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

Background Document

SECTION 4 – BASIC INFORMATION

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.

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1.1.2 L_L, load line length

1.1.2.a The definition is in accordance with International Convention on Load Lines.

1.1.3 Moulded breadth

1.1.3.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

1.1.4 Moulded depth

1.1.4.a The definition is in accordance with LR Rules Pt 3, Ch 1,6.1.4.

1.1.5 Draughts

1.1.5.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

1.1.6 Amidships

1.1.6.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

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1.1.7.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

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1.1.8.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

1.1.9 Block coefficient

1.1.9.a The definition is in accordance with IACS Unified Requirement S2.

1.1.10 Length between perpendiculars

1.1.10.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

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1.1.11.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

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1.1.13 Load line block coefficient

1.1.13.a The definition is in accordance with International Convention on Load Lines.

1.1.14 Deadweight

1.1.14.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

1.2 Position 1 and Position 2

1.2.1 Position 1

1.2.1.a The definition is in accordance with International Convention on Load Lines.

1.2.2 Position 2

1.2.2.a The definition is in accordance with International Convention of Load Lines.

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1.4.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

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1.5.1.a Nomenclature is in accordance with IACS Recommendation 82 – *Surveyor's Glossary, Hull terms and hull survey terms*.

1.6 Symbols

1.6.1 General

1.6.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

1.7 Units

1.7.1 General

1.7.1.a Standard Index units have been used.

1.8 Glossary

1.8.1 Definition of terms

1.8.1.a Terminology is in general in accordance with IACS Recommendation 82 – *Surveyor's Glossary, Hull terms and hull survey terms*. Further terms and definitions have been included where needed.

2 STRUCTURAL IDEALISATION

2.1 Definition of Span

2.1.1 Effective bending span of local support members

2.1.1.a No reduction in bending span is given in case of sniped web stiffener without a backing bracket as mentioned in *Section 4/2.1.1.3* of the Rules as this will provide little or no rotational support for the passing longitudinal. As the connection will not be symmetric at the primary support member the passing stiffener will experience a slight rotation at the support. This rotation effectively gives an increase to the bending moment at the heel of the web stiffener. Based on this no reduction to the span length is given. If a backing bracket is fitted the end connection will be more symmetric and will not rotate and hence the web stiffener may be assumed effective even though it is sniped at the end not attached to the stiffener in question.

2.1.1.b The reason why the span is reduced in way of brackets is that they provide a significant increase of section modulus/inertia compared to the cross section of the stiffener itself which results in a different load transfer than for a stiffener without brackets. The pressure applied to the stiffener in way of the stiffer ends (when bracket are fitted) will to a larger degree be transferred straight the support and not be distributed to the two ends of the stiffener. This in effect results in smaller bending moment in the stiffener outside the bracket area than is found for the configuration without brackets and equal distance between supports.

2.1.1.c When the brackets are fitted to the attached plating on the side opposite to that of the stiffener the change in section modulus/inertia is not significant as the added area is close to neutral axis and hence no the stiffness effect as described in *2.1.1.b* is not pronounced and no reduction is given in the span length. In case of very large brackets on the attached plate side, typically seen for primary support members, see *Figure 4.2.8 of the Rules*, the size of such brackets are taken into account in the definition of the effective bending span.

2.1.1.d The span definition in case of brackets, as shown in *Figure 4.2.1 and 4.2.2 of the Rules* is based on ABS Rules(SVR 5-1-4/Figure 5).

2.1.1.e For single skin structures FE analysis has shown that the tripping bracket without backing has very little effect on the effective bending span. The reason is that that the tripping bracket will rotate as the structure is non-symmetric and there is no adjoining structure to restrict the rotation. The effect of the rotation is that the bending moment is slightly reduced at the toe of the tripping bracket but increased at the heel of the tripping bracket. As an alternative to using a reduced span with a correction for the rotation the rules require that the full span be used for the calculations.

2.1.1.f It is noted that soft toe bracket gives significantly lower stresses compared to a straight type bracket. This is however not due to the effect on the span but on the stress concentration around at the termination of the bracket. The rules have included this effect in connection with the fatigue requirements. The factor r_p in *Appendix C/1.4.4.11 of the Rules* is lower for soft toe brackets compared to straight brackets and hence the peak stress will be lower and the fatigue life longer.

2.1.2 Effective shear span of local support members

2.1.2.a The reason why the shear and bending span are different is because for the shear loads, the bracket has an immediate and significant effect on the shear area which more than compensates for the increase in shear load towards the end support. Hence verification of the shear load at the end of the bracket is normally acceptable (provided the bracket is not too long and flat, hence the 1:1.5 bracket angle requirement). For the bending moments, over the first portion of the bracket, the bending moment is increasing more than the increase in section modulus of the beam including the bracket. At about the bracket half depth position, then the section modulus including the bracket has increased to such an extent that it is able to nullify the increase in bending moment and hence able to provide sufficient end rotation support.

2.1.2.b As mentioned in *2.1.2.a* the bracket has an immediate effect due to increase in shear area versus increase in shear force. The increase in shear area is independent of which side of the stiffer (face plate or attached plate) the bracket is fitted and hence reduction is given also for brackets fitted on the side of the attached plating.

2.1.2.c The minimum reduction in effective shear span is given to account for the pressure that is not transferred to the support through shear in the stiffener but that is transferred directly to the short edge of the panel. For a plate subject to pressure the load is transferred to the closest support. This effectively gives constant shear force along the last s/2 of the stiffener as the pressure applied to the plating at the last $s/2$ is transferred directly to the short edge which typically is the primary support member.

2.1.2.d For single skin structures FE analysis has shown that the tripping bracket has very little effect on the effective shear span. The reason is that that the tripping bracket will rotate as the structure is non-symmetric and there is no adjoining structure to restrict the rotation. The effect of the rotation is that the shear force will be slightly reduced at the stiffener end in way of toe of the tripping bracket but increased at the stiffener end in way of heel of the tripping bracket. As an alternative to using a reduced span with a correction for the rotation the rules require that the full span be used for the calculations.

2.1.2.e The span definition in case of brackets, as shown in *Figure 4.2.4 and 4.2.5 of the Rules* is based on ABS Rules(SVR 5-1-4/Figure 7).

2.1.3 Effect of hull form shape on span of local support members

2.1.3.a The definition of the length of the stiffener is in accordance with DNV Pt.3 Ch.1 Sec.6 A201 and ABS 5-1-4/7.5.

2.1.3.b For a stiffener in bending the smallest section modulus is typically at the face plate (free edge for flatbar) of the stiffener. Consequently the length is measured along the flange/free edge of the stiffener.

2.1.3.c Plates and stiffeners in ship structures are typically subject to pressures acting normal to the plate. When assessing curved plates and stiffeners the pressure is not corrected for the curvature effect but the length of the stiffener is corrected. The member is in other words assessed based on the projected length.

2.1.4 Effective bending span of primary support members

2.1.4.a The definition of bending span of primary support members is based on ABS Rules(SVR 5-1-4/Figure 8).

2.1.4.b The definition of the span is also related to the how the member is assessed. For a primary support subject to pressure loads the bending moment will increase towards the ends of the member. Where brackets are fitted the section modulus of a cross section will also increase when inside of the toe of the bracket. The objective of the Rule is to ensure that for any cross section along the length of the PSM that the capacity is greater than the acting load response, e.g. section modulus versus bending moment. In order to simplify the calculations the CSR Rules require that the section modulus clear of the bracket is assessed against the bending moment at the end of the effective span. In case of a continuous face plate as specified in *Section 4/2.1.4.3 of the Rules* the section modulus increases more quickly than for brackets without continuous face plate and this is reflected in the definition of the span.

2.1.4.c The 1:1.5 limit for the effective bracket defines the applicability of the assumption related to increase of section modulus versus increase of bending moment.

2.1.5 Effective shear span of primary support members

2.1.5.a The definition of shear span of primary support members is based on ABS Rules(SVR 5-1-4/Figure 7).

2.1.5.b For explanation of difference between effective bending and shear span see *2.1.2.a*.

2.2 Definition of Spacing and Supported Breadth

2.2.1 Supported load breadth of local support members

2.2.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

2.2.2 Spacing and supporting load breadth of primary support members

2.2.2.a The definition of spacing and supporting load breadth of primary support members is based on LR Rules Pt4 Ch1 Sec 1.5.

2.2.2.b For some structural arrangements the supporting load breadth also takes into account stiffness of neighbouring structure. Typical example is supporting load breadth for lower horizontal stringer on the transverse bulkhead.

2.2.3 Effective spacing of curved plating

2.2.3.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

2.3 Effective Breadth of Plating

2.3.1 Effective breadth of attached plate of local support members for strength evaluation

2.3.1.a The definition of effective breadth of local support members for strength evaluation is based on DNV Pt.3 Ch.1 Sec.3 C1001.

2.3.1.b The 600mm limit for the attached plating for thickness' less than 8mm is based on LR Rules Pt 3 Ch3 Sec 3. The associated limit thickness of 8mm has been adjusted compared to the limit give in the source Rules to account for the net thickness concept of the CSR Rules.

2.3.2 Effective breadth of attached plate and flanges of primary support members for strength evaluation

2.3.2.a The definition of effective breadth of attached plate and flanges of primary support members for strength evaluation is based on DNV Classification Note. 30.7 (Section 3.5.7). Pt.3 Ch.1 Sec.3 C1001. The theoretical background is based on "The Effective Breadth of Stiffened Plating Under Bending loads" by Henry Schade and presented in SNAME Vol. 59. The theoretical formulation has been verified by FE analysis.

2.3.2.b The effective breadth at the mid-span of a member is not the same as at the ends of a member (the end of the span). The formulations cover therefore the two locations separately. "At the end span" is defined in way of the end support of the stiffener/primary support member. This includes the length of the bracket. "At mid span" is defined as the portion of the stiffener/primary support member at the midpoint between the end supports.

2.3.3 Effective breadth of attached plate of local support members for fatigue strength evaluation

2.3.3.a The background for definition of effective breadth of attached plate and flanges of local support members for fatigue strength evaluation is as described in *Background to 2.3.2.*

2.3.4 Effective area of curved face plates or attached plating of primary support members

2.3.4.a The definition of effective area of curved face plates/attached plating of primary support members is based on DNV Rules Pt.3 Ch.1 Sec.3 C406-7.The theoretical background is based on a paper by R.W. Westrup and P. Silver: *Some Effects of Curvature on Frames*, Aero/Space Sciences, Sept. 1958.

2.3.4.b The formula represents the efficiency of a curved faceplate in terms of bending moment. The efficiency is given as a fraction of the area of the face plate. The reason for the correction is that a curvature gives a change of force direction. The moment capacity of a member with curved face plate is given by its possibility to transfer the change in shear to the face plate. The wider a curved face plate is the less efficient the section becomes. Similarly a small radius will given a larger change in force and hence less efficiency.

2.4 Geometrical Properties of Local Support Members

2.4.1 Calculation of net section properties for local support members

2.4.1.a Additional details with respect to reference point for calculation of actual section modulus is given in *Section 3/5.2.2.4 of the Rules.*

2.4.1.b Net section properties for rolled angles are calculated as for fabricated angles.

2.4.2 Effective elastic sectional properties of local support members

2.4.2.a The correction for the angle of stiffener web is based on DNV Pt 3 Ch.1 Sec.3 C1002 and gives the projected area of the stiffener along the axis which the applied pressure is acting (normal to the attached plating).

2.4.2.b The correction of section modulus due to the angle of the stiffener is based on DNV Pt 3 Ch.1 Sec.3 C1002 and gives an approximated correction of the section modulus about an axis that is parallel to the attached plating of the stiffener.

2.4.3 Effective plastic section modulus and shear area of stiffeners

2.4.3.a The he bf* and the tf* in Table 4.2.3 of the Rules are given in order that the net plastic section modulus of bulb profiles can be determined with consideration of the effect of the corrosion deduction (tcorr) and the fact that the web thickness of HP bulbs of given height is not a fixed number.

2.5 Geometrical Properties of Primary Support Members

2.5.1 Effective web area of primary support members

2.5.1.a The definition of effective web area of primary support members is based on DNV Rules Pt.3 Ch.1 Sec.3 C500.

2.5.1.b The moulded height is used as reference for ease of use as this is the web height normally given on the drawing. For stiffeners the thickness of the flanges is included in the calculation of effective shear area. The reason for the difference approach is that for stiffeners the thickness of the flanges contributes significantly to the total height of the member (typically 6-10%) while for primary support members the contribution is in the order of 1-2% and the simplification does not have a significant impact on the scantlings.

2.5.2 Effective section modulus of primary support members

2.5.2.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

2.6 Geometrical Properties of the Hull Girder Cross-Section

2.6.1 Vertical hull girder section modulus

2.6.1.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

2.6.2 Horizontal hull girder section modulus

2.6.2.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

2.6.3 Effective area for calculation of hull girder moment of inertia and section modulus

2.6.3.a The definition of effective hull girder sectional area, longitudinally continuous structural members and categorisation of openings to be deducted are based in IACS Unified Requirements S5.

2.6.3.b Definition of ineffective area in way of large openings and non-continuous decks and bulkheads is based on ABS Rules 3-2-1 9.3.

2.6.4 Effective vertical hull girder shear area

2.6.4.a It is considered that for this topic, no information in addition to that shown in the Rules, is necessary to explain the background.

3 STRUCTURAL DESIGN DETAILS

3.1 Standard Construction Details

3.1.1 Details to be submitted

3.1.1.a These requirements are based on ABS Rules 3-1-2/15.1.

3.2 Termination of Local Support Members

3.2.1 General

3.2.1.a The requirements are based on the paragraphs in ABS Rules 3-1-2/15.3 and 3-2-5/1.5, and DNV Rules Pt.3 Ch.1 Sec.3 C 201.

3.2.2 Longitudinal members

3.2.2.a The requirements are based on the paragraph in LR Rules Pt 3, Ch 5,4.1.2 and DNV Pt.3 Ch.1 Sec.8 A403.

3.2.3 Bracketed connections

3.2.3.a The requirements are based on the paragraphs in ABS Rules 3-2-5/1.5, LR Rules Pt 3, Ch 10,3.3.1 and 3.5.1. The scantlings formulas for the brackets are based on DNV Rules Pt.3 Ch.1 Sec.3 C200. The formulas are changed to net scantlings and to a ratio of yield stress instead of material factor in order to be in line with JTP philosophy. *Figure 4.3.1 of the Rules* clarifies the application of the requirements of *Section 4/ 3.2.3.3* and *3.2.3.4* of the Rules, based on LR and DNV practice.

3.2.4 Bracketless connections

3.2.4.a The requirements are based on the paragraphs in LR Rules Pt 3, Ch 10,3.1.1 and 3.5.2, and ABS Rules 3-2-5/1.5.

3.2.5 Sniped ends

3.2.5.a The requirements are based on the paragraphs in DNV Rules Pt.3 Ch.1 Sec.3 C 204 and ABS Rules 3-1-2/15.

3.2.5.b The equation is the same as the one presently used in the DNV Rules Pt.3 Ch.1 Sec.3 C 204, with the DNV corrosion addition, "t_k", removed.

3.2.6 Air and drain holes and scallops

3.2.6.a The basis of these requirements is LR Rules Pt 3, Ch 10,5.3.3. Text has been added to limit the 200 mm distance to a distance measured along the stiffener towards midspan and to limit the distance to 50mm in the opposite direction. *Figure 4.3.2* has been added to clarify this requirement. Also, the requirement has been modified to permit holes and scallops at locations of known low shear stress.

3.2.6.b The figures are copied from a general ship building standard in order to show some example of common shapes of scallops. The range of 0.5 to 1.0 for the ratio of a/b (as shown in *Figure 4.3.2* of the Rules) is based on experience and generally accepted practice.

3.2.7 Special requirements

3.2.7.a The requirements are in accordance with LR Rules Pt 3, Ch 10,5.3.3. Text has been added to clarify what is meant by closely spaced and to also make this requirement applicable to stiffeners that are not longitudinal strength members, consistent with present practice.

3.3 Termination of Primary Support Members

3.3.1 General

3.3.1.a The requirements are based on the paragraphs in LR Rules Pt 3, Ch 10,4.3.1 and 4.3.2.

3.3.2 End connection

3.3.2.a The requirements are based on the paragraphs in LR Rules Pt 3, Ch 10,4.3.3, 3.3.4 and 4.3.5 and DNV Rules Pt.3 Ch.1 Sec.3 C 301.

3.3.3 Brackets

3.3.3.a The requirements are based on the paragraphs in LR Rules Pt 4, Ch 9,10.13.1 and 10.13.2 and DNV Rules Pt.3 Ch.1 Sec.3 C302.

3.3.3.b The equation is the same as the equation in DNV Rules Pt.3 Ch.1 Sec.3 C302.

3.3.4 Bracket toes

3.3.4.a The requirements are based on the paragraphs in LR Rules Pt 3, Ch 10,5.1.6 and 5.1.7 and partly ABS Rules 3-1-2/15.3.

3.3.4.b The figure is copied from LR Rules Figure 10.5.1.

3.3.4.c DNV Rules Pt.3 Ch.1 Sec.3 C 304 is not included since the requirement is considered too specific and out of date. Design details and arrangement are (today) normally confirmed by FEM analysis, while the referred to rules have been in place for a long time.

3.4 Intersections of Continuous Local Support Members and Primary Support Members

3.4.1 General

3.4.1.a General requirements are in accordance with LR Rules Pt 3, Ch 10,5.2.1 except as noted below.

3.4.1.b *Section 4/3.4.1.4* of the Rules has been added by JTP. The objective of this requirement is to reduce the local stress at the connection of the longitudinal to the web-stiffener and is an implicit fatigue control. Ships in operation service records show problems with cracks in the coating and web stiffener itself at these connections. The problem is a combination of high and low cycle fatigue with the high cycle fatigue being the dominant factor for the side shell connections while the low cycle fatigue is the critical effect for the bottom and inner bottom longitudinals. The latter is a result of the loading and unloading of the vessel which gives high stress and strain at the heel of the web-stiffener. By providing a keyhole at the heel of the web-stiffener the local stress and strain at this location is significantly reduced and hence the probability of experiencing cracks in the web-stiffener or coating is significantly reduced. The requirement to provide a keyhole only applies to relatively highly stressed members, which have been defined here as 80% of the permissible stress. Connections with a double side bracket and connections at watertight bulkheads and where the primary support member web is welded to the stiffener face plate are considered to have local stresses at the heel of the web-stiffener such that the keyhole is not required.

3.4.2 Details of cut-outs

3.4.2.a The requirements are in accordance with LR Rules Pt 3, Ch 10,5.2.2.

3.4.3 Connection between primary support members and intersecting stiffeners (local support members)

3.4.3.a The requirements are derived from LR Rules Pt 3, Ch 10,5.2.3 to 5.2.15. The details of these requirements have been modified to take account of the JTP Rule development philosophy, in terms of net thickness, loads and acceptance criteria

3.4.3.b It is stressed that, with the exception of the keyhole detail the figures related to structural arrangements and details that are placed in the rules in association with these requirements are not design guidance or recommendations. The purpose of these figures is to illustrate symbols and definitions.

3.5 Openings

3.5.1 General

3.5.1.a The requirements are in based on LR Rules Pt 3, Ch 10,4.6.2 and 5.3.1, ABS Rules 5-1-4/11.17 and DNV Rules Pt.3 Ch.1 Sec.3 C 500 and C 600.

3.5.2 Manholes and lightening holes in single skin not requiring reinforcement

3.5.2.a The requirements are in accordance with LR Rules Pt 3, Ch 10,4.6.1.

3.5.3 Manholes and lightening holes in double skin not requiring reinforcement

3.5.3.a The requirements are in accordance with LR Rules Pt 4, Ch 1,8.2.8 and Pt 4, Ch 9,9.3.7.

3.5.4 Manholes and lightening holes requiring reinforcement

3.5.4.a The requirements are in accordance with DNV Rules Pt.3 Ch.1 Sec.3 C 606. The criteria have been updated to suit the JTP acceptance criteria sets.

3.5.4.b *Figure 5.4.3* of the Rules has been derived from a similar figure in DNV Rules.

3.5.4.c Similar requirements are contained in the ABS Rules 5-1-4/11.17 - When slots and lightening holes are cut in transverses, webs, floors, stringers and girders, they are to be kept well clear of other openings. The slots are to be neatly cut and well rounded. Lightening holes are to be located midway between the slots and at about one-third of the depth of the web from the shell, deck or bulkhead. Their diameters are not to exceed one-third the depth of the web. In general, lightening holes are not to be cut in those areas of webs, floors, stringers, girders, and transverses where the shear stresses are high.

3.6 Local Reinforcement

3.6.1 Reinforcement at knuckles

3.6.1.a The requirements are in accordance DNV Rules Pt.3 Ch.1 Sec.3 C700. The figure accompanying this text was selected, because it represents a typical knuckle found on tankers.

3.6.1.b General text has been included to clarify that some knuckles, such as main deck camber are, in general, exempted from the requirements of knuckle reinforcement because of their configuration and the manner in which they are loads.

3.6.2 Reinforcement for openings and attachments associated with means of access for inspection purposes

3.6.2.a This is a general requirement to note that structural elements which have access cut outs included in them are to be reinforced as necessary. Similarly attachment points for access walkways, hand grabs, etc., are to be kept clear of stress concentration points. Where the loads imposed on the structure are large then suitable reinforcement is to be provided.

3.7 Fatigue Strength

3.7.1 General

3.7.1.a It is considered that for this topic, no information in addition to that shown in the Rules is necessary to explain the background.