

IACS Common Structural Rules for Double Hull Oil Tankers, January 2006

Background Document

SECTION 6 – MATERIALS AND WELDING

NOTE:

- This TB is published to improve the transparency of CSRs and increase the understanding of CSRs in the industry.
- The content of the TB is not to be considered as requirements.
- This TB cannot be used to avoid any requirements in CSRs, and in cases where this TB deviates from the Rules, the Rules have precedence.
- This TB provides the background for the first version (January 2006) of the CSRs, and is not subject to maintenance.

IACS

INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES LTD.

© IACS - the International Association of Classification Societies and the International Association of Classification Societies Limited

All rights reserved.

Except as permitted under current English legislation no part of this work may be photocopied, stored in a retrieval system, published, performed in public, adapted, broadcast, transmitted, recorded or reproduced in any form or by means, without prior permission of the copyright owner.

Where IACS has granted written permission for any part of this publication to be quoted such quotation must include acknowledgement to IACS.

Enquiries should be addressed to the Permanent Secretary,
International Association of Classification Societies Ltd,
36 Broadway
London, SW1H 0BH
Telephone: +44 (0)20 7976 0660
Fax: +44 (0)20 7808 1100
Email: PERMSEC@IACS.ORG.UK

Terms and Conditions

The International Association of Classification Societies (IACS), its Member Societies and IACS Ltd. and their directors, officers, members, employees and agents (on behalf of whom this notice is issued) shall be under no liability or responsibility in contract or negligence or otherwise howsoever to any person in respect of any information or advice expressly or impliedly given in this document, or in respect of any inaccuracy herein or omission herefrom or in respect of any act or omission which has caused or contributed to this document being issued with the information or advice it contains (if any).

Without derogating from the generality of the foregoing, neither the International Association of Classification Societies (IACS) nor IACS Ltd. nor its Member Societies nor their directors, officers, members, employees or agents shall be liable in contract or negligence or otherwise howsoever for any direct, indirect or consequential loss to any person caused by or arising from any information, advice, inaccuracy or omission given or contained herein or any act or omission causing or contributing to any such information, advice, inaccuracy or omission given or contained herein.

Any dispute concerning the provision of material herein is subject to the exclusive jurisdiction of the English courts and will be governed by English Law.

TABLE OF CONTENTS:

1	STEEL GRADES	4
1.1	Hull Structural Steel.....	4
1.2	Application of Steel Materials	5
1.3	Aluminium Alloys	6
2	CORROSION PROTECTION INCLUDING COATINGS.....	7
2.1	Hull Protection	7
3	CORROSION ADDITIONS	8
3.1	General.....	8
3.2	Local Corrosion Additions.....	8
3.3	Application of Corrosion Additions.....	8
4	FABRICATION	11
4.1	General.....	11
4.2	Cold Forming.....	11
4.3	Hot Forming.....	11
4.4	Welding	12
5	WELD DESIGN AND DIMENSIONS	13
5.1	General.....	13
5.2	Butt Joints	13
5.3	Tee or Cross Joints.....	13
5.4	Lapped Joints	14
5.5	Slot Welds.....	14
5.6	Stud Welds	15
5.7	Determination of the Size of Welds	15
5.8	Weld for Structures Subject to High Tensile Stresses	17
5.9	Reduced Weld Size	17
5.10	End Connections of Pillars and Cross ties	17
5.11	Alternatives.....	17

1 STEEL GRADES

1.1 Hull Structural Steel

1.1.1 Scope

1.1.1.a The text is general and common to existing LR, ABS and DNV Rules. Since stainless steels are mainly used in chemical carriers, the requirements are not included as part of the present CSR for Tankers. Other materials, including stainless steels, will be dealt with by the individual Classification Society until eventually included in CSR. If alternative materials are used, the yield strength, wastage allowance and corrosion addition is to be specially considered.

1.1.2 Strength

1.1.2.a Normal strength hull structural steel is called “mild steel” by LR, “ordinary strength steel” by ABS and “normal strength structural steel” by DNV. The term “normal” was adopted in *IACS UR W11* and it is used here. Higher strength hull structural steel is called as “higher tensile steel” by LR and “high strength structural steel” by DNV.

1.1.3 Material grades

1.1.3.a The text is general and common to existing LR, ABS and DNV Rules.

1.1.4 Higher strength steel factor

1.1.4.a Higher strength steel factors for hull girder strength in existing LR, ABS and DNV Rules are as follows:

Table 1.1.1			
Higher strength steel factors			
Specified minimum yield point N/mm² (kgf/mm²)	LR k_L	ABS Q	DNV 1/f₁
235 (24)	1.00	1.00	1.00
265 (27)	0.92	-	0.926
315 (32)	0.78	0.78	0.781
340 (34)	0.74	-	0.741
355 (36)	0.72	0.72	0.719
390 (40)	0.68	0.68	0.699

1.1.4.b The higher strength steel factor of 0.68 has been adopted for 390N/mm² yield point steel based on a long time satisfactory use in the LR and ABS Rules and also noting the adoption of 0.68 in the Common Structural Rules for Bulk Carriers.

1.1.4.c The methods for dealing with higher strength steel yield stress and its application in local strength analysis are not dealt with here. The portions of the Rules on direct strength analysis and prescriptive requirements deal with these matters. In general

the higher strength steel factors apply to longitudinal strength and a limited number of local elements, as appropriate. Local scantling requirements generally use the specified minimum yield strength to determine strength limits.

1.1.5 Through thickness property

1.1.5.a The text is general and common to existing LR, ABS and DNV Rules.

1.1.6 Steel castings and forgings

1.1.6.a The use of steel casting and forgings is limited and left to the requirements of the individual classification society. It is also noted that IACS Materials and Welding Unified Requirements are in place to cover casting and forgings.

1.2 Application of Steel Materials

1.2.1 Selection of material grades

1.2.1.a The source of the requirements is *IACS UR S6*. It is noted that some of the items addressed in *Table 6.1.3* of the Rules are not applicable to tankers but have been included for completeness rather than removed. In some areas where items from *IACS UR S6* are open to interpretation, additional requirements have been included. These come from present requirements of LR, ABS and DNV. See *1.2.2.b*.

1.2.2 Applicable thickness

1.2.2.a LR specifies steel grade to correspond to the as-fitted thickness and this has been adopted in the Rules.

1.2.2.b Further to *Table 6.1.3*:

- (a) DNV Rules have five (I, II, III, IV and V) material classes. The DNV classes II, III, and IV are corresponding to IACS classes I, II, and III, respectively. The DNV class I define A, AH up to 40mm and B, AH over 40mm, accordingly, note 8 is provided. Since the DNV class V is applicable to plating at corners of large hatch openings of container vessels, the requirement is not applicable to tankers.
- (b) Continuous longitudinal members above strength decks in primary and special structural members are included although these members are not commonly seen for normal modern crude/product oil tanker designs.
- (c) Vertical strake (hatch side girder) and upper sloped strake in top wing tank are included although these members are not common for crude/ product oil tankers.
- (d) Strength deck plating at outboard corners of cargo hatch openings for container carriers as well as bulk carriers, etc. in special category are included. However, these members are not applicable for crude/product oil tankers. The note for plating at corners of cargo hatch openings is removed.
- (e) LR specifies $0.6L$ amidships for D/DH bilge strake in vessels with length exceeding 250m. The requirement is included in note 6.
- (f) LR requires welded attachments to be similar class grades of hull envelope plating, etc. The requirement is included in note 9.

- (g) LR specifies material class for deck plating, sheerstrake and upper strake of longitudinal bulkhead in way of structural breaks of the superstructure, irrespective of position. The requirement is included in note 10.

1.2.3 Operation in areas with low air temperature

- 1.2.3.a Grades of steel for ships operating in low ambient temperatures are considered to be determined based on the applicable Ice Class. The requirements dealing with ice class will be dealt with independently of these Rules and will be left to the individual Classification Society.
- 1.2.3.b The reference to lowest daily mean temperature *Section 6/1.2.3.1 of the Rules* has been specified as -15 degrees C. The design temperature is stricter than *IACS URS 6* (-20 degrees C). Ships operating in a more severe environment than defined in *Section 2/3.1.7.4* of the Rules should thus be subject to special consideration.

1.2.4 Guidance for repairs

- 1.2.4.a The information provided is based on ABS Rules 3-1-2/1.1.4.

1.3 Aluminium Alloys

1.3.1 General

- 1.3.1.a Since aluminium alloys are applicable only for some limited local components on tankers, scantling material and scantling requirements are left to the individual Classification Society.

1.3.2 Incendiary sparking on impact with steel

- 1.3.2.a The Rule text is based on LR Rules Pt 4, Ch 9,2.3.1, with references to requirements for aluminium anodes removed.

2 CORROSION PROTECTION INCLUDING COATINGS

2.1 Hull Protection

2.1.1 General

- 2.1.1.a The purpose and intention of this section is to ensure that the Rules are inline with the SOLAS requirement with respect to corrosion prevention of ballast tanks.
- 2.1.1.b The text provides reference to the requirements of SOLAS Reg. II-1/3-2, IMO Resolution A.798(19) and IACS UI SC 122. The requirements are open with respect to application date, which is yet to be finalized by IMO.
- 2.1.1.c Text on anodes in *Section 6/2.1.1.7* of the Rules is extracted from DNV Rules Pt. 3 Ch.3 Sec.7 A203.

2.1.2 Internal cathodic protection systems

- 2.1.2.a The text is in accordance with DNV Rules Pt. 3. Ch.3. Sec.7 B300 and LR Rules Pt 3 Ch 2/3.3 and 3.4.

2.1.3 Paint containing aluminium

- 2.1.3.a Text is in accordance with on LR Rules Pt 4, Ch 9,2.3.3.

3 CORROSION ADDITIONS

3.1 General

3.1.1 Introduction

- 3.1.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background. It should be noted however that the corrosion additions used during the newbuilding evaluations are related to the Ship In Operation corrosion wastage allowances. For additional information on the actual values for SIO wastage allowance, see *Section 12 of the Rules* and *Section 12* of this background document. Additional information and explanation on the concept of the net thickness approach is described in *Section 2/4.3.4 of the Rules*
- 3.1.1.b Alternative corrosion additions for stainless steel as referred to in *Section 6/3.1.1.2 of the Rules* need to be reviewed in connection with allowable wastage allowance given for those members.

3.2 Local Corrosion Additions

3.2.1 General

- 3.2.1.a The local corrosion additions are derived by adding 0.5mm to wastage allowances for the particular local structural element. The background on the relationship of corrosion additions and wastage allowances is explained in *Section 2/4.3.4* and the details on local wastage allowances, are explained in *Section 12/1.4 of the Rules*.
- 3.2.1.b The 0.5mm is added in reserve for the wastage occurring between the inspection intervals of approximately 2.5 years. The verified strength of the vessel is performed on the net thickness (gross minus corrosion addition t_{corr}). As the wastage allowance is assessed based on thickness measurements performed in connection with the renewal survey some margin is needed on the wastage allowance as the vessel will operate for approximately another 2.5 years before being re-assessed. During this 2.5 year interval the thicknesses should not reduce below the net thickness.

3.3 Application of Corrosion Additions

3.3.1 General

- 3.3.1.a Example of the assessment of plating as described in *Section 6/3.3.1.2 of the Rules*:
Bottom plate with proposed thickness from yard is 15mm and corrosion addition is 3mm. If the net required rule thickness is 11.8mm which is rounded to 12mm compliance with the rules can be shown by one of two ways.
- a) check that gross proposed thickness is equal or greater than gross required:
 $15 \geq 12 + 3 = 15$ mm, or
 - b) check that net proposed is equal or greater than the net required:
 $15 - 3 = 12 \geq 12$ mm

The procedure for rounding is given in *Section 3/5.4.1* of the Rules.

- 3.3.1.b For assessment of sectional properties of stiffeners the Rule gross required is not uniquely defined since the addition to the net Rule required depends on the actual

type and size of the cross section. The absolute difference in shear area between net and gross for a stiffener will for instance depend on the height of the stiffener. Consequently as the Rule net sectional requirement is uniquely defined the practical assessment is performed by verifying that the net proposed sectional property is equal or greater to the Rule net required.

Example: Assessment of shear area for a stiffener.

Yard proposed flatbar stiffener FB 200x12 in a ballast tank ($t_{corr}=3\text{mm}$) is to be assessed against a net Rule requirement of 16cm^2 . Assessment is hence done by verifying that the net proposed web area is equal or greater to net required.

$$20 \times (1.2-0.3) = 18 \geq 16 \quad \text{cm}^2$$

3.3.2 Application for hull girder longitudinal strength calculations

- 3.3.2.a Details regarding the net thickness philosophy are given in *Section 2/4.3.4* of the Rules.
- 3.3.2.b The hull girder stresses are calculated based on net hull girder sectional properties (using $0.5t_{corr}$) and the associated local buckling capacity is based on the local net scantlings (using $1.0t_{corr}$)
- 3.3.2.c The concept of deducting half the local corrosion addition when calculating the hull girder stresses should not be confused as being a “half net” concept. As the minimum allowable hull girder cross sectional properties during operation are defined as the hull girder cross section equivalent to deducting $0.5 t_{corr}$ on all structural elements simultaneously this reduction is actually the full hull girder deduction. The longitudinal stresses are in other words calculated based on the minimum hull girder sectional properties allowed during operation of the vessel.
- 3.3.2.d Deduction of $0.5t_{corr}$ on all elements simultaneously gives a reduction in the hull girder cross section by 8-11%, depending on vessel size and scantlings, which is similar to the existing allowable reduction of 10%. Review of survey records show that excessive steel renewal has not been required due to this criterion and hence there is no indication that the allowable reduction in the hull girder should be increased.

3.3.3 Application for scantling strength assessment of plates and local support members

- 3.3.3.a Details regarding the net thickness philosophy are given in *Section 2/4.3.4* of the Rules.
- 3.3.3.b The hull girder stresses are calculated based on net hull girder sectional properties and the local stresses are calculated based on the local net scantling. See also 3.3.2.c.

3.3.4 Application of corrosion additions for scantling strength assessment of primary support members

- 3.3.4.a Details regarding the net thickness philosophy are given in *Section 2/4.3.4* of the Rules.

3.3.4.b In terms of corrosion the primary support members are assessed based on the overall global corrosion applicable to simultaneous corrosion to large areas. Hence corrosion addition is in general $0.5t_{corr}$. The large area assumption is adopted as the sectional properties depend on scantlings of several local structural components simultaneously (example: the deck transverse web frame comprises the deck plating and the deck transverse web and face plate). However, the minimum thickness requirements apply to the local components of the primary support member individually (web, face plate) and hence are assessed based on applying the full local corrosion addition t_{corr} .

3.3.5 Application of corrosion additions for hull girder ultimate strength analysis

3.3.5.a Details regarding the net thickness philosophy are given in *Section 2/4.3.4* of the Rules.

3.3.5.b While the buckling strength assessment performed as part of the longitudinal strength assessment given in *Section 8/1.4 of the Rules* is performed for the various structural components individually the hull girder ultimate strength assessment calculates the capacity of the hull girder. Hence while buckling capacity of single components are performed based on the full local corrosion addition the buckling capacity for the hull girder ultimate strength is performed by deduction of half the local corrosion addition following the assumption of overall global corrosion.

3.3.6 Application of corrosion additions for strength assessment by finite element analysis

3.3.6.a Details regarding the net thickness philosophy for strength assessment by finite element analysis are given in *Section 2/4.3.4* of the Rules.

3.3.7 Application of corrosion additions for fatigue strength assessment

3.3.7.a Details regarding the net thickness philosophy for fatigue strength analysis are given in *Section 2/4.3.4.8* of the Rules.

4 FABRICATION

4.1 General

4.1.1 Workmanship

- 4.1.1.a The text was developed based on ABS Rules 3-1-2/9, and the statement on defect repairs is in accordance with LR Rules Pt 3, Ch 1,8.2.1.

4.1.2 Fabrication standard

- 4.1.2.a The text was developed based on ABS Rules 3-1-2/15.5. IACS Recommendation No.47, *Shipbuilding and Repair Quality Standard* is included as the basic requirement for an acceptable fabrication standard. However, it is also realised that other recognised fabrication standards exist that have a proven record of satisfactory performance. The rules permit continued acceptance of these recognised fabrication standards. The scope of items to be included in the fabrication standard was taken from the contents of *IACS Recommendation No.47*.

4.2 Cold Forming

4.2.1 Special structural members

- 4.2.1.a Cold forming of special structural members is in accordance with ABS Pt.2, Ch. 4, Section 1/3.13 (second paragraph) with slight modification to accommodate LR and DNV practice. A minimum radius of 10 times the thickness, which corresponds to a cold deformation of approximately 5%, is used in the Rules and is based on DNV acceptance of this for offshore structures. Additional requirements related to acceptance of lesser radiuses is contained in *Section 6/4.2.3* of the Rules and is generally in accordance with DNV Rules DNV Pt.3, Ch. 1, Sec.3 C1102. Criteria for stainless steels are not applicable here and are left to the individual society.

4.2.2 Other members

- 4.2.2.a Cold Forming for other members is in accordance with DNV Pt.3, Ch. 1, Sec.3 1100. Additional requirements related to acceptance of lesser radiuses is contained in *Section 6/4.2.3* of the Rules and is generally in accordance with DNV Rules DNV Pt.3, Ch. 1, Sec.3 C1102. Criteria for stainless steels are not applicable here and are left to the individual society.

4.2.3 Additional requirements

- 4.2.3.a Cold Forming for other members is in accordance with DNV Pt.3, Ch. 1, Sec.3C. 1002. The criteria have been slightly modified from the DNV source criteria to satisfy LR and ABS views.

4.3 Hot Forming

4.3.1 Temperature requirements

- 4.3.1.a General precaution for hot forming is in accordance with ABS Rules 2-4-1/3.13 (first paragraph) and ABS Rules 2-4-1/1.9 (for TMCP plates). This also addresses LR Rules Pt 3, Ch 1,8.2.1.

4.3.2 Line or spot heating

4.3.2.a Line or Spot Heating is in accordance with LR Rules Pt 3, Ch10,2.12.17.

4.4 Welding

4.4.1 General

4.4.1.a Text is in accordance with LR Rules Pt 3, Ch 10,2.12.5

4.4.1.b LR specifies other items related to welding in LR Rules Pt 3, Ch 10,2.12, Workmanship and shipyard practice, which, as appropriate, will be indicated in the section on Welding.

4.4.2 Welding sequence

4.4.2.a Text is in accordance with LR Rules Pt 3, Ch 10,2.12.6.

4.4.3 Arrangements at junctions of welds

4.4.3.a The requirements are in accordance with LR Rules Pt 3, Ch 10,2.2.2.

4.4.4 Leak Stoppers

4.4.4.a The requirements are in accordance with LR Rules Pt 3, Ch10,2.6.11.

5 WELD DESIGN AND DIMENSIONS

5.1 General

5.1.1 Scope

- 5.1.1.a Items on welder qualifications, welding sequence and welding particulars are cross referenced to *Section 6/4.4*.
- 5.1.1.b A general note has been added to indicate that weld sizes are based on gross scantlings, i.e., t_{gr-req} , gross thickness Rule required scantlings.

5.1.2 Plans and specifications

- 5.1.2.a The requirements are in accordance with ABS Rules 3-2-19/1.1.1, with notes added on the need to submit/specify additional information where weld sizes are reduced as permitted by *Section 6/5.9* of the Rules.

5.1.3 Tolerance requirements

- 5.1.3.a The requirements are in accordance with ABS Rules 3-2-19/1.1.2. A 2mm gap is consistent with IACS Recommendation No.47 *Shipbuilding and Repair Quality Standard* for fillet welds.

5.1.4 Special precautions

- 5.1.4.a The requirements are in accordance with ABS Rules 3-2-19/1.1.3.

5.2 Butt Joints

5.2.1 General

- 5.2.1.a The requirements are based on DNV Rules Pt.3 Ch.1 Sec.12 B100.
- 5.2.1.b Figures are taken from IACS Recommendation No.47 *Shipbuilding and Repair Quality Standard*.

5.2.2 Thickness difference in butt welds

- 5.2.2.a The requirements are based on ABS Rules 2-4-1/3.1, LR Rules Pt 3, Ch 10,2.2.1 and DNV Rules Pt.3 Ch.1 Sec.12 B102. DNV Rules and those of some other Societies allow a total of 4mm difference in while ABS and LR only permit a maximum difference of 3mm on either side. 4mm was accepted over 3mm.

5.3 Tee or Cross Joints

5.3.1 General

- 5.3.1.a General text based on the DNV Rules Pt.3 Ch.1 Sec.12 B300.
- 5.3.1.b Figures are taken from IACS Recommendation No.47 *Shipbuilding and Repair Quality Standard*.

5.3.2 Continuous welding

- 5.3.2.a The locations requiring continuous welding are based on LR Rules Pt 3, Ch 10,2.6.9. It is noted fore peak tanks and voids have also been added, based on present practice. Structural terms have been modified as follows: the term “primary structure” to “primary support member” and modified the term “secondary structure” to “stiffener”.

5.3.3 Intermittent welding

- 5.3.3.a The requirements for intermittent welds are based on ABS Rules 3-2-19/3.5 and LR Rules Pt 3, Ch 10,2.6.10.

5.3.4 Full or partial penetration corner or tee joints

- 5.3.4.a The locations requiring penetration welding are based on DNV Rules Pt.3 Ch.1 Sec.12 C201 and C203. In addition, requirements were included to address the welding of main structural members at the lower end of the corrugated bulkhead; such as the welding at the bulkhead to the inner bottom/lower hopper, the welding in way of gussets plates, and the welding of double bottom floors/girders/hopper tank webs to the inner bottom below the bulkhead. These additional requirements are added to address relatively high stress in these connections, particularly in configurations without lower stools, and they are consistent with present practice.

5.4 Lapped Joints

5.4.1 General

- 5.4.1.a The text is adapted from LR Rules Pt 3, Ch 10,2.3.1, DNV Pt.3 Ch.1 Sec.12 B200 and ABS 3-2-19/11.
- 5.4.1.b The width between three and four times of the thickness specified by LR is generally agreed, with “twice the thinner plate thickness plus 25mm” specified by ABS. The LR text has been expanded to permit modification of the requirement in way of heavy plates and in way of lugs and collars so as to avoid unnecessary excessive overlaps.
- 5.4.1.c The figure is taken from IACS Recommendation No.47 *Shipbuilding and Repair Quality Standard*.

5.4.2 Overlapped end connections

- 5.4.2.a The requirements are in accordance with ABS Rules 3-2-19/11.3.

5.4.3 Overlapped seams

- 5.4.3.a The requirements are in accordance with ABS Rules 3-2-9/11.5.

5.5 Slot Welds

5.5.1 General

- 5.5.1.a The requirements are in accordance with ABS Rules 3-2-19/13 and DNV Rules Pt.3 Ch.1 Sec.12 C601. Regarding spacing: DNV specifies 3 times of slot length with the

maximum 250mm; ABS specifies “about 305mm” and; LR specifies 230mm with slot length of 90mm for closing plates.

- 5.5.1.b The figure and the specific information on the slot geometry and spacing of slots are taken from IACS Recommendation No.47 *Shipbuilding and Repair Quality Standard*.

5.5.2 Closing plates

- 5.5.2.a The requirements are in accordance with LR Rules Pt 3, Ch 10,2.4. The specific information on the slot geometry and spacing of slots has been updated to correspond with *Figure 6.5.7* of the Rules.

5.5.3 Rudder closing plates

- 5.5.3.a The requirements are in accordance with LR Rules Pt 3, Ch 13,2.2.5. The specific information on the slot geometry and spacing of slots has been updated to correspond with *Figure 6.5.7* of the Rules. The weld size has been updated to correspond with requirements contained in *Section 6/5.7.1.2* of the Rules.

5.6 Stud Welds

5.6.1 General

- 5.6.1.a The requirements are in accordance with LR Rules Pt 3, Ch 10,2.5.1.

5.7 Determination of the Size of Welds

5.7.1 General

- 5.7.1.a Rounding to nearest half mm is standard practice. (See also, ABS Rules 3-2-19/1.1.1.)
- 5.7.1.b The basic formulation for fillet weld size is included in *Section 6/5.7.1.2* of the Rules and more specific requirements for its use are included in the remaining sub-sections.
- 5.7.1.c Sizes of fillet weld are specified by throat thickness in LR and DNV Rules, while they are specified by leg size in ABS Rules. Since it will be convenient to control fillet weld sizes in production, leg sizes are used in this text.
- 5.7.1.d In ABS Rules, a constant of 2mm is considered to allow gap between the panel and members being attached. In DNV Rules, corrosion additions are taken into account to determine the sizes, which might be negligible, if the weld size is determined based on the actual size of members concerned.
- 5.7.1.e The difference of material factors between plates and deposit metal is taken into account as indicated in the DNV Rules (Pt.3 Ch.1 Sec.12 C100), except that the yield strength for the weld deposit metal for normal strength steel is taken at the minimum value of 305N/mm², for material with yield strength of 265 - 355N/mm² is taken as a minimum of 375N/mm², and for material with yield strength of 390 N/mm² is taken as a minimum of 400N/mm². This is consistent with minimum deposit weld material yield strengths as specified in IACS UR W17.
- 5.7.1.f For weld size limits, *Table 6.5.2* of the Rules is based on LR Rules Pt 3, Ch 10, Table 10.2.2 converted to leg size from throat thickness, i.e. throat thickness of $0.44t_{pl}$ converted to $0.62t_{pl}$.

- 5.7.1.g Minimum weld factors are dealt with within the Rule text so are not included in the table. While the requirements for application to thin plates are separated at a thickness of 7.5mm in LR Rules, the separation at 6.5mm is proposed in order to agree with the requirements for thinner plates in *Section 6/5.7.1.2* of the Rules.
- 5.7.1.h The definition of thickness to be used is modified to include the ABS requirement for slab longitudinals and to be based on the thickness of the abutting member.
- 5.7.1.i The requirements for thin plating are in accordance with ABS Rules 3-2-19/3.11, with modifications made to account for weld deposit material strength as indicated in the DNV Rules incorporated into the general formula.
- 5.7.1.j The requirements for size limits for the use of intermittent welds are based on ABS Rules 3-2-19/3.3.
- 5.7.1.k The paragraph on dealing with large gaps and the maximum gap requirement of 5 mm is based on ABS Rules 3-2-19/1.1.2.

5.7.2 Welding of fillet joints in main structural components

- 5.7.2.a Weld factors for sizing of fillet welds are provided in *Table 6.1.2* of the Rules. Comparing required fillet weld sizes between three societies, the required sizes will be higher for thinner plates by ABS Rules, and higher for thicker plates (Generally $t > 15\text{mm}$) by LR Rules, in general. Accordingly, the ABS standard is used as the base and it is adjusted for differences compared to LR/DNV requirements where necessary.
- 5.7.2.b In general, *Section 6/5.7.2* of the Rules does not cover end connections for primary support members and local support members (stiffeners). These are dealt with specifically in *Section 6/5.7.4* and *5.7.5* of the Rules.

5.7.3 Welding of primary support members

- 5.7.3.a The requirements are in accordance with LR Rules Pt 3, Ch 10, 2.7.1 thru 2.7.4. *Table 6.5.4* of the Rules is based on LR Rules Pt 3, Ch 10, *Table 10.2.3*, converted to leg size from throat thickness.

5.7.4 Welding of end connections of primary support members

- 5.7.4.a The requirements are in accordance with LR Rules Pt 3, Ch 10, 2.8.1. The concept of "Rule" minimum cross sectional area is introduced.

5.7.5 Welding at ends of stiffeners

- 5.7.5.a The requirements are in accordance with LR Rules Pt 3, Ch 10, 2.8.2 through 2.8.6.
- 5.7.5.b *Table 6.5.5* of the Rules is based on LR Rules Pt 3 Ch 10 *Table 10.2.4* converted to leg size from throat thickness.
- 5.7.5.c The additional requirements in LR Rules Pt 3, Ch 5, 1.5.6 applicable to Strengthening of Bottom have also been incorporated into *Section 8/6.3* and *Section 4/3.4* of the Rules.

5.8 Weld for Structures Subject to High Tensile Stresses

5.8.1 Minimum leg size

- 5.8.1.a The requirements are in accordance with DNV Rules Pt.3 Ch.1 Sec.12 C200.
- 5.8.1.b In the equation for weld sizing in structure with high shear stress, the equation is modified to correct for weld leg length. The equation includes an allowance for the weld deposit material strength as indicated in the DNV Rules, consistent with *Section 6/5.7.1.2* of the Rules.

5.9 Reduced Weld Size

5.9.1 General

- 5.9.1.a General text has been added to clarify documentation with particular emphasis placed on what may be needed to support the ship during its operational life.

5.9.2 Controlled gaps

- 5.9.2.a The requirements are in accordance with ABS Rules 3-2-19/9.3.

5.9.3 Deep penetration welding

- 5.9.3.a The requirements are combined with basing on LR Rules Pt 3, Ch 10,2.6.3 and ABS Rules 3-2-19/9.5. Amounts of reductions between 15% and 20% are in accordance with LR, but not more than 1.5mm in accordance with ABS.

5.9.4 Controlled welding consumables

- 5.9.4.a The requirement for reduction in weld thickness based on yield stress of the weld deposit is based on current DNV Rule philosophy.
- 5.9.4.b Reference to Quality Assurance processes and a need to supply a repair plan are included as a condition upon which a reduction in weld sizes, based on yield stress of the weld deposit, is permitted under *Section 6/5.7.1.2* of the Rules.

5.10 End Connections of Pillars and Cross ties

5.10.1 Effective weld area

- 5.10.1.a The requirements are in accordance with DNV Rules Pt.3 Ch.1 Sec.12 C303.
- 5.10.1.b The equation for sizing welds for pillars and cross ties is based on a weld area calculation, i.e., effective throat area times weld length. The equation includes an allowance for the weld deposit material strength as indicated in the DNV Rules, consistent with *Section 6/5.7.1.2* of the Rules.

5.11 Alternatives

5.11.1 General

- 5.11.1.a The requirements are in accordance with ABS Rules 3-2-19/17.