Amendments of the Guidance

〈External Review〉

Pt. 7 Ships of Special Service

Annex 7-12 Liquefaction of Ore Bulk Cargo

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Hull Rule Development Team

Background and main contents of the amendments

1. Background of amendments

(1) Bulk cargo liquefaction

- When ore bulk cargo is transported, if the moisture content (MC) contained in the cargo exceeds a specific value (TML), the cargo may be liquefied. This can seriously affect the structural strength and stability of the ship.
- Establish specific requirements for loading cargoes that can be liquefied
  (cargoes that convert to a stable state after liquefaction / cargo that does not convert to a stable state after liquefaction)

2. Main contents : refer to main text

(1) Requirements for the loading of cargoes that may be liquefied

(2) Addition of stability and structural strength requirements

(Examples of liquefied materials: -1 : iron concerate, iron ore fine -2: Bauxite fine, Nickel ore)

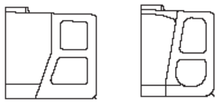
3. Reference

(1) IMSBC Code Group A

Present	Amendment	Note
〈Guidance〉 - Pt 1	〈Guidance〉 - Pt 1	

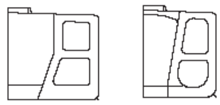
Present

Annex 1-1 Character of Classification

Ship Types	Special Feature Notations		Remarks
7. Ore Carrier 'ESP'[(16)] *(2018)*	A		(16) : The notation "ESP" shall be assigned to ships which are constructed generally with single deck, two longitudinal bulkheads and a double bottom throughout the cargo length area and intended primarily to carry ore cargoes in the centre holds only. (Typical midship sections are given in **Fig 4**)
	no MP*[1)]	GRAB[X]*[2)]	 Fig 4 Typical midship sections of Ore Carrier 'ESP' *1) : This notation shall be assigned to ships has not been designed for loading and unloading in multiple ports as **Pt 7 Annex 7-10** of the Guidance. *2) : This notation shall be assigned to ships with holds designed for loading/unloading by grabs having a maximum specific weight up to [X] tons in compliance with the requirements of **Pt 7, Ch 2, 101. 2** of the Guidance.

Amendment

Annex 1-1 Character of Classification

Ship Types	Special Feature Notations	Remarks
7. Ore Carrier 'ESP'[(16)] *(2018)*	no MP*[1)] GRAB[X]*[2)] LIQBC-1*[3)], LIQBC-2*[4)] *(2023)*	(16) : same as current  Fig 4 Typical midship sections of Ore Carrier 'ESP' *1) : This notation shall be assigned to ships has not been designed for loading and unloading in multiple ports as **Pt 7 Annex 7-10** of the Guidance. *2) : This notation shall be assigned to ships with holds designed for loading/unloading by grabs having a maximum specific weight up to [X] tons in compliance with the requirements of **Pt 7, Ch 2, 101. 2** of the Guidance. *3),*4) : to ships designed (specially constructed or equipped) to carry solid bulk cargoes (cargoes in Group A of the IMSBC code) that may liquefy during voyage, in accordance with **Pt 7, Annex 7-12** of the Guidances *(2023)*

	Anactment	Note

〈Guidance〉 - Pt 7

Annex 7-12 Liquefaction Ore Bulk Cargoes

Note: - refer to IMSBC code

1. General

(1) Application

This Annex applies to Ore carriers specially constructed to transport solid bulk cargoes that may liquefy during voyage when transporting cargoes whose moisture content(MC) exceeds thetransportable moisture limit (TML). Ships that meet the requirements of this Annex are assigned additional special feature notations LIQBC-1 or LIQBC-2. It is subject to the Flag Administration's decision for compliance with the requirements to specially constructed ore cargo ships according to the IMSBC Code. The Society will issue a certificate accordingly, if authorised by the Administration.

(2) Cargo liquefaction types are divided into two types:

(A) Cargoes resettled in stable condition after cargo liquefaction: It occurs in cargoes with a mixture of fine and large particles, and liquefaction occurs most often immediately after departure. The liquefaction state is a transient state that usually lasts for a limited time. After a cargo is stable, it is unlikely to re-liquefy. (e.g. iron ore fines)

(B) Cargoes that are not re-established in a stable condition after cargo liquefaction: It occurs on very fine clay-like cargoes, and liquefaction can occur days or weeks after departure. After the cargo is liquefied, it is not well stabilized (e.g. bauxite fines)

(3) Ships designed for cargo liquefaction are to comply with the requirements of this Annex in addition to the relevant requirements in **Pt 3** and **Pt 7, Ch 2.**

(4) Definitions used in this Annex are;

(A) solid bulk cargo : Cargo other than liquid or gas, which generally means a material composed of a combination of particles, granules, or slightly larger pieces of uniform composition which is loaded directly into the cargo space of a ship without any intermediate form of containment.

(B) IMSBC-A cargo : any solid bulk cargo which may liquefy if shipped at a moisture content in excess of their transportable moisture limit (TML)

(C) moisture content (MC) : the portion of water, ice or other liquid in the cargo sample. Percentage of total moisture content to the total mass of the sample

(D) transportable moisture limit (TML): the maximum moisture content of the cargo which is considered safe for carriage in ships

(5) In order to transport cargoes exceeding the permitted water limit, the following data must be submitted to the Society for approval:

	Anactment	Note

(A) Longitudinal / transverse sections and other plans indicating the weight, density, etc. of the cargo to be considered.
(B) Distribution and stability calculations of cargo handling equipment, cargo and liquids in tanks;
(C) Other materials deemed necessary by the Society

2. Stability

(1) Loading manual

In the loading manual, the cargo characteristics including the design cargo density are to be stated. And in the loading manual, the following is to be included: “When loading cargoes other than design cargoes, compliance with regulations shall be verified through an approved loading guidance.”

(2) Loading conditions:

(A) For liquefied cargo designs, loading conditions according to the design scenario is to be included in the loading manual. Where applicable, the requirements of (3) and (4) are tol be complied with.

(a) Design scenarios
- liquefaction : the cargo acts as a dense, viscous fluid
- shifting : the cargo slides during heavy rolling

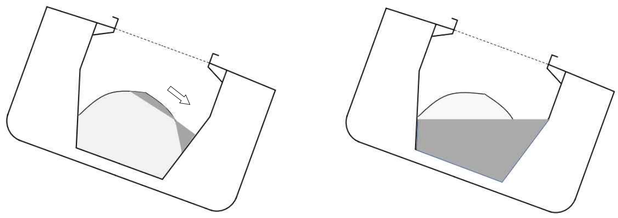


Fig 1 Design scenario : shifting (left), liquefaction (right)

(B) Loading computer

The ships are to be equipped with a loading computer capable of verifying the design scenarios and additional requirements as given in (3) and (4) as applicable.

	Anactment	Note

(3) Intact stability

(A) Liquefaction scenario : the cargo is assumed to be a liquid and full free surface of the cargo is to be considered. The requirements of stability for this scenario are to be in compliance with the Part A Ch 2 of IMO IS Code.

(B) Shift scenario : the cargo is assumed to shift at an angle of 25 degrees. The requirements of stability for this scenario are to be in compliance with IMO Resolution MSC.23(59)(International Code for the Safe Carriage of Grain in Bulk).

Note: The Internattional Code for the Safe Carriage of Grain in Bulk 7. Stability Requirements

(4) Damage stability

(A) For ships assigned LIQBC-2 notation, all stowed holds are assumed to be liquid with a free surface. Where applicable, it shall be calculated according to the GM limit curve based on the damage stability requirements of SOLAS Reg II-1/6 to 7-3, Reg. II-1/9.8 and Reg. XII/4.

(B) In addition to (A) above, for ships with reduced freeboard, the GM limit curve is to take into account the above requirements of SOLAS with the assumed deepest subdivision draft at the assigned reduced freeboard.

(C) In addition to (A) and (B) above, the GM used to demonstrate compliance with the damage stability requirements of Reg. 27 of ICLL is to be equal to or less than that applied at the deepest subdivision draft in the GM limit curve calculation.

	Anactment	Note

3. Hull Strength

(1) Cargo loads

(A) For hull strength evaluation, the cargo loads due to the liquefied design cargo are to be calculated in accordance with (B). The design density (γ) of cargo in the liquefied state of each cargo hold is to be given in the Classification Certificate. The design cargo density is to be considered more than the value given below. and The angle of repose is taken as 0 degrees.

	Density of cargo γ ($\mathrm{ton/m^3}$)
LIQBC-1	γ_{design}
LIQBC-2	M' / V_H (≥1.0)

M' : Cargo weight of the cargo hold. The following formula is applied.

$$M' = M + \frac{1}{n} Min(3000,\ 0.1M)\ \ (t)$$

M : Maximum permissible bulk cargo weight of the cargo hold (t)

n : Minimum number of loading in one cargo hold

V_H : Volume, in m^3, of cargo hold up to level of the intersection of the main deck with the hatch coaming excluding the volume enclosed by hatch coaming.

γ_{design} : for LIQBC-1, the cargo density is to be presented by the designer. When the cargo density is not constant, the minimum and maximum value are to be determined by considering the range of cargo density.

Note: cargo density : refer to Pt 7 annex 7-10

	Anactment	Note

(B) LIQBC-1

The load of cargo on the inner wall of the cargo hold is given by the following formula.

• For **Fig 2**

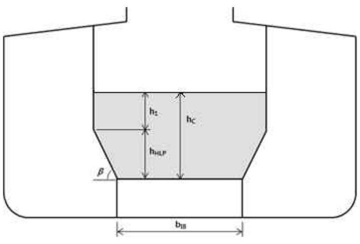


Fig 2 Assumed cargo surface

$$h_C = h_{HPL} + h_1$$

Where;

h_{HPL} : Vertical distance between inner bottom plate and top intersection of hopper tank and inner plate (m)

h_1 : Vertical distance(m) is as follows;

$$h_1 = \frac{M'}{\gamma B_H l_H} - \frac{B_H + b_{IB}}{2B_H} h_{HPL} + \frac{V_{TS}}{B_H l_H}$$

B_H : Breadth of cargo hold(m)

l_H : Length of cargo hold(m)

b_{IB} : Breadth of double bottom(m)

V_{TS} : The total volume($\mathrm{m^3}$) of the transverse stool at the bottom of the transverse bulkhead within the cargo hold length, l_H considered. In this volume, the volume of the portion of the hopper tank passing through the transverse bulkhead is excluded.

Note: Repose Ange : 0

	Anactment	Note

• For **Fig 3**

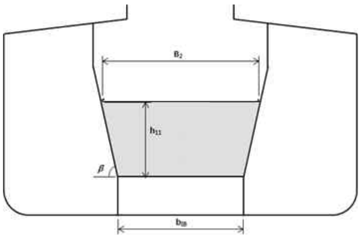


Fig 3 Assumed cargo surface

$h_C = h_{11}$

Where;

h_{11} : Vertical distance(m) is as follows;

$$h_{11} = h_{HPL}\left(\frac{B_2 - b_{IB}}{B_H - b_{IB}}\right)$$

$$B_2 = \sqrt{\frac{\frac{1}{l_H}\left(\frac{M'}{\rho_c} + V_{TS}\right) + \frac{1}{2}\left(\frac{h_{HPL}\, b_{IB}^2}{B_H - b_{IB}}\right)}{\frac{1}{2}\left[\left(\frac{h_{HPL}}{B_H - b_{IB}}\right)\right]}}$$

	Anactment	Note

(C) LIQBC-2

The load of cargo on the inner wall of the cargo hold is given by the following formula.

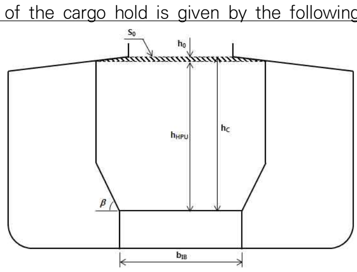


Fig 4 Assumed cargo surface

$h_c = h_{HPU} + h_0$

where;

$h_0 = \frac{S_A}{B_H}$

$S_A = S_o + \frac{V_{HC}}{l_H}$

h_{HPU} : Vertical distance (m) between inner bottom and lower intersection of top side tank and side shell or inner side

S_o : Shaded area (m^2) above the lower intersection of top side tank and side shell or inner side and up to the upper deck level

V_{HC} : Volume (m^3) enclosed by the hatch coaming

	Anactment	Note
	(2) Longitudinal bulkhead platings (A) The thickness of longitudinal bulkhead plating and hopper plating are not to be less than the value obtained from following; $t = CS\sqrt{Kh_c} + 1.5 \quad (\mathrm{mm})$ where: S = length of the shorter side of the panel enclosed by stiffeners, etc. (m) h_c = When considering cargo liquefaction, the vertical distance from the bottom of the panel to the top of the cargo at the center line (m). C = coefficient obtained from the following formula. However, in no case is it to be less than 3.2. $C = 4.25\, C_1 \sqrt{\gamma}$ C_1 = coefficient obtained from the following formula where $1 \le \frac{l}{S} < 3.5$ $C_1 = \left(0.11\frac{l}{S} + 0.615\right)$ where $3.5 \le \frac{l}{S}$ $C_1 = 1$ l = length of the longer side of the panel enclosed by stiffeners, etc. (m)	refer to Pt 7 Ch 2 302.2

	Anactment	Note
	(3) Stiffeners The section modulus of stiffeners attached to longitudinal bulkheads is to be in accordance with the requirements in the following (A) and (B). (A) The section modulus of longitudinal stiffeners is not to be less than the value obtained from the following formula: $Z = 104\gamma\, CSh_c l^2 \quad (\mathrm{cm}^3)$ where: S : spacing of longitudinal stiffeners (m). h_c : when considering cargo liquefaction, vertical distance from the center of the stiffener under consideration to the top of the cargo at the center line (m). l : length of longitudinal stiffener between transverse webs (m). $C = \frac{K}{24 - \alpha K}$ α = α_1 or α_2 as given below $\alpha_1 = 15.0\, f_D \left(\frac{y - y_B}{Y'}\right) \quad \mathrm{for} \quad y > y_B$ $\alpha_2 = 15.0\, f_B \left(\frac{y_B - y}{y_B}\right) \quad \mathrm{for} \quad y \le y_B$ f_B , y : specified in **Ch. 2, 303. 2.** of the Rule y_B, Y' and f_D : specified in **Ch. 2, 303. 2.** of the Rules (B) The section modulus of transverse stiffeners is not to be less than that obtained from the following formula : $Z = 7.5\gamma\, KS h_c l^2 \quad (\mathrm{cm}^3)$ where: S = spacing of transverse stiffeners (m). h_c = when considering cargo liquefaction, vertical distance from the center of the stiffener under consideration to the top of the cargo at the center line (m). l = distance between the supports of stiffeners (m).	refer to Pt7 Ch2 303.5

	Anactment	Note

(4) Transverse bulkhead and stool in ore cargo hold

(A) The thickness of bulkhead plating is not to be less than the value obtained from the following formula;

$$t = 3.6\,CS\sqrt{K\gamma h_c} + 2.5 \quad (\mathrm{mm})$$

where:

S = spacing of stiffeners. (m).

h_c = when considering cargo liquefaction, the vertical distance from the bottom of the panel to the top of the cargo at the center line (m).

C = coefficients determined according to values of L as specified below :

C = 1.0 where L is 230 m and under,

C = 1.07 where L is 400 m and above.

For intermediate values of L, C are to be obtained by linear interpolation.

refer to Pt3 Ch15 202

(B) Section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula :

$$Z = 5.6\,C_1 C_2 C_3 \gamma K S h_c l^2 \quad (\mathrm{cm}^3)$$

refer to Pt3 Ch15 203

where:

h_c = when considering cargo liquefaction, the vertical distance from the center of the stiffener under consideration to the top of the cargo at the center line (m).

C_1 = in accordance with C of (A)

C_2 = as determined from **Table 1** according to the fixity condition of stiffener ends

C_3 = 1.0 for longitudinal stiffener

= 1.2 for vertical stiffener

S and l = as specified in **Pt 3, Ch 14, 303.**

	Anactment	Note

Table 1 Coefficient C_2

One end of stiffener / The other end of stiffener	Connection be hard bracket	Connection be soft bracket	Supported by rule girder or lug connection	Snip
Connection be hard bracket	0.70	1.15	0.85	1.30
Connection be soft bracket	1.15	0.85	1.30	1.15
Supported by rule girder or lug connection	0.85	1.30	1.00	1.50
Snip	1.30	1.15	1.50	1.50

1. Connection by hard bracket is a connection by bracket to the double bottoms or to the adjacent members, such as longitudinals or stiffeners in line, of the same or larger sections, or a connection by bracket to the equivalent members mentioned above. (See **Fig 5** (a))
2. Connection by soft brackets is a connection by bracket to the transverse members such as beams or equivalent thereto. (See **Fig 5** (b))

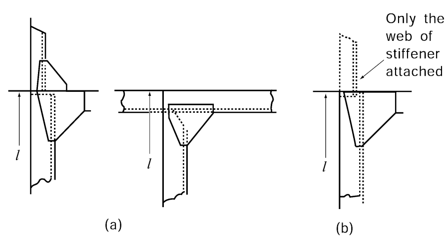


Fig 5 Types of end connection

	Anactment	Note

(5) Corrugated bulkheads

(A) The thickness of plates of corrugated bulkheads is not to be less than that obtained from the following formula:

refer to Pt3 Ch15 207

$$t = 0.0036 C S_1 \sqrt{\gamma h_c K} + 2.5 \quad (\mathrm{mm})$$

where:

S_1 = breadth of face part and web part, respectively (mm), indicated as a and b in **Fig 6.**

C = coefficient given below:

Face part: $C = \dfrac{1.5}{\sqrt{1 + \left(\dfrac{t_w}{t_f}\right)^2}}$

Web part: $C = 1.0$

t_f , t_w = thickness of plates of face part and web part, respectively (mm).

h_c : when considering cargo liquefaction, vertical distance from the bottom of the panel to the top of the cargo at the center line (m).

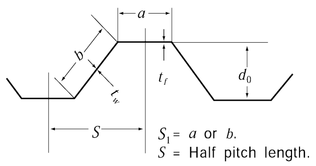


Fig 6 Measurement of S

	Anactment	Note

(B) The section modulus per half pitch of corrugated bulkheads is not to be less than that obtained from the following formula:

$$Z = 7 C K S \gamma h_c l^2 \quad (\mathrm{cm}^3)$$

where:

S = half pitch length of the corrugation (m). (See **Fig 6**)

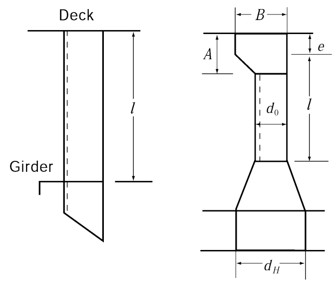
l = length between the supports (m), as indicated in **Fig 7.**

h_c = when considering cargo liquefaction, the vertical distance from the center of the stiffener under consideration to the top of the cargo at the center line (m).

C = coefficient given in **Table 2,** according to the type of end connection. As for bulkheads with lower stools of which the width in longitudinal direction at the lower end, d_H is less than 2.5 times of web depth of the bulkhead, d_0 (See **Fig 7**), the measurement of $l$and the values of C are to be at the discretion of the Society.

Table 2 Values of C

Col.	Upper end / Lower end	Supported by Girders	Welded directly to deck	Welded to stool efficiently supported by ship structure
(1)	Supported by girders or welded directly to deck or inner bottoms	1.00	1.50	1.35
(2)	Welded to stool efficiently supported by ship structure	1.50	1.20	1.00



$$e = A - \frac{d_0}{2B} \cdot A$$

Fig 7 Measurement of l

As an alternative evaluation method for determining the required section modulus of corrugated bulkheads, strength evaluation through cargo hold structure analysis presented in Annex 7-10 is possible. At this time, in order to evaluate the strength of the corrugated bulkhead, a dummy beam element with a cross-sectional area of 1 mm^2 should be modeled at the location where the web and face plate of the corrugated bulkhead meet.

	Anactment	Note

(C) The thickness of plates at end parts for 0.2 l in line with l is not to be less than that obtained from the following formulae :

Thickness of web part : $t = 41.7\frac{CKS\gamma h_c l}{d_0} + 2.5$ (mm)

It is not to be less than that obtained from the following formula :

$$t_{\min} = 0.174 \sqrt[3]{\frac{CS\gamma h_c l b^2}{d_0}} + 2.5 \quad \text{(mm)}$$

Thickness of the face part except the upper end part of vertically corrugated bulkheads:

$$t_f = \frac{0.012a}{\sqrt{K}} + 2.5 \quad \text{(mm)}$$

where:

S, h, C and l : as specified in (B)

d_0 : depth of corrugation (mm).

a and b : breadth of face part and web part respectively (mm)

	Anactment	Note

4. Finite element analysis

(1) Strength assessment

The finite element analysis is to be performed in accordance with **Annex 7-10** Guidance for Direct Strength Assessment of Ore Carriers, including additional load combinations for cargo liquefaction. This additional load combination includes all cargo loading combinations in which liquefaction cargoes are loaded in lieu of solid bulk cargoes.

(2) Buckling strength

for plating, stiffeners and overall stiffened panels. it is to be calculated in accordance with **Annex 7-10** Guidance for Direct Strength Assessment of Ore Carriers, taking into account the additional design loads. ⚓