Common Structural Rules for
Bulk Carriers and Oil Tankers

Technical Background for Urgent Rule Change Notice 1 to 01 JAN 2015 version

Rule Change Notice

1. Introduction

IACS developed 'Common Structural Rules for Bulk Carriers and Oil Tankers' CSR [1] which were based on the single IACS Rules books 'Common Structural Rules for Oil Tankers' (2006) and 'Common Structural Rules for Bulk Carriers' (2006). The current CSR were entered into force in 2015.

The IACS CSR was submitted in December 2014 to IMO for auditing according to the IMO International Goal-Based Ship Construction Standards for Bulk Carriers and Oil Tankers (Resolution MSC 287(87)). The audit was conducted by IMO during 2015 and the audit results were reported to MSC 96 (MSC 96/5), [2]. Load and fatigue issues have been managed by audit team no. 5. Non-conformities as well as observations were identified and in response to that IACS developed corrective action plans, which were submitted to MSC 96 [3].

In total three load and fatigue related non-conformities (NCs) were identified which are rectified by Rule changes [4]. The related general technical background is handled in this document i.e.

- NC01, Non-uniform ship heading probability distribution (Section 2)
- NC03, Fraction of time in heavy ballast loading condition for BC-B and BC-C ships with L < 200 m (Section 3)
- NC04, Time in corrosive environment (Section 4)

The following presents the Rules to be changed, which are affected by the same reason:

Part	Chapter	Section	Paragraph/Table	Referring to:
1	4	4	Symbols	Heading correction factor
1	4	5	1.3.2	Hydrodynamic pressures for HSM load cases
1	4	5	1.3.4	Hydrodynamic pressures for FSM load cases
1	5	1	Symbols	Heading correction factor
1	5	1	2.2.2/Table 2	Normal stresses induced by vertical bending moments
1	5	1	2.4.1/Table 3	Hull girder stresses at baseline and moulded deck line
1	5	1	3.3.1	Permissible vertical shear force
1	5	2	2.2.1	Hull girder ultimate bending loads
1	9	1	Table 3	Fraction of time in heavy ballast condition
1	9	3	Table 5	Time in corrosive environment

2. Non-uniform ship heading probability distribution

(2015 GBS audit IACS/2015/FR1-8/NC 01)

2.1. Reason for the Rule Change

The methodology used to develop the equivalent design wave for extreme design loads was audited by IMO. The auditors objected to the "Equal heading probability" (i.e. uniform distribution) used in the methodology and issued the Non-conformity No.: IACS/2015/FR1-8/NC/01 [2].

In order to rectify this Non-conformity IACS conducted a study of how different assumptions affect the development of the non-uniform ship heading distributions.

Different assumptions/approaches were applied, but all yielded a quite similar ratio of M_{wv}(*non-uniform*)/M_{wv}(*uniform*) and Q_{wv}(*non-uniform*)/Q_{wv}(*uniform*), not exceeding the value 1.05.

Therefore heading correction factor f_β = 1.05 for HSM and FSM load cases for the extreme sea loads design load scenario was offered as the Rules Change Notice.

2.2. Background

A sensitivity analysis using different assumptions/approaches was applied:

- to develop the non-uniform ship heading distributions; and
- to compute the ratio of M_{wv}(*non-uniform*)/M_{wv}(*uniform*) for wave vertical bending moment M_{wv} (similarly on vertical wave shear force Q_{wv}).

The ratio M_{wv}(*non-uniform*)/M_{wv}(*uniform*) determines the impact of the non-uniform distribution on computed M_{wv} (similarly on vertical wave shear force Q_{wv}).

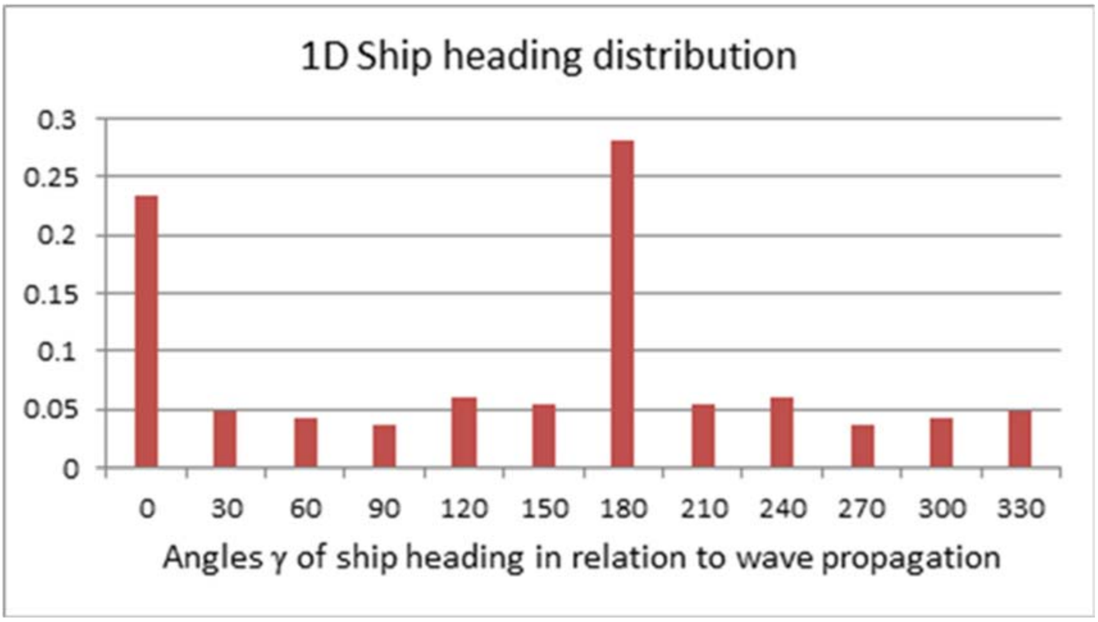
The development of non-uniform ship heading distributions based on the sensitivity analysis is presented in Technical Background report [5]. The examples of the developed ship heading distributions based on different approaches are presented in Figure 1 and Figure 2, which come directly from the Technical Background report [5].

Lack of field data does not allow a decision as to which of the assumption is the most accurate. Nevertheless, the impact on the M_{wv} and Q_{wv} for different ship heading distributions is quite similar, and does not exceed 5%.

Based on the computations of M_{wv}(*non-uniform*)/M_{wv}(*uniform*), the heading correction factor f_β (Pt1 Ch. 4 Sec 4) was thus set on the conservative level: f_β = 1.05 for HSM and FSM in the extreme sea loads design scenario.

The 1D non-uniform ship heading distribution yields greater results for M_{wv}, Q_{wv} than the 1D uniform distribution (the uniform distribution is optimistic). For other responses, such as for example M_{wh} (horizontal bending moment), M_{wt} (wave torsional moment), p (dynamic pressure), this relationship is reversed (the uniform distribution is conservative).

(a)



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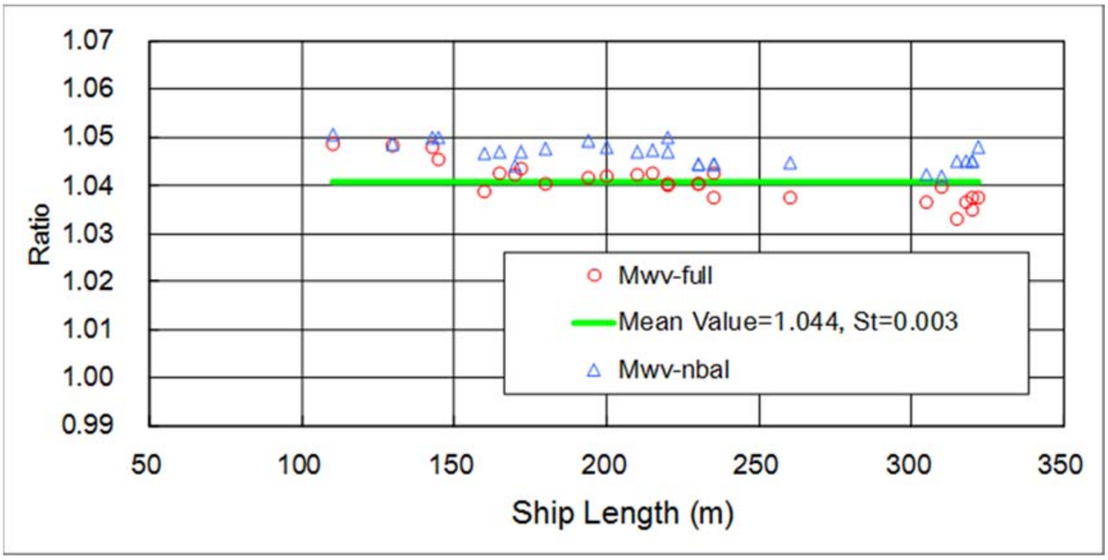
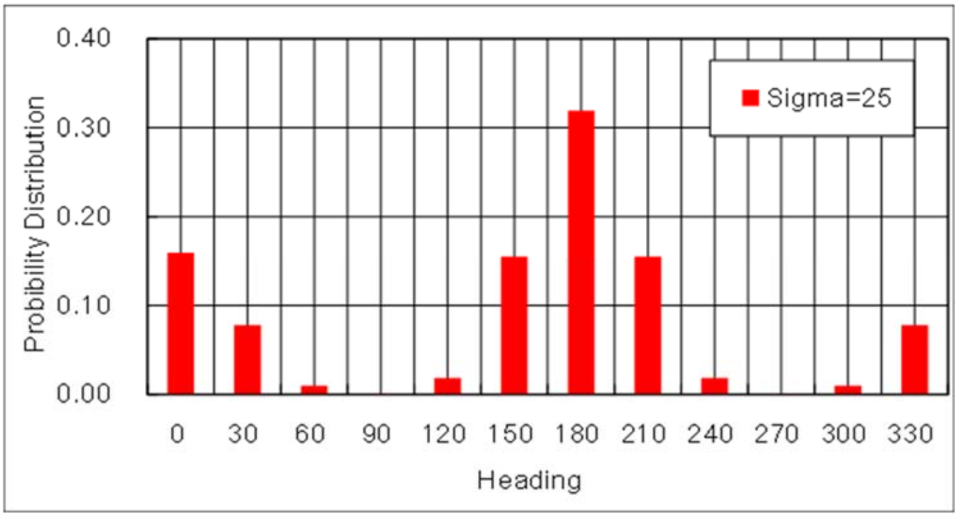


Figure 1:

(a) 1D non-uniform ship heading distribution based on criteria and good seamanship;
(b) Computed ratio M_{wv}(*non-uniform*)/M_{wv}(*uniform*) for bulk carriers and tankers of different size based on this distribution

(a)



(b)

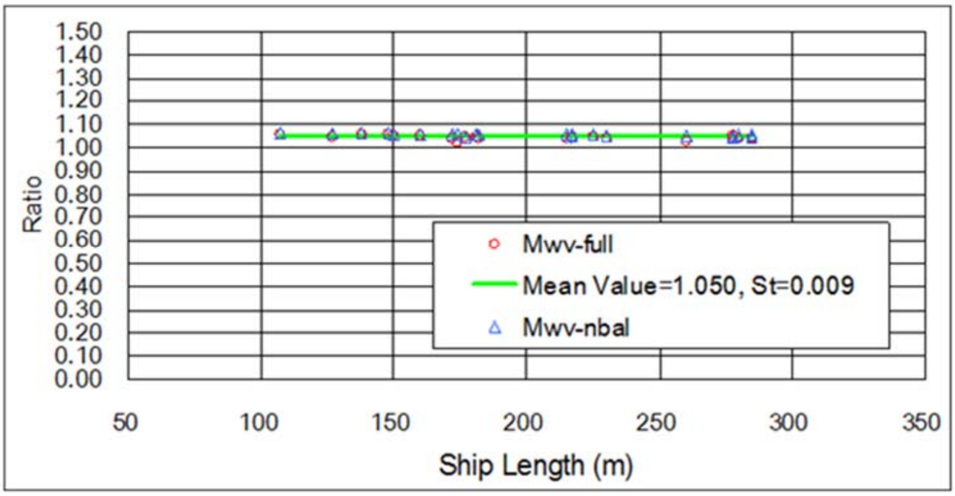


Figure 2:

(a) 1D non-uniform ship heading distribution developed using heuristic approach;
(b) Computed ratio M_{wv}(*non-uniform*)/M_{wv}(*uniform*) for bulk carriers and tankers of different size based on this distribution

2.3. Urgent Rule Change Notice

The developed heading corrective factor f_β = 1.05 for HSM and FSM in the extreme sea loads design scenario was used to change the Rules. The changed Rules are proposed in [6] and [4].

The heading corrective factor f_β as determined in Ch 4, SEC 4, HULL GIRDER LOADS, SYMBOLS; after Rules change [4], used in determining the hull girder loads, external loads and internal loads, occurs in the following requirements of the CSR:

- Ch 4, Sec 4 Hull girder loads: [3.5.2], [3.5.3];
- Ch 4, Sec 5 External loads: [2.3.1], [2.3.2];
- Ch 4, Sec 6 Internal loads: [1.3.1], [1.5.1], [2.4.3], [2.5.3], [2.5.4], [5.2.1], [5.3.1];
- Ch 7, Sec 2 Cargo Hold Structural Strength Analysis: [4.3.3].

2.4. Impact in Scantlings

A consequence assessment of the impact of the Rules Change Notice in the form of heading correction factor f_β = 1.05 [6] on the ship scantlings was performed.

The consequence assessment was conducted for 9 ships – 6 bulk carriers and 3 oil tankers of different size. The ships are pre-harmonised CSR designs (either CSR OT or CSR BC).

The requirements of CSR BC&OT, January 2015 release, and requirements of the Rules with proposed heading correction factor f_β=1.05 for HSM and FSM in extreme sea loads design scenario, as presented in the URCN, were applied to the structures of these ships in the consequence assessment.

The conclusions of the consequence assessment performed are as follows:

2.4.1. Hull girder strength

In Ch 5, Sec 1 HULL GIRDER STRENGTH ([2.2.2], [2.4.1], [3.3.1]); f_β=1.05 is applied for seagoing condition.

$Z_{\text{required by CSR BC\&OT}}/Z_{\text{required by 1.05 CSR BC\&OT}}$ is equal to 0.98, where 1.05 CSR BC&OT is the Rules incorporating the effect of non-uniform ship heading distribution introduced by the proposed heading correction factor f_β = 1.05.

For assessed ships the offered hull section modulus is greater than the section modulus required by the changed Rules.

The criterion for permissible vertical shear forces (CSR BC&OT Ch 5, Sec 1 [3.3.1]) is not satisfied for two BCs (pre-CSR BC&OT Cape and Panamax size designs), because the total vertical hull girder shear capacity Q_R is insufficient. However, after adjusting Q_R to meet the criterion for $|Qsw|/(|QR|-|QWV|) = 1$ the difference between CSR BC&OT and 1.05 CSR BC&OT requirements is 2.5% for Cape size BC and 1.5% for Panamax size BC.

The increase in the hull girder strength requirements based on CSR BC&OT and 1.05 CSR BC&OT (as presented in section 2 of the Report [6]) is around 2%.

2.4.2. Hull girder ultimate strength

In Ch 5, Sec 2, 2. CHECKING CRITERIA, [2.2.1]; f_β=1.05 is applied for seagoing condition.

In general, for all ships except one bulk carrier, the load utilization factor $LUF=M/(M_U/\gamma_R) \leqslant 1$.

The LUF at midship region of one Capesize bulk carrier in hogging condition exceeds requirements of both CSR BC&OT and 1.05 CSR BC&OT. If the ship fulfil the CSR BC&OT requirements then the increase of the LUF due to the Rules Change Notice will be about 3%.

The computations show that the increase of the LUF due to the Rules Change Notice in the scope of hull girder ultimate strength is as follows:

- the midship region: 3.0% for Capesize BC, and about 2.0% for other ship sizes;
- hold No. 1: 1.0% for Capesize BC and 0.6% for Panamax OT;
- the aft most hold/tank: is around 2.0%.

2.4.3. Hull local scantling

Hull local scantling requirements are affected by: Ch 4, Sec 4, 3. DYNAMIC HULL GIRDER LOADS, [3.5.2 – Table 1 and 3.5.3 – Table 2] and Sec 5, 1. SEA PRESSURE [1.3.2] and [1.3.4] where f_β as determined in URCN is applied, and also through the requirements presented in Sec. 2.3.

The computations show that the impact of the Rules Change Notice on local scantlings is as follows:

- slight impact only on the bottom plating adjacent to bilge plating (increase of 0.5 mm for Capesize BC midship region). No other impact was identified.
- slight impact on longitudinal stiffeners (bottom, inner bottom, double bottom girder web stiffener, deck zone longitudinal stiffener); the section modulus required may be increased by 1% to 5%.

2.4.4. Direct strength analysis

The direct strength analysis is affected by: Ch 4, Sec 4, 3. DYNAMIC HULL GIRDER LOADS, [3.5.2 – Table 1 and 3.5.3 – Table 2], Sec 5, 1. SEA PRESSURE [1.3.2] and [1.3.4] where f_β as determined in URCN is applied, and also through the requirements presented in section 2.3.

Some minor increase of scantlings is observed.

3. Fraction of time in heavy ballast loading condition for BC-B and BC-C ships with L<200 m (2015 GBS audit IACS/2015/FR1-8/NC 03)

In this chapter non-conformity NC03 is handled which deals with the fraction of time in heavy ballast loading condition for BC-B and BC-C ships with L < 200 m. It is stated that this fraction of time is too small, see audit report [2].

Following an industry response to an IACS survey, a fraction of 25% may be considered more realistic than the Rule value of 15% applied prior to this Rule change.

Based on this 25% value an impact analysis using selected bulk carriers has been performed.

The number of bulk carrier of BC-B/C with heavy ballast hold whose length is less than 200m is very limited. Therefore, two bulk carriers of BC-A were selected as the subject ships to be assessed. The impact analyses were carried out by increasing the fraction of time in the heavy ballast condition from 15% to 25% (the fraction of time in the normal ballast condition was decreased from 15% to 5%) based on the results of questionnaire to the ship owners.

Impact of increasing the fraction of time of heavy ballast condition to fatigue strength of longitudinal stiffener is different depending on the location of longitudinal stiffener and the kind of tank since the dominant load component is different. In general, the calculated fatigue life of upper part longitudinal stiffener tends to become longer but the calculated fatigue life of lower part longitudinal stiffener tends to become shorter. On the end connection of longitudinal stiffener, the impact of increasing the fraction of heavy ballast condition on the scantling is small and limited to only a few locations.

On the lower stool and bilge hopper knuckle in heavy ballast hold, the absolute impact of increasing the fraction of time of heavy ballast condition is significant since the internal pressure is the dominant load component for these structures; however it is seen that according to the offered scantlings of the two analysed ships, some hot spots were already failing the requirement after re-assessing the structures with the current CSR (1st Jan 2015) and the increased fraction in heavy ballast did not apparently cause any additional locations to fail.

A more comprehensive technical background is given in [7].

4. Time in corrosive environment

(2015 GBS audit IACS/2015/FR1-8/NC 04)

In this chapter non-conformity NC04 which deals with the fraction of time to be assumed in a corrosive environment is addressed. In the audit finding it is stated that this fraction of time is too small, see audit report [2].

In the current rule (prior to this Rule Change) the time assumed in a corrosive environment is 2 or 5 years, depending on the compartment under consideration. To rectify this non-conformity these periods are roughly doubled i.e. 2 years are increased to 5 years and 5 years to 10 years.

Based on this an impact analysis using selected bulk carriers and oil tankers has been performed. It can be summarised as follows.

The results from the application of the increased time in corrosive environment on a number of test ships, at 5 and 10 years, leads to the following conclusions:

- The rule requirement becomes more severe: the average reduction of calculated fatigue life is in the range of 5 to 11 %.
- Considering the offered scantlings, in general there is a small impact on scantlings i.e. only a few details dropped down from above the rule requirement of 25 years to below.
- For tankers: the most significant impact is in way of the bottom. The VLCC is the ship type having the largest impact.
- For bulk carriers: the most significant impact is in way of the deck, top-wing sloping plate and side.

In terms of structural modifications envisaged to match the more severe fatigue demand, although not systematically performed, it is foreseen that, in general, localised modifications would be sufficient, by:

- Improvement of stiffeners end details (lower SCFs referring to table 4 of Pt 1 Ch 9 Sec 4), e.g. brackets, soft toes, soft heels.
- Improvement of detail's design for primary members (weld size and configuration, insert plates)

However, for a few deck longitudinals of bulk carriers there may be the case where a slightly increased hull girder section modulus may be required to provide the required design life.

Instead of an improved local fatigue design or in cases of high fatigue utilisation a plate thickness increase is an appropriate counter measure. In chapter 3.10 of [8] it is outlined for two selected ships that the plate thickness increase needed is 3 mm or less. But this cannot be generalised as it depends on the design.

During the impact study mentioned in 3.10 of [8], it has been observed that the deck plating thickness increase has been necessitated by a SCF (stress concentration factor) assigned to tripping bracket soft toes which is more onerous than standard flat bar attachment soft toes.

As this is a departure from both the IACS CSR-OT and CSR-BC Rules, IACS will further investigate the technical background to this as a separate matter. If a lower SCF is found to be justified, the actual impact will be smaller than reported here-in.

A more comprehensive technical background is given in [8].

5. References

1. IACS Common Structural Rules for Bulk Carriers and Oil Tankers, January 2015
2. MSC 96/5 Annex 13, GBS Audit Team 5 Report on IACS Common Packages Regarding GBS Functional Requirements 1-8, IMO, 2016
3. MSC 96/5/1, MSC 96/5/1 Add.1, MSC 96/5/1 Add.2 Corrective Action Plans submitted by IACS and its member recognized organizations (Part 1 to 3), Note by the Secretariat, IMO, 2016
4. IACS CSR Urgent Rule Change Notice 1, IACS, London, 2016
5. CSR URCN1 TB Report(1) for NC01: The impact of non-uniform ship heading probability distributions, used in the sensitivity analysis of assumptions of the long-term wave loads, on CSRH, IACS, London, 2016.
6. CSR URCN1 TB Report(2) for NC01: Rules Change Notice incorporating effect of non-uniform ship heading distributions and consequence assessment of the change on the Rule scantlings, IACS, London, 2016.
7. CSR URCN1 TB Report for NC03: Fraction of time in heavy ballast loading condition for BC-B and BC-C ships with L < 200 m (2015 GBS audit IACS/2015/FR1-8/NC 03), IACS, London, 2016.
8. CSR URCN1 TB Report for NC04: Time in corrosive environment (2015 GBS audit IACS/2015/FR1-8/NC 04), IACS, London, 2016.