



RULES FOR CLASSIFICATION OF **SHIPS**

NEWBUILDINGS

SPECIAL SERVICE AND TYPE
ADDITIONAL CLASS

PART 5 CHAPTER 2

PASSENGER AND DRY CARGO SHIPS

JANUARY 2009

*This booklet includes the relevant amendments and corrections
shown in the July 2009 version of Pt.0 Ch.1 Sec.3.*

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CHANGES IN THE RULES

General

The present edition of the rules includes additions and amendments approved by the Board as of December 2008 and supersedes the July 2007 edition of the same chapter.

The rule changes come into force as indicated below.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the rules. Buyers of reprints are advised to check the updated list of rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

Main changes adopted July 2009

Coming into force 1 January 2010

- **Sec.2 Passenger Ships**

- In A300, the document requirements have been changed covering "Failure Analysis Report" for propulsion and steering.

Significant editorial changes adopted July 2009

Taking effect immediately

- **Sec.4 General Cargo Carriers**

- C301: Formula for k_w has been amended

Main changes coming into force 1 July 2009

- **Sec.2 Passenger Ships**

- The references to SOLAS definitions in A200 have been removed
- Item B102 has been removed as the special references to design requirements in SOLAS are now covered in Pt.3 Ch.1 Sec.3 A400 and Pt.3 Ch.1 Sec.6 A500.
- The references have been updated in general and the requirements for damage stability have been updated in line with SOLAS Ch. II-1 as amended.

- **Sec.5 Dry Bulk Cargo Carriers**

- A new **EL-2** (H400) notation has been introduced based on the previous **EL** notation so that:
 - the notation is applicable to Ore Carriers, in addition to Bulk Carriers
 - the design and operational requirements accommodate loading each cargo hold in one pass.
- The **EL** notation has been renamed to **EL-1** (H300) and has been

clarified in important areas such as definition of the "average loading rates". Its scope has also been expanded to cover Ore Carriers, in addition to Bulk Carriers.

- **Sec.6 Container Carriers**

- 1) The still water moments may be based on the envelope curve of all relevant loading conditions. This has been moved from B203 to B201 so it applies to strength evaluation in general, and not limited to longitudinal strength evaluation.
- 2) The allowable combined stress where vertical and horizontal bending stresses are combined with torsion stresses is increased to $225f_1$ in the deck and hatch coaming. Longitudinal stresses in the deck caused by torsion are explicitly taken into account in the formulation of still water and wave torsion stresses. The rule minimum still-water torsion is increased to $0.3 LB^2$.
- 3) An opening in the rules for applying the design bending moments as function of the draught is introduced. In order to combine the actual stresses arising from the local pressure with the correct global bending moment (sag or hog), alternative methods for calculating the allowable stress for stiffeners in the bottom area is introduced.
- 4) A minimum side shell thickness for container ships has been adopted as the current formulation results in requirements beyond that of current design practice for modern container ships.
- 5) A special consideration of minimum centre girder plate thickness for container ships has been introduced similarly to that of other girders.
- 6) For fatigue evaluation of longitudinals, a requirement for warping stresses to be taken into account in the calculations is introduced.
- 7) A rule requirement for fatigue evaluation of hatch corners in container ships, which is the current practise, has been introduced.
- 8) For container ships, the connection and weld area requirement for unsymmetrical profiles is divided into a shear area requirement and a connection area requirement for the stiffener on top.
- 9) The loading conditions for cargo hold analyses have been revised to better reflect actual operating conditions for container ships.
- 10) Rule requirements for wave breaker structure and its attachments to the hull according to current practise have been introduced.

- **Sec.11 Damage Stability Cargo Ships and Passenger Ships - Class Notation SSC**

- The class notation **SSC** has been deleted and the whole section has been removed because the requirements relevant to the notation have been implemented as a mandatory requirements in SOLAS.

Corrections and Clarifications

In addition to the above stated rule requirements, a number of corrections and clarifications have been made in the existing rule text.

Comments to the rules may be sent by e-mail to rules@dnv.com

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SECTION 1 GENERAL REQUIREMENTS

A. Classification

A 100 Application

101 The rules in this chapter apply to ships intended for passengers and or carriage of various dry cargoes. The requirements shall be regarded as supplementary to those given for the assignment of main class.

102 Statutory text that has been adopted in the rules will be written in normal rule text font (not italics) with a reference to the corresponding statutory regulation. Statutory requirements that are outside the scope of class but important to consider in association with the rules shall in some cases be referred to in Guidance notes.

A 200 Class notations

201 Ships complying with relevant additional requirements of this chapter will be assigned one of the following class notations:

Passenger Ship (See Sec.2)
Car Ferry A (or B) (See Sec.3)
Train Ferry A (or B) (See Sec.3)
Car and Train Ferry A (or B) (See Sec.3)
General Cargo Carrier (RO/RO) (See Sec.4)
Bulk Carrier ESP (CSR, BC-A, BC-B, BC-C, BC-B*) (See Sec.5)
Bulk Carrier (BC-A, BC-B, BC-C, BC-B*) (See Sec.5)
Ore Carrier ESP (See Sec.5)
Container Carrier (See Sec.6)
Car Carrier (See Sec.7)
X Carrier (See Sec.9)

202 The notations:

PWDK permanent decks for wheel loading (See Sec.4)
CONTAINER arranged for carriage of containers (See Sec.6)
MCDK arranged with movable car decks (See Sec.7)
PET arranged for lift on/lift off cargo handling and arranged for carriage of vehicles (see Sec.4)
...TEU number of twenty-foot containers (See Sec.6)

may be added to relevant class notations given in 201.

Ships arranged with movable car decks shall satisfy relevant design requirements regardless of the assignment of class notation.

203 The notations:

RO/RO arranged for roll on/roll off cargo handling
BC-A designed to carry dry bulk cargoes of cargo density 1.0 t/m³ and above with specified holds empty, at maximum draught in addition to **BC-B** conditions.
BC-B designed to carry dry bulk cargoes of cargo density 1.0 t/m³ and above with all cargo holds loaded in addition to **BC-C** conditions.
BC-C designed to carry dry bulk cargoes of cargo density less than 1.0 t/m³.
BC-B* designed to carry dry bulk cargoes of density 1.0 t/m³ and above with any hold empty at maximum draught. Applicable for double hull vessels and General Cargo Carriers.
HC-A designed to carry dry bulk cargoes of cargo density 1.0 t/m³ and above with specified holds

empty, at maximum draught in addition to **HC-B** conditions. Not applicable for **Bulk Carrier ESP** with length more than 150 m.

HC-B designed to carry dry bulk cargoes of cargo density 1.0 t/m³ and above with all holds loaded in addition to **HC-C** conditions. Not applicable for **Bulk Carrier ESP** with length more than 150 m.

HC-C designed to carry dry bulk cargoes of cargo density less than 1.0 t/m³. Not applicable for **Bulk Carrier ESP** with length more than 150 m.

HC-B* designed to carry dry bulk cargoes of cargo density 1.0 t/m³ and above with any holds empty at maximum draught, applicable for double hull vessels and general cargo carriers. Not applicable for **Bulk Carrier ESP** with length more than 150 m.

HC-M designed to carry dry bulk cargoes, applicable for vessels not in compliance with IACS UR S25. Not applicable for **Bulk Carrier ESP** with length more than 150 m.

HOLDS... EMPTY combination of empty holds (See Sec.5)

No MP not strengthened for multiport loading, i.e. not designed to carry maximum allowable cargo hold design mass at reduced draught

Maximum Cargo Density x.y. (t/m³) designed for a cargo density less than 3 t/m³

ES(O) enhanced strength for ore carriers (See Sec.5)

ES(S) enhanced strength for single side skin bulk carriers (See Sec.8)

ES(D) enhanced strength for double side skin bulk carriers (See Sec.8)

are primarily applicable to general cargo carriers and bulk carriers respectively as indicated in 201, but may be added to other class notations after special consideration.

B. Definitions

B 100 Symbols

101 General

L = rule length in m *)
B = rule breadth in m *)
D = rule depth in m *)
T = rule draught in m *)
f₁ = material factor *)
= 1.0 for NV-NS steel
= 1.08 for NV-27 steel
= 1.28 for NV-32 steel
= 1.39 for NV-36 steel
= 1.47 for NV-40 steel
= $\left(\frac{\sigma_f}{235}\right)^a$ for steel forgings

and castings.
 σ_f = minimum upper yield stress in N/mm², not to be taken greater than 70% of the ultimate tensile strength. If not specified on the drawings, σ_f is taken as 50% of the ultimate tensile strength.

- a = 0.75 for $\sigma_f > 235$
= 1.0 for $f < 235$
f₂ = stress factor *)
= 1.0 when midship hull girder strength in accordance with minimum section modulus.
t_k = corrosion addition in mm *)
w_k = section modulus corrosion addition in cm³ *)
L₁ = L but need not be taken greater than 300 m.
s = stiffener spacing in m measured along the plating.
l = stiffener span in m measured along the top flange of the stiffener.
z_n = vertical distance in m from the baseline or deckline to the neutral axis of the hull girder, whichever is relevant.
z_a = vertical distance in m from the baseline or deckline to the point in question below or above the neutral axis respectively.

*) For details see Pt.3 Ch.1

C. Documentation

C 100 General

101 Details related to additional classes regarding design, arrangement and strength are in general to be included in the plans specified for the main class.

102 Additional documentation not covered by the main class are specified in appropriate sections of this chapter.

SECTION 2 PASSENGER SHIPS

A. General

A 100 Classification

101 The requirements in this section apply to all ships intended for transport or accommodation of passengers. For domestic trade, see Pt.1 Ch.1 Sec.2 A300.

102 Ships arranged for transport of more than 12 passengers shall be built in compliance with the relevant requirements in this section, and will be assigned one of the mandatory service and type notations **Passenger Ship, Car Ferry A** (or **B**), **Train Ferry A** (or **B**) or **Car and Train Ferry A** (or **B**). See also Sec.3.

A 200 Definitions

201 *Strength deck*: as defined in Pt.3 Ch.1 Sec.1 B205. If the ship's sides are arranged with rows of windows which will significantly reduce the shear strength, the strength deck may be defined as a lower deck than defined in Pt.3 Ch.1 Sec.1 B205. For passenger ships with large discontinuities and reduced effective shipside, the term *strength deck* will normally not be relevant.

A 300 Documentation requirements

301 Documentation shall be submitted as required by Table A1.

Table A1 Documentation requirements			
Object	Documentation type	Additional description	For approval (AP) or For information (FI)
Decks exposed to vehicles	H020 – Design load plan		FI
Glass roofs	Z240 – Calculation report	Strength calculations.	FI
Longitudinal and transverse bulkheads	C030 – Detailed drawing	Connections between door frames and bulk-heads.	FI
Propulsion and steering	Z070 – Failure mode description	The report shall be submitted prior to approval of detail design plans. See also IACS UR M69.	FI

302 For a full definition of the documentation types, see Pt.0 Ch.3.

303 When direct stress analyses are submitted for information, such analyses shall be supported by documentation satisfactory for verifying results obtained from the analyses as described in the Pt.3 Ch.1 Sec.12 A and the Classification Note 31.8.

Guidance note:

It is recommended that the envelope limit curves include a margin of 5-8% to give allowance for possible changes to the design.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

B. Hull Arrangement and Strength

B 100 General

101 The side and end bulkheads of the superstructure shall be effectively supported. Adequate transition arrangements shall be fitted at the ends of effective continuous longitudinal strength members in the deck and bottom structures.

B 200 Global strength

201 For passenger ships it is often necessary to utilise the load carrying potential of the superstructure for longitudinal strength purpose. In order to determine the effectiveness of the superstructure and the normal and shear stress response of the hull girder, direct strength calculations using a finite element method may have to be carried out.

Guidance note:

If direct strength calculations are carried out, the procedures described in Classification Note No.31.8 may be followed.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

202 For passenger ships of unusual form or structural arrangements, special consideration and calculations, additional to those contained in the Classification Note No.31.8 may be required.

203 If direct strength calculations are carried out, the maximum still water shear force and bending moment are normally to be based on the actual loading conditions supplied by the designer and may be less than the values specified in Pt.3 Ch.1 Sec.5 B100. The maximum values from all loading conditions, calculated at each position along the ship, shall be used to define the still water shear force and bending moment envelope limit curves.

204 For ships with large openings or discontinuities in the midship area, the design still water shear force (in this area) will be specially considered.

The factor k_{sq} as defined by Pt.3 Ch.1 Sec.5 B shall not be taken less than 0.5 between 0.4L and 0.6 L from AP.

Direct strength analyses, where the design shear force envelope limit curve is applied together with the wave shear force distribution, may be required.

205 If documented that the vessel will never be in a still water sagging condition, the maximum design sagging still water moment may be taken as the minimum actual hogging bending moment.

206 The envelope limit curves used as basis for the design shall be included in the loading manual and loading computer system as permissible limits for the vessel.

207 Allowable longitudinal stresses shall be as given in Pt.3 Ch.1 Sec.5. When no strength deck is defined, the following longitudinal stress factor applies for bottom and deck respectively:

$$f_{2b} = \frac{\sigma_l}{175}$$

$$f_{2d} = \frac{\sigma_l}{175}$$

where

f_{2b} = stress factor at a position below the neutral axis of the hull girder

f_{2d} = stress factor at a position above the neutral axis of the hull girder

σ_l = actual longitudinal stress at the position considered, taken from the global FEM analysis.

B 300 Deck structure

301 Decks exposed to trolleys used in the handling of luggage shall satisfy the requirements given in Sec.4 C300 and C400.

The design pressure may be calculated as in Sec.4 C200, where the trolleys will be regarded as cargo handling vehicles in harbour condition.

If one element (plating or stiffener) is subject to more than one load area, the scantlings will be specially considered.

302 Provided that lateral and torsional buckling modes in Pt.3 Ch.1 Sec.14 C are satisfied, the minimum thickness of deck longitudinals (local stiffeners) according to Pt.3 Ch.1 Sec.8 C303, may be accepted with adjustment to the nearest mm below.

The thickness needs not to exceed the actual thickness of the deck plating.

Guidance note:

The above is based on normal welded panels.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

303 Deck plating acting as top flange for girders shall be specially checked for buckling, see Pt.3 Ch.1 Sec.13.

Transverse buckling:

The usage factor for plating acting as transverse girder flange shall not be greater than

$$\eta = \frac{\sigma_t}{\sigma_c} \leq 0.87$$

Longitudinal buckling:

The usage factor for plating acting as longitudinal girder flange is given by

$$\eta = \frac{\sigma_{MS} + \sigma_{MW} + \sigma_l}{\sigma_c} \leq 1.0$$

or

$$\eta = \frac{\sigma_{MS} + 0.59\sigma_{MW} + \sigma_l}{\sigma_c} \leq 0.87$$

σ_{MS} , σ_{MW} as defined in Pt.3 Ch.1 Sec.5
 σ_l is longitudinal stress in deck.

B 400 Pillars

401 When direct strength calculations are carried out, the axial load component from global bending shall be taken into consideration when determining the nominal axial force in pillars.

402 The compressive forces in the pillars shall in general be checked against the critical buckling load calculated from the Rules Pt.3 Ch.1 Sec.13 C.

When the axial load component from global bending is taken into consideration in combination with local deck forces as described in Pt.3 Ch.1 Sec.13 C204, k may be taken as 0.9.

403 The acceptable axial stress for pillars in tension is:

$$\sigma = 160 f_1 \text{ (MPa)}$$

The local support of tension exposed pillars shall be specially considered. Full penetration welds shall normally be arranged at the ends.

404 Direct stress analyses of deck and bottom structure in way of pillars may be necessary.

B 500 Cofferdam structure

501 Diaphragm plates in cofferdams surrounding tanks shall be specially checked for buckling. All applicable local loads in tank boundaries are given in Pt.3 Ch.1 Sec.9 Table B1. However, the formula taking into account the air pipe height shall be replaced by the following formula for buckling check:

$$p = \rho g_0 h_p + \Delta p_{\text{dyn}}$$

Guidance note:

The requirement is based on experience with cofferdams surrounding fuel oil and fresh water tanks in passenger ships. The shear buckling capacity of the diaphragms in the cofferdam structure is often critical for these structures, and details like openings need special consideration.

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502 The thickness of plating in diaphragm structure shall satisfy the buckling strength requirements given in Pt.3 Ch.1 Sec.13, taking into account also combination of shear and compressive in-plane stresses where relevant.

B 600 Movable glass roofs

601 The minimum forces acting on the glass roof and the supporting structure shall normally be taken as:

Vertical force:

$$\begin{aligned} p_v &= q (g_0 + 0.5a_v) \text{ (kN/m}^2\text{)} \\ P_v &= pA_v \\ q &= \text{minimum } 0.15 \text{ t/m}^2 + \text{self weight of glass roof} \\ a_v &= \text{vertical acceleration according to Pt.3 Ch.1 Sec.4} \\ A_v &= \text{vertical projection of glass roof.} \end{aligned}$$

Transverse force on side walls:

$$\begin{aligned} p_T &= 2.5 \text{ kN/m}^2 \\ P_T &= pA_T \\ A_T &= \text{vertical projection of glass roof.} \end{aligned}$$

Loads for horizontal stoppers:

$$\text{combine } P_{VC} = qg_0 A_v \text{ with } P_T$$

602 Allowable nominal stresses:

$$\begin{aligned} \sigma &= 160 f_1 \text{ (MPa)} \\ \tau &= 90 f_1 \text{ (MPa)} \end{aligned}$$

603 The roof shall not be opened when the wind speed exceeds 15 m/sec. This restriction shall be stated in the operation manual for the vessel.

604 The stoppers and locking devices shall be provided such that in the event of failure of the hydraulic system the roof will remain in position.

B 700 Windows and glass structure

701 The design load shall be in accordance with the rules as given in Pt.3 Ch.1 Sec.10 C100. Design pressure on windows located at front bulkheads above navigation bridge is taken as minimum 7.5 kN/m², provided that the location is above 4th tier.

702 Required glass thickness is calculated according to Pt.3 Ch.3 Sec.6 L202. Minimum glass thickness given in item 2) may be especially considered for glass doors and walls located in protected areas at sides and aft ends, 1.7 C_w (m) or more above S.W.L.

B 800 Fatigue

801 For ro-pax vessels, which are mainly intended for transport of cargo and with limited numbers of passengers, the racking strength and corresponding fatigue evaluation shall be considered

Guidance note:

This may be carried out in accordance with Classification Note 31.8.

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802 Due attention shall be made to fatigue strength of structural details. Details with high stress concentrations due to longitudinal or racking transverse stresses shall be specially assessed with respect to fatigue.

Guidance note:

Classification Note no.31.8 describes acceptable loads and procedures for such analyses.

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803 In way of stress concentration areas, increased radius, edge reinforcement and inserts with increased plate thickness may have to be applied for keeping notch effects and stress concentrations at acceptable levels.

Guidance note:

Areas normally to be considered with respect to fatigue are openings in ship side, longitudinal bulkheads and upper decks.

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804 In way of corner regions of openings for doors and windows, welding shall in general be avoided. If welds in these areas cannot be avoided completely, the details need special consideration as the maximum allowable peak stress due to fatigue then will drop considerably.

C. Machinery and Systems

C 100 General

101 For ships with class notation **Passenger Ship** the machinery and systems are in general to be as required for the main class.

Guidance note:

Requirements to bilge pumping in passenger ships are given in SOLAS Reg. II-1/21.2

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102 Electrical distribution systems shall be so arranged that fire in any main vertical zone, as defined in Pt.4 Ch.10, will not interfere with services essential for safety in any other such zone. This requirement will be met if main and emergency feeders passing through any such zone are separated both vertically and horizontally as widely as is practicable.

D. Emergency Source of Electrical Power and Emergency Installations

D 100 General

101 Statutory text that has been adopted in the rules will be written in normal rule text font (not italics) with a reference to the corresponding statutory regulation. Adopting statutory requirements by reference alone will not be used. Statutory requirements that are outside the scope of class but important to consider in association with the rules shall in some cases be referred to in Guidance notes.

102 A self-contained emergency source of electrical power shall be provided.

103 The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard shall be located above the uppermost continuous deck and shall be readily accessible from the open deck. They shall not be located forward of the collision bulkhead.

104 The location of the emergency source of electrical power

er and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency electric lighting switchboards in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard shall be such as to ensure to the satisfaction of the Administration that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard shall not be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard.

105 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits.

Non essential domestic supplies should not be directly connected to the emergency switchboard.

D 200 Services to be supplied

201 The electrical power available shall be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power shall be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation, as stated in the following items 202 to 207.

202 For a period of 36 hours, emergency lighting:

- 1) at every muster and embarkation station and over the sides as required by regulations III/11.4 and III/16.7;
- 2) in alleyways, stairways and exits giving access to the muster and embarkation stations, as required by regulation III/11.5;
- 3) in all service and accommodation alleyways, stairways and exits, personnel lift cars;
- 4) in the machinery spaces and main generating stations including their control positions;
- 5) in all control stations, machinery control rooms, and at each main and emergency switchboard;
- 6) at all stowage positions for firemen's outfits;
- 7) at the steering gear; and
- 8) at the fire pump, the sprinkler pump and the emergency bilge pump referred to in 205 and at the starting position of their motors.

203 For a period of 36 hours:

- 1) the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force; and
- 2) the VHF radio installation required by regulation IV/7.1.1 and IV/7.1.2; and, if applicable:
 - 2.1 the MF radio installation required by regulations IV/12.1.1, IV/12.1.2, IV/10.1.2 and IV/10.1.3;
 - 2.2 the ship earth station required by regulation IV/10.1.1; and
 - 2.3 the MF/HF radio installation required by regulations IV/10.2.1, IV/10.2.2 and IV/11.1.

204 For a period of 36 hours:

- 1) all internal communication equipment required in an emergency shall include:
 - The means of communication which is provided between the navigating bridge and the steering gear compartment.
 - The means of communication which is provided between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled.
 - The means of communication which is provided between the bridge and the radio telegraph or radio telephone stations.
 - The means of communication which is provided between the officer of the watch and the person responsible for closing any watertight door which is not capable of being closed from a central control station.
 - The public address system or other effective means of communication which is provided throughout the accommodation, public and service spaces.
 - The means of communication which is provided between the navigating bridge and the main fire control station;
- 2) the shipborne navigational equipment as required by regulation V/12.
- 3) the fire detection and fire alarm system, and the fire door holding and release system; and
- 4) for intermittent operation of the daylight signalling lamp, the ship's whistle, the manually operated call points and all internal signals that are required in an emergency;

unless such services have an independent supply for the period of 36 hours from an accumulator battery suitably located for use in an emergency.

205 For a period of 36 hours:

- 1) one of the fire pumps required by regulation II-2/4.3.1 and 4.3.3;
- 2) the automatic sprinkler pump, if any; and
- 3) the emergency bilge pump, and all the equipment essential for the operation of electrically powered remote controlled bilge valves.

206 For the period of time required by regulation 29.14 (Pt.4 Ch.14 Sec.1 E300) the steering gear if required to be so supplied by that subsection.

207 For a period of half an hour:

- 1) any watertight doors required by SOLAS Reg. II-1/15 to be power operated together with their indicators and warning signals.
- 2) the emergency arrangements to bring the lift cars to deck level for the escape of persons. The passenger lift cars may be brought to deck level sequentially in an emergency.

208 In a ship engaged regularly on voyages of short duration, the Administration if satisfied that an adequate standard of safety would be attained may accept a lesser period than the 36 hour period specified in items 202 to 206 but not less than 12 hours.

D 300 Arrangement of emergency source(s) of power

301 The emergency source of electrical power may be either a generator or an accumulator battery, which shall comply with the following:

302 Where the emergency source of electrical power is a generator, it shall be:

- 1) driven by a suitable prime-mover with an independent

supply of fuel having a flashpoint (closed cup test) of not less than 43°C;

- 2) started automatically upon failure of the electrical supply from the main source of electrical power and shall be automatically connected to the emergency switchboard; those services referred to in 400 shall then be transferred automatically to the emergency generating set. The automatic starting system and the characteristic of the prime-mover shall be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 seconds; unless a second independent means of starting the emergency generating set is provided, the single source of stored energy shall be protected to preclude its complete depletion by the automatic starting system; and
- 3) provided with a transitional source of emergency electrical power according to 400.

303 Where the emergency source of electrical power is an accumulator battery, it shall be capable of:

- 1) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage;
- 2) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and
- 3) immediately supplying at least those services specified in 400.

D 400 Transitional source of emergency power

401 The transitional source of emergency electrical power required by item 302.3) shall consist of an accumulator battery suitably located for use in an emergency which shall operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

402 For half an hour:

- 1) the lighting required by items 202 and 203.1;
- 2) all services required by items 204.1), 204.3) and 204.4), unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

403 Power to operate the watertight doors, as required by SOLAS Reg. II-1/15, but not necessarily all of them simultaneously, unless an independent temporary source of stored energy is provided. Power to the control, indication and alarm circuits as required by SOLAS Reg. II-1/15, for half an hour.

D 500 Low-location lighting

501 Passenger ships shall be provided with low-location lighting (LLL) complying with IMO Res. A.752(18).

D 600 Supplementary emergency lighting for ro-ro passenger ships (Reg. II-1/42-1)

- 1 In addition to the emergency lighting required by regulation 42.2 (200), on every passenger ship with ro-ro cargo spaces or special category spaces as defined in regulation II-2/3 (F101):

- 1.1 all passenger public spaces and alleyways shall be provided with supplementary electric lighting that can operate for at least three hours when all other

sources of electric power have failed and under any condition of heel. The illumination provided shall be such that the approach to the means of escape can be readily seen. The source of power for the supplementary lighting shall consist of accumulator batteries located within the lighting units that are continuously charged, where practicable, from the emergency switchboard. Alternatively, any other means of lighting which is at least as effective may be accepted by the Administration. The supplementary lighting shall be such that any failure of the lamp will be immediately apparent. Any accumulator battery provided shall be replaced at intervals having regard to the specified service life in the ambient conditions that they are subject to in service; and

- 1.2 a portable rechargeable battery operated lamp shall be provided in every crew space alleyway, recreational space and every working space which is normally occupied unless supplementary emergency lighting, as required by sub paragraph. 1, is provided.

D 700 Location of emergency switchboard, distribution

701 The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power.

702 Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

703 No accumulator battery fitted in accordance with this Regulation shall be installed in the same space as the emergency switchboard. An indicator shall be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in item 302.3) or 400 are being discharged.

704 The emergency switchboard shall be supplied during normal operation from the main switchboard by an interconnector feeder which shall be adequately protected at the main switchboard against overload and short circuit and which shall be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit.

705 In order to ensure ready availability of the emergency source of electrical power, arrangements shall be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power shall be available to the emergency circuits.

706 The arrangement of the emergency electric lighting system shall be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render the main electric lighting system required by this regulation (Pt.4 Ch.8 Sec.2 F201c) inoperative.

See also Pt.4 Ch.8 Sec.2 F.

D 800 Inclinations (list and trim of ship)

801 The emergency generator and its prime-mover and any emergency accumulator battery shall be so designed and arranged as to ensure that they will function at full rated power when the ship is upright and when inclined at any angle of list up to 22.5° or when inclined up to 10° either in the fore or aft direction, or is in any combination of angles within those limits.

D 900 Periodical testing

901 Provision shall be made for the periodic testing of the

complete emergency system and shall include the testing of automatic starting arrangements.

D 1000 Starting arrangements for emergency generating sets

1001 Starting arrangements for emergency generating sets shall comply with the requirements given for cargo ships in Pt.4 Ch.8 Sec.2 C300.

E. Fire Safety Measures for Passenger Ships

E 100 Application

101 The requirements for fire protection in this section apply to any ship which carries more than twelve passengers.

E 200 Rule references and definitions

201 These requirements are given in addition to those applicable for the main class, as given in Pt.4 Ch.10.

202 For fire technical and space definitions, see Pt.4 Ch.10.

E 300 Documentation

301 The following plans and particulars shall be submitted for approval:

- General arrangement plan showing main vertical zone arrangement including steps and recesses, stairways and doors.
- Arrangement of means of escape from different compartments and escape calculations.

E 400 Main vertical zones and horizontal zones (SOLAS Reg. II-2/9.2.2.1)

401 In ships carrying more than 36 passengers, the hull, superstructure and deckhouses shall be subdivided into main vertical zones by "A-60" class divisions. Steps and recesses shall be kept to a minimum but where they are necessary, they shall also be "A-60" class divisions. Open deck spaces, sanitary or similar spaces, tanks, voids and auxiliary machinery spaces having little or no fire risk on one side or where fuel oil tanks are on both sides of the division the standard may be reduced to "A-0".

402 In ships carrying not more than 36 passengers, the hull, superstructure and deckhouses in way of accommodation and service spaces shall be subdivided into main vertical zones by "A" class divisions.

403 As far as practicable, the bulkheads forming the boundaries of the main vertical zones above the bulkhead deck shall be in line with watertight subdivision bulkheads situated immediately below the bulkhead deck. The length and width of main vertical zones may be extended to a maximum of 48 m in order to bring the ends of main vertical zones to coincide with watertight subdivision bulkheads or in order to accommodate a large public space extending for the whole length of the main vertical zone provided that the total area of the main vertical zone is not greater than 1 600 m² on any deck. The length or width of a main vertical zone is the maximum distance between the furthestmost points of the bulkheads bounding it.

404 Such bulkheads shall extend from deck to deck and to the shell or other boundaries.

405 Where a main vertical zone is subdivided by horizontal "A" class divisions into horizontal zones for the purpose of providing an appropriate barrier between a zone with sprinklers and a zone without sprinklers, the divisions shall extend between adjacent main vertical zone bulkheads and to the shell or exterior boundaries of the ship.

406 On ships designed for special purposes, such as automobile or railroad car ferries, where the provision of main vertical

zone bulkheads would defeat the purpose for which the ship is intended, equivalent means for controlling and limiting a fire shall be substituted and specifically approved by the Society. Service spaces and ship stores shall not be located on ro-ro decks unless protected in accordance with the applicable requirements.

407 However, in a ship with special category spaces, any such space shall comply with the applicable requirements to such spaces and where such compliance would be inconsistent with other requirements for passenger ships specified in this Part, the requirements for special category spaces shall prevail.

408 The basic principle underlying the provisions of this paragraph is that the main vertical zoning required by 401 and 402 may not be practicable in vehicle spaces of passenger ships and, therefore, equivalent protection shall be obtained in such spaces on the basis of a horizontal zone concept and by the provision of an efficient fixed fire-extinguishing system. Based on this concept, a horizontal zone may include special category spaces on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

(SOLAS Reg. II-2/20.2.2.1)

409 The basic principle underlying the provisions of paragraph 408 is also applicable to ro-ro spaces.

(SOLAS Reg. II-2/20.2.2.2)

E 500 Protection of stairways and lifts in accommodation area (SOLAS Reg. II-2/9.2.2.5)

501 Stairways shall be within enclosures formed of "A" class divisions, with positive means of closure at all openings, except that:

- .1 a stairway connecting only two decks need not be enclosed, provided the integrity of the deck is maintained by proper bulkheads or self-closing doors in one 'tween-deck space. When a stairway is closed in one 'tween-deck space, the stairway enclosure shall be protected in accordance with the requirements for decks; and
- .2 stairways may be fitted in the open in a public space, provided they lie wholly within the public space.

502 Lift trunks shall be so fitted as to prevent the passage of smoke and flame from one 'tween-deck to another and shall be provided with means of closing so as to permit the control of draught and smoke. Machinery for lifts located within stairway enclosures shall be arranged in a separate room, surrounded by steel boundaries, except that small passages for lift cables are permitted. Lifts which open into spaces other than corridors, public spaces, special category spaces, stairways and external areas shall not open into stairways included in the means of escape.

E 600 Means of escape from accommodation spaces, service spaces and control stations (SOLAS Reg. II-2/13.3.2.1 - 13.3.2.4)

601 Below the bulkhead deck two means of escape, at least one of which shall be independent of watertight doors, shall be provided from each watertight compartment or similarly restricted space or group of spaces. Exceptionally, the Society may dispense with one of the means of escape for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

602 Where the Society has granted dispensation under the provisions of 601, this sole means of escape shall provide safe escape. However, stairways shall not be less than 800 mm in clear width with handrails on both sides.

603 Above the bulkhead deck there shall be at least two means of escape from each main vertical zone or similarly restricted space or group of spaces at least one of which shall give access to a stairway forming a vertical escape.

604 Stairway enclosures in accommodation and service

spaces shall have direct access from the corridors and be of a sufficient area to prevent congestion, having in view the number of persons likely to use them in an emergency. Within the perimeter of such stairway enclosures, only public toilets, lockers of non-combustible material providing storage for non-hazardous safety equipment and open information counters are permitted. Only public spaces, corridors, lifts, public toilets, special category spaces and open ro-ro spaces to which any passengers carried can have access, other escape stairways required by 605 and external areas are permitted to have direct access to these stairway enclosures. Small corridors or "lobbies" used to separate an enclosed stairway from galleys or main laundries may have direct access to the stairway provided they have a minimum deck area of 4.5 m², a width of no less than 900 mm and contain a fire hose station.

605 At least one of the means of escape required by 601 and 603 shall consist of a readily accessible enclosed stairway, which shall provide continuous fire shelter from the level of its origin to the appropriate lifeboat and liferaft embarkation decks, or to the uppermost weather deck if the embarkation deck does not extend to the main vertical zone being considered. In the latter case, direct access to the embarkation deck by way of external open stairways and passageways shall be provided and shall have emergency lighting and slip-free surfaces underfoot. Boundaries facing external open stairways and passageways forming part of an escape route and boundaries in such a position that their failure during a fire would impede escape to the embarkation deck shall have fire integrity, including insulation values, in accordance with appropriate requirements.

606 Protection of access from the stairway enclosures to the lifeboat and liferaft embarkation areas shall be provided either directly or through protected internal routes which have fire integrity and insulation values as required for stairway enclosures.

607 Stairways serving only a space and a balcony in that space shall not be considered as forming one of the required means of escape.

608 Each level within an atrium shall have two means of escape, one of which shall give direct access to an enclosed vertical means of escape meeting the requirements of 605.

609 The widths, number and continuity of escapes shall be in accordance with the requirements in the Fire Safety Systems Code.

E 700 Means of escape from machinery spaces (SOLAS Reg. II-2/13.4.1)

701 Where the space is below the bulkhead deck the two means of escape shall consist of either:

- .1 two sets of steel ladders as widely separated as possible, leading to doors in the upper part of the space similarly separated and from which access is provided to the appropriate lifeboat and liferaft embarkation decks. One of these ladders shall be located within a protected enclosure from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards shall be fitted in the enclosure. The ladder shall be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The protected enclosure shall have minimum internal dimensions of at least 800 mm × 800 mm, and shall have emergency lighting provisions; or
- .2 one steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation deck and additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the embarkation deck.

702 Where the space is above the bulkhead deck, the two means of escape shall be as widely separated as possible and the doors leading from such means of escape shall be in a position from which access is provided to the appropriate lifeboat and liferaft embarkation decks. Where such means of escape require the use of ladders, these shall be of steel.

703 In a ship of less than 1 000 gross tonnage, the Society may dispense with one of the means of escape, due regard being paid to the width and disposition of the upper part of the space. In a ship of 1 000 gross tonnage and above, the Society may dispense with one means of escape from any such space, including a normally unattended auxiliary machinery space, so long as either a door or a steel ladder provides a safe escape route to the embarkation deck, due regard being paid to the nature and location of the space and whether persons are normally employed in that space. In the steering gear space, a second means of escape shall be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

704 Two means of escape shall be provided from a machinery control room located within a machinery space, at least one of which shall provide continuous fire shelter to a safe position outside the machinery space.

E 800 Means of escape from special category and open ro-ro spaces to which any passengers carried can have access (SOLAS Reg. II-2/13.5)

801 In special category and open ro-ro spaces to which any passengers carried can have access, the number and locations of the means of escape both below and above the bulkhead deck shall be to the satisfaction of the Society and, in general, the safety of access to the embarkation deck shall be at least equivalent to that provided for under 601, 603, 605 and 606. Such spaces shall be provided with designated walkways to the means of escape with a breadth of at least 600 mm. The parking arrangements for the vehicles shall maintain the walkways clear at all times.

802 One of the escape routes from the machinery spaces where the crew is normally employed shall avoid direct access to any special category space.

E 900 Additional requirements to means of escape for ro-ro passenger ships

901 Escape routes shall be provided from every normally occupied space on the ship to an assembly station. These escape routes shall be arranged so as to provide the most direct route possible to the assembly station, and shall be marked with symbols.

(SOLAS Reg. II-2/13.7.1.1)

Guidance note:

Refer to "Symbols related to life-saving appliances and arrangements" adopted by IMO by Res. A.760(18).

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902 The escape route from cabins to stairway enclosures shall be as direct as possible, with a minimum number of changes in direction. It shall not be necessary to cross from one side of the ship to the other to reach an escape route. It shall not be necessary to climb more than two decks up or down in order to reach an assembly station or open deck from any passenger space.

(SOLAS Reg. II-2/13.7.1.2)

903 External routes shall be provided from open decks, as referred to in 902, to the survival craft embarkation stations.

(SOLAS Reg. II-2/13.7.1.3)

904 Where enclosed spaces adjoin an open deck, openings from the enclosed space to the open deck are, where practicable, to be capable of being used as emergency exits.

(SOLAS Reg. II-2/13.7.1.4)

905 Escape routes shall not be obstructed by furniture and other obstructions. With the exception of tables and chairs which may be cleared to provide open space, cabinets and other heavy furnishings in public spaces and along escape routes shall be secured in place to prevent shifting if the ship rolls or lists. Floor coverings are also to be secured in place. When the ship is underway, escape routes shall be kept clear of obstructions such as cleaning carts, bedding, luggage and boxes of goods.

(SOLAS Reg. II-2/13.7.1.5)

906 Escape routes shall be evaluated by an evacuation analysis early in the design process. The analysis shall be used to identify and eliminate, as far as practicable, congestion which may develop during an abandonment, due to normal movement of passengers and crew along escape routes, including the possibility that crew may need to move along these routes in a direction opposite the movement of passengers. In addition, the analysis shall be used to demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, embarkation stations or survival craft may not be available as a result of a casualty.

(SOLAS Reg. II-2/13.7.4)

Guidance note:

Refer to the "Interim Guidelines for a Simplified Evacuation Analysis on Ro-Ro Passenger Ships" developed by IMO (MSC/Circ.909)

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F. Stability and Watertight Integrity

F 100 Application

101 Ships with class notation **Passenger Ship** shall comply with the requirements according to 300 and 400.

102 The class requirements may be considered complied with when a national authority has carried out the approval in accordance with the SOLAS Ch. II-1 as amended.

103 For ships in domestic trade and with service restrictions, alternative stability requirements may be accepted after considerations in each separate case.

Guidance note:

Ships having a lesser Subdivision and stability standard than corresponding to the European Union (EU) Council Directive 98/18/EC of 17 March 1998 will generally not be accepted.

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F 200 Documentation

201 The following documentation shall be submitted for approval:

- preliminary damage stability calculations
- final damage stability calculations
- damage control plan
- internal watertight integrity plan including definition of subdivision limits as applied in the calculations.

Guidance note:

The internal watertight integrity plan(s) should clearly show the location of pipes, valves and ducts with their respective closing appliances.

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F 300 Intact stability

301 Passenger ships shall comply with Pt.3 Ch.3 Sec.9 with the supplementing requirements as given in 302 to 304.

302 Loading conditions

The following standard loading conditions shall be included:

- ship in the fully loaded departure condition with full cargo, stores and fuel and the full number of passengers and their luggage
- ship with full stores and fuel and the full number of passengers and their luggage, but without cargo
- ship in the fully loaded arrival condition, with full cargo and the full number of passengers and their luggage but with only 10% stores and fuel remaining
- ship with only 10% stores and fuel and the full number of passengers and their luggage, but without cargo.

303 Additional criteria

- the angle of heel on account of crowding of passengers to one side shall not exceed 10 degrees
- the angle of heel on account of turning should not exceed 10 degrees when calculated using the following formula:

$$MR = 0.02 V_o^2 D (KG - d/2)/L$$

MR = heeling moment (tm)

V_o = service speed (m/s)

L = length of ship at waterline (m)

D = displacement (t)

d = draught (m)

KG = height of centre of gravity above keel (m).

304 When applying the additional criteria in 303 the following shall be assumed:

- 1) A mass of 75 kg shall be assumed for each passenger except that this value may be reduced to not less than 60 kg where this can be justified. In addition, the mass and distribution of the luggage shall be taken into account.
- 2) The height of the centre of gravity for the passengers shall be assumed equal to:
 - 1.0 m above deck level for passengers standing upright. Account may be taken, if necessary, of camber and sheer of deck
 - 0.3 m above the seat in respect of seated passengers.
- 3) Passengers without luggage shall be considered as distributed to produce the most unfavourable combination of passenger heeling moment and or initial metacentric height, which may be obtained in practice. A value of not less than 4 persons per square metre shall be applied.

F 400 Subdivision and damage stability

401 Passenger ships shall comply with the applicable regulations of SOLAS Ch. II-1, as amended.

SECTION 3 FERRIES

A. General

A 100 Classification

101 The requirements in this section apply to ships intended for regular transport of passengers and vehicles. The requirements for passenger ships given in Sec.2 are also to be complied with.

102 Ships arranged for carriage of vehicles on enclosed decks and built in compliance with relevant requirements specified in the following will be given one of the class notations **Car Ferry A**, **Train Ferry A** or **Car and Train Ferry A** whichever is applicable.

103 Ships arranged for carriage of vehicles on weather deck only and built in compliance with relevant requirements specified in the following will be given one of the class notations **Car Ferry B**, **Train Ferry B** or **Car and Train Ferry B** whichever is applicable.

A 200 Assumptions

201 The requirements for the class notation **B** are based on the assumption that service restriction notation **R2** or stricter are included in the main class.

A 300 Documentation

301 The following plans and particulars shall be submitted for approval:

- Stern, side shell and bow doors (outer and inner) including force carrying structures of door cleat and support devices and their supporting structure of the hull.
- Closing arrangement for doors including system for operation.
- Operating and maintenance manual for bow doors, side shell doors and stern doors.

The operating and maintenance manual shall be provided on board and shall contain necessary information on:

main particulars and design drawings

- special safety precautions
- details of vessel, class, statutory certificates
- equipment and design loading (for ramps)
- key plan of equipment (doors and ramps)
- manufacturer's recommended testing for equipment
- description of equipment
 - bow doors
 - inner bow doors
 - bow ramp/doors
 - side doors
 - stern doors
 - central power pack
 - bridge panel
 - engine control room panel

service conditions

- limiting heel and trim of ship for loading/unloading
- limiting heel and trim for door operations
- doors/ramps operating instructions
- doors/ramps emergency operating instructions

maintenance

- schedule and extent of maintenance

- trouble-shooting
- acceptance/rejection criteria, acceptable clearances
- manufacturer's maintenance procedures

register of inspections, including:

- inspection of locking, securing and supporting devices
- repairs and renewals.

The operating and maintenance manual shall be submitted for approval with respect to the items listed above being contained in the manual. In addition, the inclusion of the necessary information with regard to inspections, trouble-shooting and acceptance/rejection criteria in the maintenance part shall be verified.

Guidance note:

It is recommended that recorded inspections of the door supporting and securing devices be carried out by the ship's staff at monthly intervals or following incidents that could result in damage, including heavy weather or contact in the region of the shell doors.

Any damage recorded during such inspections shall be reported to the Society. This is also to be stated in the operating and maintenance manual.

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Guidance note:

Reference is made to the safety management system described in the ISM Code.

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- Arrangement of accesses from the ro-ro deck (bulkhead deck) to spaces below (showing all doors, ramps, hatches etc.).

302 The following plans and particulars are normally to be submitted for information:

- An arrangement plan showing the position of watertight doors in the stern, sides, bow and collision bulkhead in relation to the watertight subdivision of the hull.
- Arrangement of doors including hydraulic and mechanical supporting, cleating and locking arrangements as relevant. For doors with clear opening >12 m², the design support forces considered and or determined for each support shall be stated on the arrangement drawing and submitted together with design calculations carried out. For bow doors the longitudinal, transverse and vertical projections shall be shown.
- Arrangement of air intakes, ventilators etc.
- Arrangement of doors from vehicle deck.
- Drainage openings and or freeing ports for vehicle deck and space between outer and inner bow door.
- Arrangement of wheels and axles or bogies for heavy vehicles, stating maximum axle and or bogie load.
- Fastening and securing appliances of vehicles to the hull structure.
- Types of locking arrangements used on cleats and support devices on doors with clear opening > 12 m², (Ref. D1201).

303 Documentation for the following indication, control and monitoring systems shall be submitted for approval:

- bow doors monitoring system
- water leakage monitoring system.

For requirements to documentation types, see Pt.4 Ch.9.

A 400 Definitions

401 Symbols

- t = rule thickness in mm of plating
Z = rule section modulus in cm³ of stiffeners and simple girders
s = stiffener spacing in m, measured along the plating
l = stiffener span in m, measured along the topflange of the member. For definition of span point, see Pt.3 Ch.1 Sec.3 C100. For curved stiffeners l may be taken as the cord length
S = girder span in m. For definition of span point, see Pt.3 Ch.1 Sec.3 C100
b = loading breadth for girders in m
f₁ = material factor
= 1.0 for NV-NS steel *)
= 1.08 for NV-27 steel *)
= 1.28 for NV-32 steel *)
= 1.39 for NV-36 steel *)
= 1.47 for NV-40 steel *)

*) For details see Pt.3 Ch.1 Sec.2 B to C

402 The load point where the design pressure shall be calculated is defined for various strength members as follows:

- a) *For plates*
Midpoint of horizontally stiffened plate field.
Half of the stiffener spacing above the lower support of vertically stiffened plate field, or at lower edge of plate when the thickness is changed within the plate field.
- b) *For stiffeners*
Midpoint of span.
When the pressure is not varied linearly over the span, the design pressure shall be taken as the greater of:

$$p_m \text{ and } \frac{p_a + p_b}{2}$$

p_m, p_a and p_b are calculated pressures at the midpoint and at each end respectively.

- c) *For girders*
Midpoint of load area.

403 Ro-Ro passenger ship

is a passenger ship with ro-ro spaces or special category spaces.

404 Ro-Ro spaces

are spaces not normally subdivided in any way and normally extending to either a substantial length or the entire length of the ship in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (packaged or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in a horizontal direction.

405 Special category spaces

are those enclosed spaces above or below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access.

Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

A 500 Certification of control and monitoring system

501 The Bow doors monitoring system shall be certified according to Pt.4 Ch.9. For the General alarm/public address system, see Pt.3 Ch.3 Sec.10.

B. Hull Arrangement and Strength

B 100 Vehicle decks, ramps and lifts

101 Plating with supporting stiffeners and girders for direct wheel loads shall satisfy the requirements for the class notation **PWDK** given in Sec.4 C. Decks where the free height exceed 2.5 m, shall be designed for an axle load not less than 10 t.

102 Movable car decks, if fitted, shall satisfy relevant requirements given in Sec.7.

103 External ramps, internal ramps and lift platforms are also to satisfy the requirements given in Sec.4 B.

104 Scantlings of decks, ramps, lifts etc. for railway carriages will be considered in each case.

B 200 Securing of vehicles

201 Appliances shall be provided for securing of road vehicles and railway carriages. Strength and fastening of the securing points shall satisfy the requirements given in Sec.4 B1200.

202 For ships with restricted service notation **R3**, **R4** or **RE**, the requirements with respect to securing appliances may be reduced or discarded based upon special consideration of the intended service area.

B 300 Transverse strength

301 A sufficient number of vertical side girders and/or transverse bulkheads in casing(s) shall be fitted between the vehicle deck(s) and the superstructure above. Transverse and longitudinal bulkheads shall be effectively supported below the vehicle deck(s). Calculations necessary to demonstrate that the stresses are acceptable, shall be carried out for the ship also in heeled conditions. Design loads, calculation methods and allowable stresses shall be as given for complex girder systems in Pt.3 Ch.1 Sec.13.

C. Openings and Closing Appliances

C 100 Doors

101 Arrangements and scantlings of doors in ship's side and ends are in general to satisfy the requirements given for main class, with relevant additions as given in 102 to 402.

102 Arrangement, scantlings and securing of bow doors are given in D.

103 Arrangement, scantlings and securing of side and stern doors are given in Pt.3 Ch.3 Sec.6 C.

104 For ferries with the class notation **B**, openings in sides and ends leading to the vehicle deck need not have closing appliances.

105 Doors also used as driving ramps for vehicles shall satisfy relevant requirements given in Sec.4 B and Sec.4 C.

C 200 Access openings

201 Doors and sill heights are in general to satisfy the requirements given for main class.

202 Doors leading from vehicle deck to engine room shall have sill heights not less than 380 mm. Other doors leading from vehicle deck within a closed superstructure to spaces below freeboard deck, are in no case to have sill heights less than 230 mm.

C 300 Watertight integrity from the ro-ro deck (bulkhead deck) to spaces below

301 Subject to the provisions of subparagraphs 302 and 303 all accesses that lead to spaces below the bulkhead deck shall have a lowest point which is not less than 2.5 m above the bulkhead deck.

(SOLAS Reg. II-1/20-2.1)

302 Where vehicle ramps are installed to give access to spaces below the bulkhead deck, their openings shall be able to be closed weathertight to prevent ingress of water below, alarmed and indicated to the navigation bridge. Signboard marked “To be closed at sea” to be fitted.

(SOLAS Reg. II-1/20-2.1)

303 The Society may permit the fitting of particular accesses to spaces below the bulkhead deck provided they are necessary for the essential working of the ship, e.g. the movement of machinery and stores, subject to such accesses being made watertight, alarmed and indicated to the navigation bridge. Signboard marked “To be closed at sea” to be fitted.

(SOLAS Reg. II-1/20-2.1)

304 Subject to the approval by flag-state, the Society may accept equivalent solutions to the requirements specified in 301 and 303.

D. Bow Doors

D 100 Application and definitions

101 The requirements given below are applicable for bow doors in ships with unrestricted service. For possible reduced bow impact loads for ships with service area restriction, see 402. Conditions established in this respect shall be presented in the Operating and Maintenance Manual.

102 For outer bow doors, the requirements apply to the following two types of doors:

- Visor doors opened by rotating upwards on the horizontal axis through hinges located near the top of the door and connected to the primary structure of the door by longitudinally arranged lifting arms
- Side hinged doors opened by rotating outwards on a vertical axis through two or more hinges located near the outboard edges. It is anticipated that side hinged doors are arranged by pairs.

Other types of outer door will be specially considered in association with the applicable requirements given below.

103 The closing arrangements for bow doors normally encompass:

- doors
- ramps
- hinges
- packings
- cleats
- supports
- locking arrangement.

104 Definitions:

Bow doors: Collective term for the outer and the inner bow door normally leading to a complete or long forward enclosed superstructure.

Cleats: Devices for pre-compression of packings and steel to steel contact (not load carrying devices).

Supports: Load carrying devices designed for transfer of acting forces from door- to hull structures. These may include hinges, welded supports, bolts / eye plates etc.

Locking arrangement: Preventive measures ensuring that cleats and supports as applicable always remain in position when engaged.

D 200 Arrangement

201 Bow doors shall be situated above the freeboard deck. A watertight recess in the freeboard deck located forward of the

collision bulkhead and above the deepest waterline fitted for arrangements of ramps or other related mechanical devices may be regarded as a part of the freeboard deck for the purpose of this requirement.

202 Where bow doors are leading to a complete or long forward enclosed superstructure, an inner door shall be fitted. The inner door shall be part of the collision bulkhead. The inner door needs not to be fitted directly above the bulkhead below, provided the requirements concerning the position of the collision bulkhead are complied with, see Sec.2 B. A vehicle ramp may be arranged to serve the purpose of an inner door, provided no part of the ramp protrudes forward of the location range of the collision bulkhead.

203 Outer doors shall be so fitted as to ensure tightness consistent with operational conditions and to give effective protection to inner doors. Inner doors forming part of the collision bulkhead shall be weather tight over the full height of the cargo space and shall be arranged with supports on the aft side of the doors.

204 Bow doors shall be arranged so as to preclude the possibility of the outer door causing structural damage to the collision bulkhead and the inner door in the case of damage to or detachment of the door.

Guidance note:

In order to comply with requirements given in 204 it is advised that the hinges of the outer bow door should not be attached to structural elements being part of the collision bulkhead or to the upper deck at a position aft of the collision bulkhead at the point of attachment. If the above mentioned solution is not possible, due attention should be given to the design of the hinge-pin (axle) and fastening of this to ensure this is the weak link compared to the fastening/support of the hinge-plate (lug) to the ship structure. This shall ensure that any possible damage occurs in the hinge-pin or in way of this, and not the hinge-plate fastening/support or adjacent ship structure which in turn may lead to damage of the collision bulkhead.

Furthermore, no part of the inner door (or combined inner door/ramp) should protrude forward of the adjacent hull structures.

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205 The whole steel construction between the outer and inner door, i.e. deck construction, the sides and bulkheads forming the space between the outer and inner door, shall be capable of sustaining the sea loads as given in 403 for the inner door.

D 300 Materials

301 The structural materials for bow doors shall satisfy the requirements given for hull materials.

302 Steel forgings or castings used in the closing arrangement and manoeuvring components shall be of approved ductile materials, tested in accordance with the requirements in Pt.2 Ch.2. The material factor f_1 for forgings (including rolled round bars) and castings may be taken as:

$$f_1 = \left(\frac{\sigma_F}{235} \right)^{0.75}$$

σ_F = minimum upper yield stress in N/mm², not to be taken greater than 70% for the ultimate tensile strength.

The material factor f_1 shall not be taken greater than 1.39 unless a direct fatigue analysis is carried out.

D 400 Design Loads

401 Outer doors, ordinary design sea pressure:

p_e = as given for p_2 in Pt.3 Ch.1 Sec.4 C.

402 Outer doors, design bow impact pressure:

p_{se} = as given for p_{sl} in Pt.3 Ch.1 Sec.7 E with $\gamma = 0$.

For ships with service area restrictions **R2** to **RE** the wave coefficient, C_w , may be reduced as follows for calculations of bow door impact pressure:

- service area notation **R2**: 10%
- service area notation **R3**: 20%
- service area notation **R4**: 30%
- service area notation **RE**: 40%.

403 For inner doors including surrounding structures forming part of the collision bulkhead above the freeboard deck, the design sea pressure shall be taken as the greater of:

$$p_e = 0.6 L \text{ (kN/m}^2\text{)}$$

L = ship's length, as given in Pt.3 Ch.1 Sec.1 B, need not be taken greater than 200 m

or

$$p_h = 10 h_b \text{ (kN/m}^2\text{)}$$

h_b = vertical distance (m) from load point to top of cargo space.

404 The internal design pressure for bow doors shall not be taken less than:

$$p_i = 25 \text{ kN/m}^2$$

405 The design forces (kN) on each half of the outer door for support devices, including supporting structural members and surrounding structures, are given by (see Fig. 1):

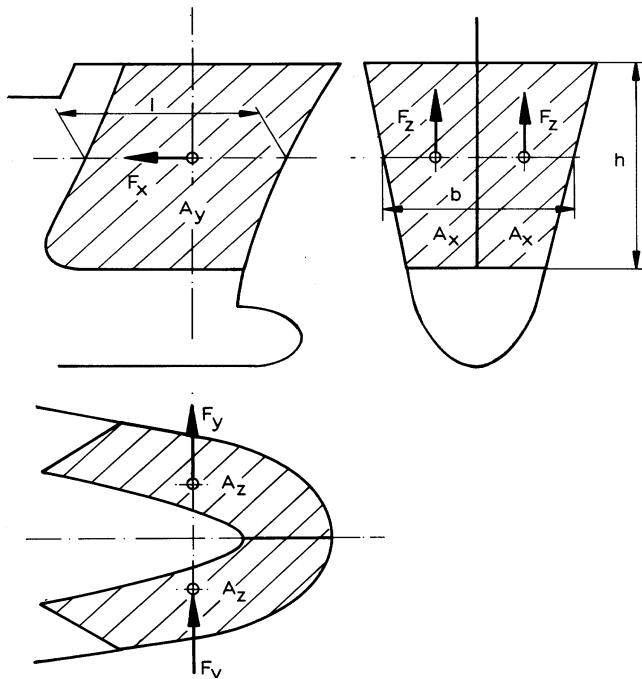


Fig. 1
Bow Doors

External forces:

— total longitudinal force:

$$F_x = 0.375 p_{se} A_x \text{ or } 1.3 p_e A_x, \text{ if greater}$$

— total transverse force:

$$F_y = 0.375 p_{se} A_y \text{ or } 1.3 p_e A_y, \text{ if greater}$$

— total vertical force:

$$F_z = 0.375 p_{se} A_z \text{ or } 1.3 p_e A_z, \text{ if greater.}$$

The vertical force shall not be taken less than $3.3 b / h$, where b , l and h are breadth, length and height, respectively, of the outer door in m as given in Fig. 1.

A_x = area (m²) of the transverse vertical projection of the outer door at one side of the centre line, between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser.

Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser.

In determining the height from the bottom of the door to the upper deck or to the top of the door, the bulwark shall be excluded.

A_y = area (m²) of the longitudinal vertical projection of the outer door between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser.

Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser.

A_z = area (m²) of the horizontal projection of the outer door at one side of the centre line, between the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser.

Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser.

The design pressures shall be calculated at the position $h/2$ above the bottom of the door and $l/2$ aft of the stem line.

For outer doors, including bulwark, of unusual form or proportions, the areas and angles used for determination of the design values of external forces may require special consideration.

Internal forces:

— total longitudinal force: $F_{xi} = p_i A_x$

— total transverse force: $F_{yi} = p_i A_y$.

406 The design force (kN) on the inner door for support devices, including supporting structural members and surrounding structures, is given by:

External force:

— total longitudinal force:

$$F_x = p_e A_x \text{ or } p_h A_x, \text{ if greater.}$$

Internal force:

— total longitudinal force:

$$F_{xi} = p_i A_x$$

A_x = inner door area (m²).

D 500 Strength criteria

501 In connection with direct strength calculations as stipulated in 903, scantlings of primary members and supports of bow doors shall be determined to withstand the design pressures using the following allowable stresses:

Table D1 Allowable stresses, outer doors			
Design pressure p (N/mm ²)	Shear stress t (N/mm ²)	Bending or normal stress σ (N/mm ²)	Equivalent stress σ_e (N/mm ²)
p_e or p_i	$80 f_1$	$120 f_1$	$150 f_1$
$0.375 p_{se}$	$105 f_1$	$160 f_1$	$200 f_1$

Table D2 Allowable stresses, inner doors			
Design pressure p (N/mm ²)	Shear stress t (N/mm ²)	Bending or normal stress σ (N/mm ²)	Equivalent stress σ_e (N/mm ²)
p_e, p_h or p_i	$105 f_1$	$160 f_1$	$200 f_1$

502 Allowable stresses in support devices and supporting members and surrounding structure:

Table D3 Allowable stresses, outer doors			
Design pressure p (N/mm ²)	Shear stress t (N/mm ²)	Bending or normal stress σ (N/mm ²)	Equivalent stress σ_e (N/mm ²)
$0.375 p_{se}, 1.3 p_e$ or $1.3 p_i$	$105 f_1$	$160 f_1$	$200 f_1$

Table D4 Allowable stresses, inner doors			
Design pressure p (N/mm ²)	Shear stress t (N/mm ²)	Bending or normal stress σ (N/mm ²)	Equivalent stress σ_e (N/mm ²)
p_e, p_h or p_i	$105 f_1$	$160 f_1$	$200 f_1$

503 The nominal tension in way of threads of bolts not carrying support forces shall not exceed $125f_1$ (N/mm²).

504 Nominal bearing pressure, determined by dividing the design force by the projected bearing area, shall not exceed $0.8 \sigma_F$ (N/mm²) for steel material where σ_F is the yield stress for the bearing material. For other bearing materials the nominal bearing pressure will be specially considered.

D 600 Structural arrangement

601 Bow doors shall be adequately stiffened, and means shall be provided to prevent lateral or vertical movement of the doors when closed. For outer doors of the visor type adequate strength shall be provided in the connections of lifting arms to the door and the ship structure.

602 For outer doors the structural arrangement and the member scantlings shall comply with the requirements for bow impact in Pt.3 Ch.1 Sec.7 E and associated requirements given under D700 - D900.

D 700 Plating

701 The thickness requirement of the bow door plating corresponding to lateral pressure is given by the greater of:

— inner and outer doors:

$$t_1 = \frac{1.58 k_a s \sqrt{p_e}}{\sqrt{f_1}} \quad (\text{mm})$$

(for calculation of t_1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i)

— outer doors:

$$t_2 = \frac{13.8 k_a s \sqrt{p_{sl}}}{\sqrt{\sigma_f}} \quad (\text{mm})$$

p_{sl} = as given in Pt.3 Ch.1 Sec.7 E.

k_a = correction factor for aspect ratio of plate field

$$= (1.1 - 0.25 s/l)^2$$

= maximum 1.0 for $s/l = 0.4$

= minimum 0.72 for $s/l = 1.0$

The thickness of the inner door shall not be less than the minimum thickness for the collision bulkhead as given in Pt.3 Ch.1 Sec.9 C.

D 800 Stiffeners

801 The elastic/plastic section modulus of horizontal or vertical stiffeners shall not be less than the greater of:

— inner and outer doors. The elastic section modulus, Z_1 shall not be less than:

$$Z_1 = \frac{0.8 l^2 s p_e}{f_1} \quad (\text{cm}^3)$$

(for calculation of Z_1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i)

— outer doors:

The plastic section modulus of shell stiffeners, Z_p , as defined in Pt.3 Ch.1 Sec.3 C shall not be less than as given in Pt.3 Ch.1 Sec.7 E with $t_k = 0$.

802 The stiffener web plate at the ends shall have a net sectional area not less than the greater of:

— inner and outer doors:

$$A_1 = \frac{0.08 l s p_e}{f_1} \quad (\text{cm}^2)$$

(for calculation of A_1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i)

— outer doors:

$A_2 = A_s$ as given for shell stiffeners in Pt.3 Ch.1 Sec.7 E with $t_k = 0$.

D 900 Girders

901 The section modulus of single girders shall not be less than the greater of:

— outer doors:

$$Z_1 = \frac{1.05 S^2 b p_e}{f_1} \quad (\text{cm}^3)$$

— inner doors (p_e to be taken as the greatest of p_e, p_h or p_i)

$$Z_1 = \frac{0.8 S^2 b p_e}{f_1} \quad (\text{cm}^3)$$

— outer doors:

$Z_2 = Z$, as given in Pt.3 Ch.1 Sec.7 E with $w_k = 1.0$ for primary members supporting shell stiffeners.

902 The web area requirement (after deduction of cut-outs) at the girder ends is given by the greater of:

— inner and outer doors:

$$A_1 = \frac{0.08 S b p_e}{f_1} \text{ (cm}^2\text{)}$$

(for calculation of A_1 for inner doors, p_e to be taken as the greatest of p_e , p_h or p_i)

— outer doors:

$A_2 = A$ as given in Pt.3 Ch.1 Sec.7 E with $t_k = 1.0$ for primary members supporting shell stiffeners.

903 For large doors with a complex girder system a direct stress analysis of the door structure including supports may be required. Allowable stresses are given in 501 and 502.

904 The buckling strength of primary members shall be verified as being adequate.

905 The arrangement, scantlings and stiffening of girders and diaphragms supporting shell frames of outer bow doors shall comply with requirements given in Pt.3 Ch.1 Sec.7 E.

906 The girder system shall be given sufficient stiffness to ensure integrity of the boundary support of the door. The stiffness of the edge girders shall be related to the distance between supports and to the loads from the main door girders.

907 Where inner doors serve as vehicle ramps wheel loads shall be considered as given in B300.

D 1000 Closing arrangement, general

1001 Adequate provisions shall be arranged for closing of bow doors so as to be commensurate with the strength and stiffness of the surrounding structure.

1002 Devices provided for closing of bow doors shall be simple to operate and easily accessible.

1003 Closing arrangement for bow doors shall be provided with devices arranged for remote control from a convenient position above the freeboard deck. The operating panel for remotely controlled bow doors shall be inaccessible for unauthorised persons.

1004 Notice plates, giving instructions that bow doors shall be closed and all devices provided for closing are closed and locked before leaving quay-side (or terminal) shall be placed at the operating panel and on the navigation bridge.

1005 For outer doors of the side-hinged type thrust bearings shall be provided in way of girder ends at the closing of the two leaves to prevent one leaf shifting towards the other one under the effect of asymmetrical forces (see example on Fig. 2). The two parts shall be kept together by means of cleats. Any other arrangement serving the same purpose may be considered.

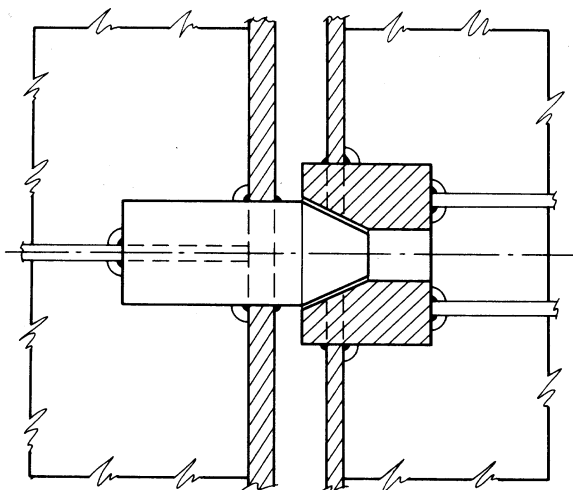


Fig. 2
Thrust bearing. Bow door leaves

1006 For outer doors of the visor type, the hinge arrangement is generally to be such that the door is effectively self closing under external loads given by:

$$\alpha = \frac{F_x a - F_z b}{\sqrt{F_x^2 + F_z^2} \sqrt{a^2 + b^2}} \geq 0.10$$

a = vertical distance (m) from visor hinge to position $h/2$
 b = horizontal distance (m) from visor hinge to position $l/2$
 F_x , F_z , h and l as given in 405.

1007 Devices shall be arranged for the bow doors to be secured in open position. Bow doors of the visor type shall be mechanically secured in open position.

1008 Where packing is required the packing material shall be of a comparatively soft type, and the supporting forces shall be carried by the steel structure only. Other types of packing may be considered. Flat bars or similar fastening devices for packing shall have scantlings and welds determined with ample consideration to wear and tear.

1009 Documented operating procedures for closing and securing the bow doors shall be kept on board and posted at the appropriate places.

D 1100 Closing arrangement, strength

1101 Only supports having an effective stiffness in a given direction shall be included in calculation of the load carrying capacity of the devices. The distribution of the total forces acting on the supports may, for doors with a complex closing arrangement, be required calculated by a direct calculation taking into account the flexibility of the door and surrounding hull structure and the position of the supports. The number of supports is generally to be the minimum practical taking into account the requirements for redundant provision as given in 1103 and the available space for adequate support in the surrounding hull structure which may limit the size of each device. Maximum design clearance for effective supports should normally not exceed 3 mm. Design clearances shall be included in the Operating and Maintenance Manual as given in A301.

1102 In general the maximum forces acting on the supports shall be established on the basis of the external and internal forces as given in 405 and 406. The following cases shall be considered:

- 1) For outer doors of the visor type the forces acting on the supports shall be determined for the following combination of simultaneous design forces:
 - a) $2 F_x$ and $2 F_z$
 - b) $1.4 F_x$, $0.7 F_y$ and $1.4 F_z$, with $0.7 F_y$ acting alternatively from either side.
- 2) For outer doors of the side hinged type the forces acting on the supports shall be determined for the following combination of simultaneous design forces:
 - a) F_x , F_y and F_z , with each force acting on both doors
 - b) $0.7 F_x$, $0.7 F_y$ and $0.7 F_z$, acting on each door separately.

Guidance note:

The support forces as determined according to 1 a) and 2 a) shall in general give rise to a zero moment in the longitudinal vertical plane about the transverse axis at $h/2$ and $l/2$.

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1103 For outer doors effective supports including surrounding door and hull structural members are, in the case of failure of any single support, to have sufficient capacity to withstand the total design forces. In this case the allowable stresses given

in Table D3 in 502 may be increased by 20%.

1104 For outer doors of the visor type, at least two securing devices shall be provided at the bottom of the door, each capable of providing the full reaction force required to prevent opening of the door within the allowable stresses given in Table D3. The opening moment to be balanced by the said reaction force shall not be taken less than:

$$M_0 = 1.3 (10 W d + 5 A_x a) \text{ (kNm)}$$

W = mass of the door (t)

a = vertical distance (m) from visor hinge to the centroid of the vertical projected area of the bow visor

d = vertical distance (m) from hinge axis to the centre of gravity of the door.

A_x as defined in 405.

1105 All load transmitting elements in the design load path, from the door through supports into the ship structure, including welded connections, shall be to the same strength standard as required for the supports.

1106 The lifting arms of a visor type outer door and its connections to the door and hull structure shall be dimensioned for the static and dynamic forces applied during lifting and lowering operations. A minimum wind pressure of 0.0015 N/mm² shall be taken into account.

D 1200 Closing arrangement, system for operation and indication and monitoring

1201 Cleats and support devices shall be equipped with locking arrangement (self locking or separate arrangement) or shall be of the gravity type.

Guidance note:

Alternative locking arrangements may be accepted depending upon the location and reliability of the arrangement.

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1202 Where hydraulic operating systems are applied, cleats and support devices shall remain locked in the closed position in case of failure in the hydraulic system.

1203 Systems for operation of cleats and support devices and, where applicable, for locking arrangement shall be interlocked in such a way that they can only operate in the proper sequence. Hydraulic operating systems shall be isolated from other circuits and shall be inhibited when doors and closing arrangement are in the closed or locked position.

1204 Indication of the open or closed position of any of the bow doors and indication that cleats, support and locking devices, as applicable, are properly positioned shall be provided at the operating panel for remote control. The indication panel shall be provided with a lamp test function.

When a mechanical lock is placed inside the hydraulic cylinder operating a cleat or support, indication of the open or closed position of the cleat or support shall be made on the lock inside the cylinder.

1205 Separate indicator lights and audible alarms shall be provided on the navigation bridge to show and monitor that each of the bow doors is properly closed and that cleats, support and locking devices as applicable are properly positioned.

The indicator system shall show by visual indication if any of the bow doors are not fully closed and not fully locked, and by audible alarms if securing devices become open or locking devices become unsecured.

1206 The alarm and indication panel on the navigation bridge shall be equipped with a mode selection function "harbour/sea voyage" so arranged that audible alarm is given on the navigation bridge if the vessel departs the quay side (or terminal) with any of the bow doors not properly closed or any of the cleats, support and locking devices not properly positioned.

1207 The indicator and alarm systems on the navigation bridge mentioned under D1200 shall be designed on the fail-to-safe principle in compliance with the following:

- 1) The indication panel shall be provided with:
 - a power failure alarm, provided for both power sources
 - an earth failure alarm
 - a lamp test device
 - for each door, separate indications for door closed / not closed, door locked/not locked.
 - a dimmer (however, it shall not be possible to turn off the indicator lights completely).
- 2) The electrical circuits used for indicating door position shall be normally closed when the door is completely closed and completely open. When more limit switches are provided for each door they may be connected in series.
- 3) The electrical circuit used for indicating securing arrangements position shall be normally closed when the securing arrangements are completely locked and completely unlocked. When more limit switches are provided for each door they may be connected in series.
- 4) Separate circuits shall be arranged for indication of door position (closed/not closed) and for securing arrangements position (locked/not locked). Multicore cable is permitted.
- 5) In case of dislocation of limit switches, this shall be indicated by not closed/not locked/securing arrangement not in place - as appropriate.

1208 The power supply for indicator and alarm systems for operating and closing doors shall be independent of the power supply for the operating and closing arrangements and shall be provided with a backup power supply from the emergency source of power or other secure power supply, e.g. UPS (Uninterrupted Power Supply) with a minimum capacity of 30 minutes.

1209 Sensors for the indicator system shall be protected from water, ice formation and mechanical damage.

1210 A water leakage detection system with audible alarm and television surveillance shall be arranged to provide an indication to the navigation bridge and to the engine control room of leakage through the inner door.

1211 In the space between the outer and the inner doors a television surveillance system shall be arranged with monitors on the navigation bridge and in the engine control room. The system shall monitor the position of the doors and a sufficient number of devices for the closing arrangement. Special consideration shall be given for the lighting and contrasting colour of objects under surveillance.

1212 A drainage system shall be arranged in the space between the bow door and ramp, or where no ramp is fitted, between the bow door and inner door. The system shall be equipped with an audible alarm function to the navigation bridge being set off when the water levels in these areas exceed 0.5 m or the high water level alarm, whichever is lesser.

1213 Special category spaces and ro-ro spaces shall be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorised access by passengers thereto can be detected whilst the ship is underway.

Guidance note:

Items 1204 to 1212 apply to shell doors, loading doors and other closing appliances for all passenger ships with ro-ro spaces or special category spaces as defined in A400 which, if left open or not properly closed and locked, could lead to a major flooding of such spaces.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

E. Inlets and Drainage Arrangement

E 100 Air intakes, ventilators, etc.

101 Location of air intakes for engines will be considered in each case.

102 In ships with the class notation **A** the following apply:

- a) If air intakes for engines are led through superstructure sides, the distance from the lower side of the opening to the freeboard deck shall not be less than 4.5 m, and a drainage box shall be fitted between the ship's side and the engine room, draining directly overboard.
- b) If ventilators, etc. without weathertight closing appliances are led through superstructure sides, the distance from the lower side of the ventilator opening to the freeboard deck shall not be less than 4.5 m.

E 200 Drainage of vehicle deck (class notation **A**)

201 In addition to the requirements in 202 and 203, drainage of vehicle decks within superstructures shall comply with the requirements given in Pt.4 Ch.6.

202 If the drainage openings in the vehicle deck will be lower than the waterline when the ship loaded to summer freeboard has a list of 5°, the outlets shall be led down to a separate tank.

203 Each scupper shall have an automatic non-return valve with a positive means of closing it from a position above the freeboard deck. Where, however, the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions. The means for operating the positive action valve shall be readily accessible and provided with an indicator showing whether the valve is open or closed.

E 300 Freeing ports (class notation **B**)

301 The vehicle deck freeing port area shall not be less than required for an open freeboard deck according to Pt.3 Ch.3 Sec.6 M.

F. Stability

F 100 General

101 Ships with class notation **Car Ferry, Train Ferry** or **Car and Train Ferry** shall comply with the requirements of Pt.3 Ch.3 Sec.9 as well as the requirements of Sec.2 F for **Passenger Ships**.

Guidance note:

For vessels arranged with a lower ro-ro cargo hold below the bulkhead deck Regulation 4, 5, 6 and 7 of SOLAS 74, Ch. II-1, Part B are not considered applicable. For such ferries two alternatives are considered applicable:

Compliance with IMO Res. A.265(VIII) when applied in its entirety.

The inboard penetration of SOLAS damages in way of the lower

ro-ro cargo hold, including damages involving the boundary bulkheads, are extended to the centreline. The lower ro-ro cargo hold should be assumed to have a permeability equal to 0.90 unless a lesser value can be demonstrated by calculation. For this damage conditions the vessel should meet the criteria according to SOLAS 74, Ch. II-1, Part B, Reg. 8.2.3. It is recommended that a double bottom in way of the lower cargo hold has a value of at least B/10.

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102 For ships in domestic trade and with service restrictions, alternative stability requirements may be accepted after considerations in each separate case.

G. Life Saving Appliances and Arrangements

G 100 Application

101 Ships with class notation **Car Ferry, Train Ferry** or **Car and Train Ferry** shall comply with the requirements of subsection F.

G 200 Additional requirements for ro-ro passenger ships (Regulation III/26)

- 1 This regulation applies to all ro-ro passenger ships. Ro-ro passenger ships constructed:
 - 1.1 on or after 1 July 1998 shall comply with the requirements of paragraphs 2.3, 2.4, 3.1, 3.2, 3.3, 4 and 5.
- 2 Liferafts
 - 2.3 Every liferaft on ro-ro passenger ships shall be of a type fitted with a boarding ramp complying with the requirements of paragraph 4.2.4.1 or 4.3.4.1 of the Code, as appropriate.
 - 2.4 Every liferaft on ro-ro passenger ships shall either be automatically self-righting or be a canopied reversible liferaft which is stable in a seaway and is capable of operating safely whichever way up it is floating. Alternatively, the ship shall carry automatically self-righting liferafts or canopied reversible liferafts, in addition to its normal complement of liferafts, of such aggregate capacity as will accommodate at least 50% of the persons not accommodated in lifeboats. This additional liferaft capacity shall be determined on the basis of the difference between the total number of persons on board and the number of persons accommodated in lifeboats. Every such liferaft shall be approved by the Administration having regard to the recommendations adopted by the Organization.*
- 3 Fast rescue boats
 - 3.1 At least one of the rescue boats on a ro-ro passenger ship shall be a fast rescue boat approved by the Administration having regard to the recommendations adopted by the Organization.* *
 - 3.2 Each fast rescue boat shall be served by a suitable launching appliance approved by the Administration. When approving such launching appliances, the Administration shall take into account that the fast rescue boat is intended to be launched and retrieved even under severe adverse weather conditions, and also shall have regard to the recommendations adopted by the Organization.* *
 - 3.3 At least two crews of each fast rescue boat shall be trained and drilled regularly having regard to the Seafarers Training, Certification and Watchkeeping (STCW) Code and recommendations adopted by the Organization,*** including all aspects of rescue, handling, manoeuvring, operating these craft in various conditions, and righting them after capsizing.

4 Means of rescue

- 4.1 Each ro-ro passenger ship shall be equipped with efficient means for rapidly recovering survivors from the water and transferring survivors from rescue units or survival craft to the ship.
- 4.2 The means of transfer of survivors to the ship may be part of a marine evacuation system, or may be part of a system designed for rescue purposes.
- 4.3 4.3 If the slide of a marine evacuation system is intended to provide the means of transfer of survivors to the deck of the ship, the slide shall be equipped with handlines or ladders to aid in climbing up the slide.

5 Lifejackets

- 5.1 Notwithstanding the requirements of regulations 7.2 and 22.2, a sufficient number of life jackets shall be stowed in the vicinity of the muster stations so that passengers do not have to return to their cabins to collect their life jackets.
- 5.2 In ro-ro passenger ships, each lifejacket shall be fitted with a light complying with the requirements of paragraph 2.2.3 of the Code.

* Refer to the requirements for automatically self-righting liferafts and canopied reversible liferafts, MSC/Circ.809.

** Refer to recommendations to be adopted by the Organization.

*** Refer to the Recommendation on training requirements for crews of fast rescue boats, adopted by the Organization by resolution A.771(18) and section A-VI/2, table A-VI/2-2 "Specification of the minimum standard of competence in fast rescue boats" of the Seafarers' Training, Certification and Watchkeeping (STCW) Code. (SOLAS Reg. III/26)

SECTION 4 GENERAL CARGO CARRIERS

A. General

A 100 Classification

101 The requirements in this section apply to ships intended for carriage of general dry cargoes.

102 Ships arranged for general cargo handling and built in compliance with relevant requirements specified in the following may be given the class notation **General Cargo Carrier**.

103 Ships arranged for roll on/roll off cargo handling and built in compliance with relevant requirements specified in the following may be given the class notation **General Cargo Carrier RO/RO**.

104 Ships arranged for general cargo handling and where the decks and inner bottom are built in compliance with relevant requirements in C, will be given the additional class notation **PWDK**.

105 Ships arranged for general cargo handling and also arranged for carriage of vehicles with fuel in their tanks shall comply with requirements given in SOLAS Reg. II-2/20, and will, when in compliance, be given the class notation **PET**. For further information regarding SOLAS requirements, reference is made to Pt.4 Ch.10 Sec.4.

106 Ships arranged for roll on/roll off cargo handling (class notation **General Cargo Carrier RO/RO**) shall have decks, inner bottom, ramps and lifts fulfilling the strength requirement in C. Additionally, the requirements for class notation **PET** (see 105) shall be complied with.

107 Ships intended for carriage of dry bulk and built in compliance with the requirements given in Sec.5 will be given the class notation **General Cargo Carrier HC-A** (or **HC-B**, **HC-C**, **HC-B*** **HC-M**). The bulk carrier notations **BC-A**, **BC-B**, **BC-C** or **BC-B*** may also be applied on a voluntary basis.

A 200 Documentation

201 For the approval of deck structure of **General Cargo Carrier**, the following plans shall be submitted:

- type of cargo handling vehicles including maximum axle load and details of wheel and/or foot print arrangement
- uniform deck load
- plans according to 203, when relevant.

202 For the approval of structures subjected to wheel loading (**PWDK**) the following information shall be submitted:

- type of cargo handling vehicles including maximum axle load and details of wheel and/or foot print arrangement
- maximum axle load including details of wheel and/or foot print arrangement for all vehicles (cars, trucks, dumpers, road trailers, MAFI trailers, busses, etc.) to be carried on-board.
- uniform deck load
- stowage and securing arrangement for all vehicles to be carried. Stowage plan shall include the most unfavourable combination of vehicles that may be positioned on deck
- plans for supporting structure for lashing points, if relevant.

203 For approval of internal ramps and ramps for shore connections, the following information shall be submitted:

- maximum number of vehicles with and or the most unfavourable combination of vehicles which may be situated on the ramp
- maximum lifting force and hinge forces, including force direction

- hoisting and securing arrangement in working and stowed position
- tightening arrangement against water penetration, if relevant
- proposed procedure for functional testing
- plans and supplementary documentation giving pertinent particulars of the hoisting/lowering mechanical gear arrangement
- schematic diagrams of hydraulic systems, electrical systems and pneumatic systems
- braking systems
- plans showing scantling and layout of supporting structure for hinges, release hook, cleatings, operating winches, king post and other relevant RO/RO equipment.

204 For the approval of securing points for road vehicles and cars, the following information shall be submitted:

- securing points for lashing with data regarding position, type, design of fittings and Maximum Securing Load (MSL)
- stowage and securing arrangement for all vehicles to be carried
- maximum axle load and number of axles of vehicles.

205 For ships built for carriage of vehicles with fuel in their tanks (**PET**) the following plans and particulars shall be submitted for approval:

- arrangement plan(s) as specified in Pt.4 Ch.8 showing all electrical equipment in spaces where vehicles are carried, with specification of make, type and rating of all such equipment and of cable types.
- plan(s) as specified in Pt.4 Ch.10 Sec.4 Table A1 with reference to SOLAS 2000 Amend. Ch.II-2 Reg.20.

206 For ships built in compliance with the requirement for class notation (**General Cargo Carrier RO/RO**) the following plans and particulars shall be submitted for approval:

- plans according to 201, 202, 204, 205.

207 If water ingress detection is arranged documentation specified in Sec.5 A305 shall be submitted for approval.

B. Hull Arrangement and Strength

B 100 General

101 Where direct stress analysis is required in the following, the design loads, calculation methods and allowable stresses are in general to be as given for complex girder systems in Pt.3 Ch.1 Sec.12.

102 For ships with class notation **General Cargo Carrier RO/RO**, a general reference is given to Classification Note 31.2 for the strength analysis of racking constraining structure, girder system and pillars.

Classification Note 31.2 shows acceptable load cases, loads and relevant acceptance criteria for different structural elements.

103 In ships with cargo hatchways the upper deck and 'tween deck(s) are normally supported by deck transverses (hatch side cantilevers) extending from a side vertical to the hatch side coaming. The scantlings shall be dimensioned as given in B600.

104 For open type ships with weather deck hatch openings in one transverse section of substantial breadth and length, the combined effects of hull girder bending and torsion related to possible local bending and shear may have to be specially considered as outlined in Classification Note No. 31.7.

105 Movable car decks, if fitted, shall satisfy relevant requirements given in Sec.7 C.

106 If cargo decks are supported by pillars, the pillars shall normally extend to the bottom structure or a supporting bulkhead. Direct stress analysis of deck structure and bottom structure in way of pillars may be necessary.

107 Supports for pillars shall be designed so as also to withstand tensile forces, if relevant.

108 Strength of pillars shall be assessed assuming summary of maximum loads of the decks.

109 Double bottom in ships with decks supported by pillars on the double bottom shall be investigated for relevant seagoing draught including maximum ballast draught, minimum 0.6 T, with no loads on decks above. Counteracting forces due to ballast in double bottom may be taken into account in the analysis.

110 Double bottoms not supported by pillars or vertical pillar bulkheads shall be investigated for relevant draught, normally maximum draught, with no load on the inner bottom.

111 Double bottom structure may have to be specially considered for the docking condition with relevant acceptance criteria according to Classification Note 31.2.

112 Deck girder structure shall be checked for the uniform deck load (UDL) at relevant seagoing condition draught and applied as evenly and unevenly distributed on the deck.

113 The deck girder structure shall be checked for the most severe axle position for load handling vehicles and vehicles to be carried.

114 The hull structure shall be assessed for damage condition with acceptance criteria according to Pt.3 Ch.1 Sec.12.

115 Due attention shall be put to fatigue of structural details. For further information, references are made to B500.

116 Strength of decks intended for carrying MAFI trailers or other vehicles carrying more than one tier of containers, shall be specially considered in a heeled condition.

B 200 Strength analysis levels

201 The hull structure for **General Cargo Carrier RO/RO** and **Car Carrier** (see Sec.7) shall be analysed according to Level 1 as described in Classification Note 31.2.

202 The hull structure for **General Cargo Carrier RO/RO** and **Car Carrier** (see Sec.7) that are also analysed according to Level 2 (Classification Note 31.2) will be given the additional class notation **NAUTICUS (Newbuilding)**.

203 The hull structure for **General Cargo Carrier RO/RO** and **Car Carrier** (Sec.7) that are also analysed according to Level 3 (Classification Note 31.2) will be given the additional class notation **CSA-2** (see Pt.3 Ch.1 Sec.15 E).

B 300 Longitudinal strength

301 Longitudinal strength shall be checked for relevant loading conditions as described in Pt.3 Ch.1 Sec.5 B100. Due attention should be put to the sagging and hogging bending moments for non-homogenous loading conditions.

302 A still water sagging moment below the minimum Rule sagging moment may only be accepted provided the strength can be documented for a non-homogenous loading with maximum realistic load concentration within 0.4 L amidships.

B 400 Transverse strength

401 Vessels with a limited number of effective transverse strength structures for racking (class notation **General Cargo Carrier RO/RO**) shall be subject to a direct strength analysis to demonstrate that the stresses are acceptable in a heeled condition. Acceptable calculation methods are given in Classification Note No. 31.2.

402 For ships with limited hull depth (class notation **General Cargo Carrier RO/RO**), the transverse strength is usually secured by having self supporting side verticals. A simplified racking assessment using beam models will then be accepted for documentation of the transverse strength.

B 500 Fatigue

501 Structural details of transverse racking constraining structure shall be specially considered to ensure a proper resistance against fatigue. Classification Note 31.2 describes acceptable loads and procedures for such analyses.

502 For ships with limited hull depth (class notation **General Cargo Carrier RO/RO**), the side verticals are usually designed self supporting with respect to racking. In such case, a proper fatigue life can be ensured by controlling the general stress level in the support areas of the side verticals. Relevant loads and allowable nominal stresses are those described in Classification Note 31.2.

B 600 Hatch side cantilevers

601 Hatch side cantilevers and side verticals are shown in Fig. 1.

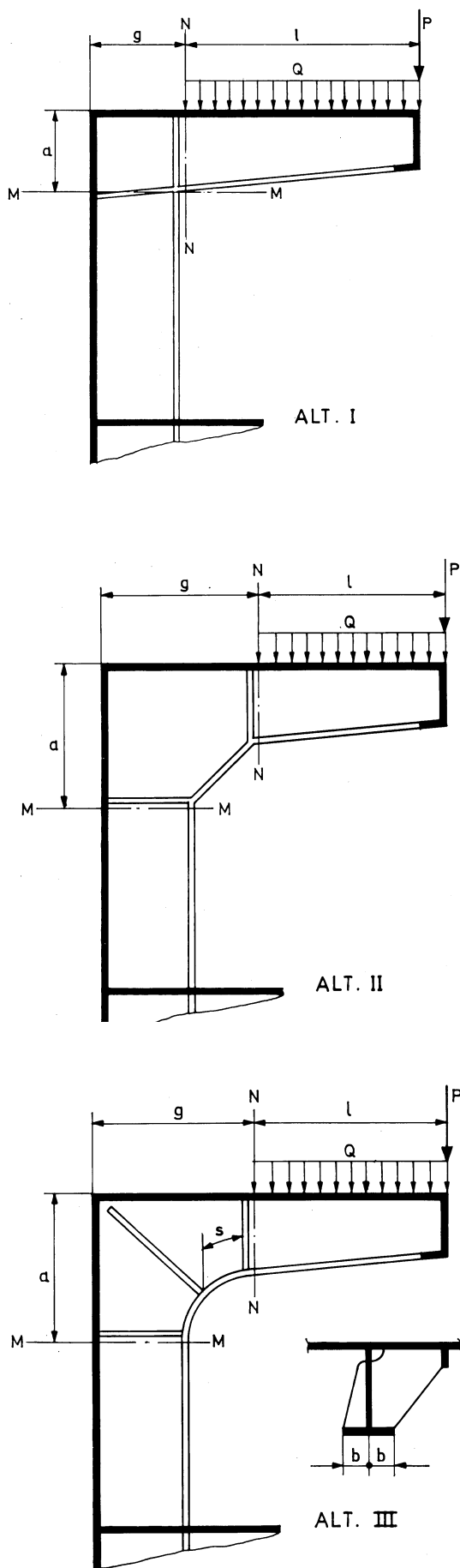


Fig. 1
Hatch side cantilevers

602 When the cantilever may be considered as a simple girder the section modulus in sections M-M and N-N shall not be less than:

$$Z = \frac{6}{f_1} l (P + 0.5Q) \quad (\text{cm}^3)$$

l = as given in Fig. 1 in m

P = point load in kN at side coaming (from cargo on hatch cover and transversely stiffened deck)

Q = distributed load in kN (from cargo on longitudinally stiffened deck).

The design pressures from cargo loads shall be calculated as given for the main class.

603 For rounded corners shown in Fig. 1 (Alt. III), the effective width of the face plate shall be taken as given in Pt.3 Ch.1 Sec.3 C400.

For corner designs according to Fig. 1 (Alt. I or Alt. II), the effective width of the face plate shall be taken equal to the actual width.

604 The total effective width of the attached area of deck and shell plating may be taken as $0.4 l$. The width is, however, not to be taken greater than the cantilever spacing or the distance g in Fig. 1.

605 The net web area of the cantilever shall not be less than:

$$A = \frac{0.12}{f_1} \left(P + Q \frac{x}{l} \right) \quad (\text{cm}^2)$$

x = distance in m from end of cantilever

P and Q = as given in 202.

606 The thickness of the corner plate between the sections M-M and N-N shall not be less than:

$$t = \frac{0.012}{f_1} (P + 0.5 Q) \frac{l}{ag} \quad (\text{mm})$$

The corner plate in Fig. 1 (Alt. I and Alt. II) shall be additionally stiffened if a and g is greater than $70 t$.

P and Q = as given in 202

l , a and g = as given in Fig. 1.

B 700 External vehicle ramps

701 Vehicle ramps for shore connection are normally to be built with a grillage system of girders, and local stiffeners in the vehicle's moving direction. The ramps shall have sufficient strength for the specified design working loads and maximum loads during hoisting operation. After end ramps shall have sufficient flexibility for resting on the quay during loading/unloading operations with a minimum list of 3 degrees. A direct stress analysis may have to be carried out to demonstrate that stresses and flexibility are acceptable.

702 Plates and stiffeners shall satisfy the strength requirements given in C.

703 If the ramp is also acting as a watertight door, relevant requirements given for the main class shall be satisfied.

704 The support structure for large ramps in stowed position will have to be specially considered based on design loads as given for heavy units in Pt.3 Ch.1 Sec.4 C. A direct stress analysis may have to be carried out.

705 Satisfactory functional tests shall be carried out.

706 Control handles for winches or operation devices shall be so arranged that they quickly revert to the neutral (stop) position when released. Provision shall be made to lock handles in the neutral position when the operating gear is unattended.

B 800 Internal ramps and lifts

801 Internal ramps and lift platforms shall have sufficient strength for the specified design working load. For hoistable ramps and lifts also the maximum loads during hoisting conditions shall be considered.

802 Plates and stiffeners shall satisfy the strength requirements given in C for permanent decks for wheel loading.

803 Ramps or lift platforms acting as deck opening covers shall satisfy the relevant requirements to the deck according to the main class.

804 Satisfactory functional tests shall be carried out.

B 900 Ceilings and cargo battens

901 Ships with single bottom in cargo holds shall be fitted with ceiling on top of floors, extending to the upper part of the bilges. Limber boards shall be arranged to provide easy access for inspection of the bottom structures.

902 Any wooden ceiling on inner bottom shall be fitted either directly in a layer of tightening and preserving composition or on battens of thickness at least 12.5 mm. The thickness of wooden ceiling shall not be less than 63 mm. In way of the bilges removable ceiling shall be fitted. Deck composition as mentioned in 304 instead of wooden ceiling shall be satisfactory strengthened. There shall be effective drain to the bilges.

903 In spaces for general dry cargo, battens are normally to be fitted on ship's sides from upper turn of bilge (or from deck in between deck spaces and superstructures) up to the under side of beam knees. The clear space between adjacent rows of battens shall not exceed 300 mm. The thickness of wooden battens shall not be less than 50 mm.

904 Deck compositions are subject to approval by the Society. See "Register of Type Approved Products No.3: Containers, Cargo Handling, Lifting Appliances and Miscellaneous Equipment".

B 1000 Protection of cargo

1001 It is assumed that adequate precautions are taken when necessary to prevent hazards from cargoes which are subject to gassing, oxidation, self-heating or spontaneous combustion in connection with heating, moisture or other detrimental affecting of the cargo. The above mentioned assumption will be stated in the appendix to the classification certificate for the ship.

B 1100 Support of cargo handling equipment

1101 Masts and posts shall be efficiently supported and connected to at least two decks or to one deck and a mast house top above. If the latter arrangement is adopted, the mast house top shall be of sufficient size and adequately stiffened. A winch house of usual size and scantlings is not considered to meet the requirements.

1102 At fastenings for standing rigging and for guys and topping lifts, the deck shall be securely stiffened and reinforced for the additional loading.

1103 The support of other lifting arrangement will be specially considered.

B 1200 Securing points for lashing

1201 Decks intended for carriage of vehicles shall be equipped with a satisfactory number of securing points (cargo securing device) for lashing of the vehicles. The arrangement of securing is left to the discretion of the owner, provided the minimum requirements in 1202 through 1208 are satisfied.

1202 Unless otherwise specified, each lashing point shall have a Maximum Securing Load (MSL) of not less than:

$$\text{MSL} = k Q g_0$$

min. 100 kN in decks for road vehicles
min. 15 kN in decks for cars only

$$k = n/r$$

r = number of effective lashing points at each side of the vehicle for the number n of axles in group.

If r is different from 1, k to be increased by 10%.

Q = the maximum axle load given in tons.

For MAFI road trailers, Q can be calculated as the total weight with $n = 1$ and r = the total number of lashings at each side.

1203 Maximum securing loads in securing points shall not exceed:

$$\text{MSL} = 0.5 P_m$$

P_m = minimum breaking load of the considered cargo securing device.

1204 If the securing point is designed to accommodate more than one lashing, the magnitude and direction of the lashing loads shall be taken into account when determining the total MSL of the securing point.

1205 Lashing points intended for a maximum working load of 15 kN can normally be arranged without any strengthening of the deck plating.

1206 Lashing points intended for a maximum working load of more than 15 kN shall have documented its strength in terms of structural analysis or mock-up tests.

1207 Fixed cargo securing devices shall be certified by DNV, according to the requirements given in Sec.6 D and E.

Portable cargo securing devices shall be of a certified type. If the securing devices shall be certified by DNV, the requirements are as given in Sec.6 D and E.

1208 Nominal normal and shear stresses in local structures of hull structural steel, supporting sockets for lashing shall not exceed:

$$\sigma = 210 f_1 \text{ N/mm}^2$$

$$\tau = 120 f_1 \text{ N/mm}^2$$

In structures also subjected to longitudinal stresses (e.g. deck longitudinals and girders) in combination with such stresses as given in Pt.3 Ch.1 Sec.8, the allowable bending stresses in Pt.3 Ch.1 Sec.8 Table C1 and D201 shall be increased by 30%.

B 1300 Steel coils

1301 For vessels intended to carry steel coils, the inner bottom plating and inner bottom longitudinals will be especially considered.

1302 An acceptable calculation method is given in Classification Note No. 31.1.

C. Permanent Decks for Wheel Loading

C 100 General

101 Ships strengthened in accordance with the following requirements may have the additional class notation **PWDK**.

102 The requirements cover wheel loads from cargo handling vehicles and from cargo transporting vehicles kept on-board and supported on their wheels when the ship is at sea. Vehicles supported by crutches, horses etc. will be specially considered.

103 Scantling for stiffeners of decks intended for carrying MAFI trailers or other vehicles carrying more than one tier of container, shall be specially considered in a heeled condition.

104 The strength requirements are based on the assumption that the considered element (plating or stiffener) is subjected to one load area only, and that the element is continuous in both directions across several evenly spaced supports. Requirements for other loads and or boundary conditions will be specially considered.

105 Signboards stating the maximum permissible axle load, the maximum tyre pressure of pneumatic tyre wheels, wheel arrangement on axles, and specially approved vehicles shall be fitted in suitable positions onboard. Detailed information of the basis for approval will be stated in the appendix to the classification certificate.

106 Other types and combinations of car decks and materials may be approved after special considerations in the individual case.

C 200 Design loads

201 For individual vehicles with specified arrangement and dimensions of footprints, the design pressure is in general to be taken as:

$$p = \frac{Q}{n_o ab} (9.81 + 0.5a_v) \quad (\text{kN/m}^2)$$

- Q = maximum axle load in t
n_o = number of loads areas on the axle
a = extent in m of the load area parallel to the stiffeners (See Fig. 2)
b = extent in m of the load area perpendicular to the stiffeners (see Fig. 2)
a_v = $6/\sqrt{Q}$ for moving cargo handling vehicles, harbour conditions.
= vertical acceleration as defined in Pt.3 Ch.1 Sec.4 for stowed vehicles, sea going conditions

The load area as indicated in Fig. 2 are defined as:

- the footprint area of individual wheels or
- the rectangular enveloped area of footprints of a wheel group.

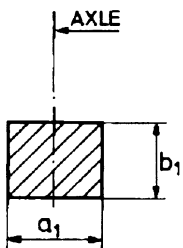
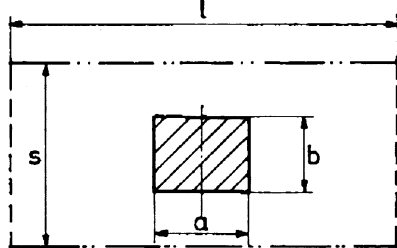
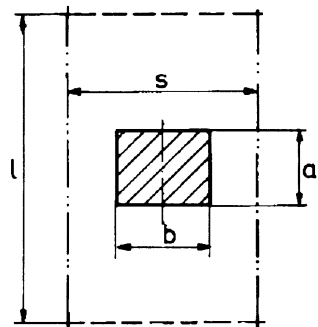
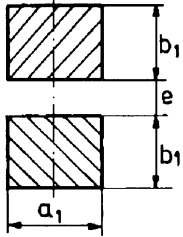
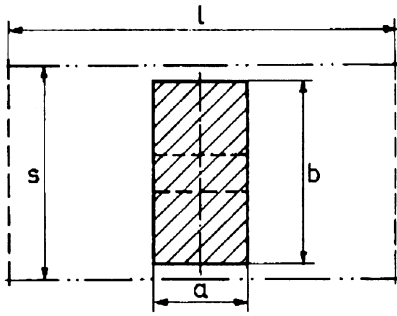
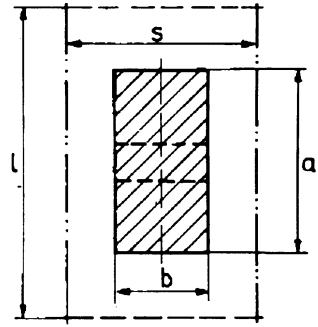
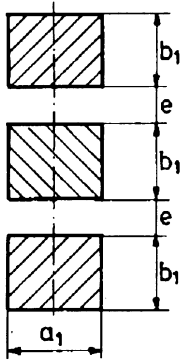
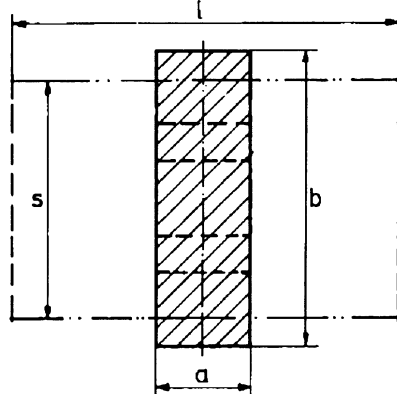
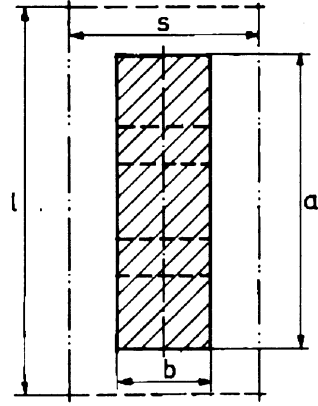
1 Number of wheels in group	2 Footprint dimensions (real contact areas between tyres and deck)	3 Design load area for axle perpendicular to stiffeners	4 Design load area for axle parallel to stiffeners
Single wheel			
Double wheels			
Triple wheels			

Fig. 2
Definition of load area

In general the scantlings shall be checked according to both definitions. If, however, the distance e between individual footprints is less than the breadth b_1 of the prints, the load area may normally be calculated for the group of wheels only.

202 If the arrangement and dimensions of footprints are not available for vehicles with pneumatic tyres, the design pressure may normally be taken as:

$$p = \frac{p_o(9.81 + 0.5a_v)}{9.81w} \quad (\text{kN/m}^2)$$

- p_o = maximum tyre pressure in kN/m^2
 = 1 000 for cargo handling vehicles unless otherwise specified
 = $120\sqrt{Q+3}$ for road transporters unless otherwise specified
 w = 1.0 in general
 = 1.20 when double wheels are specified
 = 1.27 when triple wheels are specified
 a_v = as given in 201.

The load area dimensions are in general to be taken as:

$$a = \sqrt{kA} \quad (\text{m})$$

$$b = \sqrt{A/k} \quad (\text{m})$$

- k = k_1 in general
 = k_2 for plating when $k_2 < k_1$ and:

$$\frac{wQ}{n_o s^2} > \sim 100$$

- k_1 = 2.0 for single wheel
 = 2.0 for multiple wheels with axle parallel to stiffeners
 = 0.8 for double wheels with axle perpendicular to stiffeners
 = 0.5 for triple wheels with axle perpendicular to stiffeners

$$k_2 = \frac{\sqrt{A}}{2s}$$

$$A = \frac{9.81wQ}{n_o p_o} \quad (\text{m}^2)$$

Q and n_o = as defined in 201

n_o = 2 unless otherwise specified.

203 For heavy vehicles where the stowing and lashing arrangement may significantly affect the load distribution at sea, the design pressure for individual load areas will be specially considered.

204 Deck areas for wheel loads from cargo handling vehicles, which are frequently operating in all directions, shall be checked for design loads with axle parallel and perpendicular to stiffeners.

C 300 Plating

301 The thickness of deck plating subjected to wheel loading shall not be less than:

$$t = \frac{77.4k_a \sqrt{k_w csp}}{\sqrt{m\sigma}} + t_k \quad (\text{mm})$$

- k_a = $1.1 - 0.25 s/l$
 maximum 1.0 for $s/l = 0.4$
 minimum 0.85 for $s/l = 1.0$

$$k_w = 1.3 - \frac{4.2}{\left(\frac{a}{s} + 1.8\right)^2}$$

- maximum 1.0 for $a \geq 1.94 s$
 c = b for $b < s$
 = s for $b > s$

p , a and b = as given in 200

$$m = \frac{38}{\left(\frac{b}{s}\right)^2 - 4.7\frac{b}{s} + 6.5} \quad \text{for } \frac{b}{s} \leq 1.0$$

$$m = 13.57 \quad \text{for } \frac{b}{s} > \text{than } 1.0.$$

Between specified values of b/s the m -value may be varied linearly. The m -value may also be obtained from Fig. 3.

- σ = $320 f_1 \text{ N/mm}^2$ (maximum) in general for seagoing conditions.
 = $370 f_1 \text{ N/mm}^2$ (maximum) in general for harbour conditions.
 = as given in Table C1, but not exceeding the above general maximum values, for upper deck within 0. L amidships

For upper deck between 0.4 L amidships and 0.1 L from the perpendiculars, σ shall be varied linearly.

For 'tweendecks' σ shall be found by linear interpolation between upper deck value and general maximum value taken at the neutral axis.

Table C1 Allowable bending stress for upper deck plating within 0.4 L amidships

Arrangement	Condition	σ in N/mm^2
Longitudinally stiffened	Seagoing	$280 f_1 + 60 (f_1 - f_2)$
Longitudinally stiffened	Harbour	$355 f_1 + 20 (f_1 - f_2)$
Transversely stiffened	Seagoing	$185 f_1 + 135 (f_1 - f_2)$
Transversely stiffened	Harbour	$285 f_1 + 85 (f_1 - f_2)$

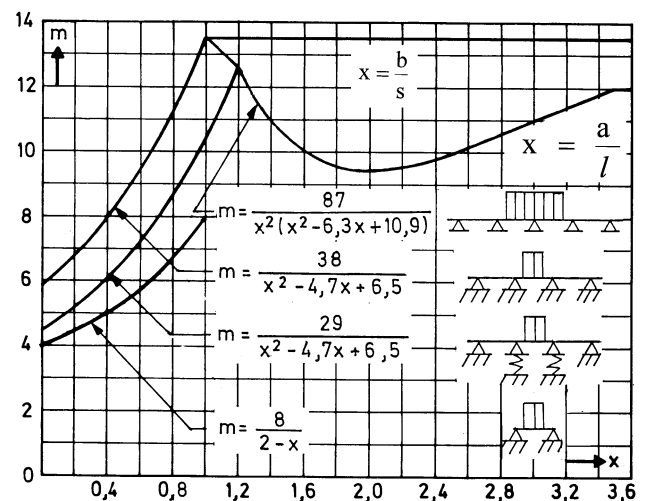


Fig. 3
Bending moment factor (m-values)

- $x = \frac{b}{s}$ not greater than 1.0 for plating
 $x = \frac{a}{l}$ for stiffeners.

302 In Fig. 4 a — d the general thickness requirements of deck plating subjected to various wheel loading from pneumatic tyres are given. The following parameter values have been assumed:

- tyre pressure: $p_0 = 800 \text{ kN/m}^2$
- aspect ratio of plate field: $l/s \geq 2.5$
- allowable stress: $\sigma = 370 \text{ N/mm}^2$
- corrosion addition: $t_k = 0 \text{ mm}$.

303 The minimum deck plate thickness in dry cargo spaces can be taken as 5.0 mm for vessels with more than two continuous decks above 0.7 D from the base line and provided the deck is kept coated and free from corrosion. (See also Pt.3 Ch.1 Sec.8 C104.)

C 400 Stiffeners

401 The section modulus for deck beams and longitudinals subjected to wheel loading shall not be less than:

$$Z = \frac{1000 k_z l c d p w_k}{m \sigma} \quad (\text{cm}^3)$$

$$k_z = 1.0 \text{ for } b/s < 0.6 \text{ and } b/s > 3.4$$

$$= \left(1.15 - 0.25 \frac{b}{s} \right) \text{ for } 0.6 < b/s < 1.0$$

$$= \left(1.15 - 0.25 \frac{b}{s} \right) \frac{b}{s} \text{ for } 1.0 < b/s < 3.4$$

c = as given in 301.

d = a for $a < l$
= l for $a > l$

a, b and p = as given in 200

$$m = \frac{r}{\left(\frac{a}{l} \right)^2 - 4.7 \frac{a}{l} + 6.5} \text{ for } \frac{a}{l} \leq 1.0$$

$$m = \frac{87}{\left(\frac{a}{l} \right)^2 \left[\left(\frac{a}{l} \right)^2 - 6.3 \frac{a}{l} + 10.9 \right]} \text{ for } 1.2 < \frac{a}{l} \leq 2.5$$

$$m = 12 \text{ for } \frac{a}{l} \geq 3.5$$

r = factor depending on the rigidity of girders supporting continuous stiffeners, taken as 29 unless better support conditions are demonstrated
= 38 when continuous stiffener may be considered as rigidly supported at each girder.

Between specified values of a/l the m-value may be varied linearly. The m-value may also be obtained from Fig. 3.

σ = $160 f_1 \text{ N/mm}^2$ (maximum) in general for seagoing conditions
= $180 f_1 \text{ N/mm}^2$ (maximum) in general for harbour conditions
= as given in Table C2, but not exceeding the general maximum values, for longitudinals within 0.4 L amidships.

For longitudinals between 0.4 L amidships and 0.1 L from the perpendiculars σ shall be varied linearly.

For longitudinals in 'tweendecks σ may be found by interpolation as given for plating in 301.

Table C2 Allowable bending stresses for deck longitudinals	
Condition	σ in N/mm^2
Seagoing	$225f_1 - 130f_2 \frac{z_n - z_a}{z_n}$
Harbour	$225f_1 - 85f_2 \frac{z_n - z_a}{z_n}$

402 If more than one load area can be positioned simultaneously on the same stiffener span or adjacent spans, the sections modulus will be specially considered, based on direct stress analysis.

C 500 Girders

501 The scantlings of girders will be specially considered based on the most severe condition of moving or stowed vehicles. Allowable stresses are as given in Pt.3 Ch.1 Sec.12 B400.

The vehicle loads shall be taken as forces

$$P_V = Q_W (9.81 + 0.5 a_v) \quad (\text{kN})$$

a_v = vertical acceleration as given in 201

Q_W = load on wheel group or single wheel in t. For more than one axles in group, the strength of the girder system shall be specially considered.

502 For class notation **General Cargo Carrier RO/RO**, the scantlings of girders being part of a complex system shall normally be based on a direct stress analysis as shown in Classification Note 31.2 "Strength analysis of hull structure in Roll on/Roll off ships and Car Carriers".

503 The girder structure shall be based on the most severe of the uniform deck load, UDL (evenly and unevenly distributed) and the vehicle axle load (cargo handling vehicle and vehicles to be carried). The position of the vehicles shall be taken as the most unfavourable for the girder strength.

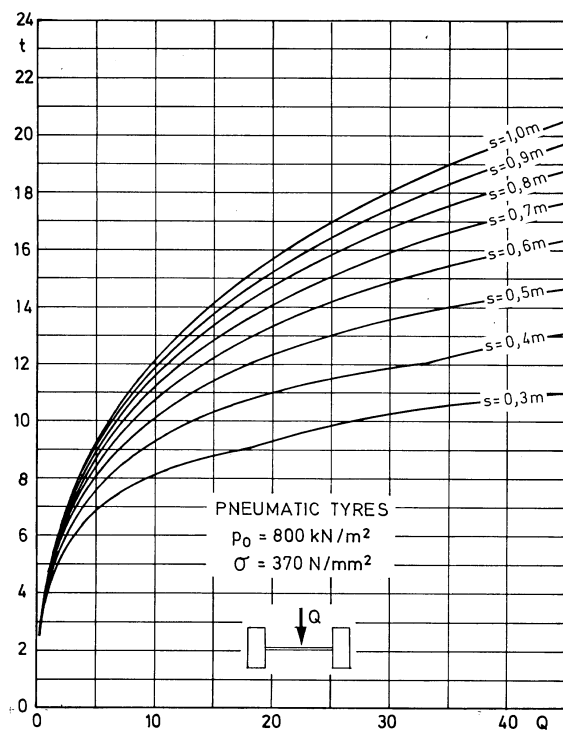
504 The scantlings of girders shall also be considered based on the most severe condition of cargo handling or stowed vehicles. Unless otherwise specified, the girder system shall be designed for a condition where the axles of several trailers side by side are acting on the same transverse girder.

C 600 Details

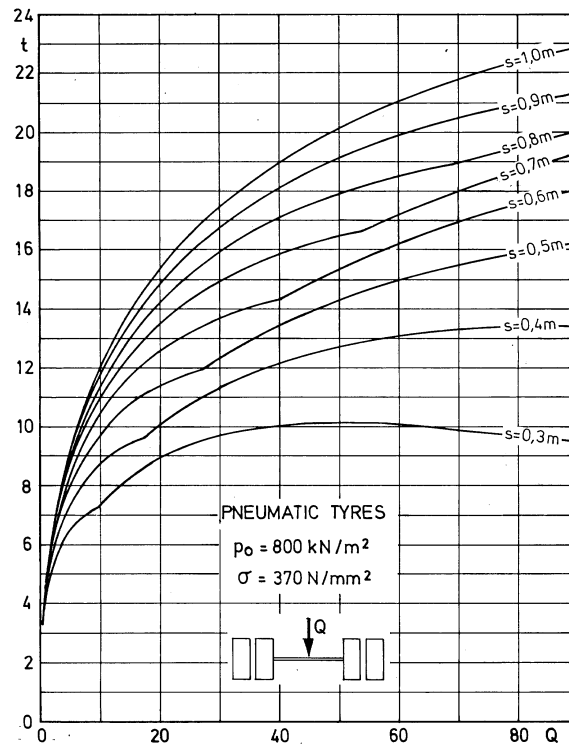
601 Lap joints between deck plates intended for cars only shall be specially considered with due attention to fatigue.

602 Girders and stiffeners shall not be scalloped. However, small size scallops in block joint will be accepted. Double continuous fillet welds are normally to be used between the plating and the strength member. Chain welds may be accepted after special consideration when vehicles are fitted with pneumatic or solid rubber tyres.

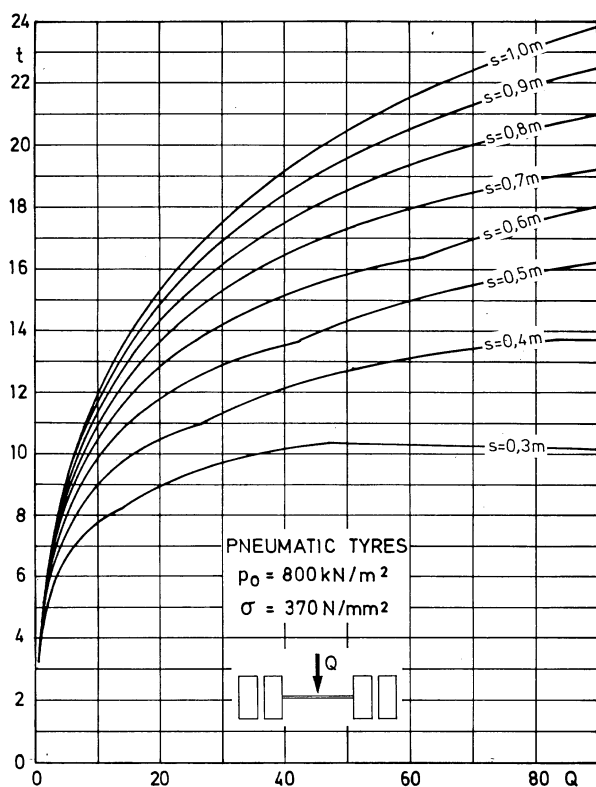
603 The necessary connection areas between stiffeners and girders will be specially considered. The shear stresses shall not exceed 100 N/mm^2 in the members to be joined and 115 N/mm^2 in the weld material.



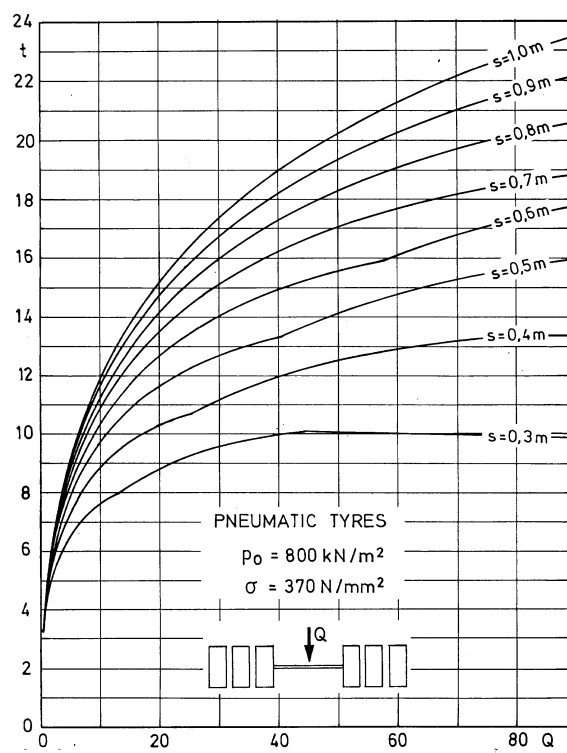
a) Single wheel, general



c) Double wheels, axle perpendicular to stiffeners



b) Double wheels, axle parallel to stiffeners



d) Triple wheels, axle parallel to stiffeners

Fig. 4
Plate thickness for wheel loadings

D. Detection of Water Ingress in Single Hold Cargo Ships

D 100 Performance requirements

101 Single hold cargo ships shall be fitted with water level detectors giving audible and visual alarms on the navigation bridge:

- 1) when the water level above the inner bottom in the cargo hold reaches a height of not less than 0.3 m,
- 2) and another when such level reaches not more than 15% of the mean depth of the cargo hold.

(SOLAS II-1/23-3)

102 The water ingress detector equipment shall be type tested in accordance with MSC.188 (79) “Performance Standards for Water Level Detectors on Bulk Carriers and Single Hold Cargo Ships other than Bulk Carriers”, and be suitable for the cargoes intended.

Guidance note:

The appendix to the Classification Certificate will contain information as to which cargoes the systems are approved for.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

D 200 Installation

201 The sensors shall be located in a protected position that is in communication with the aft part of the cargo hold or above its lowest point in such ships having an inner bottom not parallel to the designed waterline.

These sensors shall be located:

- either as close to the centre line as practicable, or
- at both the port and starboard sides.

202 The detector installation shall not inhibit the use of any sounding pipe or other water level gauging device for cargo holds or other spaces.

203 Detectors and equipment shall be installed where they are accessible for survey, maintenance and repair.

204 Any filter element fitted to detectors shall be capable of being cleaned before loading.

205 Electrical cables and any associated equipment installed in cargo holds shall be protected from damage by cargoes or mechanical handling equipment, associated with bulk carrier operations, such as in tubes of robust construction or in similar protected locations.

206 The part of the electrical system which has circuitry in the cargo area shall be arranged intrinsically safe.

207 The power supply shall be in accordance with Pt.4 Ch.8 Sec.2 A101 and H100.

D 300 Survey on board

301 After installation the system is subject to survey consisting of:

- inspection of the installation
- demonstration of facilities for filter cleaning
- demonstration of facilities for testing of the detector
- test of all alarm loops
- test of the alarm panel functions.

SECTION 5 DRY BULK CARGO CARRIERS

A. General

A 100 Classification

101 The requirements in this section apply to ships intended for carriage of solid bulk cargoes. Relevant requirements for general cargo ships given in Sec.4 are also to be complied with.

102 The mandatory ship type notation **Bulk Carrier ESP** shall be assigned to ships with the following characteristics:

Sea-going single deck ships with cargo holds of single and or double side skin construction, with a double bottom, hopper side tanks and top-wing tanks fitted below the upper deck, and intended for the carriage of solid bulk cargoes.

For cargo holds of double side skin construction, the breadth of the double side measured perpendicular to the shell at any location within the length of the hold shall not be less than 1 000 mm. Ships where all cargo holds are of double side skin construction are denoted as double side skin bulk carriers. Typical cargo hold cross-sections are given in Fig.1.

The notation **Bulk Carrier** may be given to vessels built in compliance with the requirements in this section and the additional requirements given in Sec.8 as specified in Table A1, with structural arrangement different from that defined above.

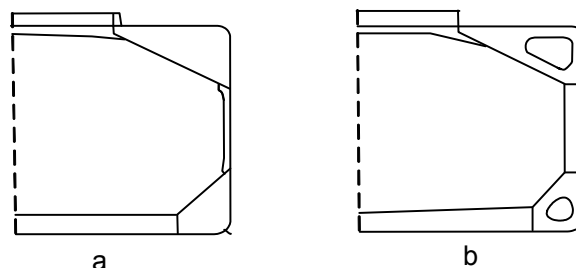


Fig. 1
Typical hold cross-sections
a) Single side skin bulk carrier
b) Double side skin bulk carrier or combination carrier

103 The mandatory notation **ES(..)** shall be assigned to ships built in compliance with the requirements in this section and the additional requirements given in Sec.8 as specified in Table A1.

The notation may be given to vessels built in compliance with the requirements in this section and the additional requirements given in Sec.8 as specified in Table A1, with structural arrangement different from that defined in 102.

Table A1 Reference to applicable requirements given in Section 8								
Ship type	Length, L (m)	Subsection A	Subsection B	Subsection C	Subsection D	Subsection E	Subsection F	Applicable class notation
Single side skin bulk carrier	$L \geq 150$	x	x	x ¹⁾	x ¹⁾	x ¹⁾	x	ES(S)
	$L < 150$	-	x	-	-	-	x	ES(S)
Double side skin bulk carrier or combination carrier	$L \geq 150$	x	-	x ¹⁾	x ¹⁾	x ¹⁾	x	ES(D)
	$L < 150$	-	-	-	-	-	x	ES(D)

x Applicable
 x¹⁾ Applicable to vessels intended to carry bulk cargo with density of 1.0 t/m³ or above
 - Not applicable

(S) Single side skin bulk carrier
(D) Double side skin bulk carrier

Subsection A refers to IACS Unified Requirement, S1A, regarding loading manual/loading instrument.
 Subsection B refers to IACS Unified Requirement, S12, regarding side frames
 Subsection C refers to IACS Unified Requirement, S17, regarding hull girder strength in flooded condition
 Subsection D refers to IACS Unified Requirement, S18, regarding transverse bulkhead strength in flooded condition.
 Subsection E refers to IACS Unified Requirement, S20, regarding allowable hold loading considering flooding.
 Subsection F refers to IACS Unified Requirement, S21, regarding hatch cover strength.

104 One of the notations **BC-A**, **BC-B** or **BC-C** is mandatory for bulk carriers as defined in UR Z11.2.2, having length $L \geq 150$ m and contracted for new construction on or after 1 July 2003. L = ship length as given by Pt.3 Ch.1 Sec.1 B101. (IACS UR S25.2, Rev. 2)

The notation **BC-B*** may be assigned to General Cargo Carriers, intended for carrying solid bulk cargoes as given in Table A2.

105 One of the notations **HC-A**, **HC-B**, **HC-C** or **HC-B*** are mandatory for bulk carriers not defined in 104, i.e. bulk carriers with $L < 150$ m. For General Cargo Carriers intended for

the carriage of solid bulk cargoes, one of the notations **HC-A**, **HC-B**, **HC-C**, **HC-B*** or **HC-M** will be given. The notations in 104 may also be given to these vessels on a voluntary basis.

The notations **HC-A**, **HC-B**, **HC-C** and **HC-B*** correspond to the notations **BC-A**, **BC-B**, **BC-C** and **BC-B*** with the exceptions as given in Table A3.

For vessels with the class notation **HC-M**, requirements in this section apply as given in Table A3 in addition to the requirements in Pt.3 Ch.1 Sec.5.

106 The loading conditions listed in 107 to 110 and 112 to 113 shall be used for the checking of Rules criteria regarding

longitudinal strength, as required by Sec.8 C and Pt.3 Ch.1 Sec.5, local strength, capacity and disposition of ballast tanks and stability. (IACS UR S25.2.2, Rev. 2)

107 The notation **BC-C** implies that the vessel is designed to carry solid bulk cargoes of cargo density less than 1.0 t/m^3 .

A homogenous cargo loaded condition where the cargo density corresponds to all cargo holds, including hatchways, being 100% full, at maximum draught with all ballast tanks empty is required. (IACS UR S25.4.1, Rev. 2)

For other required loading conditions, reference is made to Sec.8 A300.

108 The notation **BC-B** implies that the vessel is designed to carry solid bulk cargoes of any density with all holds loaded.

In addition to design loading conditions required for notation **BC-C** (ref. 107), a homogenous cargo loaded condition with cargo density 3.0 t/m^3 and the same filling rate (cargo mass / holds cubic capacity) in all cargo holds at maximum draught with all ballast tanks empty, is required.

In cases where the cargo density applied is less than 3.0 t/m^3 , the max. density of the cargo that the vessel is allowed to carry shall be indicated with the additional notation:

Maximum Cargo Density x.y t/m^3 .

(IACS UR S25.4.2, Rev. 2).

109 The notation **BC-A** implies that the vessel is designed to carry solid bulk cargoes of any density, with specified holds empty at maximum draught.

In addition to design loading conditions required for **BC-B** (ref. 108), at least one cargo loaded condition with specified holds empty with cargo density 3.0 t/m^3 , and the same filling rate (cargo mass / holds cubic capacity) in all loaded holds at maximum draught with all ballast tanks empty, is required.

The combination of specified empty holds shall be indicated with the additional notation:

Holds a, b,...may be empty.

Vessels which are designed with more than one combination of specified empty holds shall have the additional notation:

Holds a, b,...or c, d,...may be empty.

In cases where the cargo density applied is less than 3.0 t/m^3 , the maximum density of the cargo that the vessel is allowed to carry shall be indicated with the additional notation: **Maximum Cargo Density x.y t/m^3 .**

(IACS UR S25.4.3, Rev. 2)

110 The notation **BC-B*** implies that the vessel is designed to carry solid bulk cargoes of any density with any hold empty at maximum draught.

This requirement is in addition to design loading conditions required for **BC-B** (ref.108).

111 The additional notation **No MP** shall be assigned to vessels, which have not been designed for loading and unloading in multiple ports in accordance with 117. I.e. the vessel is not designed to carry maximum allowable cargo hold design mass at reduced draughts. (IACS UR S25.3.i., Rev. 2)

112 The vessel shall have a normal ballast (no cargo) condition where:

- 1) The ballast tanks may be full, partially full or empty. Where partially full option is exercised, the conditions in Pt.3 Ch.1 Sec.5 B103 shall be complied with.
- 2) Any cargo hold or holds adapted for the carriage of water ballast at sea shall be empty.
- 3) The propeller shall be fully immersed.
- 4) The trim shall be by the stern and shall not exceed 0.015 L .
- 5) The structures of bottom forward shall be strengthened in accordance with Pt.3 Ch.1 Sec.6 against slamming for the

condition listed above at the lightest forward draught.

- 6) The longitudinal strength requirements shall be met for the conditions listed above.
- 7) The longitudinal strength requirements shall be met with all ballast tanks 100% full.

(IACS UR S25.4.4.1a and 4.4.2a, Rev. 2)

113 The vessel shall have a heavy ballast (no cargo) condition where:

- 1) The ballast tanks may be full, partially full or empty. Where partially full option is exercised, the conditions in Pt.3 Ch.1 Sec.5 B103 shall be complied with.
- 2) At least one cargo hold adapted for carriage of water ballast at sea, where required or provided, shall be 100% full.
- 3) The propeller immersion I/D shall be at least 60%.
- 4) The trim shall be by the stern and shall not exceed 0.015 L .
- 5) The moulded forward draught in the heavy ballast condition shall not be less than the smaller of 0.03 L or 8 m .
- 6) The longitudinal strength requirements shall be met for the conditions above.
- 7) The longitudinal strength requirements shall be met under a condition with all ballast tanks 100% full and one cargo hold adapted and designated for the carriage of water ballast at sea, where provided, 100% full.
- 8) Where more than one hold is adapted and designated for the carriage of water ballast at sea, it will not be required that two or more holds be assumed 100% full simultaneously in the longitudinal strength assessment, unless such conditions are expected in the heavy ballast condition. Unless each hold is individually investigated, the designated heavy ballast hold and any/all restrictions for the use of other ballast hold(s) shall be indicated in the loading manual.

I = distance from propeller centerline to the waterline
D = the propeller diameter

(IACS UR S25.4.4.1b and 4.4.2b, Rev. 2)

114 The loading conditions given in 107-110 and 112-113 shall be included in the loading manual and shall be separated into one departure and one arrival condition, where:

- departure condition: with bunker tanks not less than 95% full and other consumables 100%
- arrival condition: with 10% of consumables.

(IACS UR S25.4.5, Rev. 2)

115 The following design loading conditions apply for consideration of local strength as given in C, where:

- M_H = the actual cargo mass in a cargo hold corresponding to a homogeneously loaded condition at maximum draught
- M_{FULL} = the cargo mass in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1.0 t/m^3) filled to the top of the hatch coaming, M_{FULL} shall not be less than M_H
- M_{HD} = the maximum cargo mass allowed to be carried in a cargo hold according to design loading condition(s) with specified holds empty at maximum draught.

(IACS UR S25.5.1, Rev. 2)

116 General conditions, applicable for all bulk carriers:

- any cargo hold shall be capable of carrying M_{FULL} , with fuel oil tanks in double bottom, if any, 100% filled, and ballast water tanks in double bottom in way of cargo holds

- empty, at maximum draught
- any cargo hold shall be capable of carrying minimum 50% of M_H with all double bottom tanks in way of the cargo hold being empty, at maximum draught
- any cargo hold shall be capable of being empty, with all double bottom tanks in way of cargo hold being empty, at the deepest ballast draught.

(IACS UR S25.5.2, Rev. 2)

117 Condition applicable for all notations, except when notation **No MP** is assigned:

- any cargo hold shall be capable carrying M_{FULL} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of maximum draught
- any cargo hold shall be capable of being empty with all double bottom tanks in way of the cargo hold being empty, at 83% of maximum draught
- any two adjacent cargo holds shall be capable of carrying M_{FULL} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of the maximum draught. This requirement to the mass of cargo and fuel oil in double bottom tanks in way of the cargo hold applies also to the condition where the adjacent hold is filled with ballast, if applicable
- any two adjacent cargo holds shall be capable of being empty, with all double bottom tanks in way of the cargo hold being empty, at 75% of maximum draught.

(IACS UR S25.5.3, Rev. 2)

118 Additional conditions applicable for BC-A notation only:

- cargo holds, which are intended to be empty at maximum draught, shall be capable of being empty with all double bottom tanks in way of cargo hold also being empty
- cargo holds, which are intended to be loaded with high density cargo, shall be capable of carrying M_{HD} plus 10% of M_H , with fuel oil tanks in double bottom, if any, 100% filled, and ballast water tanks in double bottom in way of cargo holds empty, at maximum draught.
In operation, the maximum allowable cargo mass shall be limited to M_{HD} .
- any two adjacent cargo holds which according to a design loading condition may be loaded with the next holds being empty, shall be capable of carrying 10% of M_H in each hold in addition to the maximum cargo load according to that design loading condition, at maximum draught. Fuel oil tanks in double bottom, if any, shall be 100% filled, and ballast water tanks in double bottom in way of cargo holds shall be empty. In operation the maximum allowable mass shall be limited to the maximum cargo load according to the design condition.

(IACS UR S25.5.4, Rev. 2)

119 Conditions applicable for notation **BC-B*** only:

- any cargo hold shall be capable of carrying 1.2 M_{FULL} , with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom being empty in way of the cargo hold, both at 67% of maximum draught
- any cargo hold shall be capable of being empty with all double bottom tanks in way of the cargo hold also being empty, at maximum draught
- any two adjacent cargo holds shall be capable of carrying 1.1 M_{FULL} , with fuel oil tanks in the double bottom in way of the cargo hold, if any being 100% full and ballast water tanks in the double bottom in way of the cargo hold being

empty, at 67% of the maximum draught

- any two adjacent cargo holds shall be capable of being empty, with all double bottom tanks in way of the cargo hold being empty, at 75% of maximum draught.

120 Additional conditions applicable during loading and unloading in harbour only:

- any single cargo hold shall be capable of holding the maximum allowable seagoing mass at 67% of maximum draught, in harbour condition
- any two adjacent cargo holds shall be capable of carrying M_{FULL} , with fuel oil tanks in the double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty at 67% of maximum draught, in harbour condition
- at reduced draught during loading and unloading in harbour, the maximum allowable mass in a cargo hold may be increased by 15% of the maximum mass allowed at the maximum draught in sea-going condition, but shall not exceed the mass allowed at maximum draught in the sea-going condition. The minimum required mass may be reduced by the same amount.

(IACS UR S25.5.6, Rev. 2)

121 Additional conditions applicable for ballast holds if any:

- Cargo holds, which are designed as ballast water holds, shall be capable of being 100% full of ballast water including hatchways, with all double bottom tanks in way of the cargo hold being 100% full, at any heavy ballast draught. For ballast holds adjacent to topside wing, hopper and double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty.

(IACS UR S25.5.5, Rev. 2)

122 The additional notation **CSR** is mandatory for bulk carriers with the following class notation and length:

- ships with class notation **Bulk Carrier ESP** and with $L \geq 90$ m.

The **CSR** notation describes that the newbuilding is designed and built according to IACS Common Structural Rules for Bulk Carriers as described in A200.

L = ship length as given in Pt.3 Ch.1 Sec.1 B101.

123 The additional notation **NAUTICUS(Newbuilding)** may be given to bulk carriers except in combination with **CSR**.

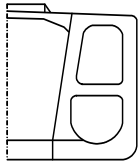
The notation **NAUTICUS (Newbuilding)** is mandatory for bulk carriers without **CSR** notation with the following class notations and lengths as described below:

- **BC-B** or **BC-C** with length $L > 190$ m.
- **BC-B*** or **BC-A** with length $L > 170$ m.

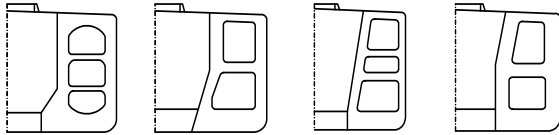
The notation **NAUTICUS(Newbuilding)** is described in Pt.3 Ch.1 Sec.16 and comprises extended fatigue- and direct strength calculations.

124 The mandatory ship type and service notation **Ore Carrier ESP** shall be assigned to sea-going single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region, and intended for the carriage of ore cargoes in the centre holds only. Typical midship sections are given in Fig. 2.

The mandatory notation **ES(O)** shall be assigned for ships built in accordance with the requirements in B, D, E and F and the additional requirements given in Sec.8 as specified in Table A4.



a



b

Fig. 2
Typical midship sections
a) Ore Carrier
b) Combination Carriers

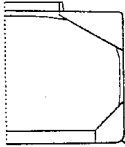
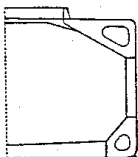
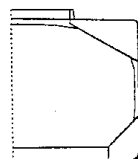
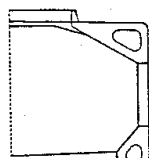
Table A2 Overview of applicable class notations								
<i>Ship type</i>	BC-A	BC-B	BC-C	BC-B*	HC-A	HC-B	HC-C	HC-B*
Bulk carrier -Single side  >150m	X	X	X	-	-	-	-	-
Bulk carrier -Double side  >150m	X	X	X	-	-	-	-	-
Bulk carrier -Single side  <150m	X ¹⁾	X ¹⁾	X ¹⁾	-	X	X	X	-
Bulk carrier -Double side  <150m	X ¹⁾	X ¹⁾	X ¹⁾	X ¹⁾ X ²⁾	X	X	X	X

Table A2 Overview of applicable class notations (Continued)

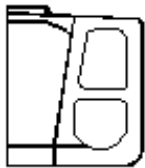
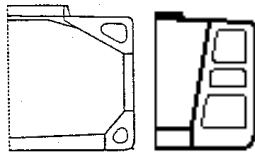
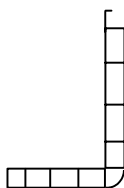
Ship type	BC-A	BC-B	BC-C	BC-B*	HC-A	HC-B	HC-C	HC-B*
Ore carrier 	X ¹⁾	X ¹⁾	-	X ¹⁾	X ¹⁾	X ¹⁾	-	X ¹⁾
Combination carriers 	X ¹⁾	X ¹⁾	X ¹⁾	X ¹⁾	X ¹⁾	X ¹⁾	X ¹⁾	X ¹⁾
General cargo (Open hatch bulk carriers) 	X ¹⁾	X ¹⁾	X ¹⁾	X ¹⁾	X	X	X	X
X = "One of..." is applicable X ¹⁾ = "One of..." is applicable on a voluntary basis X ²⁾ = Not applicable for L > 90 m - = Not applicable								

Table A3 Requirements for HC notations

Ship type	Notation	Equivalent to	Except requirements in
Bulk carrier L < 150 m	HC-A HC-B HC-C HC-B*	BC-A BC-B BC-C BC-B*	A112 items 5, 7 and A113 items 5, 7 A112 items 5, 7 and A113 items 5, 7 A112 items 5, 7 and A113 items 5, 7 A112 items 5, 7 and A113 items 5, 7
General cargo carrier	HC-A HC-B HC-C HC-B* HC-M	BC-A BC-B BC-C BC-B* -	A112 item 7 and A113 A112 item 7 and A113 A112 item 7 and A113 A112 item 7 and A113 A112-A114, A117-A119 and A120 items 1, 2.

Table A4 Reference to applicable requirements given in Sec.8

Ship type	Length (m)	Subsection A	Subsection B	Subsection C	Subsection D	Subsection E	Subsection F	Applicable class notation
Ore carrier or combination carrier	L ≥ 150	x ¹⁾	-	-	-	-	x	ES(O)
	L < 150	-	-	-	-	-	x	-

x¹⁾ Applicable except requirements relating to application of subsection C

- Not applicable

(O) Ore carrier

Subsection A refers to IACS Unified Requirement, S1A, regarding loading manual/loading instrument.

Subsection B refers to IACS Unified Requirement, S12, regarding side frames.

Subsection C refers to IACS Unified Requirement, S17, regarding hull girder strength in flooded condition.

Subsection D refers to IACS Unified Requirement, S18, regarding transverse bulkhead strength in flooded condition.

Subsection E refers to IACS Unified Requirement, S20, regarding allowable hold loading considering flooding.

Subsection F refers to IACS Unified Requirement, S21, regarding hatch cover strength.

125 Ships built in compliance with the requirements in Ch.11 may be given the class notation **DG-B**.**126** Ships built in compliance with the requirements in H200 may be given the special feature notation **EC**.**127** Ships built in compliance with the requirements in H300 may be given the given the special feature notation **EL-1**.**128** Ships built in compliance with the requirements in H400 may be given the given the special feature notation **EL-2**.

A 200 Common Structural Rules

201 **CSR** is described in Pt.8 Ch.2, and comprise the scantling requirements for the classification of new bulk carriers.

202 Requirements with respect to strength of the hull structure, including scantlings and testing of integral tanks and selection of hull materials given in Pt.3 Ch.1 and Pt.3 Ch.2 for $90\text{ m} < L < 100\text{ m}$, and the requirements given in this section are not applicable to vessels with **CSR** notation.

203 The following requirements are in addition covered by the common structural rules and are not applicable to vessels with **CSR** notation:

- Pt.3 Ch.3 Sec.2 Sub-sections A, B, C, D, E, F, G, H
- Pt.3 Ch.3 Sec.3 Anchoring and Mooring Equipment
- Pt.3 Ch.3 Sec.6 Opening and Closing Appliances
- Pt.3 Ch.3 Sec.7 Corrosion Prevention
- Pt.3 Ch.3 Sec.8 Protection of the Crew
- Pt.5 Ch.2 Sec.8 Enhanced Strength for Bulk Carriers.

204 For regions of the structure for which the common structural rules do not apply, the appropriate classification rules shall be applied. In cases where the common structural rules do not address certain aspects of the ship's design, the applicable classification rules shall be applied.

205 Optional design feature notations described in Pt.3 Ch.1 may be given to vessels with **CSR** notation.

Vessels complying with **CSR** notation may also be given class notation **ES(S)** or **ES(D)** as applicable.

A 300 Documentation

301 For ships with class notations **BC-A**, **BC-B**, **BC-C** and **BC-B***, the loading conditions (separated into one departure and one arrival condition, ref. A114) shall be submitted for approval. The associated longitudinal strength calculation(s) and possible special still water bending moment limit (hogging and sagging), see C300, shall be submitted for information in accordance with Pt.3 Ch.1 Sec.1 C200.

302 Design loads shall be submitted for information in accordance with Pt.3 Ch.1 Sec.1 C200 as follows:

- design load for holds in terms of maximum cargo mass (M_{FULL} or M_{HD}) in hold in t, design pressure load (p) for inner bottom in kN/m^2 , or maximum cargo stowage rate (ρ) filling the hold and hatch in t/m^3 . Note that the design cargo stowage rate is generally assumed to be related to the design pressure load for the inner bottom by the following formula:

$$\rho = \frac{p}{g_0 H} \quad (\text{t/m}^3)$$

H = height from inner bottom to top of hatch coaming in m

- lateral design load for cargo bulkheads in terms of stowage rate and angle of repose of bulk cargoes. Note that the maximum lateral bulkhead load is generally given by a cargo filling the complete hold with the largest bulkhead lateral pressure density, ρ_e , defined as:

$$\rho_e = \rho \tan^2 (45 - \delta / 2) \quad (\text{t/m}^3)$$

$$= 0.43 \text{ minimum.}$$

- ρ = cargo stowage rate in t/m^3
- δ = associated angle of repose of cargo in degrees

- design load for cargo on deck and hatch covers in kN/m^2 as applicable
- load limitations for tanks as applicable.

303 Based on the design loading criteria for local strength as given in A115 - A120, on submitted information given in accordance with 200 and on the direct calculations as required in C400, hold mass curves shall be included in the loading manual and the loading instrument (see Pt.3 Ch.1 Sec.5).

The curves shall show:

- maximum allowable and minimum required mass as a function of draught, still water bending moment limit etc., in sea-going condition as well as during loading and unloading in harbour.
- hold mass curves for each single hold, as well as for any two adjacent holds, shall be included.

Accepted procedures for the determination of load limitations are given in Classification Note No. 31.1 "Strength Analysis of Hull Structures in Bulk Carriers and Container Ships".

(IACS UR S25.5.7, Rev. 2)

304 Specifications for corrosion prevention systems for water ballast tanks, comprising selection, application and maintenance, as defined in Table A1 in Pt.3 Ch.3 Sec.7 shall be submitted for information for **Bulk Carrier ESP** and **Ore Carrier ESP**.

305 If water ingress detection is arranged the following documentation shall be submitted for approval:

- type test reports unless type approved by the Society
- functional description of the alarm system unless type approved by the Society
- specification of cargo types for which the ship is intended
- location of water ingress detectors
- location of alarm panel
- power supply arrangement
- single line diagrams.

Manuals provided on board shall contain the following information and operational instructions:

- 1) A description of the equipment for detection and alarm arrangements together with a listing of procedures for checking that as far as practicable, each item of equipment is working properly during any stage of ship operation.
- 2) Evidence that the equipment has been type tested to the requirements in the performance standard.
- 3) Line diagrams of the detection and alarm system showing the positions of equipment.
- 4) Installation instructions for orientation, setting, securing, protecting and testing.
- 5) List of cargoes for which the detector is suitable for operating in a 50% seawater slurry mixture.
- 6) Procedures to be followed in the event equipment not functioning correctly.
- 7) Maintenance requirements for equipment and system.

306 For ships with the special feature notation **EC**, the following shall be submitted for information:

- Supply lines and discharge lines for each cargo hold.
- Cleaning equipment and mucking pump as applicable.

307 For ships with the special feature notation **EC**, the following shall be submitted for approval:

- Hold wash water holding/water ballast tank(s) arrangement.

308 For ships with the special feature notation **EL-1**, the following shall be submitted for approval:

- Loading sequences according to H301.

Guidance note:

For a full definition of the required documentation types, see Pt.0 Ch.3 Sec.2 H112.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

309 For ships with the special feature notation **EL-2**, the following shall be submitted for approval:

— Loading sequences according to H401.

Guidance note:

For a full definition of the required documentation types, see Pt.0 Ch.3 Sec.2 H112.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 400 Structural and leak testing

401 Testing shall be in accordance with Pt.2 Ch.3 Sec.8 Table B1.

A 500 Grab cargo handling

501 For vessels with class notation **General Cargo Carrier** intended for grab cargo handling, the optional class notation **IB-X** given in Pt.3 Ch.1 Sec.6 may be assigned.

B. Design Loads

B 100 Design cargo density and angle of repose

101 The design load for cargo hold shall be based on the largest cargo mass, M_H or M_{HD} (as defined in A115), according to the submitted loading conditions, see A200, for the hold considered, but is in any case not to be taken less than as given by:

$$M_{FULL} = 1.0 V_H (t)$$

V_H = cargo hold volume including hatch in m^3 .

102 The design angle of repose, δ , of bulk cargo is generally not to be taken greater than:

Light bulk cargo (grain etc.): $\delta = 20$ degrees

Heavy bulk cargo: $\delta = 35$ degrees

Cement cargo: $\delta = 25$ degrees (associated cargo density $1.35 t/m^3$).

103 For the calculation of plates and stiffeners the cargo density of any hold shall be taken as:

For **BC-A** (ore hold):

$$\rho = (M_{HD} + 0.1 M_H) / V_H (t/m^3)$$

For **BC-A** (empty hold), **BC-B** and **BC-C**:

$$\rho = M_{FULL} / V_H (t/m^3)$$

$$\rho = \min 1.0 t/m^3$$

For **BC-B***:

$$\rho = 1.2 M_{FULL} / V_H (t/m^3)$$

For **HC-M**:

$$\rho = M_{FULL} / V_H (t/m^3) \text{ in general}$$

$$\rho = M_{HD} / V_H (t/m^3) \text{ for ore loading}$$

$$\rho = \min. 1.0 t/m^3$$

For **Ore Carrier**:

$$\rho = M_{FULL} / V_H (t/m^3)$$

104 For the direct calculation of girder structures, the design cargo density of any hold shall be taken as the greater of:

For **BC-A** (ore hold):

$$\rho = (M_{HD} + 0.1 M_H) / V (t/m^3)$$

For **BC-A** (empty hold), **BC-B** and **BC-C**:

$$\rho = M_{FULL} / V (t/m^3)$$

For **BC-B***:

$$\rho = 1.2 M_{FULL} / V (t/m^3)$$

For **HC-M**:

$$\rho = M_{FULL} / V (t/m^3) \text{ in general}$$

$$\rho = M_{HD} / V (t/m^3) \text{ for ore loading}$$

For **Ore Carrier**:

$$\rho = M_{FULL} / V (t/m^3)$$

V = V_H for calculation of cargo bulkhead structures, plates and stiffeners.

= V_{HR} for calculation of hold girder structure other than cargo bulkheads

V_{HR} = bulk carrier hold volume below a level $0.3 H + 0.14 b_f$ within 60% of the middle width/length of the hold, and linearly reduced to a level $0.3 H$ at hold sides and to $0.3 H + 0.07 b_f$ at transverse bulkheads

= ore carrier hold volume below a level $0.4 H + 0.2 b_f$ within the 60% of the middle width of the hold, and linearly reduced to $0.4 H$ at the hold sides

H = height of hold in m from inner bottom to top of coaming

b_f = breadth of hold in m at level $0.3 H$ ($0.4 H$ for ore carriers) above inner bottom at hold midlength.

B 200 Lateral pressure loads

201 The design pressures for local elements (i.e. plates and stiffeners) shall be determined as given in Pt.3 Ch.1 Sec.4 using parameters given in 100.

202 For direct calculation of girder structures, design pressures shall be determined as given in Pt.3 Ch.1 Sec.13 using parameters given in 100.

203 For vessels intended to carry steel coils the inner bottom plating and inner bottom longitudinals will be especially considered.

An acceptable calculation method is given in Classification Note No. 31.1.

C. Bulk Carriers (full breadth holds)

C 100 Hull arrangement

101 The ship shall have a double bottom in way of the cargo holds, and is in general arranged with a single deck.

Larger bulk carriers ($> 100\,000$ DWT) with hopper and top wing tanks, shall be arranged with strength bulkheads (tank or wash bulkheads) in line with the cargo bulkhead upper and lower stool.

102 The strength requirements are given for cargo holds extending over the full breadth of the ship (or between double side structures).

103 A longitudinal stiffening system is assumed applied for the bottom- and inner bottom panels within the cargo region.

C 200 Longitudinal strength

201 The longitudinal strength shall be determined as given in Pt.3 Ch.1 Sec.5 (Ch.2 Sec.4 for ships with $L < 100$ m).

202 In the region between fore bulkhead in after cargo hold and after bulkhead in fore cargo hold, the side plating thickness shall not be less than:

$$t = \frac{0.0036}{f_1} L_1^3 \sqrt[3]{LB} \quad (\text{mm})$$

In way of double side skin regions, the thickness t may be taken to represent the combined thickness of the side and the inner side plating.

If the ratio between the cargo hold length and ship's breadth exceeds 1.0 the side plating thickness will be specially considered.

Outside the region mentioned above, the side plating thickness can be varied linearly to give the shear area required by the main class at fore end of machinery spaces and after end of fore peak or adjacent deep tank.

C 300 Plating and stiffeners

301 Thicknesses and cross-sectional properties are in general to be calculated as given for the main class using design pressure according to B200 where applicable.

302 For the design of structural members of the double bottom, the stress factor f_{2B} (in hogging and sagging) as given in Pt.3 Ch.1 Sec.6 A may for the loading conditions with specified holds empty on full draught be based on reduced still water bending moment limits. The limits are defined by the maximum moments in hogging and sagging ($= 0.5 M_{s0}$ as given in Pt.3 Ch.1 Sec.5 B, minimum occurring for these loading conditions, unless higher limits are specified to be used).

303 The thickness of inner bottom plating between hopper or side tanks shall not be less than as required in Pt.3 Ch.1 Sec.6 C400.

The thickness is in no case to be less than:

$$t = 9.0 + \frac{0.03L_1}{\sqrt{f_1}} + t_k \quad (\text{mm})$$

304 The section modulus of bottom longitudinals (except in way of hopper and side tanks) for sea pressure loads in ore loading conditions shall not be less than according to the requirements given in Pt.3 Ch.1 Sec.6 with:

$$\begin{aligned} \sigma &= 245 f_1 - 40 f_{2BH} - 0.7 \sigma_g \text{ h in empty holds} \\ &= 245 f_1 - 40 f_{2BS} - 0.7 \sigma_g \text{ s in ore loaded holds} \\ &= 160 f_1 \text{ maximum} \end{aligned}$$

f_1 = material factor as given in Sec.1 B100 with respect to the bottom longitudinal

σ_{gh} = $190 f_{1B}$, but need not be taken larger than

σ_{gs} = $190 f_{1B}$, but need not be taken larger than $\sigma_{DB} + 130 f_{2BH}$

f_{1B} = material factor f_1 as given in Sec.1 B100 with respect to the bottom plating

σ_{DB} = longitudinal double bottom girder stress at middle of hold in N/mm^2 with respect to the bottom plating according to direct calculation as described in Classification Note No. 31.1

f_{2BH} = f_{2B} as given in Pt.3 Ch.1 Sec.6 A with respect to hogging still water bending moment (see also 302)

f_{2BS} = f_{2B} as given in Pt.3 Ch.1 Sec.6 A with respect to sagging still water bending moment (see also 302).

305 The section modulus of inner bottom longitudinals shall for ore pressure loads not be less than according to the requirement given in Pt.3 Ch.1 Sec.6 with:

$$\begin{aligned} \sigma &= 265 f_1 - 30 f_{2BH} - 0.7 \sigma_g \\ &= 160 f_1 \text{ maximum} \end{aligned}$$

f_1 = material factor as given in Sec.1 B100 with respect to the inner bottom longitudinal

σ_g = $190 f_{1B}$, but need not be taken larger than

f_{1B} = material factor f_1 as given in Sec.1 B100 with respect to the inner bottom plating

σ_{DB} = longitudinal double bottom girder stress at middle of hold in N/mm^2 with respect to the inner bottom plating according to direct calculation as described in Classification Note No 31.1

f_{2BH} = as given in 305.

C 400 Girder systems

401 For girders which are parts of a complex 2- or 3-dimensional structural system, a complete structural analysis may have to be carried out to demonstrate that the stresses are acceptable when the structure is loaded as described in 404.

402 Calculations as mentioned in 401 are applicable for:

- double bottom structures in way of full breadth holds/tanks intended for ballast or liquid cargo
- top wing tank, side and hopper tank structure in long bulk cargo holds
- transverse bulkhead structure in bulk cargo holds
- transverse web frame structures in ships with a small number of transverse bulkheads
- deck and cargo hold structures in open type ships
- other structures as required elsewhere in the rules or otherwise when deemed necessary by the Society.

403 The following load cases are generally to be considered.

For vessels with the class notation **HC-M**, the design cargo mass and the design draught shall be determined according to Table C1. Any special loading conditions included in the vessel's Loading Manual shall also be considered.

- a) Heavy cargo in hold (with adjacent hold empty), see A100, with respect to strength of double bottom of the loaded and adjacent empty holds. Generally only condition(s) with untrimmed ore cargo filling the volume V_{HR} (as given in B104) of the hold need be considered, see Fig.3. The mass and draught varies depending on the class notation. Details are stated in the Classification Note 31.1.

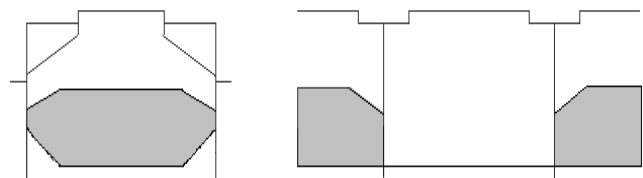


Fig. 3
Heavy cargo in hold

- b) Heavy cargo filling the volume V_{HR} (as given in B104) of two adjacent holds, see A100, with respect to cross-deck and bulkhead shear strength, see Fig.4. The mass and draught varies depending on the class notation. Details are stated in the Classification Note 31.1.

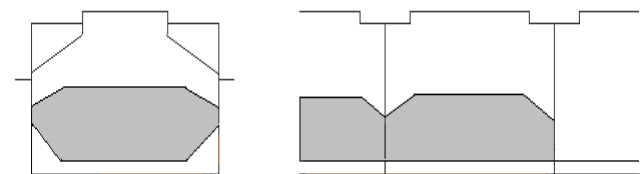


Fig. 4
Heavy cargo adjacent holds

- c) Heavy cargo as given in A100 filling the entire cargo hold with respect to cargo bulkhead strength for lateral load. See Fig.5. The mass and draught varies depending on the class notation. Details are stated in the Classification Note 31.1.

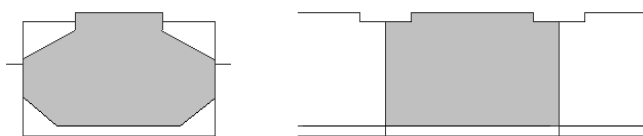


Fig. 5
Bulkhead loading

- d) Ballast in ballast hold (with adjacent holds empty), with all double bottom tanks in way of cargo hold being 100% full, at ballast draught, T_{HB} , and with respect to double bottom, transverse bulkhead and top wing tank/ship side strength. It shall also be strengthwise acceptable that ballast holds are filled when the topside wing, hopper and double bottom tanks are empty. For the top wing tank and side structures also the heeled condition shall be considered, see also Fig.6.

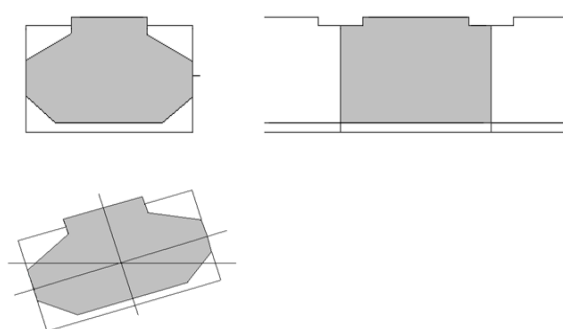


Fig. 6
Ballast hold

- e) Ballast in top wing tank with respect to top wing tank strength in the upright and heeled conditions, see Fig.7.

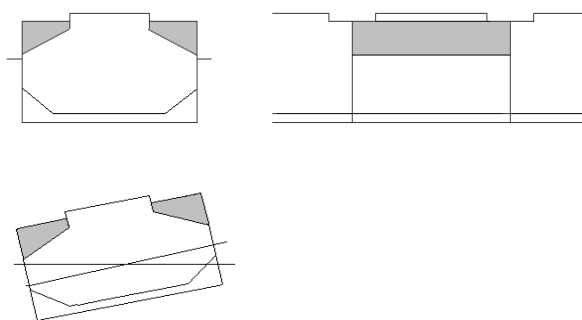


Fig. 7
Ballast in top wing tank

- f) Cargo on deck (as specified) and external sea pressure on deck (in particular forward holds) with respect to deck (and top wing tank) strength, see Fig.8.

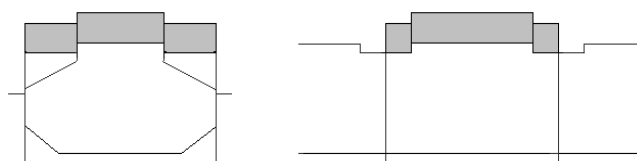


Fig. 8
Cargo on deck

Table C1 Loading conditions for HC-M			
Condition	Cargo mass	Design draught	Remark
Heavy cargo in hold	M _{FULL}	T	ref. A116
Heavy cargo filled up hold	M _{FULL}	T	
Slack hold	0.5 M _H	T	
Empty hold	Nil	T _B ¹⁾	
Heavy cargo in two adjacent holds	M _{FULL}	T _A ²⁾	Applicable when the loading condition is included in the vessel's Loading Manual.
Heavy cargo in alternate loading	M _{HD}	T	
Empty hold in alternate loading	Nil	T	
Ballast in hold (harbour)		T/3	
Ballast in hold (seagoing)		T _{HB} ³⁾	
Ballast in hold (heeled)		T _{HB} ³⁾	
¹⁾ T _B = Deepest draught of any cargo loading or ballast conditions.			
²⁾ T _A = Design minimum draught of the loading condition in the vessel's Loading Manual.			
³⁾ T _{HB} = Heavy ballast draught.			

404 Fuel oil tanks in double bottom, if any, shall be assumed full when this is unfavourable. Water ballast tanks in the double bottom are generally to be assumed empty.

405 Harbour conditions need, unless the notation **No MP** is added, normally not be specially considered provided the minimum draught in harbour with filled cargo hold is not less than two thirds of the draught in the associated approved seagoing condition.

406 Allowable stresses are generally to be taken as given in Pt.3 Ch.1 Sec.13. For double bottom longitudinal girders, the girder bending stresses shall not exceed the following limits:

- bottom plate at middle of empty hold (and at transverse bulkhead of loaded or ballasted hold):

$$\sigma = 190 f_1 - 130 f_{2BH}$$

- inner bottom plate at middle of loaded holds (and at transverse bulkhead of empty hold):

$$\sigma = 190 f_1 - 100 f_{2BH}$$

- bottom plate at middle of loaded or ballasted hold (and at transverse bulkhead of empty hold):

$$\sigma = 190 f_1 - 130 f_{2BS}$$

- inner bottom plate at middle of empty hold (and at transverse bulkhead of loaded or ballasted hold):

$$\sigma = 190 f_1 - 100 f_{2BS}$$

f_{2BH} = as given in 304

f_{2BS} = as given in 304.

407 Acceptable calculation methods are given in Classification Note No. 31.1.

C 500 Corrosion prevention

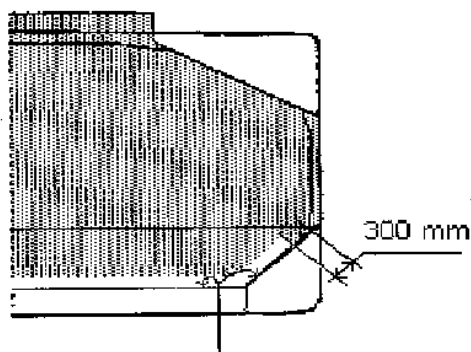
501 Specifications for corrosion prevention systems for water ballast tanks, comprising selection, application and maintenance, shall be submitted as defined in Table A1 in Pt.3 Ch.3 Sec.7.

502 All internal and external surfaces of hatch coamings and hatch covers and all internal surfaces of the cargo holds, excluding the flat tank top areas and the hopper tanks sloping plating and transverse bulkheads bottom stool approximately 300 mm below the side shell frame and brackets, shall have an efficient protective coating (epoxy or equivalent) applied in accordance with the manufacturer's and builder's recommendation. (See Fig.8)

Guidance note:

In the selection of coating, due consideration should be given by the owner to intended cargo conditions expected in service.

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Surfaces not required coated.

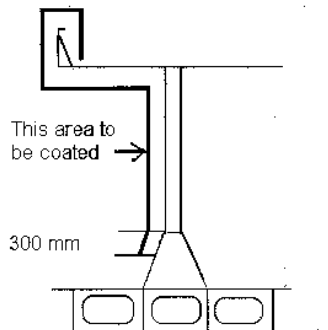


Fig. 9
Extent of coating. Transverse bulkheads bottom stool as for hopper tank

D. Ore Carriers (holds between longitudinal bulkheads)

D 100 Hull arrangement

101 The ship shall have two effective longitudinal bulkheads.

102 It is assumed that only spaces between the longitudinal bulkheads are used as cargo holds.

103 A double bottom shall be fitted in way of the cargo holds.

D 200 Plating and stiffeners

201 Thicknesses and cross-sectional properties are in general to be calculated as given for the main class using design

pressure according to B, where applicable.

202 The thickness of inner bottom plating in cargo holds shall not be less than:

$$t = 9.0 + \frac{k}{\sqrt{f_1}} + t_k \quad (\text{mm})$$

$$k = 12 \text{ s}$$

$$= 0.03 L_1, \text{ whichever is the larger.}$$

D 300 Girder systems

301 The transverse strength of the double bottom, wing tank and deck structures considered as a complete structure and transverse bulkhead structures shall be based on direct stress analysis as outlined for the main class.

302 The following cases are generally to be considered:

- a) Heavy ore cargo filling volume V_{HR} (as given in B104) of holds with other spaces empty at draught T, see Fig.10.

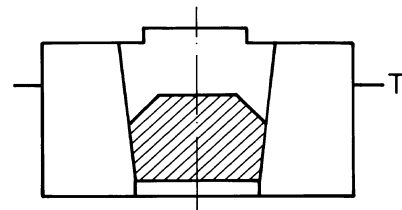


Fig. 10
Heavy ore hold

- b) Ore cargo filling hold completely with adjacent holds/spaces empty at draught T, see Fig.11.

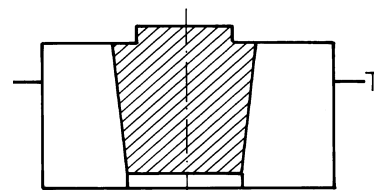


Fig. 11
Full ore hold

- c) Ballast in ballast tanks with adjacent cargo holds empty at ballast draught T_B , see Fig. 12.

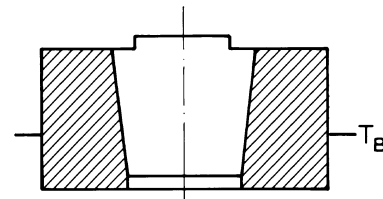


Fig. 12
Ballast tank

303 A special grillage calculation of the double bottom will normally not be required.

E. Detection of Water Ingress into Cargo Holds Ballast and Dry Spaces, and Availability of Drainage forward Spaces

E 100 Performance requirements

101 Bulk carriers shall be fitted with water level detectors

giving audible and visual alarms on the navigation bridge:

- 1) In each cargo hold, one when the water level above the inner bottom in any hold reaches a height of 0.5 m and another at a height not less than 15% of the depth of the cargo hold but not more than 2.0 m.
- 2) In any ballast tank forward of the collision bulkhead, when the liquid in the tank reaches a level not exceeding 10% of the tank capacity.
- 3) In any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, at a water level of 0.1 m above the deck. Such alarms need not be provided in enclosed spaces the volume of which does not exceed 0.1% of the ship's maximum displacement volume.

(SOLAS Ch. XII/12)

102 The water ingress detection system shall be type tested in accordance with MSC.188 (79) "Performance Standards for Water Level Detectors on Bulk Carriers", and be suitable for the cargoes intended.

Guidance note:

The appendix to the Classification Certificate will contain information as to which cargoes the systems are approved for.

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E 200 Installation

201 The sensors shall be located in a protected position that is in communication with the after part of the cargo hold or tank and or space, such that the position of the sensor detects the level that is representative of the levels in the actual hold space or tank.

These sensors shall be located:

- either as close to the centre line as practicable, or
- at both the port and starboard sides.

202 The detector installation shall not inhibit the use of any sounding pipe or other water level gauging device for cargo holds or other spaces.

203 Detectors and equipment shall be installed where they are accessible for survey, maintenance and repair.

204 Any filter element fitted to detectors shall be capable of being cleaned before loading.

205 Electrical cables and any associated equipment installed in cargo holds shall be protected from damage by cargoes or mechanical handling equipment associated with bulk carrier operations, such as in tubes of robust construction or in similar protected locations.

206 The part of the electrical system which has circuitry in the cargo area shall be arranged intrinsically safe.

207 The power supply shall be in accordance with Pt.4 Ch.9 Sec.3 B200.

E 300 Survey on board

301 After installation the system is subject to survey consisting of:

- inspection of the installation
- demonstration of facilities for filter cleaning
- demonstration of facilities for testing of the detector
- test of all alarm loops

— test of the alarm panel functions.

E 400 Availability of drainage forward spaces

401 On bulk carriers, the means for draining and pumping ballast tanks forward of the collision bulkhead, and bilges of dry spaces, any part of which extends forward of the foremost cargo hold, shall be capable of being brought into operation from a readily accessible enclosed space. The location of which shall be accessible from the navigation bridge or propulsion machinery control position, without need for traversing exposed freeboard or superstructure decks.

(SOLAS reg.XII/13)

This does not apply to the enclosed spaces the volume of which does not exceed 0.1% of the ship's maximum displacement volume. Nor does it apply to the chain cable lockers.

Guidance note:

Where pipes serving such tanks or bilges pierce the collision bulkhead, as an alternative to the valve control specified in Pt.4 Ch.6 Sec.3 A402, valve operation by means of remotely operated actuators may be accepted, provided that the location of such valve controls complies with this regulation.

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402 The dewatering system for ballast tanks forward of the collision bulkhead and for bilges of dry spaces any part of which extends forward of the foremost cargo hold shall be designed to remove water from the forward spaces at a rate of not less than 320A m³/h, where A is the cross sectional area in m² of the largest air pipe or ventilator pipe connected from the exposed deck to a closed forward space that is required to be dewatered by these arrangements.

(IACS UR M65)

403 The installation and survey on board shall be in accordance with Pt.4 Ch.6 Secs.4, 6 and 7 for bilge systems.

F. Requirements for the Fitting of a Forecastle for Bulk Carriers, Ore Carriers and Combination Carriers

F 100 Application and definition

101 These requirements apply to all bulk carriers, combination carriers and ore carriers as defined in A102 and A123.

(IACS UR S28.1, Rev. 2).

102 Structural arrangements and scantlings of the forecastle shall comply with requirements as given in Pt.3 Ch.1.

(IACS UR S28.1, Rev. 2).

F 200 Dimensions

201 The forecastle shall be located on the freeboard deck with its aft bulkhead fitted in way of the forward bulkhead of the No. 1 hold (foremost hold), see Fig. 13.

However, if this requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7% of the ship length abaft the forward perpendicular where the ship length and forward perpendicular are defined in the International Convention on Load Line 1966 and its protocol 1988.

(IACS UR S28.2, Rev. 2)

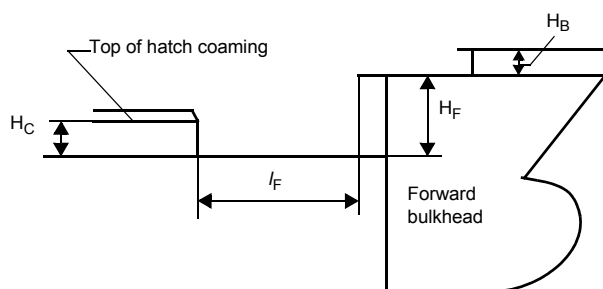


Fig. 13

202 The height H_F above the main deck shall not be less than the greater of:

- the standard height of a superstructure as specified in the International Convention on Load Line 1966 and its Protocol of 1988, or
- $H_C + 0.5$ m, where H_C is the height of the forward transverse hatch coaming of cargo hold No.1 (foremost hold).

(IACS UR S28.2, Rev. 2).

203 All points of the aft edge of the forecastle deck shall be located at a distance l_F , see Fig. 1,:

$$l_F \leq 5 \sqrt{H_F - H_C}$$

from the hatch coaming plate in order to apply the reduced loading to the No.1 forward (foremost hold) transverse hatch coaming and No.1 (foremost hold) hatch cover in applying Sec.8 F601 and Sec.8 F902, respectively.

(IACS UR S 28.2, Rev. 2).

204 A breakwater shall not be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it shall be located such that its upper edge at centre line is not less than $H_B / \tan 20^\circ$ forward of the aft edge of the forecastle deck, where H_B is the height of the breakwater above the forecastle, see Fig. 13.

(IACS UR S 28.2, Rev. 2).

G. Access

G 100 Access to and within spaces in, or forward of, the cargo area

101 Access to and within spaces in, or forward of, the cargo area shall comply with SOLAS Regulation II-1/3.6.

H. Optional Class Notations EC and EL-1 and EL-2

H 100 General

101 The special feature notation **EL-1** can only be given to Bulk Carriers with class notations **BC-A** or **BC-B** and to Ore Carriers.

102 The special feature notation **EL-2** can only be given to Bulk Carriers with class notations **BC-A** or **BC-B** and to Ore Carriers.

H 200 Optional class notation EC

201 The vessel shall be built with double side skin construction as given in A102. In addition, hatch covers which are not accessible for cleaning in open position shall be of double side skin construction.

202 Separate or combined hold wash water holding/water ballast tank(s) of adequate size for temporary storage shall be fitted. The tank(s) shall be filled by common wash water discharge line on deck, connected to individual hold branch lines, and discharged directly overboard by drop surface valve(s). At the aft of each cargo hold a valve for connection of flexible hose shall be fitted at the end of the individual hold discharge line branched down. Similar arrangement may be accepted.

Small hatch with coaming, giving unobstructed access to the holding tank, for internal cleaning, shall be fitted on upper deck. Close to access hatch air and water supply for internal cleaning shall be provided.

Provision shall be made so that deck washings can be collected and guided into the storage tank(s).

203 Water and air supply lines shall be provided in all cargo holds at easily accessible and protected locations. In addition the water and air supply lines shall be fitted with hose connection valves at lower end and isolation valves at deck.

The hold discharge line shall be provided from the bottom of hold to upper deck with hose connection valves at both ends.

204 Fixed or portable cleaning system shall be provided.

Guidance note:

Due to poor experience and need of substantial maintenance of fixed guns when handling dusty cargoes, portable cleaning guns of the jet type (air and water powered) are recommended.

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The general service pump and the service air compressor shall have adequate capacity and pressure for simultaneous operation of at least two cleaning guns, and one air-driven mucking pump. If fixed cleaning system, the general service pump and service air compressor must have adequate capacity to operate the system.

205 Handling davit for air-driven mucking pump and cargo residue shall be provided.

Small hatch with coaming, giving unobstructed access to the inner bottom for removal of cargo residue shall be fitted on upper deck at the cross deck at the aft end of each cargo hold with air outlet close by.

206 The cargo holds shall be coated with abrasive resistant painting.

207 All ladders in cargo holds shall be located in separate trunks.

H 300 Optional class notation EL-1

301 Vessels with the optional class notation **EL-1** shall be able to handle average loading rates as given in Table H1, unless higher rates are specified and provided as part of the documentation for approval.

The average loading rate is defined as rate achieved from start to completion of total cargo loading divided by time elapsed.

Special consideration shall be given if loading with two or more loaders simultaneous is specified and provided as part of the documentation for approval.

Relevant loading sequences, with average loading rates in accordance with Table H1, or higher specified average loading rates, for the following conditions shall be defined:

- homogeneous condition (one and two grade loading), if applicable
- relevant part loading conditions, if applicable

— alternate conditions, if applicable.

Each step in the loading sequences from commencement of cargo loading to full deadweight is reached, step-wise and time-wise synchronized with the de-ballasting operation, shall be documented. Each time the loading equipment changes position to a new cargo hold is defined as a step.

Time-wise synchronized in this context means that the de-ballasting is completed within the same time as the loading step.

The typical loading sequences shall also be developed to not exceed applicable strength limitations.

Guidance note:

Such loading sequences may be decisive for the vessels strength although they are considered port conditions. I.e. they may give the highest net pressure on the bottom construction and give the highest bending moment and shear forces and thus represent a design condition that should be addressed in the FEM loading conditions. For that reason also intermediate steps will have to be demonstrated, but only for design purposes.

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For all relevant loading sequences, considering one, two or more loaders acting simultaneously as applicable, a summary of all steps shall be included with at least the following information included:

- how much cargo is filled in each cargo hold during the different steps
- how much ballast is discharged from each ballast tank during the different steps
- the maximum still water bending moment and shear force at the end of each step
- the ship's trim and draught at the end of each step
- the ship's draught aft and forward, trim and air-draught, if restrictions are applicable
- the ship's local strength criteria for single and adjacent hold loading.

Table H1 Design loading rates	
DWT	Average loading rate, t/h
> 80 000	12 000
50 000 – 80 000	8 000
30 000 – 50 000	5 000

If the Master deems necessary due to operational reasons to deviate from the approved loading sequence calculations with ratings according to **EL-1** he may do so provided he is in compliance with SOLAS Ch.VI Pt.B, Reg.7.3 and on this condition agree with the terminal on a new loading plan.

302 The de-ballast capacity of the vessel at loading berth prior to commencement of loading, including arrangement of ballast tanks and relevant piping system, shall meet the requirements for the average loading rates as specified in Table H1.

If average loading rate is specified to be higher than those given in Table H1, the loading operation shall not be interrupted due to de-ballast operations.

The vessel shall be fitted with a separate stripping system. To enhance de-ballasting and stripping the trim shall be by stern during the whole operation.

303 The vessel shall be designed such that minimum 50% of maximum permissible cargo intake per cargo hold can be loaded in one pour.

304 Inner bottom strength shall be according to the requirements as given in Pt.8 Ch.2/Chapter 12 Sec.1 or Pt.3 Ch.1 Sec.6 H300, as applicable.

305 The vessel shall be fitted a remote sounding for water ballast and fuel oil storage tanks and draught reading system

with an on-line interface into the software of the onboard loading computer.

306 Check of local strength for single and adjacent hold loading pattern shall be integrated into the software of the onboard loading computer.

H 400 Optional class notation EL-2

401 Vessels with the optional class notation **EL-2** shall be able to handle average loading rates as given in Table H2, unless higher rates are specified and provided as part of the documentation for approval.

The average loading rate is defined as rate achieved from start to completion of total cargo loading divided by time elapsed.

Special consideration shall be given if loading with two or more loaders simultaneous is specified and provided as part of the documentation for approval.

Relevant loading sequences for coal and ore as applicable, with average loading rates in accordance with Table H2, or higher specified average loading rates, for the following conditions shall be defined:

- homogeneous condition (one and two grade loading), if applicable
- relevant part loading conditions, if applicable
- alternate conditions, if applicable.

Each step in the loading sequences from commencement of cargo loading to full deadweight is reached, step-wise and time-wise synchronized with the de-ballasting operation, shall be documented. Each time the loading equipment changes position to a new cargo hold is defined as a step.

Time-wise synchronized in this context means that the de-ballasting is completed within the same time as the loading step.

The typical loading sequences shall also be developed to not exceed applicable strength limitations.

Guidance note 1:

Such loading sequences may be decisive for the vessels strength although they are considered port conditions. I.e. they may give the highest net pressure on the bottom construction and give the highest bending moment and shear forces and thus represent a design condition that should be addressed in the FEM loading conditions. For that reason also intermediate steps will have to be demonstrated, but only for design purposes.

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For all relevant loading sequences, considering one, two or more loaders acting simultaneously as applicable, a summary of all steps shall be included with at least the following information included:

- how much cargo is filled in each cargo hold during the different steps
- how much ballast is discharged from each ballast tank during the different steps
- the maximum still water bending moment and shear force at the end of each step
- the ship's trim and draught at the end of each step
- the ship's draught aft and forward, trim and air-draught, if restrictions are applicable
- the ship's local strength criteria for single and adjacent hold loading.

Guidance note 2:

As guidance for ore carriers the mean draught at berth prior to loading should not be less than 60% of scantling draught taking possible air-draught restriction into consideration

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Table H2 Design loading rates	
<i>DWT</i>	<i>Average loading rate, t/h</i>
> 80 000	13 500
50 000 – 80 000	9 000
30 000 – 50 000	6 000

If the Master deems necessary due to operational reasons to deviate from the approved loading sequence calculations with ratings according to **EL-2** he may do so provided he is in compliance with SOLAS Ch.VI Pt.B, Reg.7.3 and on this condition agree with the terminal on a new loading plan.

402 The de-ballast capacity of the vessel at loading berth prior to commencement of loading, including arrangement of ballast tanks and relevant piping system, shall meet the requirements for the average loading rates as specified in Table H2.

If average loading rate is specified to be higher than those given in Table H2, the loading operation shall not be interrupted due to de-ballast operations.

The vessel shall be fitted with a separate stripping system. To enhance de-ballasting and stripping the trim shall be by stern during the whole operation.

403 The vessel shall be designed such that minimum 100% of maximum permissible cargo intake per cargo hold can be loaded in one pour.

404 Inner bottom strength shall be according to the requirements as given in Pt.8 Ch.2/Chapter 12 Sec.1 or Pt.3 Ch.1 Sec.6 H300, as applicable.

405 The vessel shall be fitted with a remote sounding for water ballast and fuel oil storage tanks and draught reading system with an on-line interface into the software of the onboard loading computer.

406 Check of local strength for single and adjacent hold loading pattern shall be integrated into the software of the onboard loading computer.

SECTION 6 CONTAINER CARRIERS

A. General

A 100 Classification

101 The requirements in this section apply to ships intended for carriage of standard freight containers for general cargo at predetermined positions on board, in holds and/or on weather deck. Relevant requirements for general cargo ships given in Sec.4 are also to be complied with.

Subsection B need in general not be considered for container carriers with length $L < 100$ m.

102 Ships exclusively intended for the carriage of containers and arranged with cell guides in holds and built in compliance with relevant requirements specified in the following may be given the class notation **Container Carrier**.

103 Ships intended also for other purposes, while arranged, strengthened and equipped for carriage of containers on deck and/or in holds and built in compliance with relevant requirements specified in the following, may be given the class notation **CONTAINER** in addition to the other notations (e.g. **General Cargo Carrier CONTAINER**).

Containers carried on deck or in holds on such ships shall be secured by an approved method. The securing arrangement shall be approved and only equipment certified or type approved by the Society shall be used for securing. However, loose container securing equipment need only be carried on-board to the extent the ship is carrying containers.

Ships intended to carry containers with dangerous goods (packed goods, dry bulk or portable tanks) shall comply with the requirements of Ch.11.

104 For ships with class notations as given in 102 and 103, a notation of the maximum number of twenty-foot equivalent units (TEU) that may be carried will be added, e.g. **1750 TEU**.

105 The additional notation **NAUTICUS(Newbuilding)** is mandatory for ships with the class notation:

Container Carrier with length, L , greater than 190 m.

L = Ship length as given in Pt.3 Ch.1 Sec.1 B101.

The notation **NAUTICUS(Newbuilding)** is described in Pt.3 Ch.1 Sec.16 and comprises extended fatigue - and direct strength calculations. Areas for fatigue calculations are further described in C308, and areas for direct strength calculations are described in C402.

A 200 Scope

201 The following matters are covered by the classification:

- arrangements for stowing and securing of containers in holds and on weather deck
- design, construction and installation of permanent supporting fittings and structures for the containers
- design and construction of removable container securing equipment For equipment produced in series the Society's Type Approval scheme may be applied
- instructions (Manual) for stowing and securing of the containers
- hull structure of ships intended for carriage of standard freight containers for general cargo in cellular cargo holds as given in B.

202 When an instrument is installed as a supplement to the Stowage and Securing manual, this shall be approved by the Society.

A 300 Assumptions

301 The classification of the ship is based on the assumptions that:

- the approved "Container Stowage and Securing Manual" is kept available on board for the stowage and securing of container cargo
- all required equipment for the securing of containers are of strength, design and make approved by the Society for its purpose
- the containers are stowed and secured in accordance with the approved Manual and the approved stowage and securing plans
- all container securing equipment is properly maintained and repaired
- damaged equipment is replaced by equipment which is type approved and of at least the same strength rating
- the approved instrument for stowage and securing of containers is checked at regular intervals.

302 The above assumptions for the classification shall be stated in the approved "Container Stowage and Securing Manual" onboard.

A 400 Definitions

401 Terms:

- *Container*: Freight container according to ISO-standard, or other specially approved container.
- *Container stack*: Containers which are stacked vertically and secured horizontally by stackers, lashings etc., see Fig. 1.
- *Container block*: A number of container stacks interconnected and secured horizontally by bridge stackers, see Fig. 2.
- *Minimum breaking load*: Tested minimum breaking strength of wire rope, chain, rod or other member in accordance with rule specifications.
- *Non-rigid securing arrangements*: Securing arrangements where the stiffnesses of containers influence support forces and internal forces in the containers, e.g. lashing arrangements including lashing bridges and container stanchions.
- *Rigid securing arrangements*: Securing arrangements where the stiffnesses of the containers do not influence support forces and internal forces in the containers, e.g. cellular containment arrangements.
- *Container securing equipment*: Loose and fixed equipment used for securing and supporting of containers.
- *Container support fittings*: Fittings welded into tank tops, decks, bulkheads or hatch covers (i.e. fittings that form an integral part of the ship structure).
- *Container securing devices*: Includes container securing equipment and container support fittings.
- *Cell guides*: An arrangement in holds or on deck of fixed vertical guide rails for support of containers.
- *Maximum securing load, MSL*: The maximum allowable load on container securing devices, based on testing or calculations.

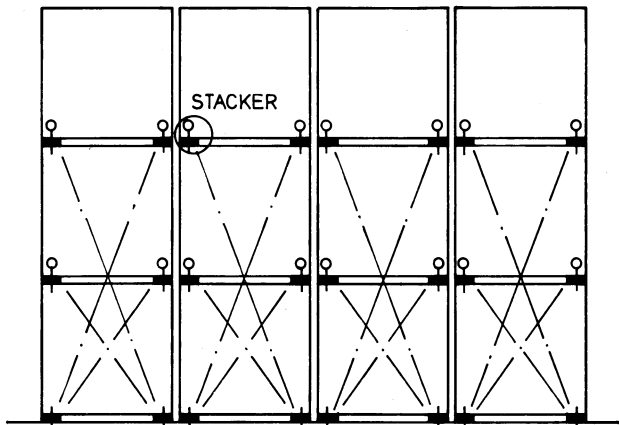


Fig. 1
Individual container stacks with lashings

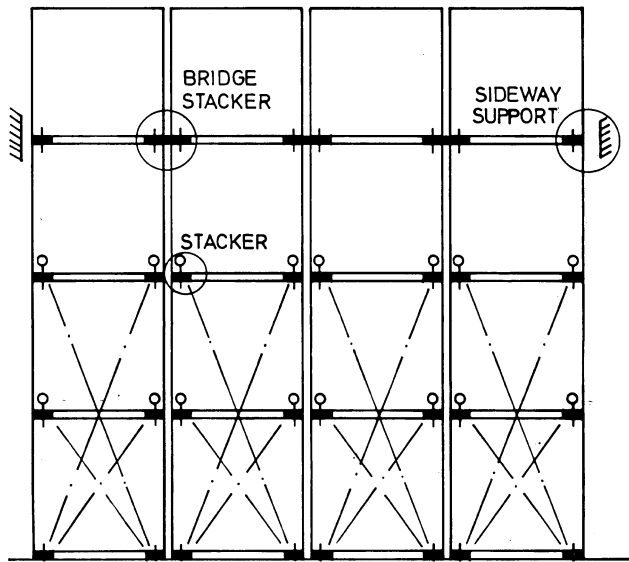


Fig. 2
Container block with lashing and sideways supports

A 500 Documentation

501 In connection with the longitudinal strength calculations and design load conditions to be submitted for information according to Pt.3 Ch.1 Sec.1 C200, information shall be submitted as relevant regarding:

- maximum hull girder still water torsional moments
- unsymmetrical design loading conditions.

502 Load data relating to the design approval of the hull structure including supporting structures and securing arrangements for containers shall be submitted for information. The following generally shall be considered:

- a) Mass limitations applicable for:
 - containers of given locations and size categories
 - container stacks of given locations
 - mean container mass for given bays of cargo holds or deck locations
 - total container mass for given hatch covers.
- b) Design load limitations for cargo holds such as:

- full draught condition with minimum mass of cargo in cargo hold or part of cargo hold
- reduced (minimum) draught condition with cargo hold or part of cargo hold fully loaded.

- c) Mass limitations in relation to specified GM limitations.

503 The following plans shall be submitted for approval for each container stowing space in holds and each stowing area on decks and on hatch covers:

- a) A container stowage plan including specification of:
 - sizes of containers to be transported
 - applicable mass limitations for loaded containers and container stacks etc.
 - strength standard for containers in relation to location etc.
- b) A container securing plan showing arrangements of loose and fixed equipment for the securing and support of containers, including:
 - container securing equipment with data regarding type, dimensions, allowable working load and specified pre-stressing
 - support fittings with data regarding position, type, dimensions and allowable working load.
- c) Drawings and specifications of structure or fitting with adjoining supporting structures in hull or hatch covers of:
 - cell guides
 - permanent support fittings.

504 A “Container Stowage and Securing Manual” shall be submitted for approval. The Manual shall include copies of the container stowage and securing plans as well as an inventory list for all container securing equipment required for the ship. The inventory list shall be supplemented by product certificates as specified in 604 for each item. The inventory list shall be updated and new product certificates added if items are replaced by alternative equipment makes or types. Instructions and sketches showing proper stowing and securing of the containers and use of securing equipment are also to be included in the Manual.

505 Calculations of maximum forces and stresses in container supports, and adjoining hull structures (e.g. hatch covers and supporting coamings and girders), cell guides, lashings, containers etc. shall be submitted for consideration. Such calculations may be based on principles and methods outlined in Classification Note No. 32.2 “Strength Analysis of Container Securing Arrangements”.

506 A drawing showing nominal cell guide/container clearances and specified building tolerances of container cell guides is normally to be submitted for information. When cargo loading conditions which are unsymmetrical about the ships' centre line are intended, information on the minimum diagonal cell guide/container clearance required for loading/unloading purpose may be requested to be submitted for information.

507 For ships furnished with an instrument for the stowage and securing of containers, see 700.

A 600 Certification

601 Container support fittings, cell guides, lashing bridges and container stanchions shall be delivered with Det Norske Veritas' material certificates.

602 Type approval will be according to the general scheme outlined in Pt.1 Ch.1 Sec.4 and in Certification Note 1.1. The Society will issue a Type Approval Certificate valid for 4 years and the product will be entered in the “List of Type Approved Products”.

603 Container securing equipment may be delivered with works material certificates from the manufacturer.

604 In addition to the material certificates required in 601 and 603, all loose and fixed container securing equipment and support fittings shall be delivered with product certificates. The certificates should contain at least the following information:

- name of manufacturer
- type designation of item
- material(s)
- identification marking
- test procedure
- test results of strength tests (breaking load and proof load) if applicable
- results of non-destructive examination if applicable
- allowable working load.

Equipment may be type approved or case-by-case approved.

If it is agreed in a Manufacturing Survey Arrangement with the Society, the Product Certificate may be issued by the manufacturer. Otherwise, the Product Certificate shall be issued by the Society.

A 700 Container stowage and securing instrument

701 The container stowage and securing instrument is subject to approval and certification.

702 For general requirements related to documentation of instrumentation and automation, including computer based control and monitoring, see Pt.4 Ch.9 Sec.1.

703 The documentation shall include:

- definition of container stowage positions and associated (alternative) securing arrangements
- strength standard of containers, securing equipment and supports
- limitations to loading condition (e.g. mass of containers at given locations, or hull girder torsional moment by container cargo etc.) as applicable
- test conditions (at least 5) with printout showing internal forces in containers, and securing and support forces etc. in relation to the allowable limits. The test conditions shall be supplemented with checks by independent calculation
- references to applicable load limitations which are not included in the instrument itself.

704 The operation manual for the container stowage and securing instrument is always to be available on board.

705 The operation manual and the instrument output must be prepared in a language understood by the users. If this language is not English a translation into English shall be included.

706 The instrument shall control that applicable requirements of the rules are complied with for given container mass and securing configuration with respect to:

- internal forces in containers
- forces in securing equipment
- forces in supports.

707 The determination of forces in containers, securing equipment and supports must be based on accepted calculation methods, see also Classification Note No. 32.2.

B. Longitudinal and Local Strength

B 100 Definitions

101 Symbols

- f_1 = as given in Sec.1 B with respect to the considered member
- f^*_2 = longitudinal stress parameter, applicable for transversely stiffened plates and longitudinal stiffeners of the hull cross-section, given by:

$$f^*_2 = \frac{5.7(M_s + M_w)}{Z}$$

The value of f^*_2 may in general be taken equal to the f_2 as given in Pt.3 Ch.1 Sec.6 A and Sec.8 A within 0.4 L amidship. The f^*_2 shall be determined for hull cross-sections at positions where the hull girder section modulus has been checked according to 202. The f^*_2 may be taken equal to 0.5 f_1 within 0.1 L from AP or FP unless the hull girder section modulus has been checked in this area according to 202.

Between the given positions, f^*_2 , may be determined by linear interpolation.

- f^*_{2B} = f^*_2 with respect to the hull girder section modulus at bottom
- f^*_{2D} = f^*_2 with respect to the hull girder modulus at deck
- f^*_{2BH} = f^*_{2BH} with respect to the hull girder section modulus at bottom and stillwater hogging moment
- f^*_{2BS} = f^*_{2BS} with respect to the hull girder section modulus at bottom and stillwater sagging moment
- k_l = parameter for determination of allowable stresses for laterally loaded plates
- = $3.5 (1 - f^*_2 / f_1)$. The k_l is, however, not to be taken larger than: $5 x/L - 1$
- x = distance in m from L/2 to considered position
- = 0.2 L minimum
- = 0.4 L maximum
- k_{lD} = k_l with respect to f^*_{2D}
- k_{lB} = k_l with respect to f^*_{2B}
- Z =

Z_B = section modulus at bottom in cm³ of hull girder as built at section considered,

Z_D = section modulus at deck in cm³ of hull girder as built at section considered

M_S = design still water bending moment at considered section in kNm

k_{sm}, M_{SO} = as given in Pt.3 Ch.1 Sec.5 B100

M_W = Rule wave bending moment at considered section in kNm given in Pt.3 Ch.1 Sec.5 B. Hogging or sagging moment shall be chosen in relation to the applied still water moment.

B 200 Longitudinal and buckling strength

201 The longitudinal and buckling hull girder strength are in general to be determined as given in Pt.3 Ch.1 Sec.5 and Sec.13.

The M_S may, subject to acceptance in each case, be based on the envelope curve representing all relevant full- and part load cargo- and ballast conditions as given in Pt.3 Ch.1 Sec.5 B101.

202 The requirements given in 203 and 204 will normally be satisfied if calculated with respect to the midship section and

characteristic sections of the end ship regions. Cross-sections where the arrangement of longitudinal material changes is of particular interest. As a minimum sections at or close to the aft and forward quarterlength positions and at the ends of the open cargo region must be evaluated.

203 The requirement for section modulus of the hull girder about the transverse axis is for any section to be taken as given in Pt.3 Ch.1 Sec.5 C303 with $\sigma_f = 175 f_1$ (N/mm²).

Guidance note:

It is advised that the still water bending moment M_S values, if based on Pt.3 Ch.1 Sec.5 B101, are taken with a margin of, say 5%, relative to the moment envelope of the ship's design loading conditions.

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204 The combined normal stress of vertical and horizontal hull girder bending and of torsional moment shall in general not exceed $195 f_1$ N/mm². In the deck and hatch coaming, the combined stress shall not exceed $225 f_1$. The combined stress may be taken as:

$$\sigma = |\sigma_{\text{STAT}} + \sigma_{\text{DYN}}| \text{ (N/mm}^2\text{)}$$

σ_{STAT}	=	$\sigma_S + \sigma_{\text{ST}}$
σ_{DYN}	=	$\sigma_W + \sigma_{\text{WH}} + \sigma_{\text{WT}}$
σ_S	=	$M_S (z_n - z_a) 10^5 / I$
σ_W	=	$M_{\text{WR}} (z_n - z_a) 10^5 / I$
M_{WR}	=	reduced vertical wave bending moment to be considered for the combined response
	=	$0.45 M_W$ in general
I	=	moment of inertia in cm ⁴ of hull girder about the horizontal axis at section considered
z_n and z_a	=	as given in Sec.1 B
σ_{WH}	=	$M_{\text{WH}} y_a 10^5 / I_H$
I_H	=	moment of inertia in cm ⁴ of hull girder about the vertical axis at section considered
y_a	=	distance in m from centreline to position considered
M_{WH}	=	as given in Pt.3 Ch.1 Sec.5 B205
σ_{ST}	=	warping stress and stress due to warping deformations in N/mm ² at position considered for the given still water torsional moment distribution, M_{ST}
σ_{WT}	=	warping stress and stress due to warping deformations at position considered due to the wave torque, M_{WT}
M_{WT}	=	as given in Pt.3 Ch.1 Sec.5 B206
M_{ST}	=	design still water torsional moment in kNm over ship length
	=	$0.3 LB^2$ (kNm) minimum.

For the purpose of calculating stresses due to still water torsion, a still water torsional distribution equal to the wave torsional distribution may be assumed.

Guidance note:

The still water- and wave induced warping stresses and stress due to warping deformations may be determined based on prismatic beam- or global coarse mesh finite element calculations. Acceptable methods for calculation of torsion response is outlined in Classification Notes 31.7.

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205 The curvatures of upper deck hatch corners are in general to be taken as given in Pt.3 Ch.1 Sec.5 E500 and in 206-207 below. In special cases the stress level in the corner region may be required to be documented to be acceptable by special calculations.

206 The curvature of streamlined hatch corners at side at the aft end of the open deck region is generally to be as given in Pt.3 Ch.1 Sec.5 E501 with transverse extension not less than:

$$a = 0.020B \sqrt{f_1} \text{ (m)}$$

f_1 = as given in B for deck plating in area considered

Alternatively double (or single) curvature corner shapes may be accepted provided the radius of curvature at the hatch side is not less than $1.8 a$ (m).

For extent of local reinforcement of deck plating at hatch corners, see Pt.3 Ch.1 Sec.8 A405.

207 For cross decks, the radius of rounded corners is generally not to be less than:

$$r = k(w + 0.8) \sqrt{f_1} \text{ (m)}$$

k = 0.16 for hatch corners at side

= 0.10 for hatch corners for longitudinal deck girders

f_1 = f_1 as given in B for deck plating in area considered

w = width of cross deck in m.

For extent of local reinforcement of deck plating at hatch corners, see Pt.3 Ch.1 Sec.8 A405.

When a corner with double curvature is desired, a reduction of the inside radius may be considered.

208 For the design of structural members of the double bottom, the hull girder compressive longitudinal stress may, subject to acceptance in each case, be based on a reduced hogging still water bending moment $M_{h, \text{reduced}}$, corresponding to the maximum allowable bending moment at scantling draught. The allowable design bending moment $M_{h, \text{reduced}}$, at scantling draught T , and the allowable design bending moment, M_h , at a lower draught, $T_{Mh, \text{full}}$ shall be stated in the Appendix to Classification Certificate. The combination of reduced draught and allowable design bending moment M_h will be checked. For draughts between $T_{Mh, \text{full}}$ and T_S , the permissible hogging bending moment shall be linearly interpolated between the values of $M_{h, \text{full}}$ and $M_{h, \text{reduced}}$, and the permissible bending moment as a function of the draught shall be implemented in the vessel's loading computer. The reduced still water bending moment, $M_{h, \text{reduced}}$ shall not be taken less than $2/3$ of $M_{h, \text{full}}$.

Guidance note:

< This consideration may only be applied if the difference between the stresses caused by full hogging moment and the reduced hogging moment

$$\Delta \sigma_{\text{sw, hogg}} = 130(f_{2BH}^* - f_{2BH, \text{reduced}}^*)$$

is greater than the difference in double bottom stresses at the reduced draught and at the full draught. The difference in double bottom stresses may be based on an evaluation of the change in the net pressure on the double bottom.

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B 300 Plating and stiffeners

301 Thicknesses and cross-sectional properties are in general to be calculated as given for the main class, considering also the requirements given for cellular container holds given in C.

The allowable stress may be based on the stillwater bending moment as given in B201.

302 Bottom plating and stiffeners shall be designed as given in Pt.3 Ch.1 Sec.6 with allowable stresses for applicable rule items taken as follows (reference to said section given):

C302: *Bottom and bilge plating*

$$\begin{aligned} \sigma &= (175 + 40 k_{IB}) f_1 - 120 f^*_{2B}, \text{ maximum} \\ &= (120 + 40 k_{IB}) f_1 \text{ where transversely stiffened} \\ &= (120 + 40 k_{IB}) f_1 \text{ where longitudinally stiffened} \end{aligned}$$

C401: *Inner bottom plating*

$$\begin{aligned} \sigma &= (200 + 20 k_{IB}) f_1 - 110 f^*_{2B}, \text{ maximum} \\ &= (140 + 20 k_{IB}) f_1 \text{ where transversely stiffened} \\ &= (140 + 20 k_{IB}) f_1 \text{ where longitudinally stiffened} \end{aligned}$$

C501: Plating in double bottom floors and longitudinal girders

$$\begin{aligned}\sigma &= (190 + 30 k_{IB}) f_1 - 120 f_{2B}^*, \text{ maximum} \\ &= (130 + 30 k_{IB}) f_1 \text{ where transversely stiffened} \\ &= (130 + 30 k_{IB}) f_1 \text{ where longitudinally stiffened} \\ &= 160 f_1 \text{ for floors}\end{aligned}$$

C701: Bottom longitudinals

$$\begin{aligned}\sigma &= \text{allowable stress, maximum } 160 f_1 \\ &= 225 f_1 - 130 f_{2B}^* (z_n - z_a) / z_n \text{ for single bottom longi-} \\ &\quad \text{tudinals} \\ &= 225 f_1 - 130 f_{2B}^* - 0.7 \sigma_{db} \text{ for double bottom longitu-} \\ &\quad \text{dinals} \\ &= \text{as given in C307 (this chapter) for bottom longitu-} \\ &\quad \text{dinals of double bottoms in cellular container holds}\end{aligned}$$

C801: Inner bottom longitudinals

The section modulus of inner bottom longitudinals exposed to tank pressure on the stiffener side only in the double bottom shall not be less than according to the requirements given in Pt.3 Ch.1 Sec.6 with:

$$\begin{aligned}\sigma &= \text{allowable stress, maximum } 160 f_1 \\ &= \text{lesser of:} \\ &\quad 2 \cdot (225 f_1 - 100 f_{2BH}^* - 0.7 \sigma_{db}) \text{ (at middle of stiffen-} \\ &\quad \text{er) or} \\ &\quad (225 f_1 - 100 f_{2BS}^* - 0.7 \sigma_{db}) \text{ (at end of stiffener)} \\ &\quad \text{with } \sigma_{db} = 20 f_1 \text{ N/mm}^2 \text{ in general.}\end{aligned}$$

C901: Stiffening of double bottom floors and girders

$$\begin{aligned}\sigma &= \text{allowable stress, maximum } 160 f_1 \\ &= 225 f_1 - 110 f_{2B}^* \text{ for longitudinal stiffeners} \\ &= 160 f_1 \text{ for transverse and vertical stiffeners in general.}\end{aligned}$$

Allowable stresses for stiffening of double bottom girders exposed to tank pressure on the stiffener side only may be taken as lesser of:

$$\begin{aligned}\sigma &= 2 \cdot (225 f_1 - 110 f_{2BH}^*) \text{ (at middle of stiffener) or} \\ \sigma &= (225 f_1 - 110 f_{2BS}^*) \text{ (at end of stiffener)} \\ &\quad \text{maximum } 160 f_1.\end{aligned}$$

303 Side longitudinals shall be designed as given in Pt.3 Ch.1 Sec.7 C301 with allowable stresses taken as follows:

$$\begin{aligned}\sigma &= 225 f_1 - 130 f_{2B}^* (z_n - z_a) / z_n, \text{ maximum } 160 f_1. \\ &= 130 f_1, \text{ maximum for longitudinals supported by side} \\ &\quad \text{verticals in single deck constructions.}\end{aligned}$$

304 Deck plating and stiffeners shall be designed as given in Pt.3 Ch.1 Sec.8 with allowable stresses for applicable rule items taken as follows (references to said section given):

C102: Strength deck plating

$$\begin{aligned}\sigma &= \text{allowable stress} \\ &= (175 + 40 k_{ID}) f_1 - 120 f_{2D}^*, \text{ maximum} \\ &= (120 + 40 k_{ID}) f_1 \text{ where transversely stiffened} \\ &= (120 + 40 k_{ID}) f_1 \text{ where longitudinally stiffened.}\end{aligned}$$

C301: Deck longitudinals

$$\begin{aligned}\sigma &= \text{allowable stress} \\ &= 225 f_1 - 130 f_{2D}^*, \text{ maximum } 160 f_1 \text{ for strength deck} \\ &\quad \text{and long superstructures and effective deck houses} \\ &\quad \text{above strength deck} \\ &= 225 f_1 - 130 f_{2D}^* (z_n - z_a) / z_n, \text{ maximum } 160 f_1 \text{ for} \\ &\quad \text{continuous decks below strength deck.}\end{aligned}$$

Allowable stresses for deck longitudinals below the neutral axis exposed to tank pressure on the stiffener side only may be taken as lesser of:

$$\begin{aligned}\sigma &= 2 \cdot (225 f_1 - 130 f_{2BH}^* (z_n - z_a) / z_n) \text{ (at middle of} \\ &\quad \text{stiffener) or} \\ \sigma &= (225 f_1 - 130 f_{2BS}^* (z_n - z_a) / z_n) \text{ (at end of stiffener)} \\ &\quad \text{maximum } 160 f_1.\end{aligned}$$

In combination with heeled condition pressures p_9 and p_{11} , $\sigma = 160 f_1$ may generally be used.

305 The arrangement of longitudinal stiffeners of the strength deck shall be taken as given in Pt.3 Ch.1 Sec.8 A403 with longitudinals arranged to be continuous within the complete open cargo hold length for ship lengths > 100 m.

306 Bulkhead plating and stiffeners shall be designed as given in Pt.3 Ch.1 Sec.9 with allowable stresses for applicable rule items taken as follows:

C201: Bulkhead longitudinals

$$\sigma = 225 f_1 - 130 f_{2B}^* (z_n - z_a) / z_n, \text{ maximum } 160 f_1$$

Allowable stresses for bulkhead longitudinals below the neutral axis exposed to tank pressure on the stiffener side may be taken as lesser of:

$$\begin{aligned}\sigma &= 2 \cdot (225 f_1 - 130 f_{2BH}^* (z_n - z_a) / z_n) \text{ (at middle of} \\ &\quad \text{stiffener) or} \\ \sigma &= (225 f_1 - 130 f_{2BS}^* (z_n - z_a) / z_n) \text{ (at end of stiffener)} \\ &\quad \text{maximum } 160 f_1.\end{aligned}$$

For longitudinals, $\sigma = 160 f_1$ may be used in any case in combination with heeled condition pressures p_6 and p_7 .

307 Simple girders shall be designed as given in Pt.3 Ch.1 with allowable stresses for applicable rule items taken as follows:

Sec.8 D201 and Sec.9 D201:

$$\begin{aligned}\sigma &= 190 f_1 - 130 f_{2B}^* (z_n - z_a) / z_n, \text{ maximum } 160 f_1 \text{ for} \\ &\quad \text{continuous longitudinal girders} \\ &= 160 f_1 \text{ for other girders}\end{aligned}$$

For longitudinal girders, $\sigma = 160 f_1$ may in any case be used in combination with heeled condition pressures.

B 400 Strength evaluation of wave breaker and supporting structure

401 Where a wave breaker is fitted in the forward part of the ship, protecting the containers from damage due to green sea on deck, the scantlings of plating, stiffeners and girders, and the supporting deck structure should be evaluated based on requirements given in the following.

402 The design load on the wave breaker structure shall be taken in accordance with the design load for unprotected front bulkhead of superstructure, Pt.3 Ch.1 Sec.10 Table C1.

403 Plating and stiffeners shall be designed as given in Pt.3 Ch.1 Sec.10 D100 with allowable stress as given in Table B1.

404 Wave breaker girder system, and its supporting structure shall be designed based on a direct calculation taking into account the efficiency of the provided deck support below the wave breaker.

Allowable stresses shall be taken as given in Table B1:

Table B1 Allowable stresses	
Wave breaker and supporting structure	
σ	$160 f_1$
τ	$90 f_1$

Where relevant, the plating of the wave breaker shall satisfy the buckling strength requirements given in Pt.3 Ch.1 Sec.13 B applying a usage factor $\eta = 1.0$.

C. Cellular Container Hold Structures

C 100 General

101 The structural requirements given in C200 to C400 are primarily applicable for container ships with cellular container holds and with a predominantly hogging hull girder still water bending moment. For other ship types with container transportation capability, e.g. open hatch bulk carriers, the structural design is mainly to be based on the rule requirements for the principal type and service class notation (e.g. **General Cargo Carrier BC-A**, or **Bulk Carrier BC-A**).

C 200 Design loads

201 Cargo holds for container cargo are generally to be considered for design loads and design load assumptions as given in 202 to 205.

202 It is assumed that the maximum allowable stack weight is defined for every 20' and 40' (45') container stack position of every cargo space. If the maximum stack weight has not been specified, the maximum allowable stack weight shall be taken equal to max. container weight multiplied with no of tiers.

203 The maximum cargo mass of any hold, deck area or cargo space is, unless a lower mass limit is specified, to be taken as the sum of maximum 20' (if applicable) container stack weights for the cargo space considered.

204 It is generally assumed that the heaviest containers are stowed in the lower positions of each container stack. A uniform distribution of container mass within each container stack may therefore generally be assumed, unless differing mass distributions are specified.

205 In the full draught condition with minimum mass of cargo in a given 40' (45') container bay, the minimum cargo mass shall be assumed for the container hold and deck region between any transverse watertight bulkhead and support bulkhead. Outside of this region container hold and deck spaces shall be assumed to have maximum cargo mass in accordance with 203.

Within the minimum cargo region, any one 40' (45') container bay of a cargo hold (or equivalent) and deck area above are in general to be assumed empty. In the remaining spaces (in hold and deck above) of the minimum cargo region, the container mass may not be greater than the maximum cargo mass based on 40' (45') container stowage (if applicable, 20' container stowage) given according to 202.

Alternatively specified minimum cargo limits may be considered.

C 300 Plates and stiffeners

301 Thicknesses and cross-section properties are with the exceptions given in 302 to 308 to be as given for the main class.

302 The minimum thickness of web and flange of stiffeners of ballast tanks may be taken as given in Pt.3 Ch.1 Sec.7 C302 and Sec.9 C202 with $k = 0.01 L_1$.

For sea chest boundaries (including top and partial bulkheads), see Pt.3 Ch.1 Sec.6 C500 and C900.

303 The thickness of webs, flanges and brackets of girders of double bottom tanks may be taken as given in Pt.3 Ch.1 Sec.6 C502 with:

- $k = 0.03 L_1$ for centre girder up to 2 m above keel plate
- $k = 0.015 L_1$ for other girders and remaining part of centre girder
- $k = 0.05 L_1$ for sea chest boundaries (including top and partial bulkheads).

304 The thickness of stiffeners and girders including webs, flanges and brackets of ballast tanks of the side- and bulkhead

structures of the cargo region as otherwise given by the requirements in Pt.3 Ch.1 Sec.7 D101 and Sec.9 D101 shall not be less than:

$$t = 5.0 + \frac{k}{\sqrt{f_1}} + t_k \quad (\text{mm})$$

$$k = 0.01 L_1$$

305 The thickness of the inner shell plating shall be as given in Pt.3 Ch.1 Sec.9 C100 with $k = 0.01$, and the requirement of C104 disregarded.

306 The minimum plate thickness of transverse bulkheads which are required for gas tightness only, may be taken as given in Pt.3 Ch.1 Sec.9 C102 with $k = 0$.

307 The section modulus of bottom longitudinals within the width of the double bottom shall not be less than according to the requirements given in Pt.3 Ch.1 Sec.6 with:

$$\sigma = 245 f_1 - 40 f_{2BH}^* - 0.7 \sigma_g$$

f_1 = material factor as given in Sec.1 B100 with respect to the bottom longitudinal

σ_g = $190 f_{1B}$, but need not be taken larger than

$$\sigma_{DB} + 130 f_{2BH}^*$$

f_{1B} = material factor f_1 as given in Sec.1 B100 with respect to the bottom plating

σ_{DB} = longitudinal double bottom stress with respect to the bottom plating in the middle of the minimum loaded hold for load case LC2 as given in 404

f_{2BH}^* = f_{2B}^* as given in B with respect to the hogging still water bending moment.

Guidance note:

If a direct double bottom calculation has not been carried out and the bottom longitudinal section modulus requirement based on the standard rule formulation given in Pt.3 Ch.1 Sec.6 C701 has not been complied with, the bottom longitudinal profile as proposed may still be accepted provided the calculated longitudinal double bottom stress σ_{db} , of the bottom plating in the mid part of the hold for the load cases LC2, LC3 as given in 404 does not exceed the following limit:

$$\sigma_{db} = 350 f_1 - 1.43 (\sigma + 130 f_{2BH}^*) \quad (\text{N/mm}^2)$$

$$\sigma = \frac{83 l^2 s p w_k}{Z}$$

Z = section modulus (cm^3) of proposed bottom longitudinal
 l, s, p, w_k = as given in Pt.3 Ch.1 Sec.6

In addition it is assumed that the σ_{db} based on the direct calculation shall not exceed the following limit:

$$\sigma_{db} = 190 f_1 - 130 f_{2BH}^* \quad (\text{N/mm}^2)$$

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308 The minimum thickness of the side plating shall be as given in Pt.3 Ch.1 Sec.7 C102 with $k = 0.037$ and Pt.3 Ch.1 Sec.7 C103 with $T = T_d$ = design draught.

309 For ships as mentioned in A105 fatigue strength assessment is in general to be carried out for end structures of longitudinals in bottom, inner bottom, side, inner side, longitudinal bulkheads and strength deck in the cargo area, as described in Pt.3 Ch.1 Sec.16. The warping stresses should in general be taken into account.

In addition, a fatigue life evaluation of the hatch corners shall be carried out.

Note:

The following item C310 shall be regarded as "Tentative Rules".

310 At support of stiffeners, the shear connection area (a_{0S}) and the connection area of the web stiffener (a_{0N}) is normally

not be less than:

$$a_{0,S} = c_S k (l - 0.5 s) s p \text{ (cm}^2\text{)}$$

$$a_{0,N} = c_N k (l - 0.5 s) s p \text{ (cm}^2\text{)}$$

where

$a_{0,S}$ = required shear area between lug(s) or collar plate and longitudinal

$a_{0,N}$ = required connection area between the stiffener and the web stiffener welded to the longitudinal.

k, l, s, p = as defined in Pt.3 Ch.1 Sec.11 C401

$$c_S = c \left(\frac{A_{\text{shear}}}{K_{ws} A_{ws} + A_{\text{shear}}} \right)$$

$$c_N = \frac{c}{\sqrt{3}} \left(1 - \frac{A_{\text{shear}}}{K_{ws} A_{ws} + A_{\text{shear}}} \right)$$

c = according to Pt.3 Ch.1 Sec.11 Table C4

= 1.0 for T-profiles

A_{shear} = shear area of the lug(s)/collar plates in the connection

A_{ws} = area of the web stiffener on top

K_{ws} = stress distribution factor as given in Table C1.

Table C1 Values of K_{ws}		
	<i>L profile</i>	<i>T profile</i>
Direct connection	1.3	0.9
Direct connection with lug	1.2	1.0
Slit type	1.15	1.0

The weld area, a_S and a_N , of the connections shall not be less than:

$$a_S = \frac{1.15 a_{0,S} \sqrt{f_1}}{f_w} + a_k$$

$$a_N = \frac{1.4 a_{0,N} \sqrt{f_1}}{f_w} + a_k$$

C 400 Girder systems

401 The scantlings of the girder structures of the double bottom, transverse bulkhead and side structure of container holds may have to be based on direct stress analysis in accordance with Pt.3 Ch.1 Sec.13.

Guidance note:

The direct calculations should generally be carried out as three-dimensional beam and/or finite element calculations covering double bottom and sides and transverse bulkhead structures as applicable. For unsymmetrical loading conditions a full breadth model (extending from side to side) may be required unless the antisymmetric boundary condition may be applied for representation of the dynamic loads of LC3 and LC4 given in 404.

For the model, vertical supports may generally be assumed at the intersection of the elements representing the transverse watertight bulkheads and the double side structure.

The longitudinal extent of the model should cover the considered container hold length and extending to the middle of the adjacent holds where the symmetry boundary condition may generally be assumed. If the symmetry condition may be assumed for structure and loads at the mid-length position of the considered hold, the total model length need only extend over two half hold lengths.

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402 Direct calculations by use of finite element methods are mandatory for vessels described in A105 and shall be carried out in accordance with principles described in Pt.3 Ch.1 Sec.12

B, in addition to the principles described here and elsewhere in the rules.

The following calculations are at least to be considered:

- support bulkhead including panel/girder and pillar structures
- typical web frame at position between support bulkhead and watertight bulkhead
- longitudinal double bottom girders.

In addition, stresses in laterally loaded local stiffeners subject to relative deformation between girders are normally to be considered.

403 For ships which give rise to warping response, a coarse mesh finite element model of the entire ship hull length may be required for torsional calculations.

404 The following design load cases are in general to be considered, see also Fig. 3 to Fig.8:

LC1: Maximum mass of cargo (20' containers as relevant) in considered hold in seagoing upright condition at reduced draught. This condition is primarily intended for dimensioning of bottom transverse members of support bulkheads. If there is no slim cell guide in hold for exclusive stowage of 20' container stack, then the number of 20' container tiers in the stack shall be in accordance with the container stowage plan. The adjacent holds shall be assumed empty, and the draught is generally not to be considered larger than 0.8T.

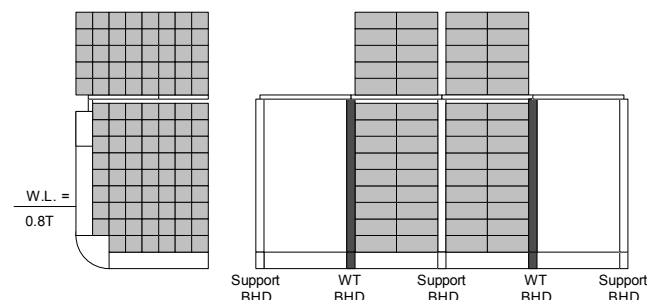


Fig. 3
Load case 1

LC2: Minimum mass of cargo in hold between adjacent watertight bulkheads which is comprised of one 40' bay empty in hold and deck above in the full draught condition. This condition is primarily intended for dimensioning of double bottom and supporting pillar bulkhead(s). The adjacent cargo holds shall be assumed filled with maximum mass of cargo (40' container cargo as relevant).

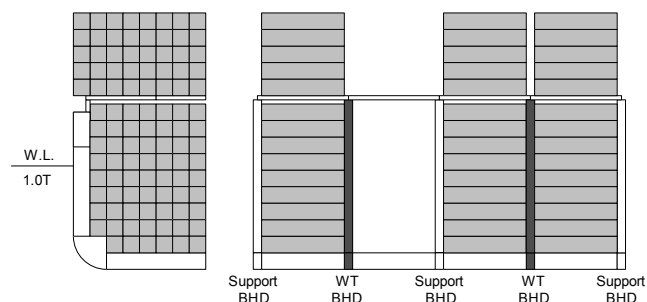


Fig. 4
Load case 2

LC3: Maximum mass of cargo in hold and on deck between watertight bulkheads, i.e. the same load description as LC1, but in heeled condition. This condition is primarily intended for dimensioning of the upper part of side structure and support bulkhead. The adjacent holds shall be assumed empty, and the draught is generally not to be considered larger than 0.8T in sea going heeled condition.

The transverse acceleration shall be taken as given in 408 (and is combined with the vertical acceleration of gravity).

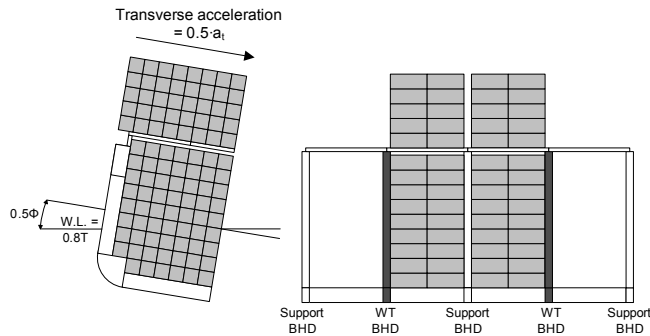


Fig. 5
Load case 3

LC4: Minimum mass of cargo in considered hold and on deck between watertight bulkheads, i.e. the same load description as LC2, but in heeled condition. This condition is primarily intended for dimensioning of the lower part of side structure and support bulkhead.

The adjacent holds shall be assumed filled with maximum mass of 40' container cargo.

The transverse acceleration shall be taken as given in 408 and is combined with the vertical acceleration of gravity.

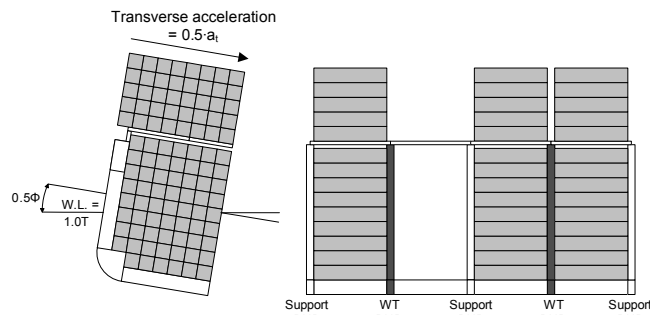


Fig. 6
Load case 4

LC5: Maximum mass cargo in hold and on deck with dynamic longitudinal acceleration. This condition is primarily intended for dimensioning of pillar- and watertight bulkheads. The adjacent holds shall be assumed filled with maximum mass of 40' container cargo.

The longitudinal acceleration shall be taken as given in 409 (and is combined with the vertical acceleration of gravity).

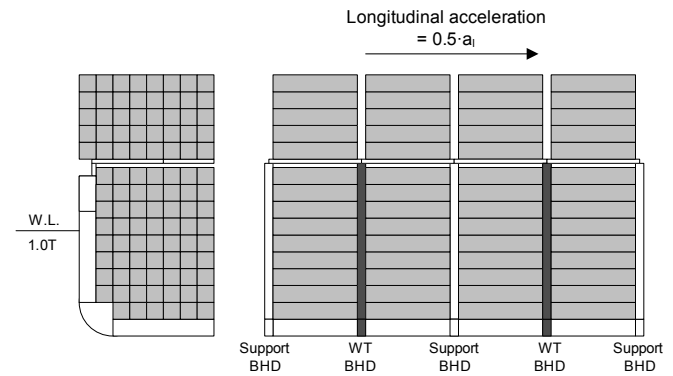


Fig. 7
Load case 5

LC6: Maximum specified mass of 40' containers in hold and on deck with one 40' bay empty in hold in upright sea-going condition at full draught. This condition is primarily intended for dimensioning of the support bulkhead structure.

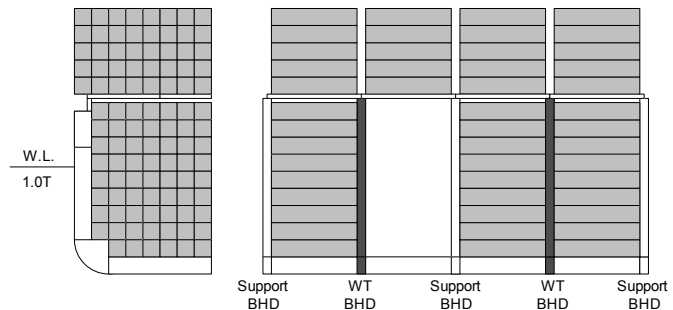


Fig. 8
Load case 6

LC7: Flooded damage condition for dimensioning of watertight bulkhead.

The flooding calculations shall be based on the equilibrium waterline in damage condition. However, if not available in early design, a flooding height up to the freeboard deck level (normally 2nd deck) may be assumed.

405 For vessels as mentioned in A105 load cases for calculation of dynamic stresses for the fatigue evaluation of longitudinals shall be taken as given in Pt.3 Ch.1 Sec.16.

406 The sea pressure in upright condition shall be taken as given in Pt.3 Ch.1 Sec.13 B300. The dynamic sea pressure in the heeled condition shall be taken as:

$$\begin{aligned}
 p &= 10 y \tan(\phi / 2) - z_s \text{ (kN/m}^2\text{) on submerged side} \\
 &= 0.0 \text{ minimum} \\
 p &= z_e, \text{ but not less than } -10 y \tan(\phi / 2) \text{ (kN/m}^2\text{) on emerged side} \\
 z_s &= 10(z - T_A), \text{ minimum} = 0.0 \\
 z_e &= 10(z - T_A), \text{ maximum} = 0.0 \\
 y &= \text{transverse distance in m from centre line} \\
 \phi &= \text{as given in Pt.3 Ch.1 Sec.4 B} \\
 z &= \text{vertical distance in m from base line to considered position.}
 \end{aligned}$$

407 The transverse acceleration shall be taken = $0.5 a_t$ where:

$$\begin{aligned}
 a_t &= \text{dynamic transverse acceleration} \\
 &= 0.4 a_y + g_0 \sin \phi + a_{ry} \text{ (m/s}^2\text{)} \\
 a_y, a_{ry} &= \text{as given in Pt.3 Ch.1 Sec.4 with } R_R \text{ taken with a negative sign for positions below the centre of rolling. The centre of rolling is generally not to be taken at a higher level than the considered draught}
 \end{aligned}$$

ϕ = as given in 406.

408 The longitudinal acceleration shall be taken $= 0.5 a_l$, where:

$$a_l = 0.6 a_x + g_0 \sin \theta + a_{px}$$

a_x, a_{px}, θ = as given in Pt.3 Ch.1 Sec.4 with R_p taken with a negative sign for positions below the centre of pitching. The centre is generally not to be taken at a higher level than the considered draught.

409 Allowable stresses are in general to be taken as given in Pt.3 Ch.1 Sec.13 B400.

410 For the design of structural members of the double bottom, the longitudinal hull girder stresses in hogging condition may, for the loading condition with minimum cargo at full draught, LC2, be based on a reduced still water bending moment $M_{h, \text{reduced}}$ as outlined in B208. In such cases, a loading condition in addition to the loading conditions specified in C404 shall be checked with minimum mass of cargo in hold and with empty deck above at a draught $T_{MH, \text{full}}$ in combination with the full design hogging bending moment, $M_{h, \text{full}}$.

D. Materials and Welding

D 100 Support fittings welded into the hull structure

101 Container supports and fittings intended for welding into the hull structure may be made of forged or cast carbon or carbon-manganese steels or may be cut from rolled materials of normal or high strength hull structural steel.

The materials shall comply with the relevant chapter/section of Pt.2 and with the additional requirements given in this subsection.

102 The carbon content of cast and forged steel shall not exceed 0.24%.

103 Specified minimum yield stress for castings and forgings shall not exceed 400 N/mm². Charpy V-notch tests for castings and forgings shall be carried out at the temperature required for hull structural materials in the adjacent area or at 0°C, whichever is the lower. Minimum absorbed energy shall comply with the requirements given in the relevant chapter/section of Pt.2.

D 200 Container securing equipment

201 Container securing equipment (not intended for welding into the hull structure) may be made of forged or cast steel or machined from rolled material. For devices and members produced without any welds, ferritic nodular cast iron may be used, subject to special approval. The materials shall comply with a recognised national or international standard, and are also to meet the additional requirements given in this subsection. Specifications deviating from the requirements given in this subsection may be evaluated on the basis of documented experience or comprehensive test results.

It may be required that the materials are delivered from manufacturers approved by the Society.

202 Carbon and carbon-manganese steels shall be fully killed.

203 For items produced without any welding the following apply:

For carbon and carbon-manganese steels the C-content shall not exceed 0.40%.

For alloy steels the C-content shall not exceed 0.45%.

When welding is used in the production, the chemical composition shall be appropriate for the welding process, dimensions and heat treatment process in question.

For thicknesses up to about 30 mm, when flash welded and

heat treated according to 300 after welding, a carbon content up to 0.35% for carbon and carbon-manganese steels and 0.40% for alloy steels may be accepted.

In other respects the chemical composition shall comply with the recognised standard.

204 Specified minimum yield stress for carbon and carbon-manganese steels shall not exceed 400 N/mm² when normalised, and 480 N/mm² when quenched and tempered. For alloy steels the specified minimum yield stress shall not exceed 750 N/mm². Alloy steel with specified yield stress up to 800 N/mm² may, however, be accepted upon special consideration of the material properties and its application in each case.

Charpy V-notch impact test shall be carried out at 0°C for container securing devices to be used under weather deck. For container securing devices to be used above weather deck, the test shall be carried out at -20°C or at the vessel design operating temperature, whichever is the lower. The average value of the absorbed energy shall be at least as shown in Fig. 9. At least 3 specimens shall be tested. One individual value may be less than the required average value, however, not less than 70% of this average. For rolled and forged materials, test specimens may be taken in the longitudinal direction. In castings the direction of test specimens is optional. For tests performed at temperatures below -20°C, the required absorbed energy may be specially considered.

In other respects the mechanical properties shall comply with the recognised standard.

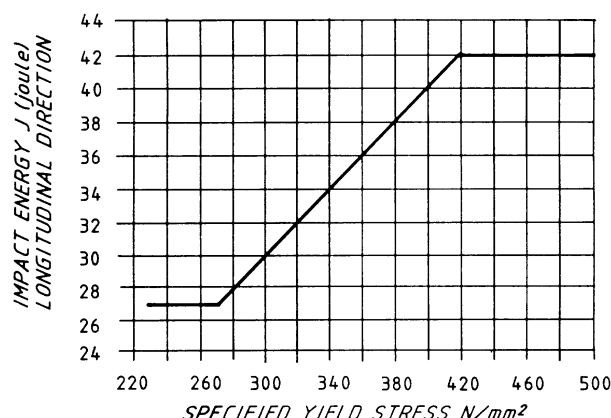


Fig. 9
Charpy V-notch, requirements for steel

D 300 Heat treatment

301 Castings and forgings of carbon and carbon-manganese steel shall be supplied in the normalised or quenched and tempered condition. Rolled materials shall be supplied in the heat treatment condition prescribed in the recognised specification.

Alloy steels shall be quenched and tempered. Ferritic nodular cast iron shall be subjected to a satisfactory heat treatment if not otherwise agreed.

D 400 Mechanical tests

401 Testing shall be carried out in accordance with relevant chapters of Pt.2 or with recognised standards taking into consideration the additional requirements given in 402 to 404.

402 When a number of pieces are heat treated in the same furnace charge, a batch testing procedure may be adopted, using pieces from each batch for test purposes. One tensile test and one set of impact tests shall be made from each batch. The batch shall consist of pieces of about the same size and from the same cast, heat treated in the same furnace charge and with a total mass not exceeding 2 tonnes.

403 For chain cables produced in continuous lengths one

tensile test and one set of impact tests shall be taken from cable produced from the same steel cast unless the length is more than 1 000 metres, in which case tests shall be taken from every 1 000 m or fraction thereof. The impact tests shall be taken clear of the weld. Test materials are obtained by supplying the cable with extra links.

404 Impact testing shall be carried out as Charpy V-notch tests according to Pt.2 Ch.1 Sec.2.

D 500 Steel wire ropes

501 The strength and construction of steel wire ropes for lashings shall comply with the requirements specified in Pt.3 Ch.3 Sec.3.

D 600 Welding

601 The relevant requirements concerning welding given in Pt.2 Ch.3 apply. Welding procedure specifications and welding procedure qualification tests may be required.

602 For carbon and carbon-manganese steel with carbon content exceeding 0.18% and for alloy steel, preheating and elevated interpass temperature may be required, except when members fulfil the requirements given in Pt.2 Ch.2 Sec.1 for hull structural steels.

603 When structural members and fittings are welded into the strength deck and other highly stressed structures, full penetration welds are required.

Flush supports shall be welded directly to stiffeners or girders below.

E. Type Approval, Testing and Marking of Container Securing Equipment and Support Fittings

E 100 Type approval

101 Type approval is based on plan approval and prototype testing. Plans shall be submitted for approval for each equipment item. In addition to detailed drawings, plans shall show material specification and heat treatment. The required minimum breaking load shall be stated.

One type approval certificate may cover different variations of the same basic equipment type. Variations may include e.g. different materials, lengths or breaking loads. Each variation may have to be prototype tested.

Type approval certificates are issued after satisfactory prototype tests are carried out. The prototype testing may upon special consideration be discarded for support fittings for welding into the hull structure in cases where the support arrangement for the fitting is subject to special approval in each case.

E 200 Prototype testing

201 Prototype testing of each item shall be performed on at least 2 samples. Test loads shall be applied in a test rig simulating the actual service conditions. All test samples shall withstand at least the specified minimum breaking strength. A test result report shall be issued in accordance with A604 above.

202 When the item shall be welded into the hull structure, the test condition shall conform with actual welded in condition.

203 The prototype testing may be replaced by suitable calculation in cases where the testing is impractical, e.g. for items to be welded into the hull structure.

E 300 Production testing

301 Production testing shall be carried out as follows:

For items produced in large quantities, at least 0.5% of all items shall be proof tested. At least one item from each lot (including prototypes) shall be tested. For items with welded parts subject to tensional loads at least 2% of all items shall be

proof tested. For lashing chain cables, each length shall be subjected to the proof load.

The test load to be applied in proof tests is normally to be taken as 1.1 times the Maximum Securing Load (MSL).

On completion of the proof test, each item shall be examined and shall be free of any deformations or significant defects.

302 For chain cables additional breaking load tests shall be performed as follows:

A breaking test specimen consists of at least 3 links connected together, and they shall be manufactured at the same time and in the same way as well as with the same heat treatment as the chain cable. One breaking test shall be made for every 1 000 m of chain cable or fraction thereof, produced in continuous length from the same steel cast.

For wires the relevant requirements according to Pt.3 Ch.3 Sec.3 G apply.

The breaking test is considered passed if no sign of fracture has occurred after application of the desired load.

303 The certification may alternatively to the production testing according to 301 and 302 be based on a scheme for Non-Destructive Examination. The details of such a scheme shall be agreed in a Manufacturing Survey Arrangement.

E 400 Marking

401 Each item shall be marked with suitable identification marking such as to allow traceability to the product certificate. Marking should include the manufacturer/ supplier's name or mark, type designation and, if relevant, charge or heat number.

F. Arrangements for Stowing and Lashing of Containers

F 100 General

101 Containers may be stowed longitudinally or transversely, and shall be effectively supported by the ship structure.

102 The containers shall be effectively prevented from sliding, lifting or tilting by a system of fixed supports or detachable lashing equipment.

103 The support fittings and securings shall withstand the loads specified in G, and shall be arranged and dimensioned in such a way that the supporting forces and internal forces in the containers are within the minimum capabilities of the containers to be used.

F 200 Containers in cell guides

201 Cell guide structures in holds or on weather deck may be permanently fastened (welded) to the hull structure, or be arranged detachable (screwed on).

202 The vertical guide rails are normally to consist of equal angles with thickness not less than 12.5 mm. On top of the rails shall be fitted strong and efficient guide heads. The guide rail angles are preferably to be connected by web plates at the levels of the container corners.

203 The vertical guide rails are in general to be supported by a system of transverse- and/or longitudinal ties transferring the transverse and longitudinal forces to the hull structure, if possible at the level of the container corners.

204 The total clearance between containers and cell guides shall not exceed 25 mm and 40 mm in the transverse and longitudinal directions respectively.

205 The net clearance between cell guides and containers, building tolerances and deformations imposed by the still water torsional loading etc. of the ship deducted, is generally to be larger than the minimum value specified for operational purpose.

F 300 Containers secured by lashings and other removable equipment

301 For containers on weather deck a combination of stacking cones (to prevent sliding), locking cones or lock stackers (to prevent tilting or lifting) and lashing shall be applied. For one or two tiers of containers lock stackers alone are normally sufficient. When more tiers are required, lashings may have to be provided in addition. Due to buoyancy forces from shipped water, all containers not secured by lashings shall be secured by lock stackers.

302 Lock stackers need not in general be applied for containers in cargo hold provided transverse shorings and lashings are fitted such that possible overturning is prevented for any relevant combination of stack height and container mass distribution.

Thus container stacks or part of such must (unless secured by lashings or shorings) generally be secured by lock stackers at level considered if the compressive vertical support force at any one of the container corners as calculated in accordance with G500 is less than $0.05 M g_0$ (kN).

M = total mass (t) of the containers of the considered stack at and above the container level considered.

303 For containers stowed in blocks several tiers high on inner bottom adequate support below each bottom container corner shall be provided. Lateral shoring may be obtained by fixed shoring elements supported at ship's side, decks or transverse bulkheads, and/or lashing. At each level of horizontal supports interconnecting stackers shall be fitted between each stack. Large blocks (several stacks) may be split vertically when special shoring elements taking both compression and tension are used.

304 Interconnecting stackers may either be of a type that transfers only horizontal forces (e.g. spectacle bridges, screw bridge fittings or separate stackers with removable connectors), or of a type that may transfer horizontal forces as well as vertical shearing forces (e.g. double stackers).

Shearing forces caused by possible variation in the container height shall be considered.

If the clearance between container stacks exceeds 30 mm, interconnecting stackers should preferably be of a type which transfers only horizontal forces. Plate thickness in double stackers shall be at least 13 mm.

305 For container positions with supports which may move relative to each other, the supports are as necessary to be such arranged that the relative movement does not lead to permanent deformation of the containers stowed.

G. Strength Evaluation of Container Securing Arrangements

G 100 General

101 Securing arrangements for containers shall be based on analysis of support and lashing forces for the most severe realistic static load conditions in combination with extreme dynamic loads.

102 When the arrangement of securing of containers is such that significant forces are generated in the containers and/or the securing members by variations in container dimension etc. in accordance with the tolerances stipulated by the ISO- standard, such forces shall be taken into consideration by the evaluation of the securing arrangement.

G 200 Static loads

201 The static conditions which give the largest support forces, lashing forces and the largest internal forces in the container structure shall be considered.

Reduction in forces due to friction between container layers shall not be considered.

202 Unless otherwise specified, the maximum mass of 20' and 40' ISO containers in any given location shall be taken as 24 000 kg and 30 480 kg, respectively.

203 When limitations regarding the maximum total mass of containers in a particular location (e.g. in a container block stack) are specified, the assumed mass of individual containers shall be such that the most severe realistic load condition is obtained.

204 Prestressing of lashings should normally be kept as small as possible. If prestressing is an integral part of a securing system, this will be subject to special consideration.

G 300 Dynamic loads

301 For container arrangements on deck the transverse dynamic acceleration, a_t , shall be taken as:

$$a_t = \frac{9}{B^{0.16}} k_{GM} \text{ (m/s}^2\text{)}$$

where:

$$k_{GM} = 1 + \frac{GM - 0.055 B}{0.165 B} \text{ minimum } 1.0$$

Not to be taken less than the combined transverse acceleration in Pt.3 Ch.1 Sec.4 B.

The combined vertical and longitudinal accelerations shall be taken as specified in Pt.3 Ch.1 Sec.4 B.

302 For container arrangements below deck the transverse dynamic acceleration, a_t , shall be taken as:

$$a_t = \frac{9}{B^{0.23}} k_{GM} \text{ (m/s}^2\text{)}$$

where:

$$k_{GM} = 1 + \frac{GM - 0.055 B}{0.165 B} \text{ minimum } 1.0$$

Not to be taken less than the combined transverse acceleration in Pt.3 Ch.1 Sec.4 B.

The combined vertical and longitudinal accelerations shall be taken as specified in Pt.3 Ch.1 Sec.4 B.

303 As an option to 301 to 303 the results from a direct wave load analysis may be utilised after special consideration.

Guidance note:

Such wave load analysis to be performed in accordance with CN 31.7 Ch.10. Normally, the North Atlantic wave scatter diagram should be used for determination of long term response. However, other wave scatter diagrams may be used as per owners requirements.

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304 All containers in a stack or a group of stacks are assumed to be subjected to the acceleration of gravity in combination with a uniform vertical acceleration according to 301 and 302.

305 The containers in a stack or group of stacks are assumed to be subjected to transverse or longitudinal acceleration in accordance with 301 and 302.

306 For non-rigid securing arrangements, acceleration loads according to 305 shall be combined with the acceleration of gravity acting downwards.

307 Containers, the side walls of which will be exposed to wind (windward side only), shall be considered for a wind force P_w which for ISO standard containers may be taken as follows:

P_w = 18.5 kN for 20' containers
= 37.0 kN for 40' containers
= 7.5 kN for container ends.

308 For containers in positions which may be exposed to wind, the acceleration loads according to 305 shall be combined with wind forces according to 307.

G 400 Strength analysis of rigid containment arrangements

401 Cellular containment structures and containment arrangements with numerous sideway supports may normally be considered as rigid containment arrangements.

402 Normally, the racking stiffnesses of the containers may be disregarded in the analysis of the overall response of the containment structure. Deflections in the supporting structure should be taken into account.

403 The analysis shall determine:

- nominal stresses in the containment structure
- vertical and horizontal support forces
- relevant internal forces in containers.

404 The calculation of stresses in cell guide structures and supporting structures for cell guide structures is in general to be based on the load cases LC4 and LC5 as given in C.

G 500 Strength analysis of non-rigid containment arrangements

501 Securing arrangements including lashings and other flexible securing members or a small number of rigid horizontal supports may normally be considered as non-rigid containment arrangements.

502 The analysis shall take duly account of the flexibilities of containers and of the securing members as well as possible deflections in the supporting structure.

503 Possible effects of clearances between stacks of containers and between containers and supports shall be taken into account.

504 The analysis shall determine:

- vertical and horizontal support forces
- forces in lashings and other securing members
- internal forces in containers.

For further details, see Classification Note No. 32.2.

G 600 Support fittings

601 The strength of support fittings is generally to be analysed for maximum support forces as determined under 100 and 200.

602 The analysis shall include the support fitting with local supporting structures. It shall show the nominal member capacities with respect to shear force, bending moment and axial force.

G 700 Acceptance criteria

701 Unless otherwise specified, calculated internal reaction forces in containers and external forces on the container structure shall not exceed the tested minimum capabilities stated in the appropriate ISO-standard for freight containers.

Applicable container strength ratings according to this stand-

ard are given in Classification Note No. 32.2.

702 Maximum Securing Load in container securing devices shall not exceed:

$$MSL = 0.5 P_m$$

P_m = minimum breaking load of considered equipment item.

Possible influence on the breaking load of fixed equipment by welding to the underlying structure shall be taken into account.

703 Members of other materials subjected to tensile loads will be specially considered.

704 Nominal normal stresses in support fittings for containers and container lashings and other non-rigid container securings (and in their local supporting structures) in hull structural steel, or as steel forgings or castings shall not exceed:

$$\sigma = 210 f_1 \text{ N/mm}^2.$$

705 Nominal shear stresses in support fittings for containers and container lashings and other non-rigid container securings (and in their local supporting structures) in hull structural steel, or as steel forgings or castings shall not exceed:

$$\tau = 120 f_1 \text{ N/mm}^2.$$

706 In supporting structures also subjected to longitudinal stresses (e.g. deck longitudinals and girders) combination with such stresses as given in Pt.3 Ch.1 Sec.8 is only to be performed for vertical container loads (rolling excluded). Allowable bending stresses may be increased by 30%.

707 Supporting structures subjected to compressive stresses shall be controlled for buckling in accordance with Pt.3 Ch.1 Sec.14.

708 Corrosion additions for supporting members being part of hull structures (in tanks) shall be in accordance with requirements given in Pt.3 Ch.1 Sec.2.

709 The compressive dynamic stress of cell guide structures is in general to be considered with respect to the lateral buckling mode according to Pt.3 Ch.1 Sec.14 C203 with $k = 0.5$.

H. Signboards

H 100 General

101 As far as found suitable for the ship in question, stowage and securing plans showing typical arrangements and giving further reference to the "Stowage and Securing Manual" shall be posted at suitable locations in each cargo space and in deck office.

I. Non-Weathertight Arrangement for Weather Deck Hatch Covers

I 100 General

101 For ships intended exclusively for the carriage of containers in cargo holds with non-weathertight arrangement of hatch covers in accordance with Pt.3 Ch.3 Sec.6 A, the requirements given under I shall be complied with.

102 A wave breaker shall be arranged for the protection of the forward non-weathertight hatch covers. Alternatively, the wave breaker may be omitted if the hatch covers forward of, or partly forward of, 0.15 L from FP are weathertight.

Guidance note:

The height of the wave breaker should normally be 5 m above the hatch cover top plate to cover two tiers of standard containers. A reduced height may be satisfactory in cases of large freeboard, i.e. when the top of the hatch cover plate is more than 3 standard superstructure heights (see ICLL Reg. 33) as calculated in K103.

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103 Non-weathertight hatch covers may be fitted to hatchways located on weather decks, which shall be at least two standard superstructure heights above an actual freeboard deck, or an assumed freeboard deck, from which a freeboard can be calculated. The calculated freeboard shall result in a draught of not less than that corresponding to the actual freeboard assigned. Where any part of a hatchway is forward of a point located one quarter of the ship's length (0.25 L) from the forward perpendicular, then that hatchway shall be located on a weather deck, at least three standard superstructure heights above the actual or assumed freeboard deck. It shall be understood that the assumed freeboard deck is used only for the purpose of measuring the height of the deck on which the hatchways are situated. The assumed freeboard deck may be an imaginary, or virtual deck and shall not be used for the actual assignment of the freeboard. The vessel's freeboard shall be assigned from an actual deck, designated as the freeboard deck, which shall be determined in accordance with the ICLL.

104 The hatch coaming height shall not be less than 600 mm.

105 The non-weathertight joints of hatch covers shall be designed to minimise the possible rate of water ingress by the arranging of labyrinths, gutter bars or equivalent.

106 The containers in cargo holds with non-weathertight arrangement of hatch covers shall be positioned on doubling

plates or equivalent fitted on the inner bottom (or deck) with a height normally not less than 25 mm.

I 200 Bilge level alarms

201 High water level alarms shall be installed for the bilge wells of container holds with non-weathertight hatch covers. The volume of each bilge well shall not be less than 1 m³.

I 300 Stability and damage stability

301 Any non-weathertight joints of hatch covers shall be considered as unprotected openings with respect to the requirements to stability and damage stability given in Pt.3 Ch.3 Sec.9.

Guidance note:

Bilge pumping capacity: The bilge capacity of container holds with non-weathertight hatch covers may in general be taken as given in Pt.4 Ch.6.

Dangerous goods: Facilities for carriage of dangerous goods may in general be arranged as for a vessel with weathertight hatches as given in Ch.11.

Note that possible questions related to perishable cargo is outside the scope of classification.

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SECTION 7 CAR CARRIERS

A. General

A 100 Classification

101 The requirements in this section apply to ships intended for carriage of cars.

102 Ships built in compliance with relevant requirements for class notation **General Cargo Carrier RO/RO** (given in Sec.4) and built in compliance with relevant requirement specified in the following, will be given the class notation **Car Carrier**.

103 Ships arranged with movable car decks or deck pontoons shall be built in compliance with relevant requirements in C and D.

Such ships may be given the class notation **MCDK**.

A 200 Documentation

201 For ships with movable car decks (**MCDK**) the following plans and particulars shall be submitted for information:

- maximum axle load including details of wheel and or foot print arrangement for all vehicles
- uniform deck load
- proposed procedure for function testing.

The following plans and particulars shall be submitted for approval:

- car deck pontoons and their weights
- supports or suspensions
- connections to hull structure with information regarding reaction forces from hoisting devices
- stowing arrangement for deck pontoons not in use.
This should include all stressed strength members, such as racks on deck, securing devices, reinforcement of supporting hull structures, etc.

B. Hull Strength

B 100 General

101 The relevant requirements given below shall be complied with.

B 200 Transverse strength

201 Vessels with strength limited by transverse racking constraining structure shall be subject to a direct strength analysis to demonstrate that the stresses are acceptable in a heeled condition. Acceptable calculation methods are given in Classification Note No. 31.2 “Strength analysis of hull structure in Roll on/Roll off ships and Car Carriers”.

202 The racking analyses shall be carried out for a realistic load distribution with maximum load carried on the upper decks.

The minimum GM for racking analysis shall be 0.05 B where B is the vessel's width.

203 Car carriers may be designed for transverse strength secured by having self supporting side verticals. A simplified racking assessment using beam models will then be accepted for documentation of the strength.

204 For vessels where the transverse strength is secured by a few heavy racking constraining structures and where the load distribution between these structural elements and the bow and

the stern area is unknown, a global Finite Element Analysis shall be carried out to document the transverse strength.

B 300 Fatigue

301 Structural details of racking constraining structure shall be specially considered to ensure a proper resistance against fatigue. The Classification Note No. 31.2 “Strength analysis of hull structure in Roll on/Roll off ships and Car Carriers” describes acceptable loads and procedures for such analyses.

302 The loading condition (i.e. mass distribution) used for analysis of fatigue, shall have a GM not less than 0.035 B.

303 For ships of limited size ($L < 150$ m), the side verticals are usually designed as self supporting with respect to racking. In such case, a proper fatigue performance can be ensured by controlling the general stress level of the side verticals in way of the supporting areas. Relevant loads and allowable nominal stresses are described in Classification Note 31.2.

C. Strength of Car Decks

C 100 General

101 The requirement in this section applies to ships equipped with permanent or movable car decks or pontoons.

102 Movable car decks are normally built as pontoons consisting of a grillage system of girders and stiffeners with deck plating welded to the supporting strength members. The pontoons may be made of steel or aluminium alloys suitable for marine use.

103 Permanent car decks are normally built as grillage systems of girders and stiffeners integrated in the hull structure with deck plating welded to the supporting strength members.

104 Other types and combinations of car decks and materials may be approved after special consideration.

105 Movable decks and deck pontoons shall be effectively supported at the ship's sides and bulkheads and by pillars or suspensions. Movable decks may also be supported by deck girders above. Due attention should then be brought to the strength assessment of the girder also taking into account the loads from the movable decks.

106 Pillars or suspensions carrying several tiers of decks shall be designed for the number of decks they carry.

107 Supports for pillars shall be designed to withstand tensile forces, if relevant.

C 200 Load and strength requirements for decks

201 The scantlings shall be based on the most severe conditions of stowed vehicles.

202 For girders the total load including the mass of deck structure may normally be regarded as evenly distributed.

The design pressure is given by:

$$p = (q_c + q_o) (9.81 + 0.5 a_v) \text{ (kN/m}^2\text{)}$$

where

- q_c = specified distributed cargo load in t/m^2
- q_o = distributed mass of deck structure in t/m^2
- a_v = vertical acceleration as defined in Pt.3 Ch.1 Sec.4
- $q_c + q_o$ shall not be taken less than 0.25 t/m^2 .

203 Plate, stiffeners and girders of car decks and pontoons shall satisfy the relevant requirements in Sec.4 C with additions as given below.

204 For the calculation of section modulus of stiffeners on movable car decks and pontoons the following m-value normally apply:

$$m = \frac{8}{2 - a/l}$$

l = span in m of stiffeners

a = extent in m of load in direction of stiffener.

The m-value may be adjusted after special consideration based on direct stress analysis.

205 For simple girders the section modulus is given by:

$$Z = \frac{6.25 S^2 b p}{m f_1} \text{ (cm}^3\text{)}$$

S = girder span in m

b = breadth in m of area supported by the girder

p = as defined in 203

m = 12 for girders fixed at both ends

= 8 for girders simply supported at both ends (pontoon edges).

For effective plate flange, see Pt.3 Ch.1 Sec.3 C.

206 The web area requirement (after deduction of cut-outs) at the girder end is given by:

$$A = \frac{0.06 S b p}{f_1} \text{ (cm}^2\text{)}$$

The web area at the middle of the span shall not be less than 0.5 A.

207 For complex girder systems and or loads not being evenly distributed, the scantlings shall be based on direct stress analysis.

Allowable stresses are:

normal stress: $\sigma = 160 f_1 \text{ N/mm}^2$

shear stress: $\tau = 90 f_1 \text{ N/mm}^2$.

208 Girders shall have a moment of inertia not less than:

$$I = C_1 Z f_1 S \text{ (cm}^4\text{)}$$

where

$C_1 = 1.1$ for steel

$C_1 = 3.0$ for aluminium alloy

Z = section modulus of the girder in cm^3

S = girder span in m.

209 The critical buckling stress of plating acting as girder flange shall not be less than:

$$\sigma_c = \frac{\sigma_a}{0.87} \text{ (N/mm}^2\text{)}$$

σ_a = calculated compressive design stress.

Tripping brackets and local stiffening of plating shall be provided where necessary.

C 300 Load and strength requirements for support and suspension

301 For calculation of supports and suspensions the total load on the movable deck or pontoon including the self mass shall be considered.

The design load shall be as for the girders (i.e. uniform deck load).

302 The scantlings shall be based on direct stress analysis.

303 Allowable nominal stresses in support elements are:

— normal stress (tensile, compressive):

$$\sigma = 110 f_1 \text{ N/mm}^2$$

— shear stress:

$$\tau = 65 f_1 \text{ N/mm}^2$$

— equivalent stress ($\sqrt{\sigma^2 + 3\tau^2}$)

$$\sigma_e = 120 f_1 \text{ N/mm}^2$$

304 Due attention shall be given to the local stress concentrations.

305 If slender supports are loaded in compression, it may be necessary to consider the allowable stress specially.

306 For wire suspensions the minimum breaking load shall not be less than:

$$P_m = 4 P_a \text{ (kN)}$$

P_a = calculated design force in kN of wire.

The construction and testing of steel wire suspensions shall comply with the requirements given in Pt.3 Ch.3 Sec.3 for tow-lines and mooring lines.

D. Stowing Arrangement for Deck Pontoons not in Use (Class Notation MCDK)

D 100 General

101 The ship shall have stowing arrangement for all movable deck pontoons.

102 The stowing devices shall be of such design that the pontoons can be fastened and secured by means which will not slacken or loosen by the stresses arising when the ship is at sea. Hoisting equipment for pontoons is normally not to be stressed when the pontoons are in stowed position. If the hoisting equipment will be stressed by the stowed pontoons, its scantlings shall be determined accordingly.

D 200 Arrangement on weather deck

201 In racks for stowing of movable deck pontoons on weather deck the clearance between pontoon and racks shall not be greater than necessary for pontoon handling. Pontoons in contact with the securing arrangement shall be lockable in racks.

202 The requirements to drainage given in 203 and 204 are generally to be complied with for all cargo hatches on weather deck. If the pontoon stacks at the foremost 30% of the ship's length L extend higher than top of nearest cargo hatch, a significant increase of the drainage area as calculated from 203 and 204 may be required, upon consideration in each case.

203 At forward and after ends of pontoon stacks (or continuous row of stacks) and below these, there shall be a total free transverse drainage area on each side of the ship, taken to top of pontoon stacks, not less than:

$$a = \frac{v}{30\sqrt{h}} \text{ (m}^2\text{)}$$

v = volume in m^3 of the quantity of water which can fill the space between pontoon stacks on each side of the ship to top of stacks, taken over a length of deck between mid-points of openings at forward and after ends of stacks (or continuous row). The length is, however, not to be taken to extend more than the stack height h beyond the forward and after end of stacks

h = height in m from deck to top of pontoon deck.

204 Outside pontoon stacks, passages overboard for water, shall be provided. Any bulwark shall have openings with area

as calculated from 203, and such that the volume v is increased by the quantity of water which can fill the space between bulwark and pontoon stacks up to top of bulwark. The area between top of bulwark and top of stacks at their ends, which is included in the calculation of v from 203, may be deducted from the requirement to openings in bulwark.

D 300 Design loads

301 For determination of scantlings of racks on weather deck and supporting structures, the pontoon stacks shall be regarded as subjected to the following one-sided pressure:

$$p = a \left(p_l + \frac{135y}{B + 75} - 4h_0 \right) \quad (\text{kN/m}^2)$$

minimum 12.5 kN/m²

- a = 1.7 in transverse direction
- = 1.3 in longitudinal direction for ends protected by another stack or bulkhead
- = 2.0 in longitudinal direction for unprotected ends (e.g. forward end in ships not having a forecastle terminating forward of the foremost cargo hatch)

$$p_l = k_s C_W + f \quad \text{in general}$$

$$= (k_s C_W + f) \left(0.8 + 0.15 \frac{V}{\sqrt{L}} \right) \quad \text{when } \frac{V}{\sqrt{L}} > 1.5$$

- f = vertical distance in m from the waterline to top of ship's side at transverse section considered, maximum C_W

- y = horizontal distance in m from the centre line to the point considered, minimum $B/4$

$$k_s = 2 + \frac{3.1}{\sqrt{C_B}} \quad \text{at A.P. and abaft}$$

$$= 2 \text{ between } 0.2 L \text{ and } 0.7 L \text{ from A.P.}$$

$$= 2 + \frac{4.7}{C_B} \quad \text{at F.P. and forward}$$

C_W = wave coefficient as given in Pt.3 Ch.1 Sec.4.

Between specified areas k_s shall be varied linearly.

Transverse and longitudinal pressures need not be considered as acting simultaneously.

302 For pontoons stowed under deck, stowing and securing devices shall be designed for:

- transverse force not less than 5Q kN
- vertical force not less than 13Q kN
- longitudinal force not less than 2.5 kN.

Q = total load in t of pertinent stowed pontoons.

D 400 Allowable stresses

401 Calculated, nominal combined stresses in stowing devices and their connections to supporting structures shall not exceed 120 f_1 N/mm².

402 Strength members subjected to buckling loads, shall have a safety factor against buckling not less than 1.7.

SECTION 8 ENHANCED STRENGTH FOR BULK CARRIERS

A. Additional Requirements for Loading Conditions, Loading Manuals and Loading Instruments for Bulk Carriers, Ore Carriers and Combination Carriers

A 100 Application

101 The requirements in this section shall be complied with by vessels as defined in Sec.5 A.

A 200 Loading manual

201 The loading manual shall describe the following:

- a) The loading conditions on which the design of the ship has been based, including permissible limits of still water bending moments and shear forces.
- b) The results of calculations of still water bending moments, shear forces and where applicable, limitations due to torsional loads.
- c) Envelope results and permissible limits to still water bending moments and shear forces in the hold flooded conditions are also to be included. See C200.
- d) The cargo hold(s) or combination of holds that might be empty at full draught. If no cargo hold is allowed to be empty on full draught, this shall be clearly stated in the loading manual.
- e) Maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position.
- f) Maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions.
- g) Maximum allowable load on tank top together with specification of the nature of the cargo for cargoes other than bulk cargoes.
- h) Maximum allowable load on deck and hatch covers. If the vessel is not approved to carry load on deck or hatch covers, this shall be clearly stated in the loading manual.
- i) The maximum rate of ballast change together with the advice that a load plan shall be agreed with the terminal on the basis of achievable rates of change of ballast.

(IACS UR S1A.2.1, Rev. 5)

A 300 Loading instrument

301 The Loading computer system shall be an approved digital system as given in Pt.3 Ch.1 Sec.5 and Pt.6 Ch.9. The Loading computer system is, in addition to requirements given in Pt.3 Ch.1 Sec.5 A202, to ascertain as applicable that:

- the mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position
- the mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds
- the still water bending moments and shear forces in the hold flooded conditions are within permissible values.

(IACS UR S1A.2.2, Rev. 5)

A 400 Conditions of approval of loading manuals

401 The loading manual is, in addition to the requirements as

given in Sec.5 A107 to 110 and A112 to 113 and Pt.3 Ch.1 Sec.5 F200, to include the following loading conditions, subdivided into departure and arrival:

- a) Alternate light and heavy cargo loading conditions at maximum draught, where applicable.
- b) Homogeneous light and heavy cargo loading conditions at maximum draught.
- c) Ballast conditions. For vessels having ballast holds adjacent to topside wing, hopper and double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty.
- d) Short voyage conditions where the vessel shall be loaded to maximum draught but with limited amount of bunkers.
- e) Multiple port loading and unloading conditions.
- f) Deck cargo conditions, where applicable.
- g) Typical loading sequences where the vessel is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable. Typical unloading sequences for these conditions shall also be included. The typical loading and unloading sequences shall be developed to not exceed applicable strength limitations. The typical loading sequences shall also be developed paying due attention to the loading rate, and the de-ballasting capability.
- h) Typical sequences for change of ballast at sea, where applicable.

(IACS UR S1A.3, Rev. 5)

Guidance note:

The above listed loading conditions should be considered as mandatory for all vessels as applicable. I.e. loading conditions, which are not applicable or not intended to be used, need not be considered in the design.

Furthermore, the specification of e.g. short voyage and multiple port conditions are in general subject to agreement between owner and builder. This relates to the specification of the design loading conditions, which should take into consideration the intended modes and areas of operation. A short voyage condition may be a homogeneous or an alternate condition where the cargo deadweight is increased with approximately 50% of the bunker weight.

However, if some or all of the above conditions are not included in the Loading Manual a note to this effect shall be given in the Loading Manual.

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A 500 Condition of approval of loading instrument

501 The loading instrument is subject to approval. The approval of loading instrument shall include as applicable:

- acceptance of hull girder bending moments limits for all read-out points
- acceptance of hull girder shear force limits for all read-out points
- acceptance of limits for mass of cargo and double bottom contents of each hold as a function of draught
- acceptance of limits for mass of cargo and double bottom contents in any two adjacent holds as a function of draught
- acceptance of shear force corrections.

(IACS UR S1A.4, Rev. 5)

B. Side Structure

B 100 Application

101 These requirements apply to side structure of cargo holds of single side construction.

B 200 Plating and stiffeners

201 Thickness and cross section properties are in general to be calculated as given in Pt.3 Ch.1 Sec.7.

202 The minimum thickness of side plating, located between hopper and top wing tanks and extending in length over the whole cargo area, shall not be less than:

$$t = \sqrt{L}$$

when L is as defined in Pt.3 Ch.1 Sec.1 B.

(IACS UR S12.8, Rev. 4)

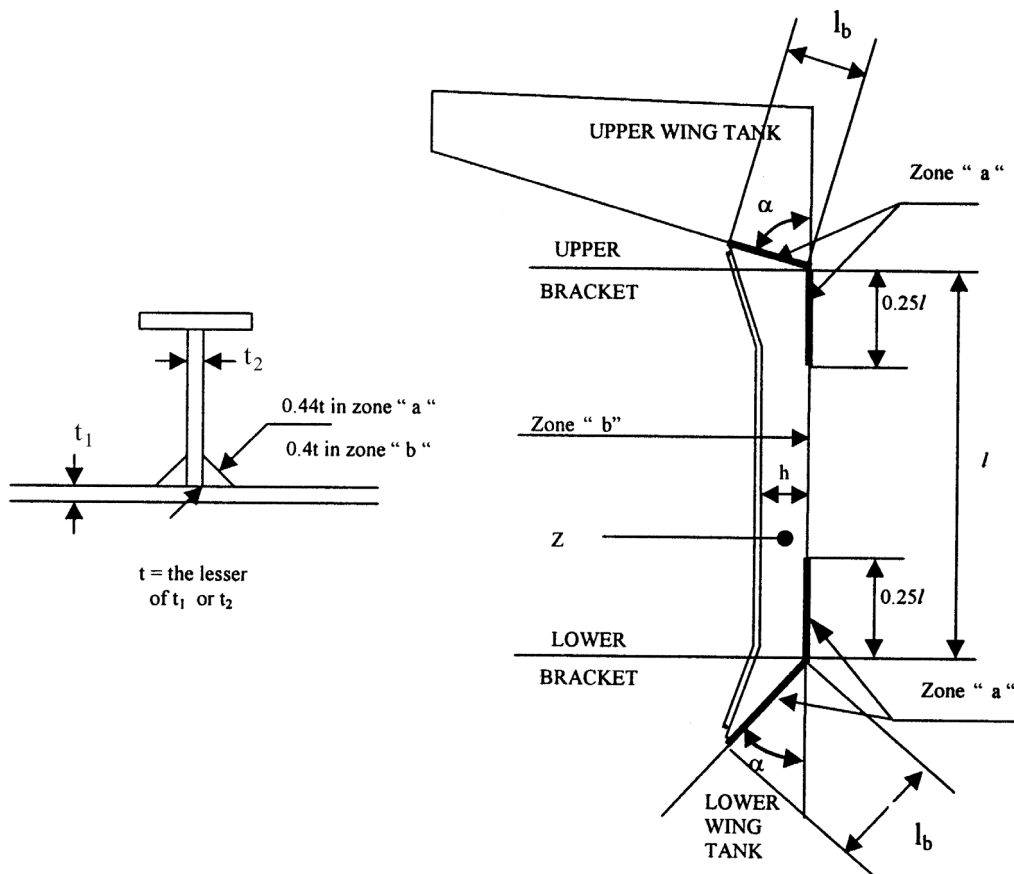


Fig. 1
Typical main frame

B 300 Main frames

301 Main frames are frames located outside the peak tanks, connected to hopper tanks and extended to the top wing tank on the ship side, see Fig. 1. Main frames, including brackets built in compliance with the requirements given in this subsection need not to be checked for the requirements as given in Pt.3 Ch.1 Sec.7 C400.

302 The section modulus requirement is given by:

$$Z = \frac{1000 l^2 s p w_k}{m \sigma} \quad (\text{cm}^3)$$

p = p₁ to p₈ whichever is relevant, as given in Pt.3 Ch.1 Sec.7 Table B1

w_k = 1.05 when calculating sectional modulus for midspan and upper end

= 1.15 when calculating sectional modulus for lower end

σ = 130 f₁ for internal loads p₃ to p₈

σ = 150 f₁ for external loads p₁, p₂ and p_{min} given above

m = 18 in general

m = 12 at upper end (including bracket) in combination

with internal loads, p₃ to p₈
m = 9 at lower end (including bracket) and for upper end in combination with external loads p₁, p₂ and p_{min}.

For main frames situated next to plane transverse bulkheads, e.g. at the ends of the cargo region, the section modulus of the mid portion of the frame is generally to exceed the section modulus of the adjacent frame by a factor 3h_a/h where:

h_a = web height of adjacent frame

h = web height of considered frame.

The increased section modulus of the main frame adjacent to plane transverse bulkheads need not be fitted if other equivalent means are applied to limit the deflection of these frames.

303 The minimum thickness of frame webs within the cargo area shall not be less than t_{w, min} in mm, as given by:

$$t_{w, \min} = 7.0 + 0.03 L$$

where L is as defined in Pt.3 Ch.1, but need not be taken greater than 200 m.

(IACS UR S12.3, Rev. 4)

304 The minimum thickness of frame webs in way of the foremost hold shall not be taken less than $t_{w1, \min}$, in mm, given by:

$$t_{w1, \min} = 1.15 t_{w, \min}$$

(IACS UR S12.3, Rev. 4)

305 The web depth to thickness ratio of frames shall not exceed the following values:

$$\frac{h}{t_w} \leq 60 \sqrt{\frac{1}{f_1}} \quad \text{for symmetrical flanged frame}$$

$$\frac{h}{t_w} \leq 50 \sqrt{\frac{1}{f_1}} \quad \text{for asymmetrical flanged frame}$$

For outstanding flanges the flange breadth, b_f , shall not exceed:

$$b_f \leq 10 \cdot t_f \sqrt{\frac{1}{f_1}}$$

The face plate or flange of bracket shall be sniped at ends. Brackets shall be arranged with soft toes. To control the stress concentration at end of sniped flanges the total sniping angle, ϕ , of the top flange or bracket stiffener shall not exceed:

$$\phi < 35 \frac{t_w}{t_f} \quad (\text{degrees})$$

h = as defined in Fig. 1

f_1 = as defined in Pt.3 Ch.1 Sec.2

t_w = web thickness

t_f = flange thickness.

(IACS UR S12.5, Rev. 4)

306 The thickness of the frame lower brackets shall not be less than the greater of t_w , $t_{w, \min}$ and $t_{w1, \min}$ as given in 303 and 304 plus 2 mm, where t_w is the as fitted thickness of side frame web. The thickness of the frame upper brackets shall not be less than the greater of t_w , $t_{w, \min}$ and $t_{w1, \min}$ as given in 303 and 304. The welded length of brackets, l_b , as shown in Fig. 1 shall not be less than:

$$l_b = \frac{60 \sqrt{\frac{Z}{(t_w - t_{kw}) w_k}}}{\sin \alpha} \quad (\text{mm})$$

Z, w_k = as defined in 302

t_w as defined above and α as defined in Fig. 1

t_{kw} = 3 mm for the lower bracket and 1 mm for upper bracket

In no case are the dimensions of the lower and upper brackets to be less than those shown in Fig. 2.

(IACS UR S12.4, Rev. 4)

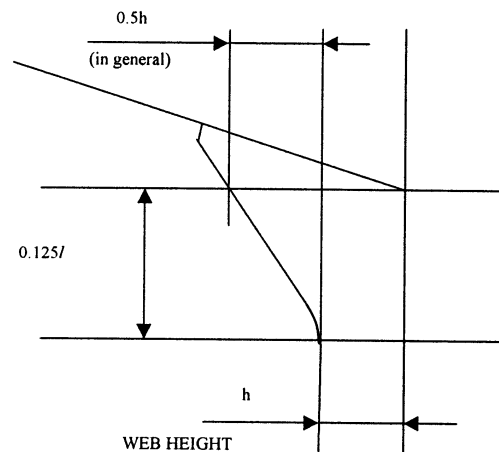


Fig. 2
Minimum dimensions of brackets

307 Structural continuity with the upper and lower end connections of side frames shall be ensured within top sides and hopper tanks by connecting brackets. The brackets shall be in accordance with Fig. 3 and shall be adequately stiffened against buckling.

(IACS UR S12.4, Rev. 4)

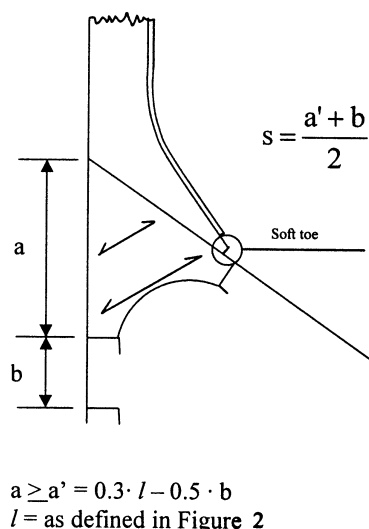


Fig. 3
Details of brackets

308 The section modulus of the side and sloping bulkhead longitudinals which support the connecting brackets (at top and bottom) shall be determined according to Pt.3 Ch.1 Sec.7 C300 and Pt.3 Ch.1 Sec.9 C200 with the span taken between the transverses.

Alternatively, the scantlings of side and sloping bulkhead longitudinals may be based on direct strength calculations. In such cases the most extreme loading for the supporting bracket/longitudinal connection (at top and bottom) shall be applied. The calculations should also reflect any relative deformation between connection supporting bracket/longitudinal and the adjacent transverse frame/transverse bulkhead.

(IACS UR S12.4, Rev. 4)

Guidance note:

As a guidance to the bracket size the bracket length a may be taken as:

$$a \geq a' = 0.3 l - 0.5 b$$

a , b and l are as defined in Fig. 1. When checking the supporting longitudinals, the spacing should be taken as:

$$s = \frac{a' + b}{2}$$

As a mean to reduce the relative deformation as described in 308, one enlarged supporting bracket may be arranged midway between frames and connected to the next longitudinal.

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309 Frames shall be fabricated symmetrical sections with integral upper and lower brackets and shall be arranged with soft toes. See also 311.

(IACS UR S12.5, Rev. 4)

310 The side frame flange shall be curved (not knuckled) at the connection with the end brackets. The radius of curvature shall not be less than r , in mm, given by:

$$r = \frac{0.4 b_f^2}{t_f}$$

b_f and t_f are the flange width and thickness, respectively, in mm.

(IACS UR S12.5, Rev. 4)

311 In ships less than 190 m in length, mild steel frames may be asymmetric and fitted with separate brackets.

(IACS UR S12.5, Rev. 4)

312 In way of foremost hold, side frames of asymmetrical section shall be fitted with tripping brackets at every two frames, as shown in Fig. 4. (see also Pt.3 Ch.1 Sec.7 E).

(IACS UR S12.6, Rev. 4)

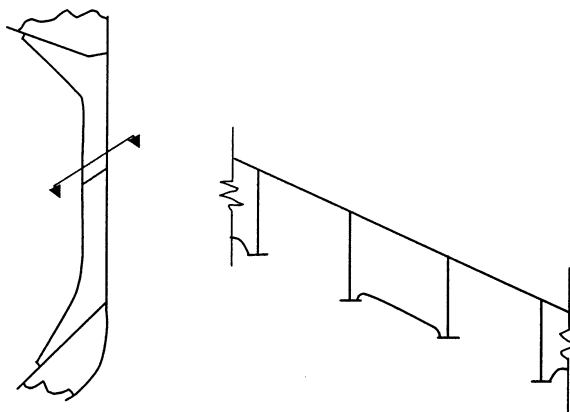


Fig. 4
Positioning of tripping brackets

313 Double continuous welding shall be adopted for the connections of frames and brackets to side shell, hopper and upper wing tank plating and web to face plates. For this purpose, the weld throat, a , shall be (see Fig. 1):

$a = 0.44 t$ in Zone “a”

$a = 0.40 t$ in Zone “b”

where t is the thinner of the two connected members and represent the as fitted thickness.

Where the hull form prohibits an effective fillet weld, edge preparation of the web of frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated above. The weld throat thickness for the connecting bracket shall be according to Pt.3 Ch.1 Sec.12, using a C-factor of 0.52.

(IACS UR S12.7, Rev. 4)

C. Longitudinal Strength of Hull Girder in Flooded Condition for Bulk Carriers

C 100 General

101 The requirements in this section shall be complied with in respect of the flooding of any cargo hold of bulk carriers with **BC-A** or **BC-B** class notation, as given in Sec.5 A.

The hull girder strength shall be checked for specified flooded conditions in each of the cargo and ballast loading conditions given in Pt.3 Ch.1 Sec.5 B and in every other condition considered in the intact longitudinal strength calculations, including those given in Sec.8 A, except that harbour conditions, docking condition afloat, loading and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not to be considered.

(IACS UR S17.1, Rev. 7)

C 200 Flooded conditions

201 Each cargo hold shall be considered individually flooded to the equilibrium waterline.

The still water loads in flooded conditions shall be calculated for cargo and ballast loading conditions as given in 101.

The wave loads in the flooded conditions are assumed to be equal to 80% of those given in Pt.3 Ch.1 Sec.5 B.

(IACS UR S17.2, Rev. 7)

C 300 Flooding criteria

301 To calculate the mass of water ingress, the following assumptions shall be made:

- The permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo shall be taken as 0.95.
- Appropriate permeabilities and bulk densities shall be used for any cargo carried. For iron ore, a minimum permeability of 0.3 with a corresponding bulk density of 3.0 t/m³ shall be used. For cement, a minimum permeability of 0.3 with a corresponding bulk density of 1.3 t/m³ shall be used. In this respect, “permeability” for solid bulk cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo.

For packed cargo conditions (such as steel mill products), the actual density of the cargo should be used with a permeability of zero.

(IACS UR S17.3, Rev. 7)

Guidance note:

In order to check the longitudinal strength in flooded condition a permeability of 0.3 is considered generally acceptable also for light cargoes.

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C 400 Stress assessment

401 The actual hull girder bending stress σ_{fd} , in N/mm², at any location is given by:

$$\sigma_{fld} = \frac{M_{sf} + 0.8M_w}{Z_z} 10^3$$

where:

M_{sf} = still water bending moment, in kNm, in the flooded conditions for the section under consideration

M_w = wave bending moment as given in Pt.3 Ch.1 Sec.5 B

Z_z = section modulus, in cm³, for the corresponding location in the hull girder.

$\sigma_{fld} \leq 175 f_1 \text{ N/mm}^2$ within the cargo area.

The shear strength of the side shell and the inner hull (longitudinal bulkhead) if any, shall at any location of the vessel be checked according to the requirements given in Pt.3 Ch.1 Sec.5 D in which Q_s and Q_w shall be replaced by Q_{sf} and Q_{wf} respectively, where:

Q_{sf} = still water shear force, in kN, in the flooded conditions for the section under consideration

$Q_{wf} = 0.8Q_w$

Q_w = wave shear force, in kN, as given in Pt.3 Ch.1 Sec.5 B203 for the section under consideration

$\tau_{fld} \leq 110 f_1 \text{ N/mm}^2$.

(IACS UR S17.4, Rev. 7)

402 The damaged structure is assumed to remain fully effective in resisting the applied loading.

Uniaxial buckling capacity shall be checked according to Pt.3 Ch.1 Sec.13.

(IACS UR S17.5, Rev. 7)

D. Corrugated Transverse Watertight Bulkheads, Considering Hold Flooding

D 100 Application and definition

101 These requirements apply to vertically corrugated transverse watertight bulkheads. The requirements in this section shall be complied with in respect to the flooding of any cargo hold of bulk carriers, as defined by Sec.5A.

The net thickness t_{net} is the thickness obtained by applying the strength criteria as given in 300 to 308.

The required thickness is obtained by adding the corrosion addition t_s , given in 500, to the net thickness t_{net} .

In this requirement, homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, does not exceed 1.2 (corrected for different cargo densities).

For non-corrugated bulkheads, scantlings for plates, stiffeners and girders shall not be less than required in Pt.3 Ch.1 Sec.9, applying the pressure loads as given in 201 to 207.

Vertically corrugated bulkheads built in compliance with the requirements given in this subsection need not to be checked for the requirements relating to watertight bulkhead loads given in Pt.3 Ch.1 Sec.9.

(IACS UR S18.1, Rev. 7)

D 200 Load model

201 General

The loads to be considered as acting on the bulkheads are those given by the combination of the cargo loads with those induced

by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone shall be considered. The most severe combinations of cargo induced loads and flooding loads shall be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions
- non-homogeneous loading conditions

considering the individual flooding of both loaded and empty holds.

The specified design load limits for the cargo holds shall be represented by loading conditions defined by the designer in the loading manual.

Non-homogeneous part loading conditions associated with multi port loading and unloading operations for homogeneous loading conditions need not be considered according to these requirements.

Holds carrying packed cargoes shall be considered as empty holds for this application.

Unless the ship is intended to carry, in non-homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1.78 t/m³, the maximum mass of cargo which may be carried in the hold is also to be considered to fill that hold up to the upper deck level at centreline.

(IACS UR S18.2.1, Rev. 7)

Guidance note:

Bulk Carriers as defined in Sec.5 A100 without class notation **BC-A** and **BC-B***, and only to be homogeneously loaded as defined in 101, may have their bulkheads checked for homogeneous loading and flooding water alone only, provided this limitation is explicitly stated in the ship's Loading Manual.

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202 Bulkhead corrugation flooding head

The flooding head h_f (see Fig. 5) is the distance, in m, measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f , in m, from the baseline equal to:

a) in general:

- D for the foremost transverse corrugated bulkhead
- 0.9 D for the other bulkheads.

Where the ship shall carry cargoes having bulk density less than 1.78 t/m³ in non-homogeneous loading conditions, the following values can be assumed:

- 0.95 D for the foremost transverse corrugated bulkhead
- 0.85 D for the other bulkheads.

b) for ships less than 50 000 tonnes deadweight with Type B freeboard:

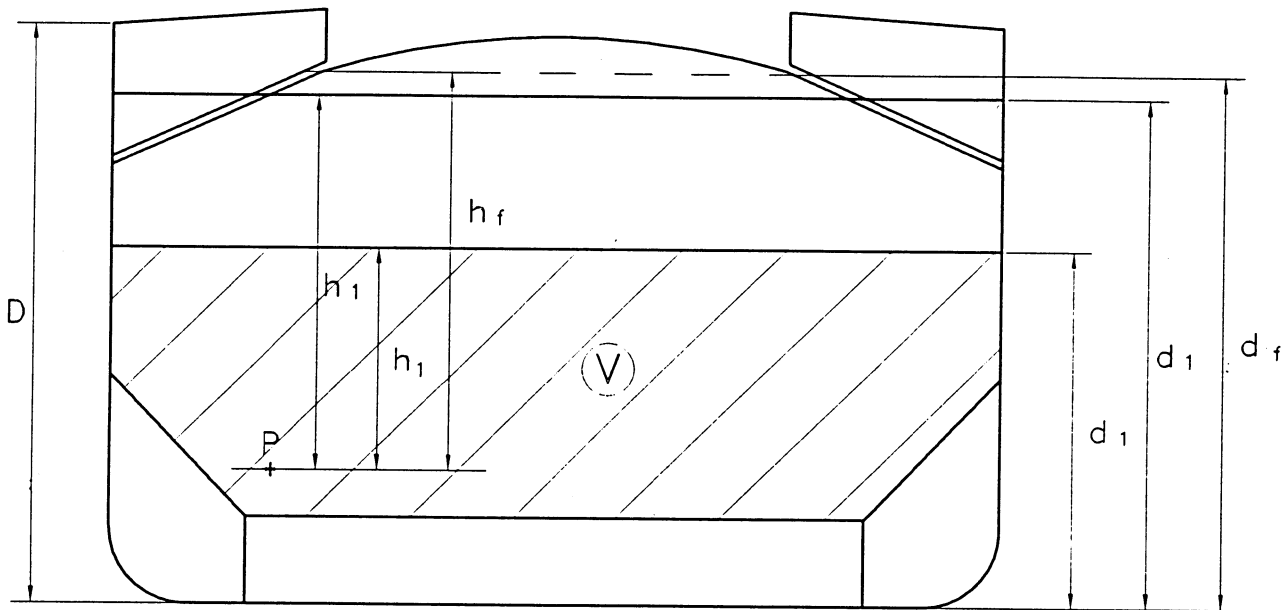
- 0.95 D for the foremost transverse corrugated bulkhead
- 0.85 D for the other bulkheads.

Where the ship shall carry cargoes having bulk density less than 1.78 t/m³ in non-homogeneous loading conditions, the following values can be assumed:

- 0.9 D for the foremost transverse corrugated bulkhead
- 0.8 D for the other bulkheads

D is the distance, in m, from the baseline to the freeboard deck at side amidships (see Fig. 5).

(IACS UR S18.2.2, Rev. 7)



V = Volume of cargo

P = Calculation point

Fig. 5
Definition of D , h_1 and d_1 .

203 *Pressure in non-flooded bulk cargo loaded holds*

At each point of the bulkhead, the pressure p_c , in kN/m^2 , is given by:

$$p_c = \rho_c g h_1 K$$

- ρ_c = bulk cargo density, in t/m^3
 g = 9.81 m/s^2 , gravity acceleration
 h_1 = vertical distance, in m, from the calculation point to horizontal plane corresponding to the volume of the cargo (see Fig. 5), located at a distance d_1 , in m, from the baseline
 K = $\sin^2 \alpha \tan^2 (45 - 0.5 \delta) + \cos^2 \alpha$
 α = angle between panel in question and the horizontal plane, in degrees
 δ = angle of repose of the cargo, in degrees, that may generally be taken as 35° for iron ore and 25° for cement.

The force F_c , in kN, acting on a corrugation is given by:

$$F_c = \rho_c g s_1 \frac{(d_1 - h_{DB} - h_{LS})^2}{2} K$$

ρ_c , g , d_1 , K = as given above

- s_1 = spacing of corrugations, in m (see Fig. 6)
 h_{LS} = mean height of the lower stool, in m, from the inner bottom
 h_{DB} = height of the double bottom, in m.

(IACS UR S18.2.3, Rev. 7)

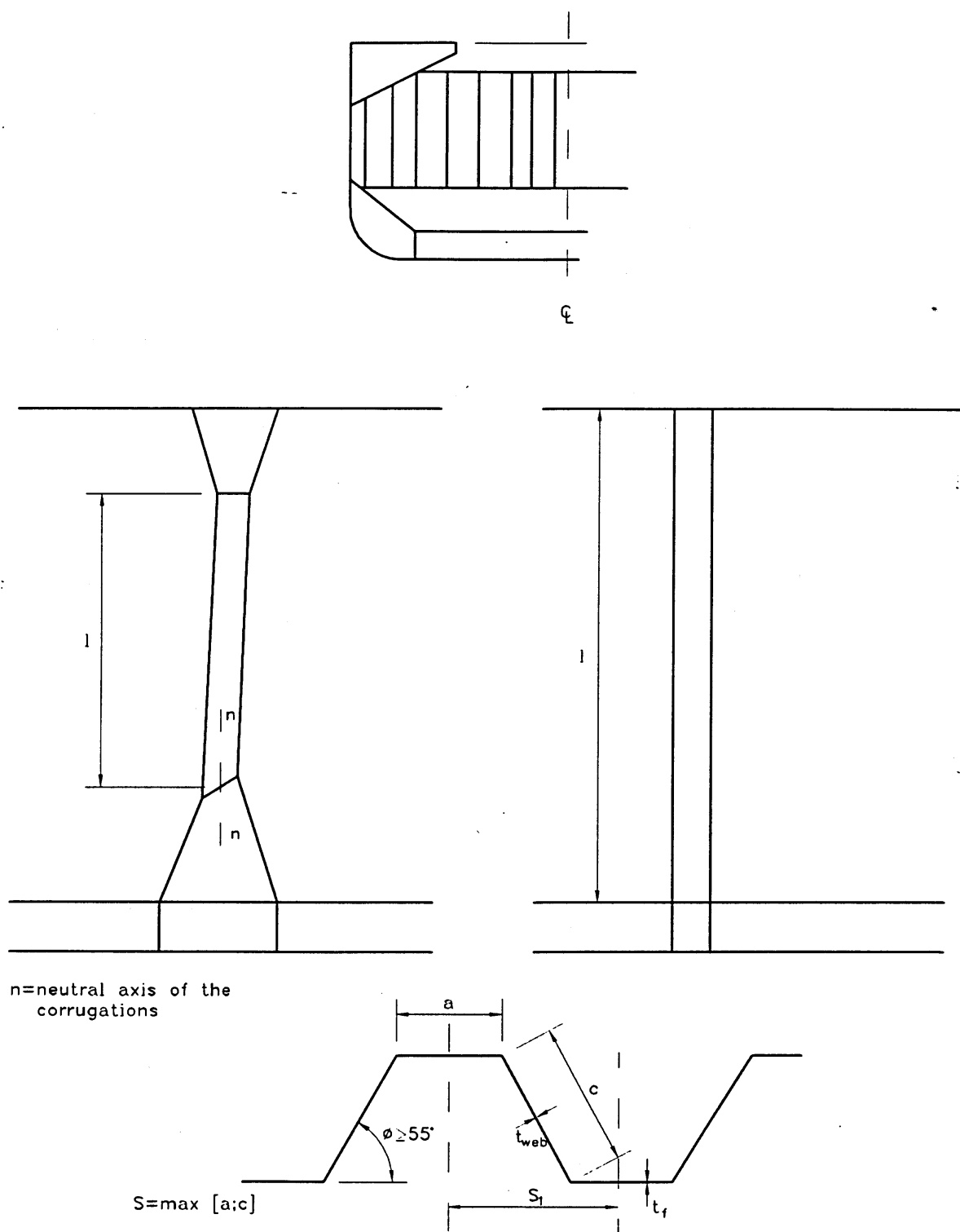


Fig. 6
Spacing of corrugations

204 Pressure in flooded bulk cargo holds

Two cases shall be considered, depending on the values of d_1 and d_f .

a) $d_f \geq d_1$

At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure $p_{c,f}$, in kN/m^2 , is given by:

$$p_{c,f} = \rho g h_f$$

ρ = sea water density, in t/m^3

g = as given in 203

h_f = flooding head as defined in 202.

At each point of the bulkhead located at a distance lower than d_1 from the baseline, the pressure $p_{c,f}$, in kN/m^2 , is given by:

$$p_{c,f} = \rho g h_f + [\rho_c - \rho (1 - \text{perm})] g h_1 K$$

ρ, h_f = as given above

ρ_c, g, h_1, K = as given in 203

perm = permeability of cargo, to be taken as 0.3 for ore (corresponding bulk cargo density for iron ore may generally be taken as 3.0 t/m³), coal cargoes and for cement (corresponding bulk cargo density for cement may generally be taken as 1.3 t/m³)

The force $F_{c,f}$, in kN, acting on a corrugation is given by:

$$F_{c,f} = s_1 \left[\rho g \frac{(d_f - d_1)^2}{2} + \frac{\rho g (d_f - d_1) + (p_{c,f})_{le}}{2} (\delta_1 - \eta_{DB} - \eta_{LS}) \right]$$

ρ = as given above
 $s_1, g, d_1, h_{DB}, h_{LS}$ = as given in 203
 d_f = as given in 202
 $(p_{c,f})_{le}$ = pressure, in kN/m², at the lower end of the corrugation.

b) $d_f < d_1$

At each point of the bulkhead located at a distance between d_f and d_1 from the baseline, the pressure $p_{c,f}$, in kN/m², is given by:

$$p_{c,f} = \rho_c g h_1 K$$

ρ_c, g, h_1, K = as given in 203.

At each point of the bulkhead located at a distance lower than d_f from the baseline, the pressure $p_{c,f}$, in kN/m², is given by:

$$p_{c,f} = \rho g h_f + [\rho_c h_1 - \rho (1 - \text{perm}) h_f] g K$$

ρ, h_f, perm = as given in a) above
 ρ_c, g, h_1, K = as given in 203.

The force $F_{c,f}$, in kN, acting on a corrugation is given by:

$$F_{c,f} = s_1 \left[\rho_c g \frac{(d_f - d_1)^2}{2} K + \frac{\rho_c g (d_f - d_1) K + (p_{c,f})_{le}}{2} (d_f - h_{DB} - h_{LS}) \right]$$

$s_1, \rho_c, g, d_1, h_{DB}, h_{LS}, K$ = as given in 203

d_f = as given in 202
 $(p_{c,f})_{le}$ = pressure, in kN/m², at the lower end of the corrugation.

(IACS UR S18.2.4.1, Rev. 7)

205 Empty holds and pressure due to flooding water alone

At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f shall be considered.

The force F_f , in kN, acting on a corrugation is given by:

$$F_f = s_1 \rho g \frac{(d_f - h_{DB} - h_{LS})^2}{2}$$

s_1, g, h_{DB}, h_{LS} = as given in 203
 ρ = as given in 204 a)
 d_f = as given in 202.

(IACS UR S18.2.4.2, Rev. 7)

206 Resultant pressure and force - Homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p , in kN/m², to be considered for the scantlings of the bulkhead is given by:

$$p = p_{c,f} - 0.8 p_c$$

The resultant force F , in kN, acting on a corrugation is given by:

$$F = F_{c,f} - 0.8 F_c$$

(IACS UR S18.2.5.1, Rev. 7)

207 Resultant pressure and force - Non-homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p , in kN/m², to be considered for the scantlings of the bulkhead is given by:

$$p = p_{c,f}$$

The resultant force F , in kN, acting on a corrugation is given by:

$$F = F_{c,f}$$

(IACS UR S18.2.5.2, Rev. 7)

208 Bending moment in the bulkhead corrugation

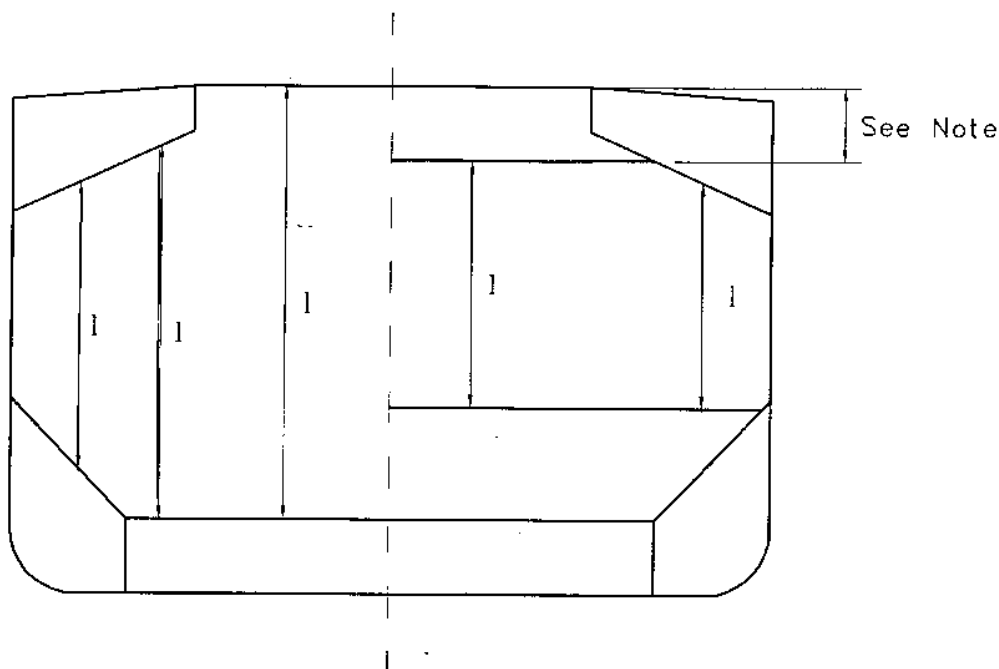
The design bending moment M , in kNm, for the bulkhead corrugation is given by:

$$M = \frac{F l}{8}$$

F = resultant force, in kN, as given in 205, 206 or 207 as relevant

l = span of the corrugation, in m, to be taken according to Fig. 6 and Fig. 7.

(IACS UR S18.3.1, Rev. 7)



Note For the definition of l , the internal end of the upper stool is not to be taken more than a distance from the deck at the centre line equal to:

- 3 times the depth of corrugations, in general
- 2 times the depth of corrugations, for rectangular stool

Fig. 7
Definition of l

209 Shear force in the bulkhead corrugation

The shear force Q , in kN, at the lower end of the bulkhead corrugations is given by:

$$Q = 0.8 F$$

F = as given in 208.

(IACS UR S18.3.2, Rev. 7)

D 300 Strength criteria

301 General

The following criteria are applicable to transverse bulkheads with vertical corrugations (see Fig.6 and Fig.7). For ships of 190 m of length and above, these bulkheads shall be fitted with a lower stool, and generally with an upper stool below deck. For smaller ships, corrugations may extend from inner bottom to deck; if the stool is fitted, it shall comply with the requirements in D.

The corrugation angle ϕ shown in Fig.6 shall not be less than 55° .

Requirements for local net plate thickness are given in 308.

In addition, the criteria as given in 302 and 305 shall be complied with.

The thickness of the lower part of corrugations considered in the application of 302 and 303 shall be maintained for a distance from the inner bottom (if no lower stool is fitted), or the top of the lower stool not less than $0.15 l$.

The thickness of the middle part of corrugations as considered in the application of 302 and 304 shall be maintained to a distance from the deck (if no upper stool is fitted), or the bottom of the upper stool not greater than $0.3 l$.

The section modulus of the corrugation in the remaining upper part of the bulkhead shall not be less than 75% of that required for the middle part, corrected for different yield stresses.

(a) Lower stool

The height of the lower stool is generally to be not less than 3 times the depth of the corrugations. The thickness and material of the stool top plate shall not be less than those required for the bulkhead plating above. The thickness and material of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top shall not be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation. However, the thickness of the stool side plating and the section modulus of the stool side stiffeners shall not be less than those required in Pt.3 Ch.1 Sec.9 C, on the basis of loads as given in 201 to 207. Corresponding allowable stresses to be used in combination with above loads is given in Pt.3 Ch.1 Sec.9 C as for watertight bulkheads and corrosion additions shall be in compliance with Pt.3 Ch.1 Sec.2 D. The ends of stool side vertical stiffeners shall be attached to brackets at the upper and lower ends of stool.

The distance from the edge of the stool top plate to the surface of the corrugation flange shall be in accordance with Fig.13. The stool bottom shall be installed in line with double bottom floors and shall have a width not less than 2.5 times the mean depth of the corrugation. The stool shall be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate shall be avoided.

Where corrugations are cut at the lower stool, corrugated bulkhead plating shall be connected to the stool top plate by full penetration welds. The stool side plating shall be connected to

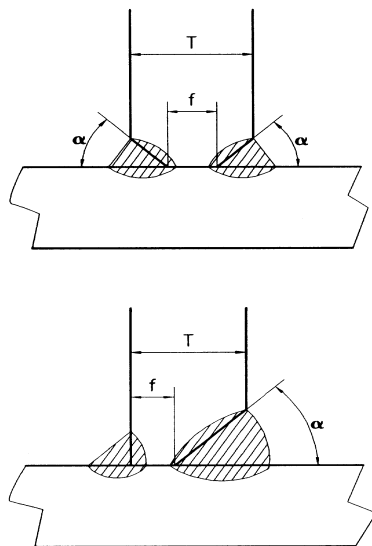
the stool top plate and the inner bottom plating by either full penetration or deep penetration welds (See Fig.8). The supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds (see Fig.8).

(b) Upper stool

The upper stool, where fitted, shall have a height generally between 2 and 3 times the depth of corrugations. Rectangular stools shall have a height generally equal to 2 times the depth of corrugations, measured from the deck level and at hatch side girder. The upper stool shall be properly supported by girders or deep brackets between the adjacent hatch-end beams.

The width of the stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non-rectangular stools shall have a width not less than 2 times the depth of corrugations. The thickness and material of the stool bottom plate shall be the same as those of the bulkhead plating below. The thickness of the lower portion of stool side plating, within the depth equal to the corrugation flange width from the stool bottom plate, shall not be less than 80% of that required for the upper part of the bulkhead plating where the same material is used. However, the thickness of the stool side plating and the section modulus of the stool side stiffeners shall not be less than those required in Pt.3 Ch.1 Sec.9 C, on the basis of pressure loads as given in 201 to 207. Corresponding allowable stresses to be used in combination with above loads is given Pt.3 Ch.1 Sec.9 C as for watertight bulkheads and corrosion additions shall be in compliance with Pt.3 Ch.1 Sec.2 D.

The ends of stool side stiffeners shall be attached to brackets at upper and lower end of the stool. Diaphragms shall be fitted inside the stool in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallop in the brackets and diaphragms in way of the connection to the stool bottom plate shall be avoided.



Root Face (f) : 3 mm to T/3 mm
Groove Angle (α) : 40° to 60°

Fig. 8
Full penetration or deep penetration welds

(c) Alignment

At deck, if no stool is fitted, two transverse reinforced beams shall be fitted in line with the corrugation flanges.

At bottom, if no stool is fitted, the corrugation flanges shall be in line with the supporting floors. Corrugated bulkhead plating shall be connected to the inner bottom plating by full penetra-

tion welds. The plating of supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds (see Fig.8).

The thickness and material properties of the supporting floors shall be at least equal to those provided for the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinals to double bottom floors shall be closed by collar plates. The supporting floors shall be connected to each other by suitably designed shear plates.

Stool side plating shall align with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool shall align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating shall not be knuckled anywhere between the inner bottom plating and the stool top.

(IACS UR S18.4.1, Rev. 7)

302 Bending capacity and shear stress τ

The bending capacity shall comply with the following relationship:

$$10^3 \frac{M}{0.5Z_{le}\sigma_{a,le} + Z_m\sigma_{a,m}} \leq 0.95$$

M = bending moment, in kNm, as given in 208

Z_{le} = section modulus, in cm^3 , at the lower end of corrugations, to be calculated according to 303

Z_m = section modulus, in cm^3 , at the midspan of corrugations, to be calculated according to 304

$\sigma_{a,le}$ = allowable stress, in N/mm^2 , as given in 305, for the lower end of corrugations

$\sigma_{a,m}$ = allowable stress, in N/mm^2 , as given in 305, for the mid-span of corrugations.

In no case is Z_m to be taken greater than the lesser of $1.15 Z_{le}$ and $1.15 Z'_{le}$ for calculation of the bending capacity, Z'_{le} as being defined below.

In case shedder plates are fitted which:

- are not knuckled
- are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent
- are fitted with a minimum slope of 45° and their lower edge is in line with the stool side plating
- have thickness not less than 75% of that provided by the corrugation flanges
- and material properties at least equal to those provided by the flanges

or gusset plates are fitted which:

- are in combination with shedder plates having thickness, material properties and welded connections in accordance with the above requirements
- have a height not less than half of the flange width
- are fitted in line with the stool side plating
- are generally welded to the top of the lower stool by full penetration welds, and to the corrugations and shedder plates by one side penetration welds or equivalent
- have thickness and material properties at least equal to those provided for the flanges

the section modulus Z_{le} , in cm^3 , shall be taken not larger than the value Z'_{le} , in cm^3 , given by:

$$Z'_{le} = Z_g + 10^3 \frac{Qh_g - 0.5h_g^2 s_1 p_g}{\sigma_a}$$

Z_g = section modulus, in cm^3 , of the corrugations calculated, according to 304, in way of the upper end of shedder or gusset plates, as applicable

- Q = shear force, in kN, as given in 209
 h_g = height, in m, of shedders or gusset plates, as applicable (see Fig.9, Fig.10, Fig.11 and Fig.12)
 s_1 = as given in 203
 p_g = resultant pressure, in kN/m², as defined in 206 or 207 as relevant calculated in way of the middle of the shedders or gusset plates, as applicable
 σ_a = allowable stress, in N/mm², as given in 305.

Stresses, τ , are obtained by dividing the shear force, Q , by the shear area. The shear area shall be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by $(\sin \phi)$, ϕ being the angle between the web and the flange.

When calculating the section modulus and the shear area, the net plate thickness shall be used.

The section modulus of corrugations shall be calculated on the bases of the following requirements given in 303 and 304.

(IACS UR S18.4.2, Rev. 7)

303 Section modulus at the lower end of corrugations

The section modulus shall be calculated with the compression flange having an effective flange width, b_{ef} , not larger than as given in 306.

If the corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part, the section modulus of the corrugations shall be calculated considering the corrugation webs 30% effective.

- a) Provided that effective shedder plates, as defined in 302, are fitted (see Fig.9 and Fig.10), when calculating the section modulus of corrugations at the lower end (cross-section (1) in Fig.9 and Fig.10), the area of flange plates, in cm², may be increased by $(2.5 a \sqrt{t_f t_{sh}})$ (not to be taken greater than $2.5 a t_p$) where:

- a = width, in m, of the corrugation flange (see Fig.6)
 t_{sh} = net shedder plate thickness, in mm
 t_f = net flange thickness, in mm.

- b) Provided that effective gusset plates, as defined in 302, are fitted (see Fig.11 and Fig.12) when calculating the section modulus of corrugations at the lower end (cross-section (1) in Fig.11 and Fig.12), the area of flange plates, in cm², may be increased by $(7 h_g t_f)$ where:

h_g = height of gusset plate in m, see Fig.11 and Fig.12, not to be taken greater than:

$$\left(\frac{10}{7} s_{gu} \right)$$

- s_{gu} = width of the gusset plates, in m
 t_f = net flange thickness, in mm, based on the as built condition.

- c) If the corrugation webs are welded to a sloping stool top plate which have an angle not less than 45 degrees with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in b) above. No credit can be given to shedder plates only.

For angles less than 45 degrees, the effectiveness of the web may be obtained by linear interpolation between 30% for zero degrees and 100% for 45 degrees.

(IACS UR S18.4.3, Rev. 7)

304 Section modulus of corrugations at cross-sections other than the lower end

The section modulus shall be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{ef} , not larger than as given in 306.

(IACS UR S18.4.4, Rev. 7)

305 Allowable stress check

The normal and shear stresses σ and τ , shall not exceed the allowable values σ_a and τ_a , in N/mm², given by:

$$\begin{aligned} \sigma_a &= \sigma_f \\ \tau_a &= 0.5 \sigma_f \end{aligned}$$

σ_f being the minimum upper yield stress, in N/mm², of the material.

(IACS UR S18.4.5, Rev. 7)

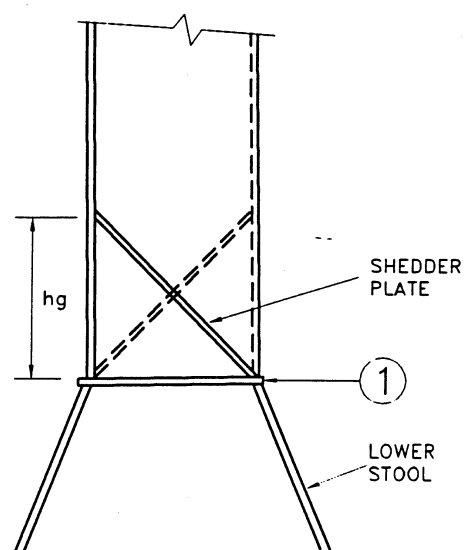


Fig. 9
Symmetric shedder plates

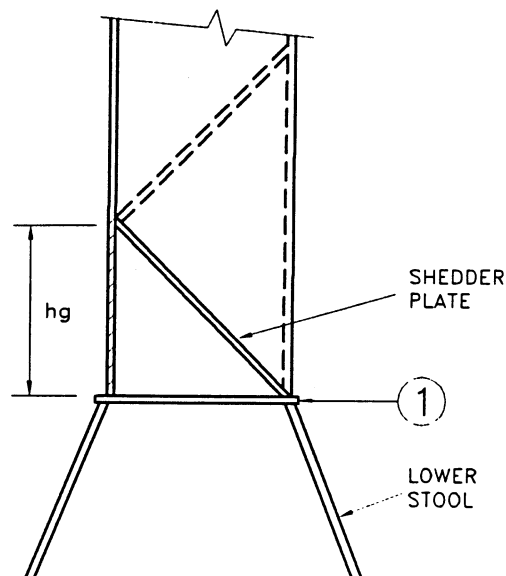


Fig. 10
Asymmetric shedder plates

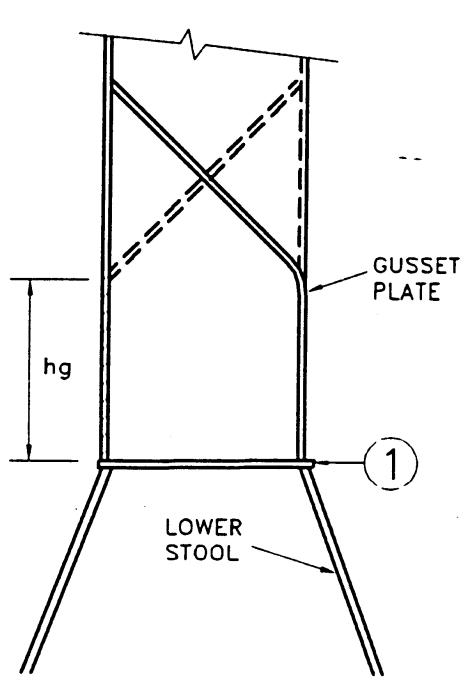


Fig. 11
Symmetric gusset/shedder plates

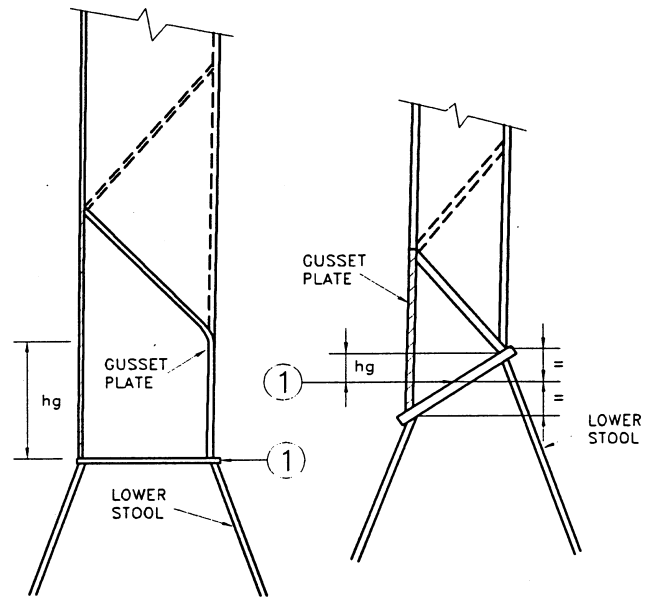


Fig. 12
Asymmetric gusset/shedder plates

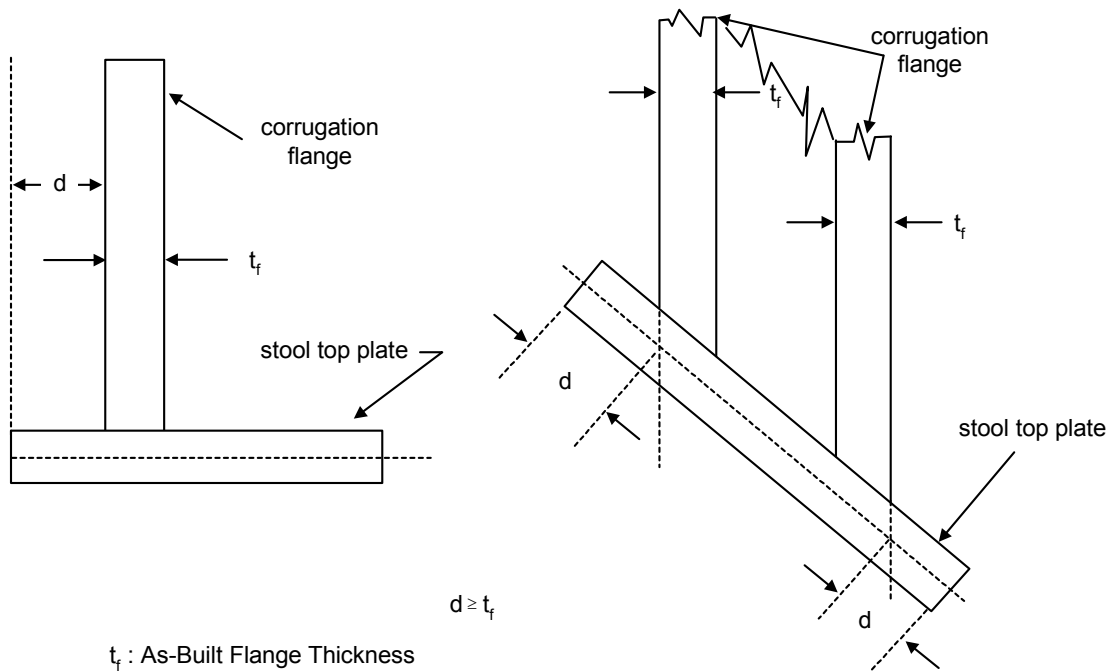


Fig. 13
Permitted distance, d , from edge of stool top plate to surface of corrugation flange

306 Effective width of compression flange of corrugations

The effective width b_{ef} , in m, of the corrugation flange is given by:

$$b_{ef} = C_e a$$

$$C_e = \frac{2.25}{\beta} - \frac{1.25}{\beta^2} \text{ for } \beta > 1.25$$

$$C_e = 1.0 \text{ for } \beta \leq 1.25$$

$$\beta = 10^3 \frac{a}{t_f} \sqrt{\frac{\sigma_f}{E}}$$

t_f = net flange thickness, in mm

a = width, in m, of the corrugation flange (see Fig.6)

σ_f = minimum upper yield stress, in N/mm², of the material

E = modulus of elasticity of the material, in N/mm², to be assumed equal to $2.06 \cdot 10^5$ for steel.

(IACS UR S18.4.6.1 Rev. 7)

307 Shear buckling

The buckling check shall be performed for the web plates at the corrugation ends.

The shear stress, τ , as obtained by applying forces as given in 209, shall not exceed the critical value τ_c , in N/mm², as given in Pt.3 Ch.1 Sec.14, assuming a buckling factor $k_t = 6.34$ and net plate thickness as defined in this subsection.

(IACS UR S18.4.6.2, Rev. 7)

308 Local net plate thickness

The bulkhead local net plate thickness t , in mm, is given by:

$$t = 14.9s_w \sqrt{\frac{1.05p}{\sigma_f}}$$

s_w = plate width, in m, to be taken equal to the width of the corrugation flange or web, whichever is the greater (see Fig.6)

p = resultant pressure, in kN/m², as defined in 206 or 207 as relevant, at the bottom of each strake of plating. In all cases, the net thickness of the lowest strake shall be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of shedders, if shedder or gusset/shedder plates are fitted

σ_f = minimum upper yield stress, in N/mm² of the material.

For built-up corrugation bulkheads, when the thickness of the flange and web are different, the net thickness of the narrower plating shall be not less than t_n , in mm, given by:

$$t_n = 14.9s_n \sqrt{\frac{1.05p}{\sigma_f}}$$

s_n being the width, in mm, of the narrower plating.

The net thickness of the wider plating, in mm, shall not be taken less than the maximum of the following values:

$$t_w = 14.9s_w \sqrt{\frac{1.05p}{\sigma_f}}$$

and

$$t_w = \sqrt{\frac{440s_w^2 1.05p}{\sigma_f}} - t_{np}^2$$

where $t_{np} \leq$ actual net thickness of the narrower plating and not to be greater than:

$$14.9s_w \sqrt{\frac{1.05p}{\sigma_f}}$$

(IACS UR S18.4.7, Rev. 7)

D 400 Local details

401 The design of local details, for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, shall reflect local stress concentration due to abrupt change in stiffness. Areas of concern are in particular connection to double bottom, cross-deck structures and connection of stool construction (upper and lower) to top-wing

and hopper tank construction.

The thickness and stiffening of effective gusset and shedder plates, as defined in 302, shall comply with Pt.3 Ch.1 Sec.9, on the basis of the pressure load as given in 201 to 207.

Unless otherwise stated, weld connections and materials shall be dimensioned and selected in accordance with Pt.3 Ch.1.

(IACS UR S18.5, Rev. 7)

D 500 Corrosion addition

501 The corrosion addition, t_s , shall be taken equal to 3.5 mm.

502 Steel renewal is required where the gauged thickness is less than $t_{net} + 0.5$ mm.

Where the gauged thickness is within the range $t_{net} + 0.5$ mm and $t_{net} + 1.0$ mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in good condition, as defined in Pt.7 Ch.1 Sec.1.

(IACS UR S18.6, Rev. 7)

E. Limit to Hold Loading, Considering Hold Flooding

E 100 Application and definition

101 These requirements apply to the double bottom structure of all cargo holds of bulk carriers, as defined by Sec.5 A.

The loading in each hold shall not exceed the limit to hold loading in flooded condition, calculated as per 401, using the loads given in 201 to 202 and the shear capacity of the double bottom given in 301 to 303.

In no case is the loading in each hold to exceed design hold loading in intact condition.

(IACS UR S20.1, Rev. 4)

E 200 Loading model

201 General

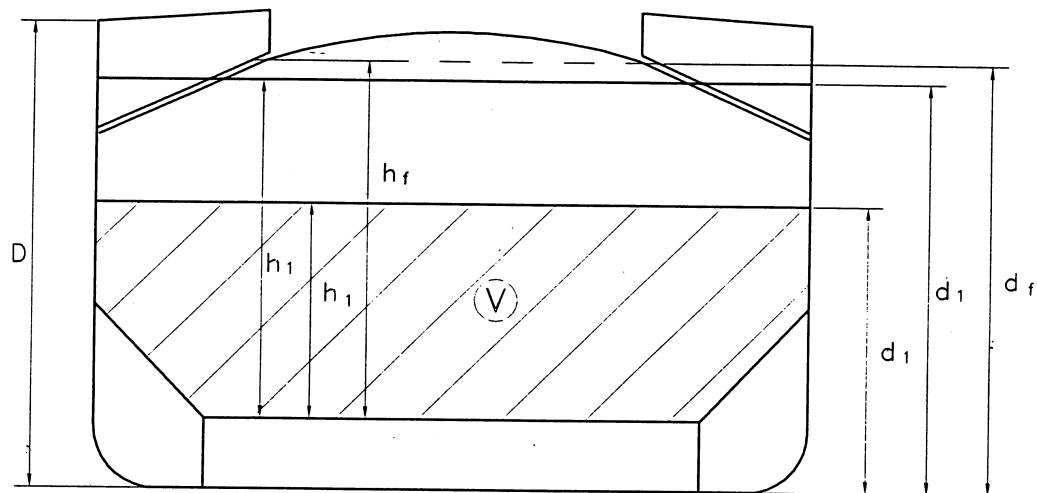
The loads to be considered as acting on the double bottom are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

The most severe combinations of cargo induced loads and flooding loads shall be used, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions
- non-homogeneous loading conditions
- packed cargo conditions (such as steel mill products).

For each loading condition, the maximum bulk cargo density to be carried shall be considered in calculating the allowable hold loading limit.

(IACS UR S20.2.1, Rev. 4)



V = Volume of cargo

Fig. 14
Definition of flooding head and D

202 Inner bottom flooding head

The flooding head h_f (see Fig.14) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance d_f in m, from the baseline equal to:

- a) in general:
 - D for the foremost hold
 - $0.9 D$ for the other holds
- b) for ships less than 50 000 tonnes deadweight with Type B freeboard:
 - $0.95 D$ for the foremost hold
 - $0.85 D$ for the other holds.

D is the distance, in m, from the baseline to the freeboard deck at side amidships (see Fig.14).

(IACS UR S20.2.2, Rev. 4)

E 300 Shear capacity

301 Shear capacity of the double bottom

The shear capacity, C , of the double bottom is defined as the sum of the shear strength at each end of:

- all floors adjacent to both hoppers, less one half of the

strength of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (see Fig.15)

- all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

In the end holds, where girders or floors run out and are not directly attached to the boundary stool or hopper girder, their strength shall be evaluated for the one end only.

Note that the floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom shall not be included.

When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, the shear capacity C of double bottom will be subject to special consideration.

In calculating the shear strength, the net thickness of floors and girders shall be used. The net thickness t_{net} , in mm, is given by:

$$t_{net} = t - 2.5$$

t = thickness, in mm, of floors and girders.

(IACS UR S20.3, Rev. 4)

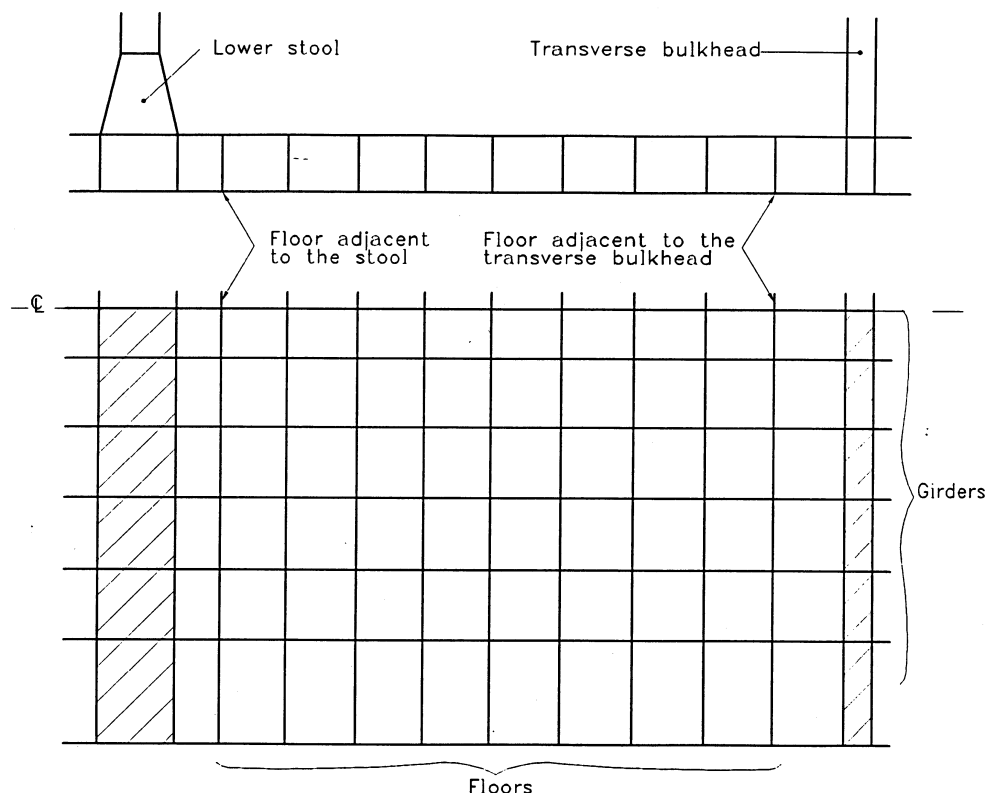


Fig. 15
Arrangement of double bottom

302 Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers S_{f1} , in kN, and the floor shear strength in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2} , in kN, are given by the following expressions:

$$S_{f1} = 10^{-3} A_f \frac{\tau_a}{\eta_1}$$

$$S_{f2} = 10^{-3} A_{f,h} \frac{\tau_a}{\eta_2}$$

- A_f = sectional area, in mm², of the floor panel adjacent to hoppers
 $A_{f,h}$ = net sectional area, in mm², of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper)
 τ_a = the allowable shear stress, in N/mm², to be taken equal to the lesser of

$$\tau_a = \frac{162 \sigma_F^{0.6}}{\left(\frac{s}{t_{net}}\right)^{0.8}} \quad \text{and} \quad \frac{\sigma_F}{\sqrt{3}}$$

For floors adjacent to the stools or transverse bulkheads, as identified in 301, τ_a may be taken as:

$$\frac{\sigma_F}{\sqrt{3}}$$

- σ_F = minimum upper yield stress, in N/mm², of the material
 s = spacing of stiffening members, in mm, of panel under consideration

$$\eta_1 = 1.10$$

$$\eta_2 = 1.20$$

η_2 may be reduced down to 1.10 when appropriate reinforcements are fitted around openings.

(IACS UR S20.3.1, Rev. 4)

303 Girder shear strength

The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1} , in kN, and the girder shear strength in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2} , in kN, are given by the following expressions:

$$S_{g1} = 10^{-3} A_g \frac{\tau_a}{\eta_1}$$

$$S_{g2} = 10^{-3} A_{g,h} \frac{\tau_a}{\eta_2}$$

A_g = minimum sectional area, in mm², of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted)

$A_{g,h}$ = net sectional area, in mm², of the girder panel in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted)

τ_a = allowable shear stress, in N/mm², as given in 302

$$\eta_1 = 1.10$$

$$\eta_2 = 1.15$$

η_2 may be reduced down to 1.10 when appropriate reinforcements are fitted around openings.

(IACS UR S20.3.2, Rev. 4)

E 400 Limit to hold loading, considering flooding

401 The limit to hold loading, W , in tonnes, is given by:

$$W = \rho_c V \frac{1}{F}$$

- F = 1.1 in general
= 1.05 for steel mill products
 ρ_c = bulk cargo density, in t/m^3 (see 201). For steel products, ρ_c shall be taken as the density of steel
 V = volume, in m^3 , occupied by cargo at a level h_1
 $h_1 = \frac{X}{\rho_{cg}}$
 X = for bulk cargoes, the lesser of X_1 and X_2 given by:

$$X_1 = \frac{Z + \rho g(E - h_f)}{1 + \frac{\rho}{\rho_c}(\text{perm} - 1)}$$

$$X_2 = Z + \rho g(E - h_f \text{ perm})$$

- ρ = sea water density, in t/m^3
 g = 9.81 m/s^2 , gravity acceleration
 E = ship immersion in m for flooded hold condition
= $d_f - 0.1 D$
 d_f , D = as given in 202
 h_f = flooding head, in m, as defined in 202
perm = cargo permeability (i.e. the ratio between the voids within the cargo mass and the volume occupied by the cargo), needs not be taken greater than 0.3
 Z = the lesser of Z_1 and Z_2 given by:

$$Z_1 = \frac{C_h}{A_{DB, h}}$$

$$Z_2 = \frac{C_e}{A_{DB, e}}$$

- C_h = shear capacity of the double bottom, in kN, as defined in 301, considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (see 302) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see 303)
 C_e = shear capacity of double bottom, in kN, as defined in 301, considering, for each floor, the shear strength S_{f1} (see 302) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see 303)

$$A_{DB, h} = \sum_{i=1}^{i=n} S_i B_{DB, i}$$

$$A_{DB, e} = \sum_{i=1}^{i=n} S_i (B_{DB} - s_l)$$

- n = number of floors between stools (or transverse bulkheads, if no stool is fitted)
 S_i = space of i th-floor, in m
 $B_{DB, i} = B_{DB} - s_l$ for floors whose shear strength is given by S_{f1} (see 302)
 $B_{DB, i} = B_{DB, h}$ for floors whose shear strength is given by S_{f2} (see 302)
 B_{DB} = breadth of double bottom, in m, between hoppers (see Fig.16)
 $B_{DB, h}$ = distance, in m, between the two considered opening (see Fig.16)

s_l = spacing, in m, of double bottom longitudinals adjacent to hoppers

(IACS UR S20.4, Rev. 4)

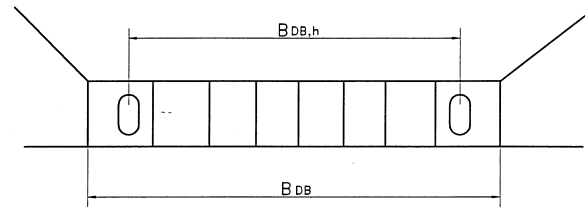


Fig. 16
Dimensions of double bottom

F. Evaluation of Scantlings of Hatch Covers and Hatch Coamings of Cargo Holds of Bulk Carriers, Ore Carriers and Combination Carriers

F 100 Application and definition

101 These requirements are applicable to hatch covers and hatch coamings of stiffened plate construction. The secondary stiffeners and primary supporting members of the hatch covers shall be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections shall not be used and appropriate arrangements shall be adopted to ensure sufficient load carrying capacity.

The spacing of primary supporting members parallel to the direction of secondary stiffeners shall not exceed 1/3 of the span of primary supporting members, i.e. between rigid supports.

The secondary stiffeners of the hatch coamings shall be continuous over the breadth and length of the hatch coamings.

These requirements are in addition to the requirements given in Pt.3 Ch.3 Sec.6.

The net thickness, t_{net} , is the thickness necessary to obtain the below net minimum scantlings.

The required thickness is obtained by adding the corrosion addition t_s , given in 1 000 to the net thickness t_{net} .

Material for the hatch covers shall be steel according to the requirements for ship's hull.

The design of closing arrangements for all hatch covers shall comply with Pt.3 Ch.3 Sec.6.

(IACS S21.1, Rev. 4, Corr. 1)

F 200 Hatch cover load model

201 The pressure p , in kN/m^2 , on the hatch cover panels is given by:

For ships of 100 m in length and above:

$$p = 34.3 + \frac{p_{FP} - 34.3}{0.25} \left(0.25 - \frac{x}{L_F} \right)$$

- $p \geq 34.3$, for hatch ways located at the freeboard deck
 $p = 34.3$, where a position 1 hatchway, as given in Pt.3 Ch.3 Sec.6 A202, is located at least one superstructure standard height higher than the freeboard deck

where:

- p_{FP} = pressure at the forward perpendicular
= $49.1 + (L_F - 100) a$
 a = 0.0726 for type B freeboard ships
= 0.356 for ships with reduced freeboard
 L_F = freeboard length, in m, as given in Pt.3 Ch.1 Sec.1 B100

x = distance, in m, of the mid length of the hatch cover under examination from the forward end of L_F .

For ships less than 100 m in length:

$$p = 15.8 + \frac{L_F}{3} \left(1 - \frac{5}{3} \frac{x}{L_F}\right) - 3.6 \frac{x}{L_F}$$

where:

$p \geq 0.195 L_F + 14.9$, for hatch ways located at the freeboard deck.

Where two or more panels are connected by hinges, each individual panel shall be considered separately.

(IACS S21.2, Rev. 4, Corr.1)

F 300 Hatch cover strength criteria

301 Allowable stress check

The normal and shear stresses σ and τ in the hatch cover structures shall not exceed the allowable values σ_a and τ_a , in N/mm², given by:

$$\begin{aligned}\sigma_a &= 0.80 \sigma_f \\ \tau_a &= 0.46 \sigma_f\end{aligned}$$

σ_f being the minimum upper yield stress, in N/mm², of the material.

The normal stress in compression of the attached flange of primary supporting members shall not exceed 0.8 times the critical buckling stress of the structure according to the buckling check as given in Pt.3 Ch.1 Sec.13.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members shall be determined by a grillage or a FE analysis.

When a beam or a grillage analysis is used, the secondary stiffeners shall not be included in the attached flange area of the primary members.

When calculating the stresses σ and τ , the net scantlings shall be used.

In case of stiffeners of variable cross section, see Pt.3 Ch.3 Sec.6 E400.

(IACS S21.3.1, Rev. 4, Corr. 1)

302 Effective cross-sectional area of panel flanges for primary supporting members

The effective flange area A_f , in cm², of the attached plating, to be considered for the yielding and buckling checks of primary supporting members, when calculated by means of a beam or grillage model, is obtained as the sum of the effective flange areas of each side of the girder web as appropriate:

$$A_f = \sum_{nf} (10 b_{ef} t)$$

where:

- nf = 2 if attached plate flange extends on both sides of girder web
= 1 if attached plate flange extends on one side of girder web only
- t = net thickness of considered attached plate, in mm
- b_{ef} = effective breadth, in m, of attached plate flange on each side of girder web
= b_p , but shall not be taken greater than $0.165 l$
- b_p = half distance, in m, between the considered primary supporting member and the adjacent one
- l = span, in m, of primary supporting members

(IACS UR S21.3.2, Rev. 4, Corr. 1).

303 Local net plate thickness

The local net plate thickness t , in mm, of the hatch cover top plating shall not be less than:

$$t = F_p 15.8 s \sqrt{\frac{p}{0.95 \sigma_f}}$$

but shall not be less than 1% of the spacing of the stiffener or 6 mm if that being greater.

where:

- F_p = factor for combined membrane and bending response
= 1.50 in general
= $1.90 \sigma / \sigma_a$, for $\sigma / \sigma_a \geq 0.8$; for the attached plate flange of primary supporting members
- s = stiffener spacing, in m
- p = as given in 201
- σ = as given in 305
- σ_a = as given in 301

(IACS UR S21.3.3, Rev. 4, Corr.1)

304 Net scantlings of secondary stiffeners

The required minimum net section modulus, in cm³, of secondary stiffeners of the hatch cover top plate, based on stiffener net member thickness, are given by:

$$Z = \frac{1000 l^2 s p}{12 \sigma_a}$$

where:

- l = secondary stiffener span, in m, shall be taken as the spacing of primary supporting members or the distance between a primary supporting member and the edge support, as applicable. When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10% of the gross span, for each bracket
- s = secondary spacing, in m.

The net section modulus of the secondary stiffeners shall be determined based on an attached plate width assumed equal to the stiffener spacing.

(IACS UR S21.3.4, Rev. 4, Corr.1).

305 Net scantlings of primary supporting members

The section modulus and web thickness of primary supporting members, based on member net thickness, shall be such that the normal stress σ in both flanges and the shear stress τ , in the web, do not exceed the allowable values σ_a and τ_a , respectively, as given in 301.

The breadth of the primary supporting member flange shall not be less than 40% of their depth for laterally unsupported spans greater than 3.0 m. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

The flange outstand shall not exceed 15 times the flange thickness.

(IACS UR S21.3.5, Rev. 4, Corr.1).

F 400 Buckling

401 Buckling for hatch cover plating with primary supporting members parallel to the direction of secondary stiffeners shall be in accordance with Pt.3 Ch.1 Sec.13 B, with $\psi = 1.0$.

Buckling for hatch cover plating with primary supporting members perpendicular to the direction of secondary stiffeners shall be in accordance with Pt.3 Ch.1 Sec.13 B.

Buckling for secondary stiffeners shall be in accordance with Pt.3 Ch.1 Sec.13 C.

For flat bar secondary stiffeners and buckling stiffeners, the ra-

ratio h/t_w shall not be greater than:

$$15 \sqrt{\frac{1}{f_1}}$$

where:

h = height of stiffener
 t_w = net thickness of stiffener

Buckling for web panels of hatch cover primary supporting members shall be in accordance with Pt.3 Ch.1 Sec.13 B300.

For primary supporting members parallel to the direction of secondary stiffeners, the actual dimensions of the panels shall be considered.

For primary supporting members perpendicular to the direction of secondary stiffeners or for hatch covers built without secondary stiffeners, a presumed square panel of dimension d shall be taken for the determination of the stress τ_c . In such a case, the average stress τ between the values calculated at the ends of this panel shall be considered.

(IACS UR S21.3.6, Rev. 4, Corr.1)

F 500 Deflection limit and connections between hatch cover panels

501 Load bearing connections between the hatch cover panels shall be fitted with the purpose of restricting the relative vertical displacements.

The vertical deflection of primary supporting members shall not be more than $0.0056 l$, where l is the greatest span of primary supporting members.

(IACS UR S21.3.7, Rev. 4, Corr.1)

F 600 Hatch coaming load model

601 The pressure p_{coam} , in kN/m^2 , on the No.1 forward (foremost hold) transverse hatch coaming is given by:

$p_{coam} = 220$, when a forecastle is fitted in accordance with Sec.5 F
 $= 290$ in other cases.

The pressure p_{coam} on the other hatch coamings is given by:

$p_{coam} = 220$
(IACS UR S21.4.1, Rev. 4, Corr.1)

F 700 Hatch coamings strength criteria

701 Local net plate thickness

The local net plate thickness, in mm, of the hatch coaming plating is given by:

$$t = 14.9s \sqrt{\frac{p_{coam}}{\sigma_{a,coam}}} S_{coam}$$

where:

s = spacing, in m, of secondary stiffener
 p_{coam} = as given in 601
 S_{coam} = safety factor
 $= 1.15$
 $\sigma_{a,coam} = 0.95 \sigma_f$

The local net plate thickness shall not be less than 9.5 mm.

(IACS UR S21.4.2, Rev. 4, Corr.1)

702 Net scantlings of longitudinal and transverse secondary stiffeners

The required net section modulus in cm^3 , of the longitudinal or transverse secondary stiffeners of the hatch coamings, based on net member thickness, is given by:

$$Z = \frac{1000 S_{coam} l^2 s p_{coam}}{m c_p \sigma_{a,coam}}$$

where:

$m = 16$ in general
 $= 12$ for the end spans of stiffeners sniped at the coaming corners
 $l =$ span, in m, of secondary stiffeners
 $c_p =$ ratio of the plastic section modulus to the elastic section modulus of the secondary stiffeners with an attached plate breadth, in mm, equal to $40 t$, where t is the plate net thickness
 $= 1.16$ in the absence of more precise evaluation

(IACS UR S21.4.3, Rev. 4, Corr.1)

703 Net scantlings of coaming stays

The required minimum net section modulus, in cm^3 , and net web thickness, in mm, of coamings stays designed as beams with flange connected to the deck or sniped and fitted with a bracket, see Fig.17, at their connection with the deck, based on member net thickness, are given by:

$$Z = \frac{1000 H_c^2 s p_{coam}}{2 \sigma_{a,coam}}$$

$$t_w = \frac{1000 H_c s p_{coam}}{h \tau_{a,coam}}$$

where

$H_c =$ stay height, in m
 $S =$ stay spacing, in m
 $h =$ stay depth, in mm, at the connection with the deck
 $\tau_{a,coam} = 0.5 \sigma_f$

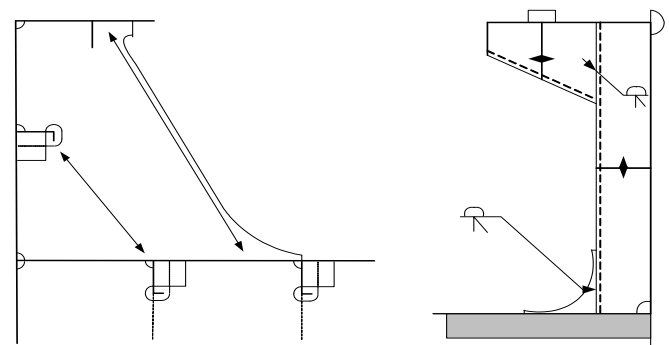


Fig. 17

For calculating the section modulus of coaming stays, their face plate area shall be taken into account only when it is welded with full penetration welds to the deck plating and adequate under deck structure is fitted to support the stresses transmitted by it.

For other designs of coaming stays, such as for example those shown in Fig.18, the stress levels as given in 301 apply and shall be checked at the highest stressed locations.

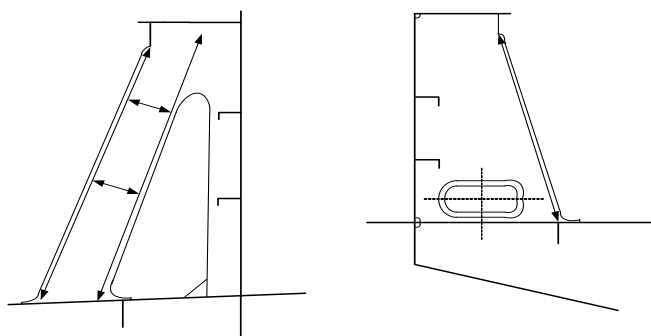


Fig. 18

(IACS UR S21.4.4, Rev. 4, Corr.1)

F 800 Local details

801 The design of local details for the purpose of transferring the pressure on the hatch covers to the hatch coamings and, through them, to the deck structures below, shall comply with requirements given in Pt.3 Ch.3 Sec.6.

Hatch coamings and supporting structures shall be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Under deck structures shall be checked against the load transmitted by the stays, adopting the same allowable stresses as given in 703.

For ships without forecastle or breakwater, the scantlings of the coamings for the No.1 hold (foremost hold) shall not be less than that required by Pt.3 Ch.1 Sec.10 for front bulkheads of deckhouses at that position.

Unless otherwise stated, weld connections and materials shall be dimensioned and selected in accordance with Pt.3 Ch.1.

Double continuous welding shall be adopted for the connections of stay webs with deck plating and the weld throat shall not be less than $0.44 t_w$, where t_w is the gross thickness of the stay web.

Toes of stay webs shall be connected to the deck plating with deep penetration double bevel welds extending over a distance not less than 15% of the stay width.

(IACS UR S21.4.5, Rev. 4, Corr.1)

F 900 Closing arrangements

901 The strength of securing devices shall comply with the following requirements:

Panel hatch covers shall be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements.

Arrangement and spacing shall be determined with due attention to the effectiveness for weather-tightness, depending upon the type and size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

The net sectional area of each securing device shall not be less than:

$$A = 1.4 \frac{a}{f} \text{ (cm}^2\text{)}$$

where:

- a = spacing in m of securing devices, not less than 2 m
- f = $(\sigma_y / 235)^e$
- σ_y = specified minimum upper yield stress in N/mm² of the steel used for fabrication, shall not be taken greater than

70% of the ultimate tensile strength

$$e = \begin{cases} 0.75 & \text{for } \sigma_y > 235 \\ 1.00 & \text{for } \sigma_y \leq 235 \end{cases}$$

Rods or bolts shall have a net diameter not less than 19 mm for hatchways exceeding 5 m² in area.

Between cover and coaming and a cross-joints, a packing line pressure sufficient to obtain weather tightness shall be maintained by the securing devices.

For packing line pressures exceeding 5 N/mm, the cross section area shall be increased in direct proportion. The packing line pressure shall be specified.

The cover edge stiffness shall be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia of edge elements shall not be less than:

$$I = 6 p a^4 \text{ (cm}^4\text{)}$$

where:

- p = packing line pressure in N/mm, minimum 5 N/mm
- a = spacing in m of securing devices

Securing devices shall be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover shall have approximately the same stiffness characteristics.

Where rod cleats are fitted, resilient washers or cushions shall be incorporated.

Where hydraulic cleating is adopted, a positive means shall be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

(IACS UR S21.5.1, Rev. 4, Corr.1)

902 Hatch covers shall be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 kN/m².

With the exclusion of the No. 1 (foremost hold) hatch cover, hatch covers shall be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m².

The No. 1 (foremost hold) hatch cover shall be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 kN/m².

This pressure may be reduced to 175 kN/m² when a forecastle is fitted in accordance with Sec.5 F.

The equivalent stress:

- in stoppers and their supporting structures, and
- calculated in the throat of the stopper welds shall not exceed the allowable value of $0.8 \sigma_y$.

(IACS UR S21.5.2, Rev. 4, Corr.1)

903 Stoppers or securing devices shall be manufactured of materials, including welding electrodes, meeting relevant IACS requirements.

(IACS UR S21.5.3, Rev. 4, Corr.1)

F 1000 Corrosion addition and steel renewal

1001 Hatch covers

For all the structures (plating and stiffeners) of single skin hatch cover, the corrosion addition t_s shall be 2.0 mm.

For double skin hatch covers, the corrosion addition shall be taken equal to:

- 2.0 mm for the top and bottom plating
- 1.5 mm for the internal structures.

For single skin hatch covers and for the plating of double skin hatch covers, steel renewal is required where the gauged thickness is less than

$$t_{\text{net}} + 0.5 \text{ mm.}$$

Where the gauged thickness is within the range $t_{\text{net}} + 0.5 \text{ mm}$ and $t_{\text{net}} + 1.0 \text{ mm}$, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in good condition, as defined in Pt.7 Ch.1 Sec.1.

For the internal structure of double skin hatch covers, thickness gauging is required when plating renewal shall be carried out or when this is deemed necessary, at the discretion of the surveyor, on the basis of the plating corrosion or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than t_{net} .

(IACS UR S21.6.1, Rev. 4, Corr.1)

1002 *Hatch coamings*

For the structure of hatch coamings and coaming stays, the corrosion addition t_s shall be 1.5 mm.

Steel renewal is required where the gauged thickness is less than

$$t_{\text{net}} + 0.5 \text{ mm.}$$

Where the gauged thickness is within the range $t_{\text{net}} + 0.5 \text{ mm}$ and $t_{\text{net}} + 1.0 \text{ mm}$, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in good condition, as defined in Pt.7 Ch.1 Sec.1.

(IACS UR S21.6.2, Rev. 4, Corr.1)

SECTION 9

SHIPS SPECIALISED FOR THE CARRIAGE OF A SINGLE TYPE OF DRY BULK CARGO

A. General

A 100 Classification

101 The requirements in this section apply to ships intended for the carriage of a single cargo type. The notation **X Carrier** may be given to ships built in compliance with the requirements in this section, where **X** denotes the type of cargo to be carried, e.g. **Alumina, Cement, Sugar** etc.

102 The cargo holds shall be arranged with a closed loading and unloading arrangement. Documentation of the intended loading and unloading system shall be submitted for information.

103 The ship is, in general, to have a double bottom within the cargo region and have double sides and a single deck. Hatches to cargo holds shall be arranged as required for access only, and for the closed loading and unloading arrangement.

A 200 Documentation

201 Data regarding properties of the cargo, relevant to the design (e.g. bulk density, angle of repose, humidity limit, etc.) shall be submitted for information.

202 Information regarding the intended cargo and ballast conditions, including typical loading and unloading sequences, shall be submitted for approval. This shall include conditions with uneven distribution of cargo between holds, e.g. part loading conditions with empty cargo holds, as applicable.

A 300 Design loads

301 The design pressures for local elements, i.e. plates and stiffeners, shall be as given in Pt.3 Ch.1 Sec.4, using parameters as given in 200, as applicable.

302 In the direct calculations, design pressures shall be as given in Pt.3 Ch.1 Sec.13, using the information given in 200.

A 400 Longitudinal strength

401 The longitudinal strength shall be determined as given in Pt.3 Ch.1 Sec.5 or Pt.3 Ch.2 Sec.4. The ships shall belong to

category I, see Pt.3 Ch.1 Sec.5 D or Pt.3 Ch.2 Sec.4 A. Ships intended for the carriage of homogeneous loads only, may upon request, be considered according to the requirements for ships in category II.

A 500 Plating and stiffeners

501 The plate thickness and the cross-sectional properties of stiffeners are in general to be calculated as given in Pt.3 Ch.1 or Pt.3 Ch.2, using design pressures according to 200 where applicable.

502 The minimum thickness of the inner bottom plating of the double bottom of cargo holds, shall be taken as given in Pt.3 Ch.1 Sec.6 C402 or Pt.3 Ch.2 Sec.5 C302 for ships with length less than 100 m, with $t_0 = 5$ mm.

503 The section modulus of longitudinal stiffeners of double bottom structures shall be calculated, as given in Pt.3 Ch.1 Sec.6, with double bottom stress $\sigma_{db} = 20 f_1$ N/mm². For ships designed for non-homogeneous seagoing loading conditions, the section modulus of double bottom longitudinals is also to be calculated, as given in Sec.5 C300, based on double bottom stresses as is determined according to 600.

A 600 Girder systems

601 Scantlings of girder structures of the bottom, sides, transverse bulkheads and deck of the cargo region may have to be determined, based on a direct stress analysis, as considered necessary by the Society.

602 In cases where direct calculations are considered necessary, the following cases are normally to be considered:

- Cargo unevenly distributed between the holds (harbour). The design condition shall be based on the intended loading and unloading sequence.
- Cargo unevenly distributed between the holds, as applicable, according to the ship's loading manual (seagoing).
- Ballast condition (seagoing).

SECTION 10 CARRIAGE OF REFRIGERATED CONTAINERS

A. Classification

A 100 Application

101 The rules, as relevant, in this chapter apply to ships equipped to carry refrigerated containers in hold and/or on deck when the class notation in A200 is requested.

102 In this regard refrigerated container means a container with a self-contained refrigeration system, located within the containers outer dimensions and driven by electrical power fed from an external power supply. This may be a clip-on or an integral unit.

103 These rules do not cover alarm and monitoring systems fitted to the individual containers.

104 Vessels with novel arrangement and design not directly covered by these rules may also be given the notations described in A200 after special consideration with respect to documentation and testing.

A 200 Class notations

201 Ships designed, built, equipped and tested under the supervision of the Society in compliance with the requirements of this section may be given the additional class notation **RC-1**, **RC-2** or **RC-3**.

202 Class notation **RC-1** is intended for vessels that carry mostly fruit (bananas) and chilled cargo in addition to deep frozen cargoes, i.e. a design ratio between 80% and 100% chilled cargo.

203 Class notation **RC-2** is intended for vessels that carry both frozen and chilled cargo with a design ratio of between 50% and 80% chilled cargo.

204 Class notation **RC-3** is mainly intended for vessels that carry mostly deep frozen cargoes with a design ratio below 50% chilled cargo.

205 For ships with class notations as given in 202 to 204, will in addition be given a notation of the maximum number of forty-foot equivalent refrigerated units (FEU) that may be carried, e.g. (200/70) meaning that the vessel may carry 200 reefer containers on deck and 70 in the holds.

206 The following information shall be provided:

- details of ambient conditions
- exact design ratio of chilled cargo
- number of containers that may be loaded which are not at their predetermined set temperature.

This information will be included in the Appendix to the Classification Certificate.

B. Operational Performance

B 100 General

101 The ship shall be designed, arranged and equipped to make it suitable for carrying cargoes as relevant according to the design operating conditions and class notation. The builders and possible subcontractors specifications of the ships operational performances and abilities will together with the specific requirements of this chapter will be used as basis for assignment of class.

102 It is assumed that the refrigerated containers in general are at their predetermined set temperature at the time of loading. If containers shall be loaded which are not at their pre-

terminated set temperature this shall be taken into consideration when calculating the capacity required for the electrical and ventilation systems.

103 It is assumed that the container refrigeration units are capable of functioning fully at an ambient temperature of +50°C.

C. Documentation

C 100 Plans and particulars

101 The following plans and particulars shall be submitted for approval, if applicable:

a) General

- The builders and possible subcontractors specifications of the ships operational performances and abilities, for information.

b) Ventilation arrangement

- Location and installation details of ventilation system showing duct arrangement and sizes, for each hold, including schematic arrangement of the ventilation system showing proposed air volume and velocity at junctions.
- Details of all fans including location, number, design condition, capacities and power consumption.
- Details of air inlets and outlets including number, type, size and location.
- Details and location of dampers and flaps, if applicable.
- Calculation of specified air through put rate and proposals for it's measurement.
- Design temperature rise in the hold space and corresponding ambient air temperature and relative humidity.
- Cooling water systems for containers equipped with water cooled condensers (fresh and sea water).

c) Hull structure

- Refrigerated container stowage plans.
- Design pressure or vacuum in each hold.
- Details of hatch cover sealing arrangements.
- Personnel access arrangements.
- Details of any pressure/vacuum safety valves in each hold space.
- Details of associated openings through the hull structure.

d) Electrical installations, in accordance with the requirements of Pt.4 Ch.8

- Calculation of electric power demand covering all refrigerated containers and the necessary fans.

e) Control and monitoring system

- Ventilation control and monitoring.
- Refrigerating container supply monitoring

For documentation types, see Pt.4 Ch.9.

f) Testing

- Details of the testing and commissioning programme, including description and set-up of instrumentation to be used to verify installation.

D. Ventilation and Hold Temperature

D 100 General

101 Means shall be provided to remove the waste heat, from each container refrigerant condenser and electrical motors, local to the condenser's air outlet. This shall be arranged in such a way as to minimize the effect on the hold space temperature. This may be accomplished by the use of a ventilation system or a combination of ventilation and water cooling.

102 Air distribution systems to be provided for air supply directed to each container refrigeration unit.

103 Separate supply air duct and fan shall be provided for each stack intended for refrigerated containers, except for the outermost stacks and in way of access to hold which may be arranged such that one duct splits into two.

104 The positions of supply air inlets and exhaust air outlets shall be such as to reduce the possibility of short circuit. The effect heat ingress from deck stowed containers into the hold as well as the effects of warm exhaust air on deck stowed containers shall be considered.

105 Air flow resistance between container refrigeration units and the exhaust air outlets shall be minimised. Restrictions to the free air flow by walkways etc. shall be kept to a minimum.

106 Where container holds are designed for simultaneous carriage of 8'6" and 9'6" containers the ventilation supply outlets must be adjustable to allow direct air supply to the containers condenser independent of the stowage pattern.

Guidance note:

Since most refrigerated containers are high cube containers (9'6") it is advisable to optimise the reefer positions for this size of container. Reference is also made to G104 concerning access to reefer containers.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

107 Fans shall be controlled centrally from a position outside of the hold. In addition means of stopping all ventilation fans shall be provided (outside the spaces being served) at positions which will not be cut-off in the event of fire in the hold. Arrangements shall be provided to permit a rapid shutdown and effective closure of the ventilation system in each hold space in case of fire.

108 A minimum of one replacement fan, or fan motor, of each size shall be carried onboard. Fans shall be arranged to enable each to be replaced whilst the remaining parts of the system continue in operation.

109 Cargo hold ventilation inlet and exhaust openings shall be arranged such that air supply to the refrigerated containers will be ensured also under heavy weather conditions.

D 200 Air supply

201 The ambient climatic conditions are in general not to be taken less than air 35°C, seawater 32°C and relative humidity 70%.

202 The permissible cargo hold temperature is in general not to exceed 45°C.

203 The air supply for each container with air cooled condensers shall not be taken less than:

$$Q = \frac{P_{\text{cont}} + P_{\text{fan}} + Q_{\text{resp}} + Q_T}{\rho_{\text{air}} c_{\text{air}} (T_{\text{hold}} - T_{\text{air}})} \frac{3600}{\text{m}^3/\text{h}}$$

where

P_{cont} = Power demand for reefer unit, not to be taken less than:
= minimum 11.0 kW for 40' and 8.4 kW for 20' for **RC-1** notation (80% chilled)
= minimum 9.8 kW for 40' and 7.4 kW for 20' for **RC-2** notation (50% chilled)

= minimum 8.6 kW for 40' and 6.4 kW for 20' for **RC-3** notation (100% frozen).

For other cargo mix linear interpolation may be used.

P_{fan} = Power demand for fans, kW.

Q_{resp} = Respiration from reefer containers

= 64 W/t for **RC-1** notation, carriage of bananas

= 0 for **RC-2** and **RC-3** notation.

Q_T = Heat transfer from adjacent tanks, heated above 45°C, kW.

c_{air} = Specific heat capacity of air, 1.01 kJ/(kg K) (at +35°C, 70% RH and 101.3 kPa).

ρ_{air} = Density of air, 1.13 kg/m³ (at +35°C, 70% RH and 101.3 kPa).

T_{hold} = Maximum allowable hold temperature, in general not to be taken more than 45°C.

T_{air} = Temperature of air at design ambient condition, in general not to be taken less than 35°C.

204 For containers with water cooled condenser the required air supply shall be calculated in accordance with 203 using the following power demand for the containers:

P_{cont} = Power demand for reefer unit, not to be taken less than minimum 2.1 kW for 40' and 1.5 kW for 20'.

205 Additional capacity shall be added for ships where containers shall be loaded which are not at their predetermined set temperature.

E. Electrical Installations

E 100 General

101 The electrical installations shall comply with Pt.4 Ch.8. Reefer containers and ventilation systems shall be considered as important services in all sailing and manoeuvring modes planned for the vessel. However, diversity factors (simultaneous factors) as given in paragraph 104 may be used.

102 Under sea-going conditions, the number and rating of service generators shall be sufficient to supply all container socket outlets and the hold space ventilation system in addition to services listed in Pt.4 Ch.8 Sec.2 B101 b), when any one generator set is out of service.

103 The number and rating of all service generators shall be sufficient to supply all container sockets and the hold space ventilation system in addition to the consumers needed under manoeuvring conditions.

104 When calculating the electric power demand the following simultaneous factors may be applied to account for the fact that not all refrigerating units are running at the same time:

Number of refrigerated FEU	Simultaneous factor
≤100 FEU	0.9
>100 FEU	0.84
>250 FEU	0.80
>500 FEU	0.77

Lower values may be applied to account for different cargo mixes, such lower values shall be documented.

Additional capacity shall be added for ships where containers shall be loaded which are not at their predetermined set temperature.

105 Socket connections for refrigerated containers shall be supplied from distribution boards, not directly from the main switchboard. The supply to these distribution boards shall be divided approximately equally between the two sides of the main switchboard with one separate supply for each distribution panel.

The number of container sockets connected to one final circuit shall not exceed 10.

Guidance note:

The electric power supply to refrigerated container sockets should preferably be galvanic isolated from the ship mains to avoid any influence in case of insulation faults. These rules do not include any requirements to earth fault disconnection or earth fault indication for individual reefer containers.

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Guidance note:

It is not required that the generating capacity connected to each side of the main switchboard is sufficient to supply power to all reefer containers.

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106 Distribution panels with feeder circuits for reefer containers shall provide individual indications for each outgoing feeder showing when a feeder breaker is switched on.

F. Instrumentation and Control System

F 100 General

101 The control and monitoring systems shall comply with Pt.4 Ch.9.

102 An alarm system for monitoring of the reefer containers and required auxiliary ship systems shall be installed. This system may be integral with the ship's main alarm and monitoring system as long as a proper grouping is arranged in order to separate container alarms from other types of alarms (e.g. machinery alarms). This also covers extension alarms, where any container alarms shall not disturb personnel without cargo responsibilities.

Guidance note:

These rules do not require that the alarms for refrigerated containers are routed through an extension alarm system.

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F 200 Ventilation alarm system

201 A separate alarm shall be initiated upon failure of each independent ventilation system in each hold. If a balanced ventilation (mechanical exhaust and supply) system is installed, alarm for failure of each individual part shall be given.

F 300 Cargo refrigerating system

301 A separate alarm shall be initiated upon power supply failure to each refrigerating container circuit.

302 Ships designed for the carriage of more than 150 reefer containers shall be equipped with a remote reefer container monitoring system of power cable transmission type in accordance with a recognised standard e.g. ISO10368.

G. Hold Access

G 100 General

101 Suitable means shall be provided to allow personnel safe access to the hold when the ventilation system is in operation. Consideration shall be given to the possible over-pressure that may occur in the hold space.

102 The maximum permitted pressure or vacuum that may occur in the hold shall be stated. If the ventilation system is capable of producing a positive pressure above this allowable figure, means shall be provided to protect the hold and personnel from the effect of over-pressure or vacuum.

103 Consideration shall be given to the use of a pressure/vacuum relief valve set to operate below the maximum allowable hold pressure/vacuum.

104 Suitable accesses shall be provided to allow the removal of each refrigerated container's compressor or electrical motor. Access from each applicable hold space to the designated container refrigeration equipment maintenance area, shall be given.

105 Access shall be provided for maintenance and replacement of the cargo hold fans in all loading conditions.

H. Inspection and Testing

H 100 General

101 Trials of the system in each hold space shall be witnessed onboard by DNV surveyors before the system is put into service and prior to a certificate being issued.

102 The ability of the ventilation system to supply and/or extract air at the specified flow rate at each outlet shall be verified by the test. The deviation from the rated flow should be maximum $\pm 10\%$.

103 Verification of function of hold ventilation system with exhaust outlets closed on one side of the vessel.

104 Control and alarm systems shall be tested to demonstrate their correct operation. Testing shall take into account the electric power supply arrangements.