Consequence Assessment on Harmonized CSR (April version) from Chinese Shipbuilding Industry

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China Association of the National Shipbuilding Industry
(CANSI)
Agenda

- Introduction
- Consequence Assessment for Oil Tankers
- Consequence Assessment for Bulk Carriers
- Technical issues on CSR-H
- Conclusions
Introduction – Status/Schedule

Common Structural Rules for Bulk Carriers and Oil Tankers

● CSR-H Status:
  ➢ 2 periods of Industry external review have been finished
  ➢ Still some issues to be revised

● CSR-H Schedule:
  ➢ Class TC review from 1 Nov 2013 to 15 Dec 2013
  ➢ IACS Adoption at the end of 2013
  ➢ Release Rules on 1 Feb 2014
Introduction – Principles

- Basic principles for CSR harmonization
  - At the adoption of the original Rules (CSR), to harmonize them based on a consistent methodology
  - Will be in compliance with the IMO Goal Based Standards where GBS Functional Requirements fall within the scope of CSR-H
  - The level of the harmonized Rule criteria in relation to the current CSR will be equivalent to or higher than the current CSR criteria. The scantlings will be used as a proxy for level of structural safety.
# Introduction – CA by CANSI

<table>
<thead>
<tr>
<th>Type</th>
<th>$L_{BP}$</th>
<th>$B$</th>
<th>$D$</th>
<th>$T_s$</th>
<th>$DWT$</th>
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<td>22.5</td>
<td>320K</td>
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<td>20.3</td>
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<td>Post Panamax</td>
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<td>Panamax</td>
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<tr>
<td>Handymax1</td>
<td>185</td>
<td>32.26</td>
<td>18</td>
<td>12.8</td>
<td>57K</td>
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<tr>
<td>Handymax2</td>
<td>172</td>
<td>30</td>
<td>14.7</td>
<td>10.1</td>
<td>35K</td>
</tr>
</tbody>
</table>
Introduction

Consequence Assessment for Oil Tankers

- 320K VLCC

Consequence Assessment for Bulk Carriers

Technical issues on CSR-H

Conclusions
VLCC – Midship: Prescriptive Requirement

For Plates: [mm]

CSRH – As-built

For Stiffeners: [%]

(CSRH – As-built) / As-built
The main reasons is:
1. internal loads increased compared to CSR-OT,
2. the yielding criteria of oil tanker decreased.
VLCC – Midship: FEM buckling

Longitudinal BHD

UF=1.10

Inner Longi. BHD

UF=1.44

Typ. PSM

UF=1.39

Deck

UF=1.07

2013-11-07
VLCC – Foremost CT: Prescriptive

For Plates: [mm]

CSRH – As-built

For Stiffeners: [%]

(CSRH – As-built) / As-built
VLCC – Foremost CT: FEM yielding

Deck

Longitudinal BHD

UF=1.02

Typ. PSM

Horiz. Girder

UF=1.26

UF=1.18

UF=1.26

UF=1.21
VLCC – Foremost CT: FEM buckling

Bottom shell

Deck

Inner hull longi. BHD

UF=1.21

UF=2.56

UF=2.54

UF=1.30
VLCC – Aftmost CT: Prescriptive

For Plates: [mm]

CSRH – As-built

For Stiffeners: [%]

(CSRH – As-built) / As-built
VLCC – Aftmost CT: FEM yielding

Shell

UF = 1.31

Inner hull longi. BHD

UF = 2.06

Longi. BHD

UF = 1.60

Trans. members

UF = 1.29
VLCC – Aftmost CT: FEM buckling

Shell

Longi. BHD

Deck

Inner Hull longi. BHD

UF = 1.28

UF = 1.52

UF = 1.82

UF = 1.77
Other parts including fore and aft ends have no change compared with CSR.
VLCC – Summary for CA

- Sheer strake, stringer plating in DH and shell plating in machinery space and aft are increased due to higher Rule Min. thickness.
- Boundaries of cargo tanks is 0.5~1.0mm increased for plating and about 10% increased for section modulus of stiffeners due to increased local pressure.
- Buckling utilization factor for stiffeners in upper deck and below 0.1D from deck is increased due to prescriptive buckling requirement.
- For midship area, FE yielding is of less impact except for PSM, while FE buckling will induce increasing for some structural members.
- For foremost and aftmost cargo tank, FE yielding is dominant for some local area, while FE buckling will induce much increasing.
Introduction

Consequence Assessment for Oil Tankers

Consequence Assessment for Bulk Carriers

- Panamax Bulk Carrier

Technical issues on CSR-H

Conclusions
Panamax BC - Midship: Empty hold

For Plates: [mm]

HCSR-As built

For Stiffeners: [%]

(HCSR-As built)/As-built

Grab notation is GRAB[20] by CSR-BC
Panamax BC - Midship: FE Buckling

**Outer shell (buckling)**

**Side Shell (Buckling)**

Empty C.H
Panamax BC - Midship: Loaded hold

For Plates: [mm]

HCSR-As built

For Stiffeners: [%]

(HCSR-As built)/As-built

Grab notation is GRAB[20] by CSR-BC
Panamax BC - Midship: FE Buckling

Outer shell (buckling)  Side Shell (Buckling)

Loaded C.H  Loaded C.H
Panamax BC - Foremost: Prescriptive

For Plates: [mm]

HCSR-As built

For Stiffeners: [%]

(HCSR-As built)/As-built

Grab notation is GRAB[20] by CSR-BC
Panamax BC - Foremost: FE yielding

Shell: UF = 1.21

Trans. BHD: UF = 2.16

Topside slant plating: UF = 1.58

Hopper: UF = 1.57
Panamax BC - Foremost: FE buckling

Shell

UF<1

Single Side Shell

UF<1

Deck

UF=1.36

Upper stool plating

UF=1.13
Panamax BC - Aftmost: Prescriptive

For Plates: [mm]  
HCSR-As built

For Stiffeners: [%]  
(HCSR-As built)/As-built

Grab notation is GRAB[20] by CSR-BC
Panamax BC - Aftmost: FE yielding

Shell

Hopper plating
Panamax BC - Aftmost: FE buckling

- Shell: UF=1.12
- Single side Shell: UF=1.31
- Deck: UF=1.34
- Inner Bottom: UF=1.38
Panamax BC - Aftmost: FE buckling

Corrugated BHD
UF=1.04

Machinery space
Fore. BHD
UF=2.98

DB floor
UF=1.61
Panamax BC – Fore/Aft end: Prescriptive

For Plates: [mm]

HCSR-As built

For Plates: [mm]

HCSR-As built

For stiffeners, no change compared with CSR.
Panamax BC – Machinery Space: Prescriptive

For Plates: [mm]  
HCSR-As built

For Stiffeners: [%]  
(HCSR-As built)/As-built
Panamax BC – Summary for CA

- Harbour design load scenario would impact hull girder ultimate strength and some local structural members.
- GRAB requirement for IB, Hopper and lower stool plate is dominant, especially for empty hold due to higher grab weight, and will induce 0.5~2.5mm increase.
- Buckling utilization factor for stiffeners in topside slop plate below 0.1D from deck is increased due to prescriptive buckling requirement.
- Although revised and improved in the 2nd draft version of CSR-H,
  - Fatigue of the longitudinals on strength deck and within 0.1D below deck at side is still a big problem for bulk carriers;
  - Side shell buckling for Panamax is still a big problem for midship area.
- For aftmost cargo hold, FE yielding is dominant for some local area, while FE buckling will induce much increasing.
Introduction

Consequence Assessment for Oil Tankers

Consequence Assessment for Bulk Carriers

Technical issues on CSR-H

- Weight Increase
- Hull girder ultimate strength
- FEA - Foremost cargo hold/tank
- Fatigue issues on:
  - longitudinal connections
  - Hot spot
- Rule Min. thickness requirement
- Prescriptive buckling of longi.

Conclusions
Weight Increase for OT

- Weight increase percentage: about 1%~2% within mid cargo region based on April version

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Size</th>
<th>VLCC</th>
<th>Suezmax</th>
<th>Aframax</th>
<th>Panamax</th>
<th>MR</th>
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<tbody>
<tr>
<td>Prescriptive requirement</td>
<td></td>
<td>+182</td>
<td>+50</td>
<td>+74</td>
<td>+11</td>
<td>+15</td>
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<tr>
<td>FEA</td>
<td></td>
<td>+38</td>
<td>+45</td>
<td>+31</td>
<td>+41</td>
<td>+26</td>
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<tr>
<td>Total</td>
<td></td>
<td>+220</td>
<td>+95</td>
<td>+105</td>
<td>+52</td>
<td>+41</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>1.2%</td>
<td>0.8%</td>
<td>1.9%</td>
<td>1.0%</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

- The detail dominant criteria:
  - Min. Rule thickness requirement
  - Local pressure
  - Buckling issue: prescriptive buckling for longitudinals and FE buckling
Weight Increase for BC

- Weight increase within mid cargo region based on April version

<table>
<thead>
<tr>
<th>Size</th>
<th>C/H</th>
<th>206K</th>
<th>180K</th>
<th>118K</th>
<th>87K</th>
<th>82K</th>
<th>57K</th>
<th>35K</th>
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</thead>
<tbody>
<tr>
<td>Typ. Empty C/H</td>
<td>+70.1</td>
<td>+90</td>
<td>+27.5</td>
<td>+42</td>
<td>+37</td>
<td>+40.6</td>
<td>+27.5</td>
<td></td>
</tr>
<tr>
<td>Typ. Loaded C/H</td>
<td>+53.1</td>
<td>+75</td>
<td>+26.2</td>
<td>+32</td>
<td>+25</td>
<td>+32.6</td>
<td>+16.9</td>
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<tr>
<td>Typ. Ballast C/H</td>
<td>+32.1</td>
<td>+80</td>
<td>+26.2</td>
<td>+39</td>
<td>+33</td>
<td>+32.6</td>
<td>+16.9</td>
<td></td>
</tr>
</tbody>
</table>

- The detail dominant criteria:
  - GRAB: the formula to determine the plate thickness will be modified, heard from 2013 Tripartite Meeting.
  - Harbour condition for hull girder strength and local scantling
  - Side shell buckling
  - Buckling issue: prescriptive buckling for longitudinals and FE buckling
  - Fatigue issue
## Rule Min. thickness for OT

<table>
<thead>
<tr>
<th>Elements</th>
<th>Scantling locations</th>
<th>Areas</th>
<th>CSR-H</th>
<th>CSR-OT</th>
<th>Impact on Oil Tankers and brief explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. net thickness for plating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shell</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keel</td>
<td></td>
<td></td>
<td>7.5+0.03L₂</td>
<td>6.5+0.03L₂</td>
<td>0.5~1.0mm ↑ for all OTs with longi. centerline BHD</td>
</tr>
<tr>
<td>Bottom/Side shell/Bilge</td>
<td>Machinery space/ Aft part</td>
<td></td>
<td>7.0+0.03L₂</td>
<td>4.5+0.03L₂</td>
<td>0.5~2.0mm ↑ except shell plating connected with stern frame</td>
</tr>
<tr>
<td></td>
<td>Cargo area</td>
<td></td>
<td>5.5+0.03L₂</td>
<td>4.5+0.02L₂</td>
<td>0.5~1.0mm ↑ for regions outside fender contact zone</td>
</tr>
<tr>
<td>Inner bottom</td>
<td></td>
<td>Cargo area</td>
<td>5.5+0.03L₂</td>
<td>4.5+0.02L₂</td>
<td></td>
</tr>
<tr>
<td>● 0.5mm ↑ for some Suezmax</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>● If IB plating with HT36, more increasing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. net thickness for Primary Support Members (PSM)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other bottom girder</td>
<td>Fore part</td>
<td></td>
<td>0.7L₂^{1/2}</td>
<td>5.5+0.02L₂</td>
<td>0.5mm ↑ for local areas</td>
</tr>
<tr>
<td>Bottom floor</td>
<td>Fore part</td>
<td></td>
<td>0.7L₂^{1/2}</td>
<td>5.5+0.02L₂</td>
<td>0.5mm ↑ for local areas</td>
</tr>
<tr>
<td>Aft peak floor</td>
<td></td>
<td></td>
<td>0.7L₂^{1/2}</td>
<td>5.5+0.02L₂</td>
<td>0.5mm ↑</td>
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<tr>
<td>Web plates of other PSM in double hull</td>
<td>Cargo Area</td>
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<td>0.6L₂^{1/2}</td>
<td>5.0+0.015L₂</td>
<td>0.5~1.0mm ↑ for upper part of side trans. and platforms in DH</td>
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<tr>
<td>Web and flanges of other PSM</td>
<td>Aft part/Fore part</td>
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<td>0.7L₂^{1/2}</td>
<td>6.5+0.015L₂</td>
<td>0.5~1.0mm ↑</td>
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<td>Web and flanges of other PSM</td>
<td>Elsewhere</td>
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<td>0.6L₂^{1/2}</td>
<td>5.5+0.015L₂</td>
<td>Only for VLCC:</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>● 0.5mm ↑ for deck trans. and upper part of vert. trans. in C.O.T.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>● 0.5mm ↑ for PSM in machinery space</td>
</tr>
</tbody>
</table>

For OTs with longi. centerline BHD, such increase is not necessary!

Tapering for shell plating:
- Hull girder strength
- Material?
- longitudinal spacing?

Not reasonable for OTs, especially for IB with HT36

Necessary?

From 2013 Tripartite Meeting, the Rule Min. thickness requirement for PSM in cargo tank area is prescribed separately. Different from double hull or other PSM in cargo tank?
# Rule Min. thickness for BC

## Proposal 1:
Lower the requirement for shell plating in machinery space and aft part;

## Proposal 2:
Separate the requirement for OT and BC for keel plate, inner bottom, PSM in cargo tank area.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Scantling locations</th>
<th>Areas</th>
<th>CSR-H</th>
<th>CSR-BC</th>
<th>Impact on Bulk carriers and brief explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. net thickness for plating</td>
<td>Fore Part</td>
<td>6.5+0.03L₂</td>
<td>0.85L₁²</td>
<td>0.5mm ↑ for some Panamax and Handysize with HT32 used</td>
<td></td>
</tr>
<tr>
<td>Shell</td>
<td>Side shell/ Bilge</td>
<td>Machinery space/ Aft part</td>
<td>7.0+0.03L₂</td>
<td></td>
<td>• 0.5-1.0mm ↑ for most bulk carriers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• If plating with HT36, more increasing</td>
</tr>
<tr>
<td>Deck</td>
<td>Platform deck</td>
<td>Machinery space</td>
<td>3.3+0.0067s</td>
<td>6.5</td>
<td>A great increase (up to 2.5mm ↑) for some bulk carriers</td>
</tr>
<tr>
<td>Other</td>
<td>Other plates in general</td>
<td></td>
<td>4.5+0.01L₂</td>
<td>None</td>
<td>A great increase (up to 2.5mm ↑) for some bulk carriers</td>
</tr>
</tbody>
</table>

**Min. net thickness for Primary Support Members (PSM)**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Scantling locations</th>
<th>Areas</th>
<th>CSR-H</th>
<th>CSR-BC</th>
<th>Impact on Bulk carriers and brief explanation</th>
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</thead>
<tbody>
<tr>
<td>D.B centerline girder</td>
<td>Elsewhere (excl. Machinery space)</td>
<td>5.5+0.025L₂</td>
<td>0.6L₁²</td>
<td>1.5-2.0mm ↑ for most bulk carriers, generally in pipe tunnel or foremost CFI</td>
<td></td>
</tr>
<tr>
<td>Other bottom girder</td>
<td>Elsewhere (excl. Machinery space/ Fore part)</td>
<td>5.5+0.02L₂</td>
<td>0.6L₁²</td>
<td>0.5-1.0mm ↑ for most bulk carriers, but only local areas in the middle of each cargo hold</td>
<td></td>
</tr>
</tbody>
</table>

Tapering for shell plating:
- Hull girder strength
- Material?
- Longitudinal spacing?
Hull girder ultimate strength

\[ M = \gamma_S M_{sw-u} + \gamma_W M_{wv} \quad M \leq \frac{M_U}{\gamma_R} \]

\[ \gamma_R : \text{Partial safety factor} \]

\[ \gamma_R = \gamma_M \cdot \gamma_{DB} \]

<table>
<thead>
<tr>
<th>CSR</th>
<th>(\gamma_R = 1.1)</th>
<th>Hogging</th>
<th>Sagging</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSR-H</td>
<td>(\gamma_R = \gamma_M \cdot \gamma_{DB})</td>
<td>BC-A</td>
<td>BC-B, BC-C, OT</td>
</tr>
<tr>
<td></td>
<td>(\gamma_M = 1.1)</td>
<td>(\gamma_{DB} = 1.25)</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>(\gamma_R = 1.375)</td>
<td>1.21</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>CSR-H/CSR for (\gamma_R)</td>
<td>1.25</td>
<td>1.1</td>
</tr>
</tbody>
</table>
For **sagging condition**, the same requirement for hull girder ultimate strength by CSR-H and CSR except for the calculation of Mu.

For **hogging condition**:
- If $\frac{M}{\mu} \leq 0.727 \ (\frac{M}{\mu/\gamma R} \leq 0.8)$ for BC-A bulk carriers by CSR, such carriers could meet the hull girder ultimate strength requirement by CSR-H;
- If $\frac{M}{\mu} \leq 0.826 \ (\frac{M}{\mu/\gamma R} \leq 0.9)$ for oil tankers and BC-B and BC-C bulk carriers by CSR, such carriers could meet the hull girder ultimate strength requirement by CSR-H;

<table>
<thead>
<tr>
<th>Vessels</th>
<th>Design load scenario</th>
<th>Hog or Sag</th>
<th>$M_{sw}$ (kNm)</th>
<th>$M_{wv}$ (kNm)</th>
<th>$\mu$ (kNm)</th>
<th>$\frac{M}{(\mu/\gamma R)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>180K_BC</td>
<td>Seagoing</td>
<td>Hog</td>
<td>4650000</td>
<td>6330292</td>
<td>13143140</td>
<td>0.832</td>
</tr>
<tr>
<td></td>
<td>Flooding</td>
<td>Hog</td>
<td>6585000</td>
<td>5064234</td>
<td></td>
<td>0.860</td>
</tr>
<tr>
<td>206K_BC</td>
<td>Seagoing</td>
<td>Hog</td>
<td>5630940</td>
<td>7351198</td>
<td>19678421</td>
<td>0.808</td>
</tr>
</tbody>
</table>
Prescriptive buckling of longitudinals

**CSR-OT**

3.3.2.2 The buckling utilisation factor for column buckling of stiffeners is to be taken as:

\[ \eta = \frac{\sigma_x + \sigma_y}{\sigma_{pl}} \]

Where:

- \( \sigma_x \) is compressive axial stress in the stiffener, in N/mm², in way of the midspan of the stiffener. See Section 3.5.2.3.1

**CSR-BC**

4.2.1 Checking criteria

The longitudinal and transverse ordinary stiffeners are to comply with the following criteria:

\[ \frac{\sigma_x + \sigma_y}{R_{sh}} S \leq 1 \]

- \( \sigma_x \) is uniformly distributed compressive stress, in N/mm² in the direction of the stiffener axis.
  - \( \sigma_x = \sigma_{a} \) for longitudinal stiffeners
  - \( \sigma_x = 0 \) for transverse stiffeners
- \( \sigma_y \) is normal stress resulting from hull girder bending, in N/mm²

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**CSR-H**

2.3.4 Ultimate buckling capacity

When \( \sigma_x + \sigma_y + \sigma_n > 0 \), the ultimate buckling capacity for stiffeners is to be checked according to the following interaction formula:

\[ \frac{\gamma \sigma_x + \sigma_y + \sigma_n}{R_{sh}} S = 1 \]

where:

- \( \sigma_x \) is effective axial stress, in N/mm², at mid span of the stiffener, acting on the stiffener with its attached plating.
  \[ \sigma_x = \sigma_n \frac{s f_p + A_s}{t_p + A_s} \]

- \( \sigma_n \) is nominal axial stress, in N/mm², acting on the stiffener with its attached plating.

- For FE analysis, \( \sigma_n \) is the FE corrected stress as defined in [2.3.6] in the attached plating in the direction of the stiffener axis.
- For prescriptive assessment, \( \sigma_n \) is the axial stress calculated according to Ch 8, Sec 3, [2.2.1] at load calculation point of the stiffener, as defined in Ch 3, Sec 7, [3].
Prescriptive buckling of longitudinals

\[ \sigma_a = \sigma_x \frac{st_p + A_s}{b_{eff} t_p + A_s} \]

\[ F = \frac{st_p + A_s}{b_{eff} t_p + A_s} \]

**TB of CSR-H:** Account for the effective width of attached plate

<table>
<thead>
<tr>
<th>Vessels/Location</th>
<th>s (mm)</th>
<th>(t_p) (mm)</th>
<th>(A_s) (mm²)</th>
<th>(b_{eff}) (mm)</th>
<th>(F) (Factor)</th>
<th>CSR-H</th>
<th>CSR</th>
<th>CSR-H/CSR</th>
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<tbody>
<tr>
<td><strong>VLCC</strong></td>
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<td>552.8</td>
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<tr>
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<tr>
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<td>4260</td>
<td>487.9</td>
<td>1.298</td>
<td>1.03</td>
<td>0.92</td>
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</table>

- Such requirement will induce the scantling increase for the longitudinals at the upper deck area and 0.1D below, similar to oil tankers and bulk carriers.
The transverse stresses induced by external and internal loads in foremost COT are a bit higher than that in midship COT, which may be decreased.
Fatigue issues on longi. connection

- Average fatigue life in year for longitudinal end connections for bulk carriers:

<table>
<thead>
<tr>
<th>Vessels</th>
<th>C/H</th>
<th>Fatigue life (CSR)</th>
<th>Fatigue life (CSR-H)</th>
<th>C/H</th>
<th>Fatigue life (CSR)</th>
<th>Fatigue life (CSR-H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capesize1</td>
<td>Empty</td>
<td>47.5</td>
<td>21.0</td>
<td>Loaded</td>
<td>51.5</td>
<td>19.9</td>
</tr>
<tr>
<td>Capesize2</td>
<td>Empty</td>
<td>47.3</td>
<td>21.0</td>
<td>Loaded</td>
<td>47.6</td>
<td>23.6</td>
</tr>
<tr>
<td>Babylcape</td>
<td>Empty</td>
<td>43.6</td>
<td>35.7</td>
<td>Loaded</td>
<td>43.8</td>
<td>22.1</td>
</tr>
<tr>
<td>Post-Panamax</td>
<td>Empty</td>
<td>76.1</td>
<td>37.2</td>
<td>Loaded</td>
<td>52.0</td>
<td>28.2</td>
</tr>
<tr>
<td>Panamax</td>
<td>Empty</td>
<td>54.7</td>
<td>13.5</td>
<td>Loaded</td>
<td>53.0</td>
<td>33.0</td>
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<tr>
<td>Handysize1</td>
<td>Empty</td>
<td>&gt;50</td>
<td>26.0</td>
<td>Loaded</td>
<td>&gt;50</td>
<td>32.0</td>
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<tr>
<td>Handysize2</td>
<td>Empty</td>
<td>&gt;100</td>
<td>27.5</td>
<td>Loaded</td>
<td>&gt;100</td>
<td>29.7</td>
</tr>
</tbody>
</table>

- For bulk carriers, fatigue life for the longitudinal connection by CSR-H is lower than that by CSR-BC.
Average fatigue life in year for longitudinal end connections for oil tankers:

<table>
<thead>
<tr>
<th>Vessels</th>
<th>Fatigue life (CSR)</th>
<th>Fatigue life (CSR-H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLCC</td>
<td>34.8</td>
<td>29.1</td>
</tr>
<tr>
<td>Suezmax</td>
<td>31.3</td>
<td>33.5</td>
</tr>
<tr>
<td>Aframax</td>
<td>30.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Panamax</td>
<td>25.8</td>
<td>35.5</td>
</tr>
<tr>
<td>MR</td>
<td>70.8</td>
<td>53.9</td>
</tr>
</tbody>
</table>

For oil tankers, similar fatigue life for the longitudinal connection both for CSR-H and CSR-OT.
Fatigue issues on hot spot

- For hopper lower knuckle area:

<table>
<thead>
<tr>
<th>Vessels</th>
<th>Fatigue life (CSR)</th>
<th>Fatigue life (CSR-H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capesize1</td>
<td>&gt;25.0</td>
<td>27.2</td>
</tr>
<tr>
<td>Capesize2</td>
<td></td>
<td>47.6</td>
</tr>
<tr>
<td>Post-Panamax</td>
<td></td>
<td>&gt;100</td>
</tr>
<tr>
<td>Panamax</td>
<td>9.6 (Empty)</td>
<td></td>
</tr>
<tr>
<td>Handysize1</td>
<td>28.1</td>
<td></td>
</tr>
<tr>
<td>Handysize2</td>
<td>73.9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vessels</th>
<th>Fatigue life (CSR)</th>
<th>Fatigue life (CSR-H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLCC</td>
<td>&gt;25.0</td>
<td>25.4</td>
</tr>
<tr>
<td>Suezmax</td>
<td></td>
<td>35.1</td>
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<tr>
<td>Aframax</td>
<td>&gt;25.0</td>
<td>18.5</td>
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<tr>
<td>Panamax</td>
<td>7.8</td>
<td></td>
</tr>
<tr>
<td>MR</td>
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<td>17.1</td>
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</tbody>
</table>
Conclusions

- Based on April version, the estimated weight increase for cargo area is about 1%~2% for oil tankers and about 2%~3% for bulk carriers, where the increase by prescriptive requirement is normally more than that by FE analysis except for corrugated bulkhead.

- How to solve the other issues may need further detail technical discussion between Owners, shipbuilders and IACS, based on not only theory but shipping experience and damage report.

- Although much reasonable modification for 2nd external draft (April version), there are still some revisions after the 2nd external review by industry. Essential time for external review and feedback for such revisions are to be ensured for industry by IACS.
Thank You for Your Attention!