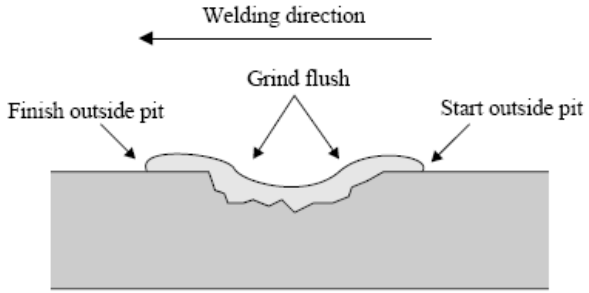
			remaining thickness is less than 6 mm, the plate should be renewed. Cleaning: Heavy rust to be removed. Pre-Heating: Required when ambient. Welding: Reverse. NDE: Min. 10% extent, Preferably MPI.	

Annex 2: List of pitting requirements for dry cargo ships/bulk carriers/container ships by IACS

No.	Organization	Applicable vessels	Original texts	Reference
1.	IACS	dry cargo ships/bulk carriers/container ships	3.3.2 …… Pitting corrosion is often found in the bottom plating or in horizontal surfaces, such as face plates, in ballast tanks and is normally initiated due to local breakdown of coating. Once pitting corrosion starts, it is exacerbated by the galvanic current between the pit and other metal.	IACS Rec.55, IACS Rec.76, IACS Rec.84
2.	IACS	dry cargo ships/bulk carriers/container ships	Area 1 Deck structure 2.1.3 Pitting corrosion may occur throughout the cross deck strip plating and on hatch covers. The combination of accumulated water with scattered residue of certain cargoes may create a corrosive reaction. 4.1.2 In the case of pitting corrosion throughout the cross deck strip plating, consideration should be given to renewal of part of or the entire cross deck plating.	IACS Rec.55, IACS Rec.76, IACS Rec.84
3.	IACS	bulk carriers	Area 3 Cargo hold side structure 2.1.4 Pitting corrosion may be found under coating blisters which need to be removed before inspection.	IACS Rec.76

			4.1.2 If pitting intensity is lower than 15% in area (see Figure 6), pitting greater than 1/4 of the original thickness can be welded flush with the original surface. If deep pits are clustered together or remaining thickness is less than 6 mm, the plate should be renewed by plate inserting instead of repairing by welding.	
4.	IACS	dry cargo ships/bulk carriers/container ships	Area 5 Double bottom tank structure including hopper 5.1.2 Plating below suction heads and sounding pipes is to be replaced if the average thickness is below the acceptable limit (See Examples 14 and 15). When scattered deep pitting is found, it may be repaired by welding. Examples If the corrosion is limited to a small area, i. e. pitting corrosion, repair by welding is acceptable.	IACS Rec.55, IACS Rec.76, IACS Rec.84
5.	IACS	side structure of bulk carriers	S31.2.5 Pitting and grooving If pitting intensity is higher than 15% in area (see Figure 5), thickness measurement is to be taken to check pitting corrosion. The minimum acceptable remaining thickness in pits or grooves is equal to: - 75% of the as built thickness, for pitting or grooving in the	IACS URS31

			frame and brackets webs and flanges - 70% of the as built thickness, for pitting or grooving in the side shell, hopper tank and topside tank plating attached to the side frame, over a width up to 30 mm from each side of it.	
6.	IACS	CSR bulk carriers	3.2.3 Renewal thickness for local corrosion If pitting intensity in an area where coating is required, according to Ch 3, Sec 5, is higher than 15% (see Fig 6), thickness measurements are to be performed to check the extent of pitting corrosion. The 15% is based on pitting or grooving on only one side of a plate. In cases where pitting is exceeding 15%, as defined above, an area of 300 mm or more, at the most pitted part of the plate, is to be cleaned to bare metal and the thickness is to be measured in way of the five deepest pits within the cleaned area. The least thickness measured in way of any of these pits is to be taken as the thickness to be recorded. The minimum remaining thickness in pits, grooves or other local areas as defined in Ch 13, Sec1, [1.2.1] is to be greater than: • 75% of the as-built thickness, in the frame and end brackets webs and flanges	CSR

			• 70% of the as-built thickness, in the side shell, hopper tank and topside tank plating attached to the each side frame, over a width up to 30 mm from each side of it, without being greater than $t_{renewal}$.	
7.	IACS	all vessels	6.7 Welding of pitting corrosion NOTES: Shallow pits may be filled by applying coating or pit filler. Pits can be defined as shallow when their depth is less than 1/3 of the original plate thickness.  Fig. 6.7 Welding of pits Extent/depth: Pits/grooves are to be welded flush with the original surface. If deep pits or grooves are clustered together or remaining thickness is less than 6 mm, the plate should be	IACS Rec.47

			renewed. Cleaning: Heavy rust to be removed. Pre-Heating: Required when ambient. Welding: Reverse. NDE: Min. 10% extent, Preferably MPI.	