標題

MSC 102 の審議結果の紹介

ClassNK

テクニカル
インフォメーション

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各位

2020 年 11 月 4 日から 11 日に第 102 回海上安全委員会（MSC 102）が開催されました。今回の会合は、新型コロナウィルス感染拡大の影響により、ビデオ会議での開催となりました。今般、IMO より MSC 102 の議事録及び決議並びにサーキュラーが発行されたことから、次の通り同会合の情報及び審議結果をお知らせ致します。

1. 採択された条約及び関連コードの主要な改正
   今回の会合で採択された主要な義務要件は以下の通りです。

   (1) 係船設備に関する SOLAS 条約の改正（添付 1 参照）
   下記 3.2(1)の通り、今回の会合において、安全な係船設備の設計及び装置の選定に関する新ガイドライン、係船索を含む係船設備の点検及び保守に関する新ガイドラインが承認されました。併せて、これらを適用する旨を規定する SOLAS 条約 II-1/3-8 の改正が採択されました。

   適用: 2024 年 1 月 1 日

   (2) 水密性に関する要件整合のための SOLAS 条約の改正（添付 1、6、7 参照）
   SOLAS 条約 II-1/B-1 - B-4 部において、水密性に関する要件を整合するための改正が採択されました。SOLAS 条約 II-1/12 改正の早期適用については下記 3.2(3)参照。

   適用: 2024 年 1 月 1 日

   (3) IGF コードの改正（添付 2 参照）
   下記 3 件の IGF コードの改正が採択されました。
   i) 6.7.1.1 において、タンクコファダムを圧力逃し装置の要求対象区画から削除
   ii) 燃料調整室に対し固定式消火装置を要求するための、11.8 の新規追加
   iii) 16.3.3.5.1 に規定のアンダーマッチ溶接継手に対する引張試験規定にアルミニウム合金材以外を追加

   適用: 2024 年 1 月 1 日

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(4) IGC コードの改正（添付 3 参照）
上記 1.(3)に記載の IGF コードの改正に合わせた、アンダーマッチ溶接継手に対する引張試験規定にアルミニウム合金材以外を追加する IGC コード 6.5.3.5.1 の改正が採択されました。

適用: 2024 年 1 月 1 日

(5) IMDG コードの改正
国連による 2 年周期での「危険物輸送に関する勧告」の改正に伴う、第 40 回 IMDG コード改正が採択されました。

適用: 2022 年 6 月 1 日（ただし、主管庁判断により 2021 年 1 月 1 日からの早期適用が可能）

2. 承認された条約及び関連コードの主要な改正
今回の会合で承認された主要な義務要件は以下の通りです。これらは、2021 年 5 月に開催される MSC 103 にて採択される見込みです。

(1) SOLAS 条約 III 章、LSA コード及び決議 MSC.81(70)の改正（添付 8、14、15 参照）
20,000GT 以上の貨物船に搭載される救命艇に対して要求される静穏な水面での 5 ノット進水試験の要件について、自由降下進水式救命艇を適用外とするための、SOLAS 条約 III/33、LSA コード及び救命設備の試験に関する勧告（決議 MSC.81(70)）の改正案が承認されました。

(2) 貨物倉に対する水面探知器の設置（添付 8 参照）
2015 年の ro-ro 貨物船 El Faro 号の沈没事故を受けて、ばら積貨物船とタンカー以外の船舶で、複数の貨物倉を有する船舶の乾舷甲板より下方の乾貨物倉に対し、水面探知器の設置を義務付ける SOLAS 条約 II-1 章改正案が承認されました。

(3) 揚貨設備の安全要件（添付 8 参照）
現行 SOLAS 条約上では揚貨設備に対する規定がないため、揚貨設備に対する安全要件を策定するための作業が船舶設備小委員会（SSE 小委員会）で行われてきました。2020 年 3 月に開催された SSE 7 において、揚貨設備の定義や適用範囲を定め、アンカーウィンチ関連及び揚貨設備関連の 2 件の新ガイドラインを適用する旨を規定するための SOLAS 条約 II-1 章改正案が最終化されました。
MSC 102 では、SOLAS 条約改正案が承認されました。SSE 8 において関連のガイドライン案が最終化されれば、今後の MSC においてガイドライン案の承認と併せて本 SOLAS 条約改正が採択される見込みです。なお、制限荷重 1,000kg 未満の揚貨設備については主管庁判断により一部の要件の適用が免除されます。

（次頁に続く）

(4) 2011 ESP コードの改正（添付 9 参照）
二重船側油タンカーの初回更新検査における板厚計測要件を見直すための、2011 ESP コードの改正案が承認されました。

(5) 貨物船の水密戸に関する LL 条約、IBC コード, IGC コードの改正（添付 10、11、12 参照）
貨物船の浸水時の残存要件で考慮される水密戸を明確にするための 1988 LL 議定書 27 規則(13)(a)及び関連する IBC コード、IGC コードの改正案が承認されました。本件に関連する MARPOL Annex I 及び IBC コードの改正案は 2021 年 6 月開催の MEPC 76 で承認される見込みです。

(6) FSS コード 9 章の改正（添付 13 参照）
貨物船及び旅客船のキャビンバルコニーに対し個別識別可能な火災探知機を備える場合の故障分離要件に関する FSS コード 9 章の改正案が承認されました。

3. 今回の会合において承認された統一解釈、ガイドライン、ガイダンス等のうち、主要なものは以下のとおりです。以下で参照されている IACS 統一解釈(UI)は、IACS ホームページ（http://www.iacs.org.uk/）にて公開されております。

3.1 統一解釈

(1) IGC コードの統一解釈（添付 20 参照）
一例として IGC コードの 4.20.1.2 について T 継手が type A または type B 独立タンクにも認められる旨や、本項が type C 双胴円筒形独立タンクにも適用される旨を始め、IGC コードの統一的な運用を促すための多岐にわたる同コード要件の解釈。(関連 IACS UI GC20、GC21、GC22、GC25、GC26、GC27、GC28、GC29、GC30)
尚、同コード 5.4.4 及び 5.13.2.4 において参照される、ガス燃料管装置の外ダクトに関する解釈は貨物運送小委員会（CCC 小委員会）で再検討することとなりました。

(2) IMDG コードの統一解釈（添付 21 参照）
"Life-saving appliances"の文言の対象を明確にするための IMDG コード 7.1.4.4.2 の解釈。

(3) SOLAS 条約 II-1 章の統一解釈（添付 26 参照）
上記 1.(2)に関連し、SOLAS 条約 II-1/B-1 - B-4 部における、水密性に関する要件の解釈の見直し。(関連 IACS UI SC156)

(4) SOLAS 条約 II-2 章の統一解釈（添付 23 参照）
SOLAS 条約 II-2/9.2.2.3.2.2(9)において"Isolated pantries containing no cooking appliances in accommodation spaces"の定義を明確にするための解釈。

（次頁に続く）

3.2 ガイドライン、ガイダンス及びその他サーキュラー

(1) 係船設備に関する2件の新規ガイドライン及び1件のガイダンスの改正（添付16, 17, 24参照）

係船設備に関し以下3件が承認されました。

i) 安全な係船設備の設計及び装置の選定に関する新規ガイドライン

ii) 係船索を含む係船設備の点検及び保守に関する新規ガイドライン

iii) 曳航設備及び係留設備のガイダンス（MSC.1/Circ.1175）の改正

(2) 第二世代非損傷時復原性基準の暫定ガイドライン（添付22参照）

「デッドシップ状態」「過大加速度」「復原力喪失」「パラメトリック横揺れ」及び「ブローチング」の 5 つの現象について波浪中を航行する状態を想定して評価するための、第二世代非損傷時復原性基準を規定した暫定ガイドライン。

(3) SOLAS II-1章12規則改正の早期適用のサーキュラー（添付27参照）

上記 1.(2)に関連し、衝突隔壁に取り付けられる隔壁弁の要件を規定した SOLAS 条約 II-1/12 改正の早期適用を促すための MSC サーキュラー。

(4) CSS コードの改正（添付 4、18、19、25 参照）

天候依存型の固縛評価方法を規定するための CSS コード Annex 13 改正。また、関連するガイドライン(MSC.1/Circ.1353/Rev.1 及び総会決議 A.581(14))及び 2011 TDC コードも併せて改正。

(5) 救命設備の再帰反射材に関する勧告（添付5参照）

救命設備の再帰反射材の促進耐候試験について定めた総会決議 A.658(16)の改正として、新技術を取り入れた試験機の使用を認めるための勧告。

（次頁に続く）

なお、本件に関してご不明な点は、以下の部署にお問い合わせください。

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添付：

1. RESOLUTION MSC.474(102)
2. RESOLUTION MSC.475(102)
3. RESOLUTION MSC.476(102)
4. RESOLUTION MSC.479(102)
5. RESOLUTION MSC.481(102)
6. RESOLUTION MSC.429(98)/REV.1
7. RESOLUTION MSC.429(98)/REV.2
8. DRAFT AMENDMENTS TO SOLAS CHAPTERS II-1 AND III
9. DRAFT AMENDMENTS TO THE 2011 ESP CODE
10. DRAFT AMENDMENTS TO THE 1988 LL PROTOCOL
11. DRAFT AMENDMENTS TO THE IBC CODE
12. DRAFT AMENDMENTS TO THE IGC CODE
13. DRAFT AMENDMENTS TO THE FSS CODE
14. DRAFT AMENDMENTS TO THE LSA CODE
15. DRAFT MSC RESOLUTION ON AMENDMENTS TO THE REVISED RECOMMENDATION ON TESTING OF LIFE-SAVING APPLIANCES (RESOLUTION MSC.81(70))
16. MSC.1/Circ.1619
17. MSC.1/Circ.1620
18. MSC.1/Circ.1623
19. MSC.1/Circ.1624
20. MSC.1/Circ.1625
21. MSC.1/Circ.1626
22. MSC.1/Circ.1627
23. MSC.1/Circ.1634
24. MSC.1/Circ.1175/Rev.1
25. MSC.1/Circ.1353/Rev.2
26. MSC.1/Circ.1572/Rev.1
27. MSC.8/Circ.1

ANNEX 1

RESOLUTION MSC.474(102)
(adopted on 11 November 2020)

AMENDMENTS TO THE INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974, AS AMENDED

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO article VIII(b) of the International Convention for the Safety of Life at Sea, 1974 ("the Convention"), concerning the amendment procedure applicable to the annex to the Convention, other than to the provisions of chapter I,

HAVING CONSIDERED, at its 102nd session, amendments to the Convention proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1 ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the Convention the text of which is set out in the annex to the present resolution;

2 DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the said amendments shall be deemed to have been accepted on 1 July 2023, unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet have notified the Secretary-General of their objections to the amendments;

3 INVITES Contracting Governments to the Convention to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 January 2024 upon their acceptance in accordance with paragraph 2 above;

4 REQUESTS the Secretary-General, for the purposes of article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the annex to all Contracting Governments to the Convention;

5 REQUESTS ALSO the Secretary-General to transmit copies of this resolution and its annex to Members of the Organization which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974, AS AMENDED

CHAPTER II-1
CONSTRUCTION – STRUCTURE, SUBDIVISION AND STABILITY, MACHINERY AND ELECTRICAL INSTALLATIONS

Part A
General

Regulation 1 – Application

1 The existing paragraph 1.3 is replaced by the following:

"1.3 For the purpose of this chapter:

.1 the expression *ships constructed* means ships the keels of which are laid or which are at a similar stage of construction;

.2 the expression *ships constructed on or after 1 January 2024* means ships:

.1 for which the building contract is placed on or after 1 January 2024; or

.2 in the absence of a building contract, the keel of which is laid or which are at a similar stage of construction on or after 1 July 2024; or

.3 the delivery of which is on or after 1 January 2028.

.3 the expression *all ships* means ships constructed before, on or after 1 January 2009;

.4 a cargo ship, whenever built, which is converted to a passenger ship shall be treated as a passenger ship constructed on the date on which such a conversion commences."

Part A-1
Structure of ships

Regulation II-1/3-8 – Towing and mooring equipment

2 Regulation 3-8 is replaced by the following:

"1 Paragraphs 4 to 6 of this regulation apply to ships constructed on or after 1 January 2007.

2 Paragraphs 7 and 8 of this regulation only apply to ships:

.1 for which the building contract is placed on or after 1 January 2024; or

.2 in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2024; or

.3 the delivery of which is on or after 1 January 2027.

3 This regulation does not apply to towing arrangements provided in accordance with regulation 3-4.

4 Ships shall be provided with arrangements, equipment and fittings of sufficient safe working load to enable the safe conduct of all towing and mooring operations associated with the normal operation of the ship.

5 Arrangements, equipment and fittings provided in accordance with paragraph 4 above shall meet the appropriate requirements of the Administration or an organization recognized by the Administration under regulation I/6.*

* Refer to the *Guidance on shipboard towing and mooring equipment* (MSC.1/Circ.1175) for ships constructed on or after 1 January 2007 but before 1 January 2024 and the *Guidance on shipboard towing and mooring equipment* (MSC.1/Circ.1175/Rev.1) for ships constructed on or after 1 January 2024.

6 Each fitting or item of equipment provided under this regulation shall be clearly marked with any limitations associated with its safe operation, taking into account the strength of the supporting ship's structure and its attachment to it.

7 For ships of 3,000 gross tonnage and above, the mooring arrangement shall be designed, and the mooring equipment including lines shall be selected, in order to ensure occupational safety and safe mooring of the ship, based on the guidelines developed by the Organization.† Ship-specific information shall be provided and kept on board.‡

† Refer to the *Guidelines on the design of mooring arrangements and the selection of appropriate mooring equipment and fittings for safe mooring* (MSC.1/Circ.1619).

‡ Refer to towing and mooring arrangement plan in the *Guidelines on the design of mooring arrangements and the selection of appropriate mooring equipment and fittings for safe mooring (*MSC.1/Circ.1619).

8 Ships of less than 3,000 gross tonnage should comply with the requirement in paragraph 7 above as far as reasonably practicable, or with applicable national standards of the Administration.

9 For all ships, mooring equipment, including lines, shall be inspected and maintained in a suitable condition for their intended purposes.§

§ Refer to the *Guidelines for inspection and maintenance of mooring equipment including lines* (MSC.1/Circ.1620.

Part B-1
Stability

Regulation 7-2 – Calculation of the factor s_i

3 Paragraphs 5.2, 5.3 and 5.5 are replaced by the following:

"5.2 The factor s_i is to be taken as zero in those cases where the final waterline, taking into account sinkage, heel and trim, immerses:

.1 for cargo ships, the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor s_i. Such openings shall include air pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers;

.2 any part of the bulkhead deck in passenger ships considered a horizontal evacuation route for compliance with chapter II-2; and

.3 for passenger ships subject to the provisions of regulation 1.1.1.1 and constructed before 1 January 2024, the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor s_i. Such openings shall include air pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers.

5.3 The factor s_i is to be taken as zero if, taking into account sinkage, heel and trim, any of the following occur in any intermediate stage or in the final stage of flooding:

.1 immersion of any vertical escape hatch in the bulkhead deck of passenger ships and the freeboard deck of cargo ships intended for compliance with chapter II-2;

.2 any controls intended for the operation of watertight doors, equalization devices, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads from above the bulkhead deck of passenger ships and the freeboard deck of cargo ships become inaccessible or inoperable;

.3 immersion of any part of piping or ventilation ducts located within the assumed extent of damage and carried through a watertight boundary if this can lead to the progressive flooding of compartments not assumed as flooded; and

.4 for passenger ships constructed on or after 1 January 2024, immersion of the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor s_i. Such openings shall include air pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers.

5.5 Except as provided in paragraph 5.3.1, openings closed by means of watertight manhole covers and flush scuttles, remotely operated sliding watertight doors, side scuttles of the non-opening type as well as watertight access doors and watertight hatch covers required to be kept closed during navigation in accordance with regulations 22 to 24 need not be considered."

Part B-2
Subdivision, watertight and weathertight integrity

Regulation 12 – Peak and machinery space bulkheads, shaft tunnels, etc.

4 At the beginning of paragraph 6.1, the text "For ships subject to the provisions of regulation 1.1.1.1 and constructed before 1 January 2024," is added; the word "Except" is replaced by "except"; and the reference to "paragraph 6.2" is replaced by "paragraph 6.3".

5 A new paragraph 6.2 is inserted after existing paragraph 6.1 and the subsequent paragraph is renumbered accordingly:

"6.2 For ships constructed on or after 1 January 2024, except as provided in paragraph 6.3, the collision bulkhead may be pierced below the bulkhead deck of passenger ships and the freeboard deck of cargo ships by not more than one pipe for dealing with fluid in the forepeak tank, provided that the pipe is fitted with a remotely controlled valve capable of being operated from above the bulkhead deck of passenger ships and the freeboard deck of cargo ships. The valve shall be normally closed. If the remote control system should fail during operation of the valve, the valve shall close automatically or be capable of being closed manually from a position above the bulkhead deck of passenger ships and the freeboard deck of cargo ships. The valve shall be located at the collision bulkhead on either the forward or aft side, provided the space on the aft side is not a cargo space. The valve shall be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable."

Regulation 13 – Openings in watertight bulkheads below the bulkhead deck in passenger ships

6 Regulation 13, including its title, is replaced by the following:

"Regulation 13 – Openings in watertight boundaries below the bulkhead deck in passenger ships

1 The number of openings in watertight boundaries shall be reduced to the minimum compatible with the design and proper working of the ship; satisfactory means shall be provided for closing these openings.

2.1 Where pipes, scuppers, electric cables, etc., are carried through watertight boundaries, arrangements shall be made to ensure the watertight integrity of the boundaries.

2.2 Valves not forming part of a piping system shall not be permitted in watertight boundaries.

2.3 Lead or other heat sensitive materials shall not be used in systems which penetrate watertight boundaries, where deterioration of such systems in the event of fire would impair the watertight integrity of the boundaries.

3 No doors, manholes or access openings are permitted in watertight transverse bulkheads dividing a cargo space from an adjoining cargo space, except as provided in paragraph 8.1 and in regulation 14.

4 Subject to paragraph 9, not more than one door, apart from the doors to shaft tunnels, may be fitted in each watertight bulkhead within spaces containing the main and auxiliary propulsion machinery including boilers serving the needs of propulsion. Where two or more shafts are fitted, the tunnels shall be connected by an intercommunicating passage. There shall be only one door between the machinery space and the tunnel spaces where two shafts are fitted and only two doors where there are more than two shafts. All these doors shall be of the sliding type and shall be so located as to have their sills as high as practicable. The hand gear for operating these doors from above the bulkhead deck shall be situated outside the spaces containing the machinery.

5.1 Watertight doors, except as provided in paragraph 8.1 or regulation 14, shall be power-operated sliding doors complying with the requirements of paragraph 6.

5.2 The means of operation whether by power or by hand of any power-operated sliding watertight door shall be capable of closing the door with the ship listed to 15º either way. Consideration shall also be given to the forces which may act on either side of the door as may be experienced when water is flowing through the opening applying a static head equivalent to a water height of at least 1 m above the sill on the centreline of the door.

5.3 Watertight door controls, including hydraulic piping and electric cables, shall be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimize the likelihood of them being involved in any damage which the ship may sustain. The positioning of watertight doors and their controls shall be such that if the ship sustains damage within one fifth of the breadth of the ship, as defined in regulation 2, such distance being measured at right angles to the centreline at the level of the deepest subdivision draught, the operation of the watertight doors clear of the damaged portion of the ship is not impaired.

6.1 Each power-operated sliding watertight door:

- .1 shall have a vertical or horizontal motion;

- .2 shall, subject to paragraph 9, be normally limited to a maximum clear opening width of 1.2 m. The Administration may permit larger doors only to the extent considered necessary for the effective operation of the ship provided that other safety measures, including the following, are taken into consideration:

  - .1 special consideration shall be given to the strength of the door and its closing appliances in order to prevent leakages; and

  - .2 the door shall be located inboard the damage zone *B*/5;

- .3 shall be fitted with the necessary equipment to open and close the door using electric power, hydraulic power or any other form of power that is acceptable to the Administration;

- .4 shall be provided with an individual hand-operated mechanism. It shall be possible to open and close the door by hand at the door itself from either side, and in addition, close the door from an accessible position above the bulkhead deck with an all-round crank motion or some other movement providing the same degree of safety acceptable to the Administration. Direction of rotation or other movement is to be clearly indicated at all operating positions. The time necessary for the complete closure of the door, when operating by hand gear, shall not exceed 90 s with the ship in the upright position. Visual indicators to show whether the door is open or closed shall be provided at the accessible position above the bulkhead deck;

.5 shall be provided with controls for opening and closing the door by power from both sides of the door and also for closing the door by power from the central operating console(s) required by paragraph 7.1;

.6 shall be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever the door is closed remotely by power and which shall sound for at least 5 s but no more than 10 s before the door begins to move and shall continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving. Additionally, in passenger areas and areas of high ambient noise the Administration may require the audible alarm to be supplemented by an intermittent visual signal at the door; and

.7 shall have an approximately uniform rate of closure under power. The closure time, from the time the door begins to move to the time it reaches the completely closed position, shall in no case be less than 20 s or more than 40 s with the ship in the upright position.

6.2 The electrical power required for power-operated sliding watertight doors shall be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck. The associated control, indication and alarm circuits shall be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck and be capable of being automatically supplied by the transitional source of emergency electrical power required by regulation 42.3.1.3 in the event of failure of either the main or emergency source of electrical power.

6.3 Power-operated sliding watertight doors shall have either:

.1 a centralized hydraulic system with two independent power sources each consisting of a motor and pump capable of simultaneously closing all doors. In addition, there shall be for the whole installation hydraulic accumulators of sufficient capacity to operate all the doors at least three times, i.e. closed-open-closed, against an adverse list of 15º. This operating cycle shall be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used shall be chosen considering the temperatures liable to be encountered by the installation during its service. The power-operating system shall be designed to minimize the possibility of having a single failure in the hydraulic piping adversely affect the operation of more than one door. The hydraulic system shall be provided with a low-level alarm for hydraulic fluid reservoirs serving the power-operated system and a low gas pressure alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators. These alarms are to be audible and visual and shall be situated on the central operating console(s) required by paragraph 7.1; or

.2 an independent hydraulic system for each door with each power source consisting of a motor and pump capable of opening and closing the door. In addition, there shall be a hydraulic accumulator of sufficient capacity to operate the door at least three times, i.e. closed-open-closed, against an adverse list of 15º. This operating cycle shall be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used shall be chosen considering the temperatures liable to be encountered by the installation during its service. A low gas pressure group alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators shall be provided at the central operating console(s) required by paragraph 7.1. Loss of stored energy indication at each local operating position shall also be provided; or

.3 an independent electrical system and motor for each door with each power source consisting of a motor capable of opening and closing the door. The power source shall be capable of being automatically supplied by the transitional source of emergency electrical power as required by regulation 42.4.2 - in the event of failure of either the main or emergency source of electrical power and with sufficient capacity to operate the door at least three times, i.e. closed-open-closed, against an adverse list of 15º.

For the systems specified in paragraphs 6.3.1, 6.3.2 and 6.3.3, provision should be made as follows: Power systems for power-operated sliding watertight doors shall be separate from any other power system. A single failure in the electric or hydraulic power-operated systems excluding the hydraulic actuator shall not prevent the hand operation of any door.

6.4 Control handles shall be provided at each side of the bulkhead at a minimum height of 1.6 m above the floor and shall be so arranged as to enable persons passing through the doorway to hold both handles in the open position without being able to set the power closing mechanism in operation accidentally. The direction of movement of the handles in opening and closing the door shall be in the direction of door movement and shall be clearly indicated.

6.5 As far as practicable, electrical equipment and components for watertight doors shall be situated above the bulkhead deck and outside hazardous areas and spaces.

6.6 The enclosures of electrical components necessarily situated below the bulkhead deck shall provide suitable protection against the ingress of water.*

* Refer to the following publication IEC 60529:2003:

.1 electrical motors, associated circuits and control components; protected to IPX 7 standard;

.2 door position indicators and associated circuit components; protected to IPX 8 standard; and

.3 door movement warning signals; protected to IPX 6 standard.

Other arrangements for the enclosures of electrical components may be fitted provided the Administration is satisfied that an equivalent protection is achieved. The water pressure IPX 8 shall be based on the pressure that may occur at the location of the component during flooding for a period of 36 h.

6.7 Electric power, control, indication and alarm circuits shall be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit. Short circuits or other faults in the alarm or indicator circuits of a door shall not result in a loss of power operation of that door. Arrangements shall be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

6.8 A single electrical failure in the power operating or control system of a power-operated sliding watertight door shall not result in a closed door opening. Availability of the power supply should be continuously monitored at a point in the electrical circuit as near as practicable to each of the motors required by paragraph 6.3. Loss of any such power supply should activate an audible and visual alarm at the central operating console(s) required by paragraph 7.1.

7.1 A central operating console for all power-operated sliding watertight doors shall be located in the safety centre in accordance with regulation II-2/23. If the safety centre is located in a separate space adjacent to the navigation bridge, a central operating console shall also be located on the navigation bridge. The central operating console(s) shall have a "master mode" switch with two modes of control: a "local control" mode, which shall allow any door to be locally opened and locally closed after use without automatic closure, and a "doors closed" mode, which shall automatically close any door that is open in not more than 60 s with the ship in an upright position. The "doors closed" mode shall permit doors to be opened locally and shall automatically re-close the doors upon release of the local control mechanism. The "master mode" switch shall normally be in the "local control" mode. The "doors closed" mode shall only be used in an emergency or for testing purposes.

7.2 For ships subject to the provisions of regulation 1.1.1.1 and constructed before 1 January 2024, the central operating console at the navigation bridge shall be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light shall indicate a door is fully open and a green light shall indicate a door is fully closed. When the door is closed remotely the red light shall indicate the intermediate position by flashing. The indicating circuit shall be independent of the control circuit for each door.

7.3 For ships constructed on or after 1 January 2024, the central operating console(s) shall be provided with a diagram showing the location of each power-operated sliding watertight door, with visual indicators to show whether each door is open or closed. A red light shall indicate a door is fully open and a green light shall indicate a door is fully closed. When the door is closed remotely the red light shall indicate the intermediate position by flashing. The indicating circuit shall be independent of the control circuit for each door. Indication shall also be provided to the onboard stability computer, if installed in accordance with regulation II-1/8-1.3.1.

7.4 It shall not be possible to remotely open any door from the central operating console.

8.1 If the Administration is satisfied that such doors are essential, watertight doors of satisfactory construction may be fitted in watertight bulkheads dividing cargo spaces on 'tween decks. Such doors may be hinged, rolling or sliding doors but shall not be remotely controlled. They shall be fitted at the highest level and as far from the shell plating as practicable, but in no case shall the outboard vertical edges be situated at a distance from the shell plating which is less than one fifth of the breadth of the ship, as defined in regulation 2, such distance being measured at right angles to the centreline at the level of the deepest subdivision draught.

8.2 Should any such doors be accessible during the voyage, they shall be fitted with a device which prevents unauthorized opening. When it is proposed to fit such doors, the number and arrangements shall receive the special consideration of the Administration.

9 Portable plates on bulkheads shall not be permitted except in machinery spaces. The Administration may permit not more than one power-operated sliding watertight door larger than those specified in paragraph 6.1.2 to be substituted for these portable plates in each watertight bulkhead, provided these doors are intended to remain closed during navigation except in case of urgent necessity at the discretion of the master. These doors need not meet the requirements of paragraph 6.1.4 regarding complete closure by hand-operated gear in 90 s.

10.1 Where trunkways or tunnels for access from crew accommodation to the machinery spaces, for piping, or for any other purpose are carried through watertight bulkheads, they shall be watertight and in accordance with the requirements of regulation 16-1. The access to at least one end of each such tunnel or trunkway, if used as a passage at sea, shall be through a trunk extending watertight to a height sufficient to permit access above the bulkhead deck. The access to the other end of the trunkway or tunnel may be through a watertight door. Such trunkways or tunnels shall not extend through the first subdivision bulkhead abaft the collision bulkhead.

10.2 Where it is proposed to fit tunnels piercing watertight bulkheads, these shall receive the special consideration of the Administration.

10.3 Where trunkways in connection with refrigerated cargo and ventilation or forced draught trunks are carried through more than one watertight bulkhead, the means of closure at such openings shall be operated by power and be capable of being closed from a central position situated above the bulkhead deck."

Regulation 15 – Openings in the shell plating below the bulkhead deck of passenger ships and the freeboard deck of cargo ships

7 Paragraph 9 is replaced by the following:

"9 For ships subject to the provisions of regulation 1.1.1.1 and constructed before 1 January 2024, gangway, cargo and fuelling ports fitted below the bulkhead deck of passenger ships and the freeboard deck of cargo ships shall be watertight and in no case be so fitted as to have their lowest point below the deepest subdivision draught."

8 The following new paragraph 10 is inserted after new paragraph 9 and existing paragraphs 10.1 and 10.2 are deleted.

"10 For ships constructed on or after 1 January 2024, cargo ports and other similar openings (e.g. gangway and fuelling ports) in the side of ships below the bulkhead deck of passenger ships and the freeboard deck of cargo ships shall be fitted with doors so designed as to ensure the same watertightness and structural integrity as the surrounding shell plating. Unless otherwise granted by the Administration, these openings shall open outwards. The number of such openings shall be the minimum compatible with the design and proper working of the ship. In no case shall these openings be so fitted as to have their lowest point below the deepest subdivision draught."

Regulation 16 – Construction and initial tests of watertight closures

9 Paragraph 1.1 is replaced by the following:

"1.1 The design, materials and construction of all watertight closures such as doors, hatches, sidescuttles, gangway and cargo ports, valves and pipes referred to in these regulations shall be to the satisfaction of the Administration."

Regulation 17 – Internal watertight integrity of passenger ships above the bulkhead deck

10 Paragraph 1 is replaced by the following:

"1 For passenger ships subject to the provisions of regulation 1.1.1.1 and constructed before 1 January 2024, the Administration may require that all reasonable and practicable measures shall be taken to limit the entry and spread of water above the bulkhead deck. Such measures may include partial bulkheads or webs. When partial watertight bulkheads and webs are fitted on the bulkhead deck, above or in the immediate vicinity of watertight bulkheads, they shall have watertight shell and bulkhead deck connections so as to restrict the flow of water along the deck when the ship is in a heeled damaged condition. Where the partial watertight bulkhead does not line up with the bulkhead below, the bulkhead deck between shall be made effectively watertight. Where openings, pipes, scuppers, electric cables, etc. are carried through the partial watertight bulkheads or decks within the immersed part of the bulkhead deck, arrangements shall be made to ensure the watertight integrity of the structure above the bulkhead deck.*"

* Refer to the *Guidance notes on the integrity of flooding boundaries above the bulkhead deck of passenger ships for proper application of regulations II-1/8 and 20, paragraph 1, of SOLAS 1974, as amended* (MSC/Circ.541, as may be amended).

11 The following new paragraphs 2 and 3 are inserted after new paragraph 1 and the subsequent paragraphs are renumbered accordingly:

"2 For ships constructed on or after 1 January 2024, the internal watertight subdivision arrangements to limit the entry and spread of water above the bulkhead deck shall be in accordance with the design arrangements necessary for compliance with the stability requirements in parts B-1, and B-2 if applicable. Where pipes, scuppers, electric cables, etc. are carried through internal watertight boundaries that are immersed at any intermediate or final stage of flooding in damage cases that contribute to the attained subdivision index *A*, arrangements shall be made to ensure their watertight integrity.

3 For ships constructed on or after 1 January 2024, doors in internal watertight subdivision arrangements above the bulkhead deck, and also above the worst intermediate or final stage of flooding waterlines, shall be capable of preventing the passage of water when immersed in the required range of positive stability for any damage cases contributing to the attained subdivision index *A*. These doors may remain open provided they can be remotely closed from the navigation bridge. They shall always be ready to be immediately closed."

Regulation 17-1 – Integrity of the hull and superstructure, damage prevention and control on ro-ro passenger ships

12 Paragraphs 1.1 to 1.3 are replaced by the following:

"1.1 All access from the ro-ro deck that leads to spaces below the bulkhead deck shall have a lowest point which is not less than 2.5 m above the bulkhead deck, unless the access is covered by the provisions of paragraphs 1.2 or 1.3.

1.2 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 and fitted with alarms and open/close indicators on the navigation bridge. The means of closure shall be watertight if the deck is intended as a watertight horizontal boundary under regulation 7-2.6.

1.3 Subject to regulations 23.3 and 23.6, the Administration 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, and subject to such accesses being made watertight, fitted with alarms and open/close indicators on the navigation bridge."

Part B-4
Stability management

Regulation 19 – Damage control information*

* Refer to the *Guidelines for damage control plans and information to the master* (MSC.1/Circ.1245), as amended by MSC.1/Circ.1570 and to the *Guidelines for verification of damage stability requirements for tankers* (MSC.1/Circ.1461).

13 The following new paragraph 5 is inserted after existing paragraph 4:

"5 For passenger ships constructed on or after 1 January 2024, and to which regulation 8-1.3 applies, the damage control information shall include a reference to activation of damage stability support from the onboard stability computer, if installed, and to shore-based support when provided."

Regulation 21 – Periodical operation and inspection of watertight doors, etc., in passenger ships

14 Paragraph 1 is replaced by the following:

"1 Operational tests of watertight doors, sidescuttles, valves and closing mechanisms of scuppers shall take place weekly. In ships in which the voyage exceeds one week in duration, a complete set of operational tests shall be held before the voyage commences, and others thereafter at least once a week during the voyage."

Regulation 22 – Prevention and control of water ingress, etc.

15 In paragraphs 1 and 4, existing reference to "regulation 13.10" is replaced by the reference to "regulation 13.9".

16 Paragraphs 5 and 6 are replaced by the following:

"5 Watertight doors fitted in watertight bulkheads dividing cargo spaces on tween decks in accordance with regulation 13.8.1 shall be closed before the voyage commences and shall be kept closed during navigation. The time at which such doors are opened or closed shall be recorded in such logbook as may be prescribed by the Administration.

6 For ships subject to the provisions of regulation 1.1.1.1 and constructed before 1 January 2024, gangway, cargo and fuelling ports fitted below the bulkhead deck of passenger ships and the freeboard deck of cargo ships shall be effectively closed and secured watertight before the voyage commences, and shall be kept closed during navigation."

17 A new paragraph 7 is inserted after existing paragraph 6 and the subsequent paragraphs are renumbered accordingly:

"7 For ships constructed on or after 1 January 2024, gangway, cargo and fuelling ports fitted below the bulkhead deck of passenger ships and the freeboard deck of cargo ships and all watertight hatches shall be effectively closed and secured watertight before the voyage commences, and shall be kept closed during navigation. However, the master may permit a watertight hatch to be opened during navigation for a limited period of time sufficient to permit passage or for access. It shall then be closed."

18 In the renumbered paragraph 8.2, existing reference to "paragraph 7.1" is replaced by reference to "paragraph 8.1".

19 In the renumbered paragraph 8.4, existing text "paragraphs 7.1 to 7.3 " is replaced by "paragraphs 8.1 to 8.3".

20 In the renumbered paragraph 10, existing text "paragraphs 7.1 and 7.4" is replaced by "paragraphs 8.1 and 8.4".

21 In the renumbered paragraph 11, existing reference to "paragraph 7" is replaced by reference to "paragraph 8".

22 In the renumbered paragraph 12, existing reference to "paragraph 12" is replaced by reference to "paragraph 13" and the existing reference to "paragraph 13" is replaced by reference to "paragraph 14".

23 Renumbered paragraph 14.2 is replaced by:

".2 For any ship that has one or more sidescuttles so placed that the requirements of paragraph 14 would apply when it was floating at its deepest subdivision draught, the Administration may indicate the limiting mean draught at which these sidescuttles will have their sills above the line drawn parallel to the bulkhead deck at side of passenger ships and the freeboard deck at side of cargo ships, and having its lowest point 1.4 m plus 2.5% of the breadth of the ship above the waterline corresponding to the limiting mean draught, and at which it will therefore be permissible for the voyage to commence without them being closed and locked and to be opened during navigation on the responsibility of the master. In tropical zones as defined in the International Convention on Load Lines, 1966 in force, this limiting draught may be increased by 0.3 m."

24 Renumbered paragraph 17 is deleted.

Regulation 23 – Special requirements for ro-ro passenger ships

25 In paragraph 5, existing reference to "regulation 22.12" is replaced by reference to "regulation 22.13".

Part D
Electrical installations

Regulation 42 – Emergency source of electrical power in passenger ships

26 In paragraph 4.2, existing reference to "regulation 13.7.3.3" is replaced by reference to "regulation 13.6.3.3" and existing reference to "regulation 13.7.2" is replaced by reference to "regulation 13.6.2".

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ANNEX 2

RESOLUTION MSC.475(102)
(adopted on 11 November 2020)

AMENDMENTS TO THE INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW-FLASHPOINT FUELS (IGF CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution MSC.391(95), by which it adopted the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels ("the IGF Code"), which has become mandatory under chapter II-1 of the International Convention for the Safety of Life at Sea, 1974 ("the Convention"),

RECALLING FURTHER article VIII(b) and regulation II-1/2.28 of the Convention concerning the procedure for amending the IGF Code,

HAVING CONSIDERED, at its 102nd session, amendments to the IGF Code proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1 ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the IGF Code, the text of which is set out in the annex to the present resolution;

2 DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 July 2023 unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet have notified their objections to the amendments;

3 INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 January 2024 upon their acceptance in accordance with paragraph 2 above;

4 REQUESTS the Secretary-General, for the purposes of article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the annex to all Contracting Governments to the Convention;

5 REQUESTS ALSO the Secretary-General to transmit copies of this resolution and its annex to Members of the Organization, which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW-FLASHPOINT FUELS (IGF CODE)

PART A-1
SPECIFIC REQUIREMENTS FOR SHIPS USING NATURAL GAS AS FUEL

6 – FUEL CONTAINMENT SYSTEM

6.7 Regulation for pressure relief system

1 Regulation 6.7.1.1 is replaced by the following:

"All fuel storage tanks shall be provided with a pressure relief system appropriate to the design of the fuel containment system and the fuel being carried. Fuel storage hold spaces, interbarrier spaces and tank connection spaces, which may be subject to pressures beyond their design capabilities, shall also be provided with a suitable pressure relief system. Pressure control systems specified in 6.9 shall be independent of the pressure relief systems."

11 – FIRE SAFETY

2 The following new regulation 11.8 is added after existing regulation 11.7:

"**11.8 Regulation for fuel preparation room fire-extinguishing systems**

For ships constructed on or after 1 January 2024, fuel preparation rooms containing pumps, compressors or other potential ignition sources shall be provided with a fixed fire-extinguishing system complying with the provisions of SOLAS regulation II-2/10.4.1.1 and taking into account the necessary concentrations/application rate required for extinguishing gas fires."

PART B-1

16 – MANUFACTURE, WORKMANSHIP AND TESTING

16.3 Welding of metallic materials and non-destructive testing for the fuel containment system

3 Regulation 16.3.3.5.1 is replaced by the following:

".1 tensile tests: cross-weld tensile strength is not to be less than the specified minimum tensile strength for the appropriate parent materials. For materials such as aluminium alloys, reference shall be made to 6.4.12.1.1.3 with regard to the regulations for weld metal strength of under-matched welds (where the weld metal has a lower tensile strength than the parent metal). In every case, the position of fracture shall be recorded for information;"

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ANNEX 3

RESOLUTION MSC.476(102)
(adopted on 11 November 2020)

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the function of the Committee,

NOTING resolution MSC.5(48), by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk ("the IGC Code"), which has become mandatory under chapter VII of the International Convention for the Safety of Life at Sea, 1974 ("the Convention"),

NOTING ALSO article VIII(b) and regulation VII/11.1 of the Convention concerning the procedure for amending the IGC Code,

HAVING CONSIDERED, at its 102nd session, amendments to the IGC Code proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1 ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the IGC Code, the text of which is set out in the annex to the present resolution;

2 DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 July 2023 unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet have notified their objections to the amendments;

3 INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 January 2024 upon their acceptance in accordance with paragraph 2 above;

4 REQUESTS the Secretary-General, for the purposes of article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the annex to all Contracting Governments to the Convention;

5 REQUESTS ALSO the Secretary-General to transmit copies of this resolution and its annex to Members of the Organization, which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

CHAPTER 6
Materials of construction and quality control

6.5 Welding of metallic materials and non-destructive testing

6.5.3 Welding procedure tests for cargo tanks and process pressure vessels

1 Paragraph 6.5.3.5.1 is replaced by the following:

".1 tensile tests: cross-weld tensile strength shall not be less than the specified minimum tensile strength for the appropriate parent materials. For materials such as aluminium alloys, reference shall be made to 4.18.1.3 with regard to the requirements for weld metal strength of under-matched welds (where the weld metal has a lower tensile strength than the parent metal). In every case, the position of fracture shall be recorded for information;"

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ANNEX 9

RESOLUTION MSC.479(102)
(adopted on 11 November 2020)

REVISED GUIDELINES FOR SECURING ARRANGEMENTS FOR THE TRANSPORT OF ROAD VEHICLES ON RO-RO SHIPS

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution A.581(14), whereby the Assembly promulgated the *Guidelines for securing arrangements for the transport of road vehicles on ro-ro ships*, as amended by MSC/Circ.812 and MSC.1/Circ.1355,

RECALLING FURTHER resolution A.886(21), by which the Assembly resolved that the functions of adopting performance standards and technical specifications, as well as amendments thereto, should be performed by the Maritime Safety Committee on behalf of the Organization,

TAKING ACCOUNT of the IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units,

RECOGNIZING that a number of serious accidents have occurred because of inadequate securing arrangements on ships and road vehicles,

RECOGNIZING ALSO the need for the Organization to establish guidelines for securing arrangements on board ro-ro ships and on road vehicles,

REALIZING that, given adequately designed ships and properly equipped road vehicles, lashings of sufficient strength will be capable of withstanding the forces imposed on them during the voyage,

REALIZING ALSO that certain requirements for side guards, particularly those positioned very low on road vehicles, will obstruct the proper securing of road vehicles on board ro-ro ships and that appropriate measures will have to be taken to satisfy both road and maritime safety aspects,

BELIEVING that the application of the Guidelines will enhance safety in the transport of road vehicles on ro-ro ships and that this can be achieved on an international basis,

HAVING CONSIDERED the draft amendments to resolution A.581(14) prepared by the Sub-Committee on Carriage of Cargoes and Containers at its sixth session,

1 ADOPTS the *Revised guidelines for securing arrangements for the transport of road vehicles on ro-ro ships* set out in the annex to the present resolution;

2 URGES Member Governments to implement the Revised Guidelines at the earliest possible opportunity in respect of new ro-ro ships and new vehicles and, as far as practicable, in respect of existing vehicles which may be transported on ro-ro ships;

3 REQUESTS the Secretary-General to bring the Revised Guidelines to the attention of Member Governments and relevant international organizations responsible for safety in the design and construction of ships and road vehicles for action as appropriate;

4 DETERMINES that this resolution supersedes resolution A.581(14), as amended;

5 INVITES the Assembly to revoke resolution A.581(14) and endorse the action taken by the Maritime Safety Committee.

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ANNEX

REVISED GUIDELINES FOR SECURING ARRANGEMENTS FOR THE TRANSPORT OF ROAD VEHICLES ON RO-RO SHIPS

Preamble

In light of experience with the transport of road vehicles on ro-ro ships, it is recommended that these Guidelines for securing road vehicles on board such ships should be followed. Shipowners and shipyards, when designing and building ro-ro ships to which these Guidelines apply, should take sections 4 and 6 particularly into account. Manufacturers, owners and operators of road vehicles which may be transported on ro-ro ships should take sections 5 and 7 particularly into account.

1 Scope

These Guidelines for securing and lashing road vehicles on board ro-ro ships outline in particular the securing arrangements on the ship and on the vehicles, and the securing methods to be used.

2 Application

2.1 These Guidelines apply to ro-ro ships which regularly carry road vehicles on either long or short international voyages in unsheltered waters. They concern:

.1 road vehicles as defined in 3.2.1, 3.2.2, 3.2.3 and 3.2.5 with an authorized maximum total mass on vehicles and cargo of between 3.5 and 40 tonnes; and

.2 articulated road trains as defined in 3.2.4 with a maximum total mass of not more than 45 tonnes, which can be carried on ro-ro ships.

2.2 These Guidelines do not apply to buses.

2.3 For road vehicles having characteristics outside the general parameters for road vehicles (particularly where the normal height of the centre of gravity is exceeded), the location and the number of securing points should be specially considered.

3 Definitions

3.1 *"Ro-ro ship"* means a ship which has one or more decks either closed or open, not normally subdivided in any way and generally running the entire length of the ship, in which goods (packaged or in bulk, in or on road vehicles (including road tank-vehicles), trailers, containers, pallets, demountable or portable tanks or in or on similar cargo transport units or other receptacles) can be loaded or unloaded normally in a horizontal direction.

3.2 In these Guidelines the term road vehicle[1] includes:

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[1] Refer to ISO Standard No.3833

.1 *Commercial vehicle*, which means a motor vehicle which, on account of its design and appointments, is used mainly for conveying goods. It may also be towing a trailer.

.2 *Semi-trailer*, which means a trailer which is designed to be coupled to a semi-trailer towing vehicle and to impose a substantial part of its total mass on the towing vehicle.

.3 *Road train*, which means the combination of a motor vehicle with one or more independent trailers connected by a drawbar (for the purpose of section 5 each element of a road train is considered a separate vehicle).

.4 *Articulated road train*, which means the combination of a semi-trailer towing vehicle with a semi-trailer.

.5 *Combination of vehicles*, which means a motor vehicle coupled with one or more towed vehicles (for the purpose of section 5 each element of a combination of vehicles is considered a separate vehicle).

4 Securing points on ships' decks

4.1 The ship should carry a Cargo Securing Manual in accordance with resolution A.489(XII) containing the information listed and recommended in paragraph 10 of the annex to that resolution.

4.2 The decks of a ship intended for road vehicles as defined in 3.2 should be provided with securing points. The arrangement of securing points should be left to the discretion of the shipowner provided that for each road vehicle or element of a combination of road vehicles there is the following minimum arrangement of securing points:

.1 The distance between securing points in the longitudinal direction should in general not exceed 2.5 m. However, there may be a need for the securing points in the forward and after parts of the ship to be more closely spaced than they are amidships.

.2 The athwartships spacing of securing points should not be less than 2.8 m nor more than 3 m. However, there may be a need for the securing points in the forward and after parts of the ship to be more closely spaced than they are amidships.

.3 The maximum securing load (MSL) of each securing point should be not less than 100 kN. If the securing point is designed to accommodate more than one lashing (y lashings), the MSL should be not less than y x 100 kN.

4.3 In ro-ro ships which only occasionally carry road vehicles, the spacing and strength of securing points should be such that the special considerations which may be necessary to stow and secure road vehicles safely are taken into account.

5 Securing points on road vehicles

5.1 Securing points on road vehicles should be designed for securing the road vehicles to the ship and should have an aperture capable of accepting only one lashing. The securing point and aperture should permit varying directions of the lashing to the ship's deck.[2]

5.2 The same number of not less than two or not more than six securing points should be provided on each side of the road vehicle in accordance with the provisions of 5.3.

5.3 Subject to the provisions of notes 1, 2 and 3 below, the minimum number and minimum strength of securing points should be in accordance with the following table:

Gross vehicle mass (GVM) tonnes	Minimum number of securing points on each side of the road vehicle	Minimum strength without permanent deformation of each securing point as lifted (kN)
3.5 t ≤ GVM ≤ 20 t 20 t < GVM ≤ 30 t 30 t < GVM ≤ 40 t	2 3 4	$\frac{GVM \times 10 \times 1.2}{n^*}$

** Where n is the total number of securing points on each side of the road vehicle.*

Note 1: For road trains, the table applies to each component, i.e. to the motor vehicle and each trailer, respectively.

Note 2: Semi-trailer towing vehicles are excluded from the table above. They should be provided with two securing points at the front of the vehicle, the strength of which should be sufficient to prevent lateral movement of the front of the vehicle. A towing coupling at the front may replace the two securing points.

Note 3: If the towing coupling is used for securing vehicles other than semi-trailer towing vehicles, this should not replace or be substituted for the above-mentioned minimum number and strength of securing points on each side of the vehicle.

5.4 Each securing point on the vehicle should be marked in a clearly visible colour.

5.5 Securing points on vehicles should be so located as to ensure effective restraint of the vehicle by the lashings.

5.6 Securing points should be capable of transferring the forces from the lashings to the chassis of the road vehicle and should never be fitted to bumpers or axles unless these are specially constructed and the forces are transmitted directly to the chassis.

5.7 Securing points should be so located that lashings can be readily and safely attached, particularly where side-guards are fitted to the vehicle.

5.8 The internal free passage of each securing point's aperture should be not less than 80 mm, but the aperture need not be circular in shape.

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[2] If more than one aperture is provided at a securing point, each aperture should have the strength for the securing point in the table in 5.3.

5.9 Equivalent or superior securing arrangements may be considered for vehicles for which the provisions of table 5.3 are unsuitable.

6 Lashings

6.1 The maximum securing load (MSL) of lashings should in general not be less than 100 kN and lashings should be made of material having suitable elongation characteristics. However, the required number and MSL of lashings may be calculated according to annex 13 to the Code of Safe Practice for Cargo Stowage and Securing (CSS Code), taking into consideration the criteria mentioned in paragraph 1.5.1 of the CSS Code.

6.2 Lashings should be so designed and attached that, provided there is safe access, it is possible to tighten them if they become slack. Where practicable and necessary, the lashings should be examined at regular intervals during the voyage and tightened as necessary.

6.3 Lashings should be attached to the securing points with hooks or other devices so designed that they cannot disengage from the aperture of the securing point if the lashing slackens during the voyage.

6.4 Only one lashing should be attached to any one aperture of the securing point on the vehicle.

6.5 Lashings should only be attached to the securing points provided for that purpose.

6.6 Lashings should be attached to the securing points on the vehicle in such a way that the angle between the lashing and the horizontal and vertical planes lies preferably between 30°and 60°.

6.7 Bearing in mind the characteristics of the ship and the weather conditions expected on the intended voyage, the master should decide on the number of securing points and lashings to be used for each voyage.

6.8 Where there is doubt that a road vehicle complies with the provisions of table 5.3, the master may, at his or her discretion, load the vehicle on board, taking into account the apparent condition of the vehicle, the weather and sea conditions expected on the intended voyage and all other circumstances.

7 Stowage

7.1 Depending on the area of operation, the predominant weather conditions and the characteristics of the ship, road vehicles should be stowed so that the chassis are kept as static as possible by not allowing free play in the suspension of the vehicles. This can be done, for example, by compressing the springs by tightly securing the vehicle to the deck, by jacking up the chassis prior to securing the vehicle or by releasing the air pressure on compressed air suspension systems.

7.2 Taking into account the conditions referred to in 7.1 and the fact that compressed air suspension systems may lose air, the air pressure should be released on every vehicle fitted with such a system if the voyage is of more than 24 hours duration. If practicable, the air pressure should be released also on voyages of a shorter duration. If the air pressure is not released, the vehicle should be jacked up to prevent any slackening of the lashings resulting from any air leakage from the system during the voyage.

7.3 Where jacks are used on a vehicle, the chassis should be strengthened in way of the jacking-up points and the position of the jacking-up points should be clearly marked.

7.4 Special consideration should be given to the securing of road vehicles stowed in positions where they may be exposed to additional forces. Where vehicles are stowed athwartship, special consideration should be given to the forces which may arise from such stowage.

7.5 Wheels should be chocked to provide additional security in adverse conditions.

7.6 Vehicles with diesel engines should not be left in gear during the voyage.

7.7 Vehicles designed to transport loads likely to have an adverse effect on their stability, such as hanging meat, should have integrated in their design a means of neutralizing the suspension system.

7.8 Stowage should be arranged in accordance with the following:

.1 The parking brakes of each vehicle or of each element of a combination of vehicles should be applied and locked.

.2 Semi-trailers, by the nature of their design, should not be supported on their landing legs during sea transport unless the landing legs are specially designed for that purpose and so marked. An uncoupled semi-trailer should be supported by a trestle or similar device placed in the immediate area of the drawplate so that the connection of the fifth-wheel to the kingpin is not restricted. Semi-trailer designers should consider the space and the reinforcements required and the selected areas should be clearly marked.

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ANNEX 23

RESOLUTION MSC.481(102)
(adopted on 9 November 2020)

REVISED RECOMMENDATION ON THE USE AND FITTING OF RETRO-REFLECTIVE MATERIALS ON LIFE-SAVING APPLIANCES

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution A.658(16), whereby the Assembly promulgated the *Recommendation on the use and fitting of retro-reflective materials on life-saving appliances* and the *Technical specification for retro-reflective materials for use on life-saving appliances* and requested the Maritime Safety Committee to keep this recommendation under review and to report as necessary to the Assembly,

RECALLING FURTHER that the Assembly, at its thirty-first session, invited the Maritime Safety Committee to consider proposals to amend resolution A.658(16), with a view to facilitating the consistent and global implementation of the provisions regarding accelerated weather testing and to reissue a revised Recommendation as an MSC resolution, given its technical nature and in order to facilitate future revisions,

MINDFUL of resolution A.886(21), by which the Assembly resolved that the functions of adopting performance standards and technical specifications, as well as amendments thereto, should be performed by the Maritime Safety Committee on behalf of the Organization,

CONSIDERING that under the provisions of paragraph 1.2.2.7 of the LSA Code life-saving appliances shall be fitted with retro-reflective material where it will assist in detection and in accordance with the recommendations of the Organization,

1 ADOPTS the *Revised recommendation on the use and fitting of retro-reflective materials on life-saving appliances* and the *Technical specification for retro-reflective materials for use on life-saving appliances*, set out in annexes 1 and 2, respectively, to the present resolution;

2 RECOMMENDS Contracting Governments to the International Convention for the Safety of Life at Sea, 1974, as amended, to make arrangements to ensure that life-saving appliances are fitted with retro-reflective materials in the manner set out in annex 1 to the present resolution or in such other manner as is considered by the Administration to be substantially equivalent;

3 RECOMMENDS that the *Technical specification for retro-reflective materials for use on life-saving appliances* set out in annex 2 to the present resolution be considered by Administrations as a standard for retro-reflective materials, the application of which will contribute to keeping life-saving appliances at the high level of quality required;

4 AGREES that the Administration may accept life-saving appliances already fitted with retro-reflective materials in accordance with resolution A.658(16);

5 INVITES the Assembly to revoke resolution A.658(16) and endorse the action taken by the Maritime Safety Committee.

ANNEX 1

REVISED RECOMMENDATION ON THE USE AND FITTING OF RETRO-REFLECTIVE MATERIALS ON LIFE-SAVING APPLIANCES

1 Lifeboats and rescue boats

Retro-reflective materials should be fitted on top of the gunwale as well as on the outside of the boat as near the gunwale as possible. The materials should be sufficiently wide and long to give a minimum area of 150 cm^2 and should be spaced at suitable intervals (approximately 80 cm from centre to centre). If a canopy is fitted, it should not be allowed to obscure the materials fitted on the outside of the boat, and the top of the canopy should be fitted with retro-reflective materials similar to those mentioned above and spaced at suitable intervals (approximately 80 cm centre to centre). In the case of partially enclosed or totally enclosed lifeboats, such materials should be placed, as follows:

.1 for detection by horizontal light beams - at suitable intervals at half the height between the gunwale and the top of the fixed cover;

.2 for detection by vertical light beams (e.g. from helicopters) - at suitable intervals around the outer portion of the horizontal (or comparable) part of the top of the fixed cover; and

.3 on the bottom of lifeboats and rescue boats which are not self-righting.

2 Liferafts

2.1 Retro-reflective materials should be fitted around the canopy of the liferaft. The materials should be sufficiently wide and long to give a minimum area of 150 cm^2 and should be spaced at suitable intervals (approximately 80 cm from centre to centre) at a suitable height above the waterline, doorways included, if suitable. On inflatable liferafts, retro-reflective materials should also be fitted to the underside of the floor, cross-shaped in the centre. The dimension of the cross should be half the diameter of the liferaft, and a similar cross should be applied to the top of the canopy.

2.2 On liferafts which are not equipped with canopies, materials which should be sufficiently wide and long (to give a minimum area of 150 cm^2) should be attached to the buoyancy chamber at suitable intervals (approximately 80 cm from centre to centre), in such a manner that they are visible both from the air and from a ship.

3 Lifebuoys

Retro-reflective materials of a sufficient width (approximately 5 cm) should be applied around or on both sides of the body of the lifebuoy at four evenly-spaced points.

4 Buoyant apparatus

Buoyant apparatus should be fitted with retro-reflective materials in the same manner as liferafts without canopies, always depending on the size and shape of the object. Such materials should be visible both from the air and from a ship.

5 Lifejackets

Lifejackets should be fitted with patches of retro-reflective materials with a total area of at least 400 cm^2 distributed so as to be useful for search from air and surface craft from all directions. In the case of a reversible lifejacket, the arrangement should be complied with no matter which way the lifejacket is put on. Such materials should be placed as high up on the lifejacket as possible.

6 Immersion suits

6.1 Immersion suits should be fitted with patches of retro-reflective material with a total area of at least 400 cm^2 distributed so as to be useful for search from air and surface craft from all directions.

6.2 For an immersion suit that does not automatically turn the wearer face up, the back of the suit should be fitted with retro-reflective material with a total area of at least 100 cm^2.

7 General remarks

.1 Retro-reflective materials should be such as will meet the minimum technical specification given in annex 2.

.2 The illustrations reproduced in this annex are intended to provide Administrations with examples from which guidance may be taken when fitting retro-reflective materials in accordance with these recommendations.

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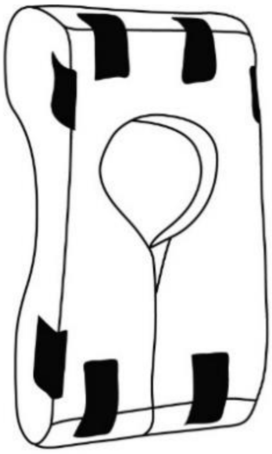

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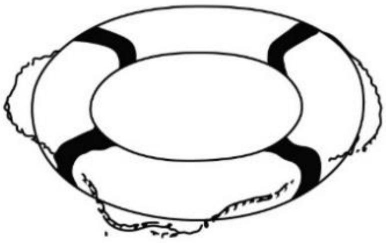

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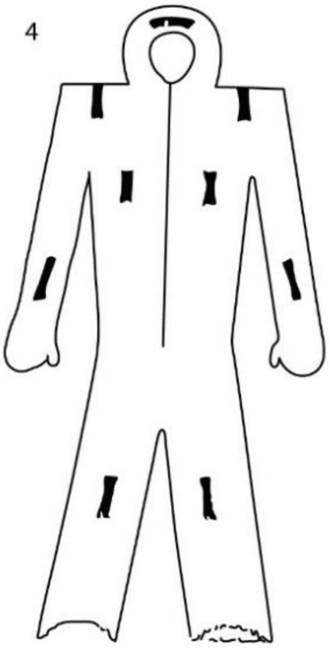

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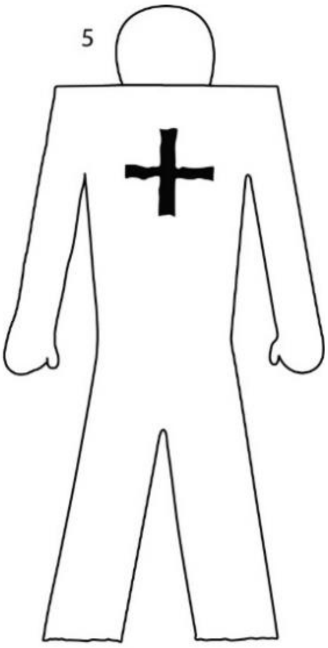

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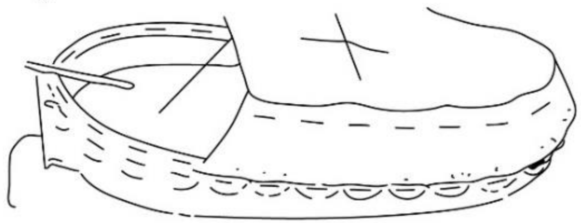

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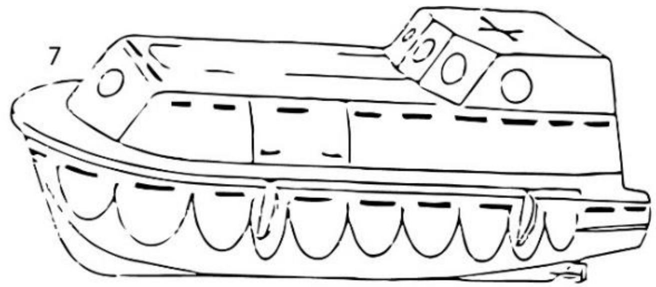

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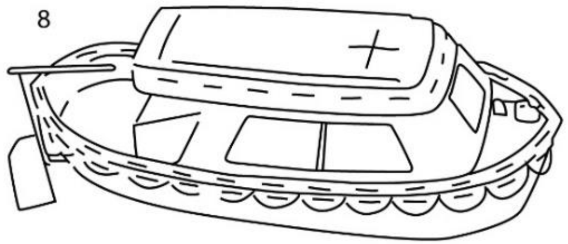

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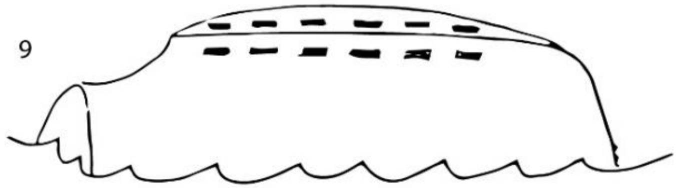

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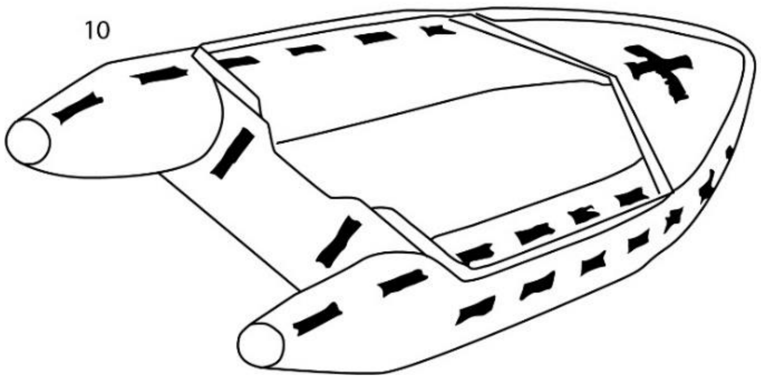

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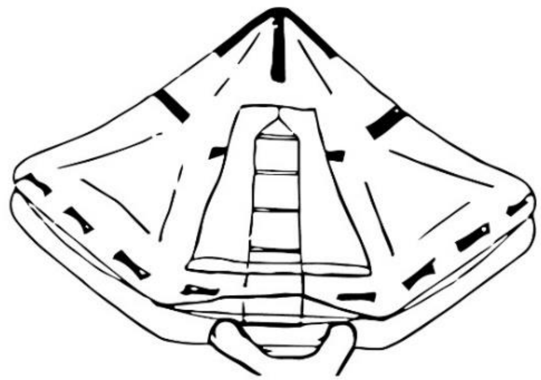

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ANNEX 2

TECHNICAL SPECIFICATION FOR RETRO-REFLECTIVE MATERIALS FOR USE ON LIFE-SAVING APPLIANCES

1 Scope

The present specification describes retro-reflective materials for application to the flexible or rigid surfaces of life-saving appliances to assist in their detection.

2 Classification

Type I: Flexible materials not for continuous outdoor exposure.

Type II: Highly weather-resistant materials for continuous outdoor exposure.

3 Performance requirements

3.1 *Photometric requirements*

The minimum coefficient of retro-reflection (R') when illuminated by CIE Standard Illuminant A (colour temperature 2856 K) should be as specified in table 3.1 for the retro-reflective areas of new and dry material when tested as described in section 4.2. The brightness of the retro-reflective material, when tested as described in section 4.9, should be not less than 80% of the table 3.1 values.

Table 3.1
Minimum coefficient of retro-reflection R' in cd•lx $^{-1}$•m^{-2}

Entrance angle B_1 (B_2=0)	Observation angles			
	0.1°	0.2°	0.5°	1°
5	180	175	72	14
30	140	135	70	12
45	85	85	48	9.4

3.2 *Accelerated weathering*

Applied to an aluminium test panel, the material should show no significant discoloration, cracking, blistering or dimensional change, and should have not less than 80% of the specified minimum reflective intensity values in table 3.1, when tested as described in section 4.10.

3.3 *Seawater immersion*

Where tested as described in section 4.3, the material should show no evidence of blistering, delamination or subsurface corrosion. The material should show no evidence of "whitening" and its retro-reflective intensity should not be reduced below the retro-reflective values in table 3.1, except within 5 mm of each side of the required cuts.

3.4 *Flexibility*

There should be no cracking of the retro-reflective material, after conditioning for 4 hours at -30° C, when bent around a 3.2 mm mandrel and tested as described in section 4.4.

3.5 *Tensile strength*

Tensile strength N (newton) per 25 mm width:

material without support	≥16 N
material with support	≥330 N longitudinal
for mechanical fastening	≥200 N transverse,

when tested as described in section 4.5.

3.6 *Adhesive strength*

For adhesive-backed material only. The adhesive strength should be not less than 16 N per 25 mm width when tested as described in section 4.6.

3.7 *Blocking*

The material should show no blocking when tested as described in section 4.7.

3.8 *Salt spray resistance*

The material should show no evidence of corrosion or degradation that would impair its effectiveness or reduce the coefficient of retro-reflection below the values in table 3.1 after exposure to a saline mist for 120 hours followed by cleaning with a dilute neutral detergent solution as described in section 4.8.

3.9 *Temperature resistance*

The material should show no evidence of cracking, distortion, or loss of coefficient of retro-reflection below the values in table 3.1 after exposure, in a dry atmosphere, for 24 hours to a temperature of 65 ± 2°C and subsequent exposure for 24 hours to a temperature of -30 ± 2°C.

3.10 *Fungus resistance*

Applied to an aluminium test panel, the material should not support fungus growth, should show no loss of coefficient of retro-reflection below the levels in table 3.1, and should not be removable from the test panel without damage, when tested as described in section 4.11.

3.11 *Abrasion resistance*

Applied to an aluminium test panel, the material should not have less than 50% of the specified minimum reflective intensity values in table 3.1, when tested as described in section 4.12.

3.12 *Soil resistance and cleanability*

Applied to an aluminium test panel, the material should not have any significant visible damage or permanent soiling when tested as described in section 4.13.

4 Test methods and interpretation of test results

4.1 *Test conditions and number of samples*

Test specimens should be conditioned for 24 hours at a temperature of 23 ± 1°C and 50 ± 5% relative humidity before being tested. All test results should be interpreted as the average obtained from testing at least three specimens.

4.2 *Photometric performance*

The photometric performance should be measured using the general procedure recommended by CIE Report No.54, 1982. The sample dimensions should be 150 mm by 150 mm. Entrance and observation angles should be as specified in table 3.1. Readings should be taken at not greater than 30° increments as the observation half-plane is rotated about the reference axis (i.e. at rotation angles (ε) of 0°, 30°, 60°, 90°,120°, 150° and 180°). Each measured value should be the average of the readings for all of the required samples.

4.3 *Seawater immersion*

4.3.1 Prepare a 75 mm x 150 mm test panel.

(A) material without support: After removing protective liner paper, apply specimens to a clean aluminium panel surface, using a hand-roller for application.

(B) material with support for mechanical fastening: Tape edges of test specimens to a clean aluminium panel.

4.3.2 The retro-reflective material on each test panel is cut with a sharp knife from each corner diagonally opposite so that an "X" is formed. The cuts must be made completely through the material to the metal panel.

4.3.3 Immerse the test panels to half-length in a 4% (by weight) saltwater solution (4 g NaCl dissolved in 96 ml distilled water) at 25°C, using a glass beaker covered by a glass plate. After a 16-hour immersion period, remove the panels from the beaker, rinse salt deposits from the panels, and examine the sample following a 10-minute recovery period and again after 4 hours for compliance with the requirements described in section 3.3.

4.4 *Flexibility*

4.4.1 Condition test specimen for 4 hours in a cold chamber at -30°C. A 3.2 mm mandrel should be conditioned at the same temperature. The sample should be bent over the free-standing mandrel, gently applying gloved finger pressure.

4.4.2 For material without support, remove protective liner and talc the adhesive to prevent sticking.

4.5 Tensile strength

Prepare three test samples 25 mm in width and 150 mm in length. Insert samples into the grips or jaws of the testing machine so that the load is distributed evenly across the width of the samples and the initial test length is 100 mm. Determine tensile strength at a speed of 300 mm per minute. Record average tensile strength at break in newtons per 25 mm width for all three test samples. For material without support, remove protective liner paper before inserting samples in the tensile tester.

4.6 *Adhesive strength (for material without support only)*

4.6.1 Prepare three test samples 25 mm in width and 200 mm in length for each type of surface to which the material is to be applied. Remove protective liner paper for 80 mm in length and apply test specimens to the test surfaces. Test surfaces should be aluminium, GRP, each type of lifejacket and lifebuoy that the material is to be used on, and inflatable liferaft buoyancy tube material. Test surfaces should be 50 mm in width, 90 mm in length, and of the thickness normally used and should be properly cleaned by wiping the surface with a suitable solvent.

4.6.2 Apply test specimens with a solid brass roller, 80 mm in diameter and 40 mm in width covered with rubber approximately 6 mm thick and having a hardness of 80 ± 1 RHD and a total mass of approximately 2 kg. Use three passes for roller application and allow to have a 120 mm free overlap strip to be used for inserting into the jaw clamp of the testing instrument. One test panel should be immersed in distilled water in a covered container for 16 hours before adhesive strength testing and the other test panel should be immersed in salt water (4% NaCl by weight) in a covered container for 16 hours before adhesive strength testing (this test method is required only for retro-reflective material that is designed for use with an adhesive. If a particular test panel used in testing results in a test failure, the retro-reflective material should not be approved for attachment to material of the type used in the test panel). Peel back at an angle of 180° at a speed of 300 mm per minute. Record adhesive strength in newtons per 25 mm width. Repeat the adhesive strength tests on samples subjected to the weathering test in section 4.10.

4.7 *Blocking*

Stack two 100 mm x 100 mm pieces of material, retro-reflective face to retro-reflective face, between two pieces of glass plate 3 mm thick of the same size as the samples and place in an air-circulating oven operating at 65°C. Place an 18 kg weight centrally on the top glass plate and close the oven. After 8 hours, remove the test assembly from the oven, take the retro-reflective material from between the plates and cool for 5 min. Separate the two pieces of retro-reflective material and examine for evidence of adhering or peeling of the surface.

4.8 *Salt spray resistance*

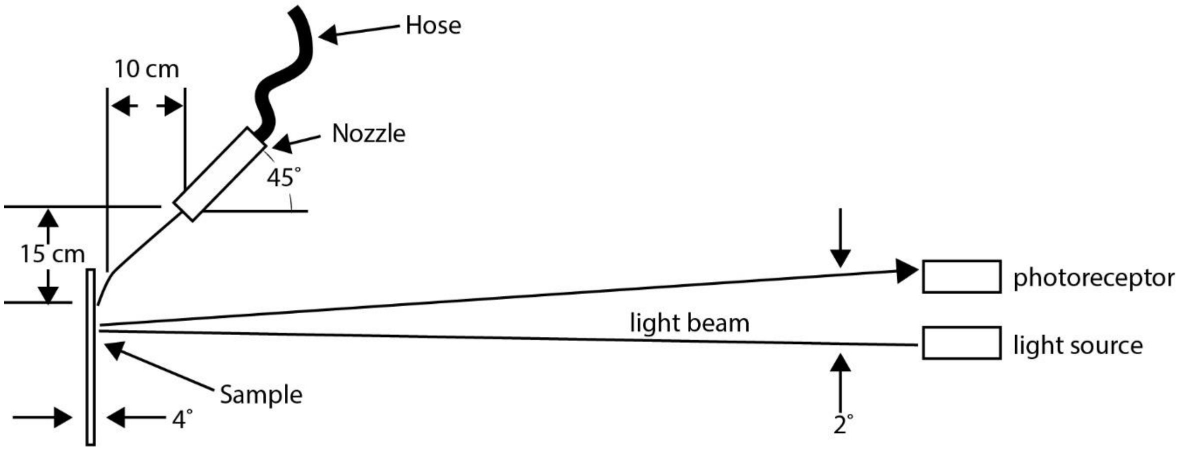
4.8.1 Prepare test specimens as described in section 4.3 (A) and (B), respectively, and expose them to a salt spray chamber.

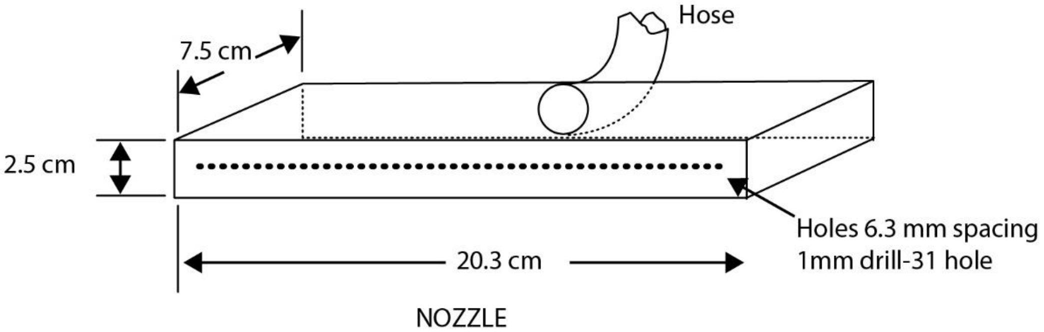
4.8.2 The test should consist of five periods of 22 hours' exposure each, separated by an interval of 2 hours during which samples are allowed to dry. The saline mist should be produced by atomizing, at a temperature of 35 ± 2°C, a saline solution obtained by dissolving five parts of NaCl in 95 parts of water, containing not more than 0.2% of impurities.

4.9 *Photometric performance when wet*

An unweathered 150 mm x 75 mm specimen should be mounted in a vertical plane, with the 150 mm dimension oriented horizontally. Apply sufficient water so that the entire specimen surface is covered by a continuous moving film of water. Measure the coefficient of retro-reflection at 0.2° observation angle and 5° entrance angle. An example of an appropriate test apparatus is shown in figure 1.

Figure 1





Suggested Wet Test Apparatus

4.10 *Accelerated weathering*

4.10.1 The photometric performance of the material should be determined according to section 4.2 after the material has been exposed in a sunshine carbon arc weatherometer for the following periods:

Type I material: 750 h
Type II material: 1,500 h

4.10.2 Alternative light sources other than a carbon arc may be used and exposure times for such sources should give an equivalent degree of accelerated weathering. Accelerated weathering should follow the test methodology in accordance with an international standard acceptable to the Organization.*

4.10.3 After exposure, the material should be examined for the requirements and characteristics in section 3.2.

4.11 *Fungus resistance*

4.11.1 Prepare three 75 mm x 75 mm test panels as described in section 4.3 (A). Prepare three additional test panels as described in section 4.3 (B), using non-rusting, non-staining clips or fasteners (in lieu of tape) to hold the material flat. Expose the panels to mildew, using the soil burial method, for a period of 2 weeks. The microbial activity of the soil should be verified by exposing untreated cotton fabric of 400 g/m^2 to 475 g/m^2 to the soil bed for the first 5 days. The soil should be considered to be satisfactory if this control sample loses not less than 50% of its original tensile strength during this exposure.

4.11.2 At the end of the exposure period, the test panels should be removed from the soil bed, gently washed to remove soil, and wiped with a soft cloth wet with a 70% ethanol solution. Condition the panels under standard conditions for 48 hours. Test the photometric performance of the specimens as described in section 4.2 and, when finished, attempt to remove the material from the test panel.

4.12 *Abrasion resistance*

4.12.1 An apparatus is required which should consist of an electric motor mounted on a flat metal plate, and a mechanism through which the motor will impart a reciprocating motion to a brush lengthwise across the full length of a test panel clamped to the plate. Prepare one test panel 150 mm wide x 425 mm long, as described in section 4.3 (A). Mount the panel firmly on the test apparatus and place the brush on the panel.

4.12.2 The block of the brush should be aluminium, 90 mm long x 40 mm wide and 12.5 mm thick. The brush stock should be stiff, black, butt-cut Chinese hog bristle. There should be 60 holes on the block, 4 mm in diameter, solidly filled with bristle. The bristles should extend 20 mm beyond the block to form an abrading surface as nearly planar as possible. The total weight of the brush should be 450 ± 15 g. Weights may be fastened to the top of the brush to attain this weight.

4.12.3 Start the motor. The apparatus should be adjusted so that the brush travels at a rate of 37 ± 2 cycles (74 ± 4 strokes) per minute. Remove the panel after 1,000 brush strokes and wipe with a clean, soft cloth. Test the photometric performance of the material, as described in section 4.2.

4.13 *Soil resistance and cleanability*

Prepare a test panel 150 mm x 150 mm, as described in section 4.3 (A). Soil the panel by applying a film, 90 mm wide x 0.075 mm thick, of thoroughly mixed soiling medium across the middle of the test panel. The soiling medium should consist of a mixture of 8 g carbon black, 60 g mineral oil and 32 g odourless mineral spirits. Cover the soiled area for 24 hours with a

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* Refer to the recommendations by the International Organization for Standardization, in particular ISO 4892-1:2016, and ISO 4892-2:2013 or ISO 4892-3:2016 or ISO 4892-4:2013.

laboratory watch glass or similar device. Uncover the material and wipe off the soiling medium with a clean, dry, soft cloth. Wet the material with mineral spirits and wipe with a cloth soaked in mineral spirits. Wash with a 1% (by weight) solution of detergent in warm water, rinse, and dry with a clean, dry, soft cloth. Examine the sample for compliance with section 3.12.

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ANNEX 13

RESOLUTION MSC.429(98)/Rev.1
(adopted on 11 November 2020)

REVISED EXPLANATORY NOTES TO THE SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the function of the Committee,

RECALLING ALSO that, by resolution MSC.216(82), it adopted the regulations on subdivision and damage stability as contained in SOLAS chapter II-1 which are based on the probabilistic concept, using the probability of survival after collision as a measure of ships' safety in a damaged condition,

NOTING that, at the eighty-second session, it approved *Interim explanatory notes to the SOLAS chapter II-1 subdivision and damage stability regulations* (MSC.1/Circ.1226), to assist Administrations in the uniform interpretation and application of the aforementioned subdivision and damage stability regulations,

NOTING ALSO that, at the eighty-fifth session, it adopted the *Explanatory notes to the SOLAS chapter II-1 subdivision and damage stability regulations* (resolution MSC.281(85)),

NOTING FURTHER that, by resolution MSC.421(98), it adopted amendments to regulations on subdivision and damage stability, as contained in SOLAS chapter II-1,

RECOGNIZING that the Revised Explanatory Notes should be adopted in conjunction with the adoption of the aforementioned amendments to subdivision and damage stability regulations (resolution MSC.421(98)),

RECOGNIZING ALSO that the appropriate application of the Revised Explanatory Notes is essential for ensuring the uniform application of the SOLAS chapter II-1 subdivision and damage stability regulations,

RECALLING that, having considered, at its ninety-eighth session (7 to 16 June 2017), the recommendations made by the Sub-Committee on Ship Design and Construction at its fourth session, it adopted, by resolution MSC.429(98), the *Revised explanatory notes to the SOLAS chapter II-1 subdivision and damage stability regulations*,

HAVING CONSIDERED, at its 102nd session, minor amendments to paragraph 4 of the Explanatory Note to SOLAS regulation 17 (Internal watertight integrity of passenger ships above the bulkhead deck),

1 ADOPTS the *Revised explanatory notes to the SOLAS chapter II-1 subdivision and damage stability regulations* set out in the annex to the present resolution;

2 URGES Contracting Governments and all parties concerned to utilize the Revised Explanatory Notes when applying the SOLAS chapter II-1 subdivision and damage stability regulations adopted by resolution MSC.216(82), as amended;

3 INVITES Contracting Governments to note that these Revised Explanatory Notes take effect on ships as defined in SOLAS regulation II-1/1.1.1, as adopted by resolution MSC.421(98).

4 REVOKES resolution MSC.429(98).

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ANNEX

REVISED EXPLANATORY NOTES TO THE SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS

Contents

PART A

INTRODUCTION

1 The harmonized SOLAS regulations on subdivision and damage stability, as contained in SOLAS chapter II-1, are based on a probabilistic concept which uses the probability of survival after collision as a measure of ships' safety in a damaged condition. This probability is referred to as the "attained subdivision index *A*" in the regulations. It can be considered an objective measure of ships' safety and, ideally, there would be no need to supplement this index by any deterministic requirements.

2 The philosophy behind the probabilistic concept is that two different ships with the same attained index are of equal safety and, therefore, there is no need for special treatment of specific parts of the ship, even if they are able to survive different damages. The only areas which are given special attention in the regulations are the forward and bottom regions, which are dealt with by special subdivision rules provided for cases of ramming and grounding.

3 Only a few deterministic elements, which were necessary to make the concept practicable, have been included. It was also necessary to include a deterministic "minor damage" on top of the probabilistic regulations for passenger ships to avoid ships being designed with what might be perceived as unacceptably vulnerable spots in some part of their length.

4 It is easily recognized that there are many factors that will affect the final consequences of hull damage to a ship. These factors are random and their influence is different for ships with different characteristics. For example, it would seem obvious that in ships of similar size carrying different amounts of cargo, damages of similar extents may lead to different results because of differences in the range of permeability and draught during service. The mass and velocity of the ramming ship is obviously another random variable.

5 Owing to this, the effect of a three-dimensional damage to a ship with given watertight subdivision depends on the following circumstances:

.1 which particular space or group of adjacent spaces is flooded;

.2 the draught, trim and intact metacentric height at the time of damage;

.3 the permeability of affected spaces at the time of damage;

.4 the sea state at the time of damage; and

.5 other factors such as possible heeling moments owing to unsymmetrical weights.

6 Some of these circumstances are interdependent and the relationship between them and their effects may vary in different cases. Additionally, the effect of hull strength on penetration will obviously have some effect on the results for a given ship. Since the location and size of the damage is random, it is not possible to state which part of the ship becomes flooded. However, the probability of flooding a given space can be determined if the probability of occurrence of certain damages is known from experience, that is, damage statistics. The probability of flooding a space is then equal to the probability of occurrence of all such damages which just open the considered space to the sea.

7 For these reasons and because of mathematical complexity as well as insufficient data, it would not be practicable to make an exact or direct assessment of their effect on the probability that a particular ship will survive a random damage if it occurs. However, accepting some approximations or qualitative judgments, a logical treatment may be achieved by using the probability approach as the basis for a comparative method for the assessment and regulation of ship safety.

8 It may be demonstrated by means of probability theory that the probability of ship survival should be calculated as the sum of probabilities of its survival after flooding each single compartment, each group of two, three, etc., adjacent compartments multiplied, respectively, by the probabilities of occurrence of such damages leading to the flooding of the corresponding compartment or group of compartments.

9 If the probability of occurrence for each of the damage scenarios the ship could be subjected to is calculated and then combined with the probability of surviving each of these damages with the ship loaded in the most probable loading conditions, the attained index *A* as a measure for the ship's ability to sustain a collision damage can be determined.

10 It follows that the probability that a ship will remain afloat without sinking or capsizing as a result of an arbitrary collision in a given longitudinal position can be broken down to:

.1 the probability that the longitudinal centre of damage occurs in just the region of the ship under consideration;

.2 the probability that this damage has a longitudinal extent that only includes spaces between the transverse watertight bulkheads found in this region;

.3 the probability that the damage has a vertical extent that will flood only the spaces below a given horizontal boundary, such as a watertight deck;

.4 the probability that the damage has a transverse penetration not greater than the distance to a given longitudinal boundary; and

.5 the probability that the watertight integrity and the stability throughout the flooding sequence is sufficient to avoid capsizing or sinking.

11 The first three of these factors are solely dependent on the watertight arrangement of the ship, while the last two depend on the ship's shape. The last factor also depends on the actual loading condition. By grouping these probabilities, calculations of the probability of survival, or attained index *A*, have been formulated to include the following probabilities:

.1 the probability of flooding each single compartment and each possible group of two or more adjacent compartments; and

.2 the probability that the stability after flooding a compartment or a group of two or more adjacent compartments will be sufficient to prevent capsizing or dangerous heeling due to loss of stability or to heeling moments in intermediate or final stages of flooding.

12 This concept allows a rule requirement to be applied by requiring a minimum value of *A* for a particular ship. This minimum value is referred to as the "required subdivision index *R*" in the present regulations and can be made dependent on ship size, number of passengers or other factors legislators might consider important.

13 Evidence of compliance with the rules then simply becomes:

$$A \geq R$$

13.1 As explained above, the attained subdivision index *A* is determined by a formula for the entire probability as the sum of the products for each compartment or group of compartments of the probability that a space is flooded, multiplied by the probability that the ship will not capsize or sink due to flooding of the considered space. In other words, the general formula for the attained index can be given in the form:

$$A = \Sigma p_i s_i$$

13.2 Subscript "i" represents the damage zone (group of compartments) under consideration within the watertight subdivision of the ship. The subdivision is viewed in the longitudinal direction, starting with the aftmost zone/compartment.

13.3 The value of "p_i" represents the probability that only the zone "i" under consideration will be flooded, disregarding any horizontal subdivision, but taking transverse subdivision into account. Longitudinal subdivision within the zone will result in additional flooding scenarios, each with its own probability of occurrence.

13.4 The value of "s_i" represents the probability of survival after flooding the zone "i" under consideration.

14 Although the ideas outlined above are very simple, their practical application in an exact manner would give rise to several difficulties if a mathematically perfect method were to be developed. As pointed out above, an extensive but still incomplete description of the damage will include its longitudinal and vertical location as well as its longitudinal, vertical and transverse extent. Apart from the difficulties in handling such a five-dimensional random variable, it is impossible to determine its probability distribution very accurately with the presently available damage statistics. Similar limitations are true for the variables and physical relationships involved in the calculation of the probability that a ship will not capsize or sink during intermediate stages or in the final stage of flooding.

15 A close approximation of the available statistics would result in extremely numerous and complicated computations. In order to make the concept practicable, extensive simplifications are necessary. Although it is not possible to calculate the exact probability of survival on such a simplified basis, it has still been possible to develop a useful comparative measure of the merits of the longitudinal, transverse and horizontal subdivision of a ship.

PART B

GUIDANCE ON INDIVIDUAL SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS

REGULATION 1 – APPLICATION

Regulation 1.3

1 If a passenger ship built before 1 January 2009 undergoes alterations or modifications of major character, it may still remain under the damage stability regulations applicable to ships built before 1 January 2009.

2 If a passenger ship constructed on or after 1 January 2009 but before the applicable dates in regulation 1.1.1.1[1] undergoes alterations or modifications of major character that do not impact the watertight subdivision of the ship, or only have a minor impact, it may still remain under the damage stability regulations that were applicable when it was constructed. However, if alterations or modifications of major character significantly impact the watertight subdivision of the ship, it should comply with the damage stability regulations in part B-1 applicable when the alterations or modifications of major character are carried out unless the Administration determines that this is not reasonable and practicable, in which case the attained subdivision index *A* should be raised above the original construction required subdivision index *R* as much as practical.

3 Application of MSC.1/Circ.1246 is limited to cargo ships constructed before 1 January 2009.

4 A cargo ship constructed on or after 1 January 2009 of less than 80 m in length that is later lengthened beyond that limit should fully comply with the damage stability regulations according to its type and length.

5 If a passenger ship that has been in domestic service only and never been issued a SOLAS Passenger Ship Safety Certificate is converted to international service, for purposes of the stability requirements in parts B, B-1, B-2, B-3 and B-4 it should be treated as a passenger ship constructed on the date on which such a conversion commences.

REGULATION 2 – DEFINITIONS

Regulation 2.1

Subdivision length (L_s) – Different examples of L_s showing the buoyant hull and the reserve buoyancy are provided in the figures below. The limiting deck for the reserve buoyancy may be partially watertight.

The maximum possible vertical extent of damage above the baseline is d_s + 12.5 metres.

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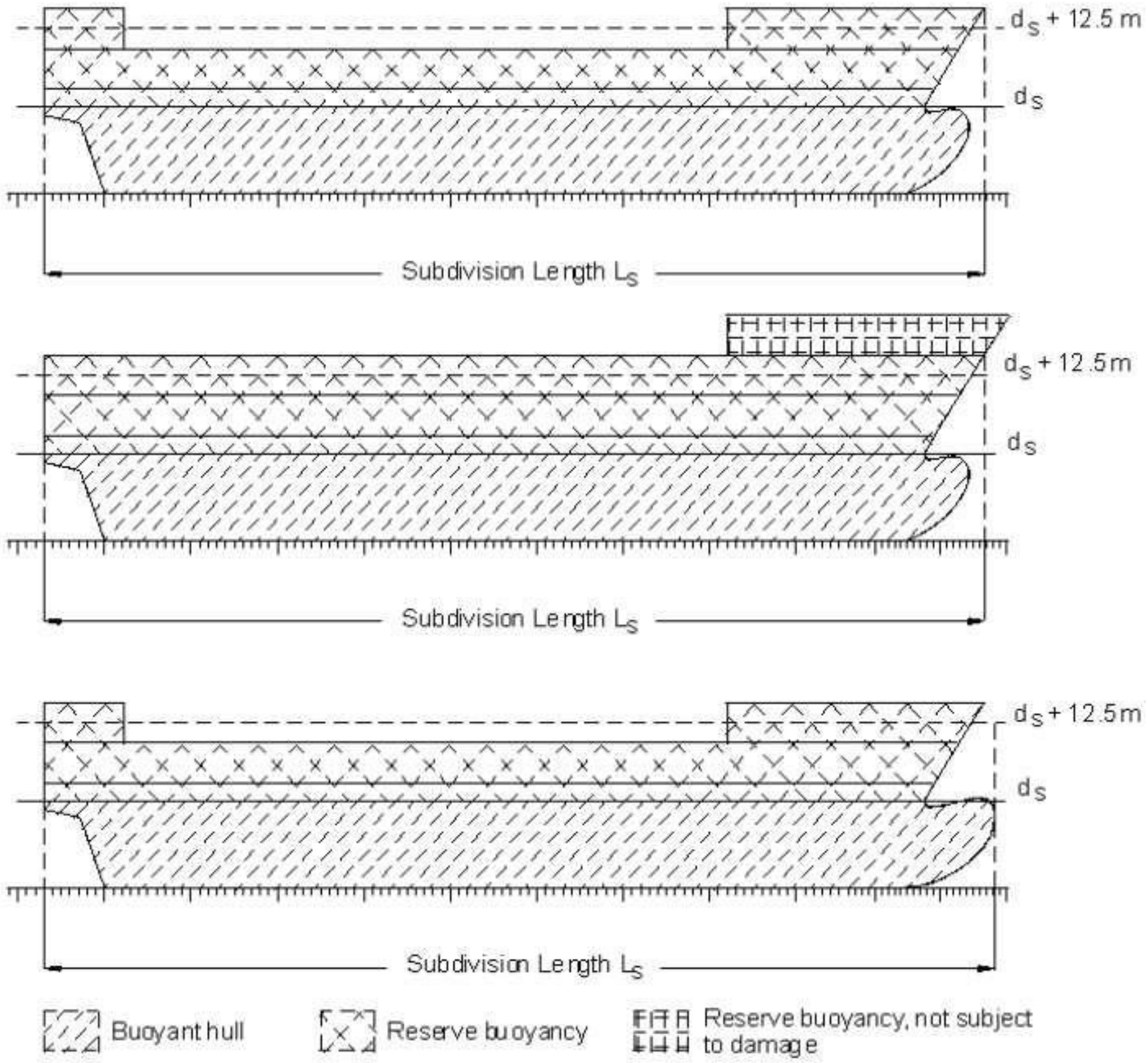
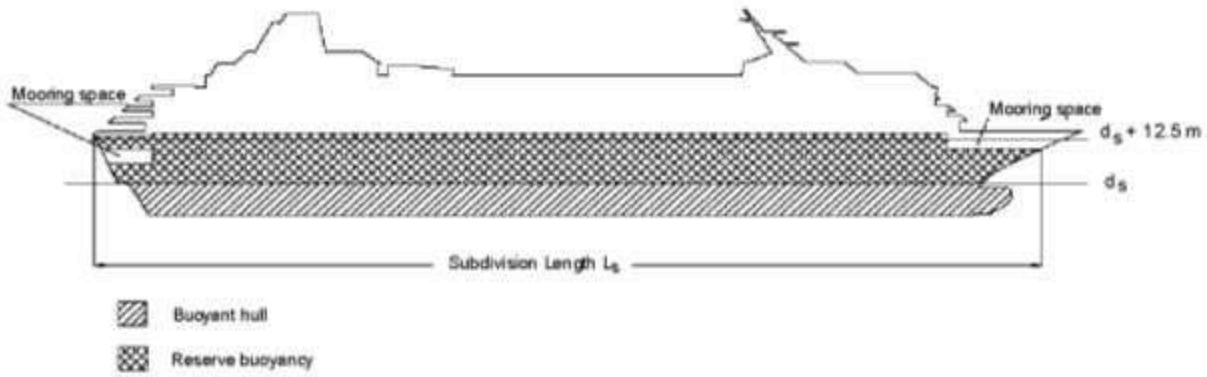
[1] References to regulations in this Guidance are to regulations of SOLAS chapter II-1, unless expressly provided otherwise.





Regulation 2.6

Freeboard deck – See explanatory notes for regulation 13-1 for the treatment of a stepped freeboard deck with regard to watertightness and construction requirements.

Regulation 2.11

Light service draught (d_l) – The light service draught (d_l) corresponds, in general, to the ballast arrival condition with 10% consumables for cargo ships. For passenger ships it corresponds, in general, to the arrival condition with 10% consumables, a full complement of passengers and crew and their effects, and ballast as necessary for stability and trim. Any temporary ballast water exchange conditions for compliance with the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 or any non-service conditions, such as dry-docking, should not be taken as d_l.

Regulation 2.19

Bulkhead deck – See explanatory notes for regulation 13 for the treatment of a stepped bulkhead deck with regard to watertightness and construction requirements.

REGULATION 4 – GENERAL

Regulation 4.5

See explanatory notes for regulation 7-2.2, for information and guidance related to these provisions.

REGULATION 5 – INTACT STABILITY

Regulation 5.2

1 For the purpose of this regulation, a sister ship means a cargo ship built by the same shipyard from the same plans.

2 For any new sister ship with known differences from the lead sister ship that do not exceed the lightship displacement and longitudinal centre of gravity deviation limits specified in regulation 5.2, a detailed weights and centres of gravity calculation to adjust the lead sister ship's lightship properties should be carried out. These adjusted lead sister ship lightship properties are then used for comparison to the new sister ship's lightweight survey results. However, in cases when the known differences from the lead sister ship exceed lightship displacement or longitudinal centre of gravity deviation limits specified in regulation 5.2, the ship should be inclined.

3 When the lightweight survey results do not exceed the specified deviation limits, the lightship displacement and the longitudinal and transverse centres of gravity obtained from the lightweight survey should be used in conjunction with the higher of either the lead sister ship's vertical centre of gravity or the calculated, adjusted value.

4 Regulation 5.2 may be applied to the SPS Code ships certified to carry less than 240 persons.

Regulation 5.4

1 When alterations are made to a ship in service that result in calculable differences in the lightship properties, a detailed weights and centres of gravity calculation to adjust the lightship properties should be carried out. If the adjusted lightship displacement or longitudinal centre of gravity, when compared to the approved values, exceeds one of the deviation limits specified in regulation 5.5, the ship should be re-inclined. In addition, if the adjusted lightship vertical centre of gravity, when compared to the approved value, exceeds 1%, the ship should be re-inclined. The lightship transverse centre of gravity is not subject to a deviation limit.

2 When a ship does not exceed the deviation limits specified in explanatory note 1 above, amended stability information should be provided to the master using the new calculated lightship properties if any of the following deviations from the approved values are exceeded:

.1 1% of the lightship displacement; or

.2 0.5% of L for the longitudinal centre of gravity; or

.3 0.5% of the vertical centre of gravity.

2.1 However, in cases when these deviation limits are not exceeded, it is not necessary to amend the stability information supplied to the master.

3 When multiple alterations are made to a ship in service over a period of time and each alteration is within the deviation limits specified above, the cumulative total changes to the lightship properties from the most recent inclining also should not exceed the deviation limits specified above or the ship should be re-inclined.

Regulation 5.5

When the lightweight survey results do not exceed the specified deviation limits, the lightship displacement and the longitudinal and transverse centres of gravity obtained from the lightweight survey should be used in conjunction with the vertical centre of gravity derived from the most recent inclining in all subsequent stability information supplied to the master.

REGULATION 5-1 – STABILITY INFORMATION TO BE SUPPLIED TO THE MASTER

Regulation 5-1.3

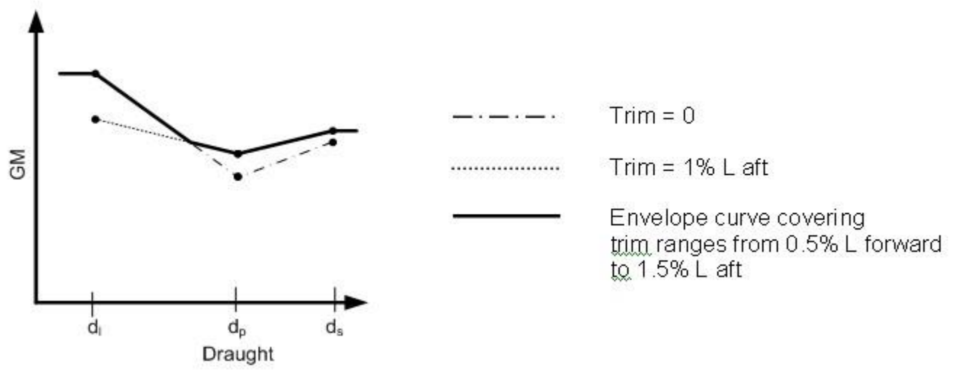
The requirement that applied trim values shall coincide in all stability information intended for use on board is intended to address initial stability calculations as well as those that may be necessary during the service life of the ship.

Regulation 5-1.4 (see also regulation 7.2)

1 Linear interpolation of the limiting values between the draughts d_s, d_p and d_l is only applicable to minimum *GM* values. If it is intended to develop curves of maximum permissible *KG*, a sufficient number of KM_T values for intermediate draughts should be calculated to ensure that the resulting maximum *KG* curves correspond with a linear variation of *GM*. When light service draught is not with the same trim as other draughts, KM_T for draughts between partial and light service draught should be calculated for trims interpolated between trim at partial draught and trim at light service draught.

2 In cases where the operational trim range is intended to exceed ±0.5% of *L*, the original *GM* limit line should be designed in the usual manner with the deepest subdivision draught and partial subdivision draught calculated at level trim and estimated service trim used for the light service draught. Then additional sets of *GM* limit lines should be constructed on the basis of the operational range of trims which is covered by loading conditions for each of the three draughts d_s, d_p and d_l ensuring that intervals of 1% *L* are not exceeded. The sets of *GM* limit lines are combined to give a single envelope limiting *GM* curve. The effective trim range of the curve should be clearly stated.

3 If multiple *GM* limiting curves are obtained from damage stability calculations of differing trims in accordance with regulation 7, an envelope curve covering all calculated trim values should be developed. Calculations covering different trim values should be carried out in steps not exceeding 1% of *L*. The whole range including intermediate trims should be covered by the damage stability calculations. Refer to the example showing an envelope curve obtained from calculations of 0 trim and 1% of *L*.

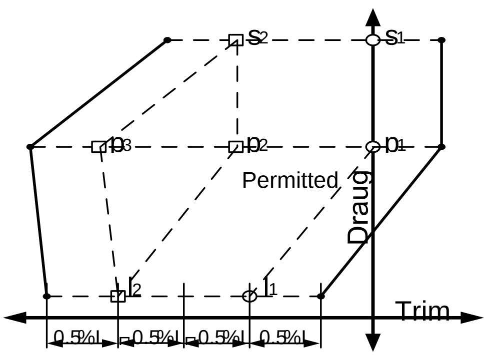


4 Temporary loading conditions may occur with a draught less than the light service draught d_l due to ballast water exchange requirements, etc. In these cases, for draughts below d_l, the *GM* limit value at d_l is to be used.

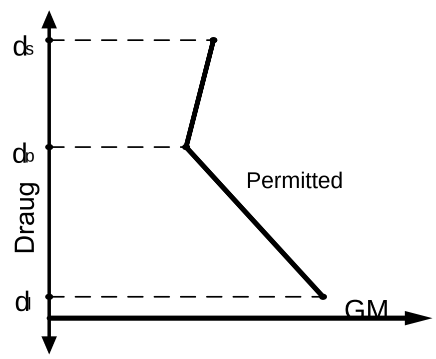
5 Ships may be permitted to sail at draughts above the deepest subdivision draught d_s according to the International Convention on Load Lines, e.g. using the tropical freeboard. In these cases, for draughts above d_s the *GM* limit value at d_s is to be used.

Regulation 5-1.5

There could be cases where it is desirable to expand the trim range, for instance around d_p. This approach is based on the principle that it is not necessary that the same number of trims be used when the *GM* is the same throughout a draught and when the steps between trims do not exceed 1% of *L*. In these cases there will be three *A* values based on draughts s_1, p_1, l_1 and s_2, p_2, l_2 and s_2, p_3, l_2. The lowest value of each partial index A_s, A_p and A_l across these trims should be used in the summation of the attained subdivision index *A*.



Trim limit diagram



GM limit curve

Regulation 5-1.6

This provision is intended to address cases where an Administration approves an alternative means of verification.

REGULATION 6 – REQUIRED SUBDIVISION INDEX *R*

Regulation 6.1

To demonstrate compliance with these provisions, see the *Guidelines for the preparation of subdivision and damage stability calculations*, set out in the appendix, regarding the presentation of damage stability calculation results.

REGULATION 7 – ATTAINED SUBDIVISION INDEX *A*

Regulation 7.1

1 The probability of surviving after collision damage to the ship's hull is expressed by the index *A*. Producing an index *A* requires calculation of various damage scenarios defined by the extent of damage and the initial loading conditions of the ship before damage. Three loading conditions should be considered and the result weighted as follows:

$$A = 0.4A_s + 0.4A_p + 0.2A_l$$

where the indices *s*, *p* and *l* represent the three loading conditions and the factor to be multiplied to the index indicates how the index *A* from each loading condition is weighted.

2 The method of calculating *A* for a loading condition is expressed by the formula:

$$A_c = \sum_{i=1}^{i=t} p_i [v_i s_i]$$

2.1 The index *c* represents one of the three loading conditions, the index *i* represents each investigated damage or group of damages and *t* is the number of damages to be investigated to calculate A_c for the particular loading condition.

2.2 To obtain a maximum index *A* for a given subdivision, *t* has to be equal to *T*, the total number of damages.

3 In practice, the damage combinations to be considered are limited either by significantly reduced contributions to *A* (i.e. flooding of substantially larger volumes) or by exceeding the maximum possible damage length.

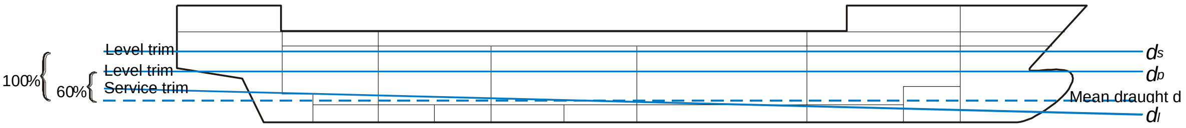
4 The index *A* is divided into partial factors as follows:

p_i The *p* factor is solely dependent on the geometry of the watertight arrangement of the ship.

v_i The *v* factor is dependent on the geometry of the watertight arrangement (decks) of the ship and the draught of the initial loading condition. It represents the probability that the spaces above the horizontal subdivision will not be flooded.

s_i The *s* factor is dependent on the calculated survivability of the ship after the considered damage for a specific initial condition.

5 Three initial loading conditions should be used for calculating each index *A.* The loading conditions are defined by their mean draught *d,* trim and *GM (*or *KG).* The mean draught and trim are illustrated in the figure below.



6 The *GM* (or *KG*) values for the three loading conditions could, as a first attempt, be taken from the intact stability *GM* (or *KG*) limit curve. If the required index *R* is not obtained, the *GM* (or *KG*) values may be increased (or reduced), implying that the intact loading conditions from the intact stability book must now meet the *GM* (or *KG*) limit curve from the damage stability calculations derived by linear interpolation between the three *GM*s.

7 For a series of new passenger or cargo ships built from the same plans each of which have the same draughts d_s, d_p and d_l as well as the same *GM* and trim limits, the attained subdivision index *A* calculated for the lead ship may be used for the other ships. In addition, small differences in the draught d_l (and the subsequent change in the draught d_p) are acceptable if they are due to small differences in the lightship characteristics that do not exceed the deviation limits specified in regulation 5.2. For cases where these conditions are not met, a new attained subdivision index *A* should be calculated.

"Built from the same plans" means that the watertight and weathertight aspects of the hull, bulkheads, openings and other parts of a ship that impact the attained subdivision index *A* calculation remain exactly the same.

8 For a passenger or cargo ship in service which undergoes alterations that materially affect the stability information supplied to the master and require it to be re-inclined in accordance with regulation 5.4, a new attained subdivision index *A* should be calculated. However, for alteration cases where a re-inclining is not required and the alterations do not change the watertight and weathertight arrangements of the ship that impact the attained subdivision index *A*, if d_s and the *GM* and trim limits remain the same then a new attained subdivision index *A* is not required.

9 For passenger ships subject to lightweight surveys every 5 years, if the lightweight survey results are within the limits specified in regulation 5.5, and d_s and the *GM* and trim limits remain the same, a new attained subdivision index *A* is not required. However, if the lightweight survey results exceed either limit specified in regulation 5.5, a new attained subdivision index *A* should be calculated.

10 For any new passenger or cargo ship for which the deviation in lightship characteristics between the preliminary and the as built values are within the limits specified in regulation 5.2 and d_s is unchanged, then the preliminary attained subdivision index *A* calculation may be approved as the final attained subdivision index *A* calculation. However, for cases where these conditions are not met, then a new attained subdivision index *A* should be calculated.

Regulation 7.2

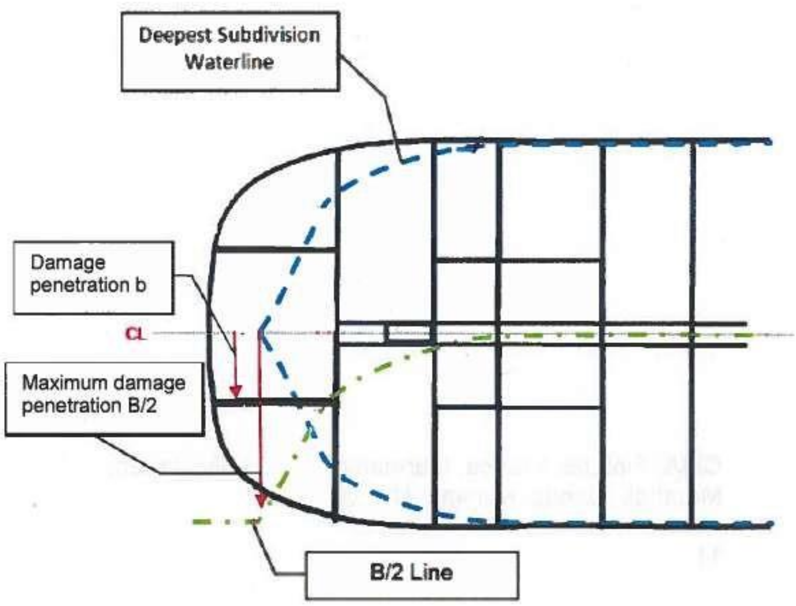
When additional calculations of *A* are performed for different trims, for a given set of calculations the difference between trim values for d_s, d_p and d_l may not exceed 1% *L*.

Regulation 7.5

1 With the same intent as wing tanks, the summation of the attained index *A* should reflect effects caused by all watertight bulkheads and flooding boundaries within the damaged zone. It is not correct to assume damage only to one half of the ship's breadth *B* and ignore changes in subdivision that would reflect lesser contributions.

2 In the forward and aft ends of the ship where the sectional breadth is less than the ship's breadth *B*, transverse damage penetration can extend beyond the centreline bulkhead. This application of the transverse extent of damage is consistent with the methodology to account for the localized statistics which are normalized on the greatest moulded breadth *B* rather than the local breadth.

3 Where, at the extreme ends of the ship, the subdivision exceeds the waterline at the deepest subdivision draught, the damage penetration *b* or *B*/2 is to be taken from centreline. The figure below illustrates the shape of the *B*/2 line.



4 Where longitudinal corrugated bulkheads are fitted in wing compartments or on the centreline, they may be treated as equivalent plane bulkheads provided the corrugation depth is of the same order as the stiffening structure. The same principle may also be applied to transverse corrugated bulkheads.

Regulation 7.6

Refer to the explanatory notes for regulation 7-2.2 for the treatment of free surfaces during all stages of flooding.

Regulation 7.7

1 Pipes and valves directly adjacent or situated as close as practicable to a bulkhead or to a deck can be considered to be part of the bulkhead or deck, provided the separation distance on either side of the bulkhead or deck is of the same order as the bulkhead or deck stiffening structure. The same applies for small recesses, drain wells, etc.

2 For ships up to L = 150 m the provision for allowing "minor progressive flooding" should be limited to pipes penetrating a watertight subdivision with a total cross-sectional area of not more than 710 mm^2 between any two watertight compartments. For ships of L = 150 m and upwards the total cross-sectional area of pipes should not exceed the cross-sectional area of one pipe with a diameter of L/5000 m.

REGULATION 7-1 – CALCULATION OF THE FACTOR p_i

General

1 The definitions below are intended to be used for the application of part B-1 only.

2 In regulation 7-1, the words "compartment" and "group of compartments" should be understood to mean "zone" and "adjacent zones".

3 Zone – a longitudinal interval of the ship within the subdivision length.

4 Room – a part of the ship, limited by bulkheads and decks, having a specific permeability.

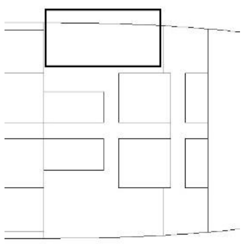
5 Space – a combination of rooms.

6 Compartment – a space within watertight boundaries.

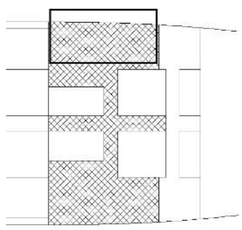
7 Damage – the three-dimensional extent of the breach in the ship.

8 For the calculation of p, v, r and b only the damage should be considered, for the calculation of the s-value the flooded space should be considered. The figures below illustrate the difference.

Damage shown as the bold square:



Flooded space shown below:



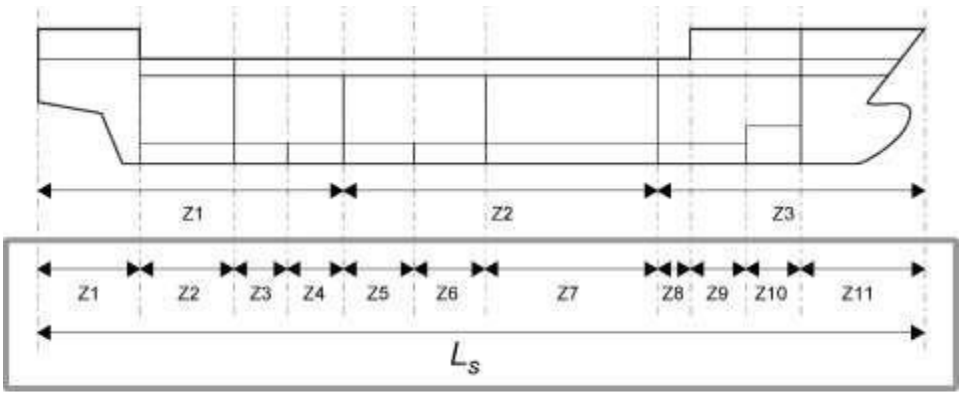
Regulation 7-1.1.1

1 The coefficients b_{11}, b_{12}, b_{21} and b_{22} are coefficients in the bi-linear probability density function on normalized damage length (J). The coefficient b_{12} is dependent on whether L_s is greater or less than L^* (i.e. 260 m); the other coefficients are valid irrespective of L_s.

1. Longitudinal subdivision

2 In order to prepare for the calculation of index A, the ship's subdivision length L_s is divided into a fixed discrete number of damage zones. These damage zones will determine the damage stability investigation in the way of specific damages to be calculated.

3 There are no specific rules for longitudinally subdividing the ship, except that the length L_s defines the extremities of the zones. Zone boundaries need not coincide with physical watertight boundaries. However, it is important to consider a strategy carefully to obtain a good result (that is a large attained index A). All zones and combination of adjacent zones may contribute to the index A. In general it is expected that the more zone boundaries the ship is divided into the higher the attained index will be, but this benefit should be balanced against extra computing time. The figure below shows different longitudinal zone divisions of the length L_s.



4 The first example is a very rough division into three zones of approximately the same size with limits where longitudinal subdivision is established. The probability that the ship will survive a damage in one of the three zones is expected to be low (i.e. the s-factor is low or zero) and, therefore, the total attained index A will be correspondingly low.

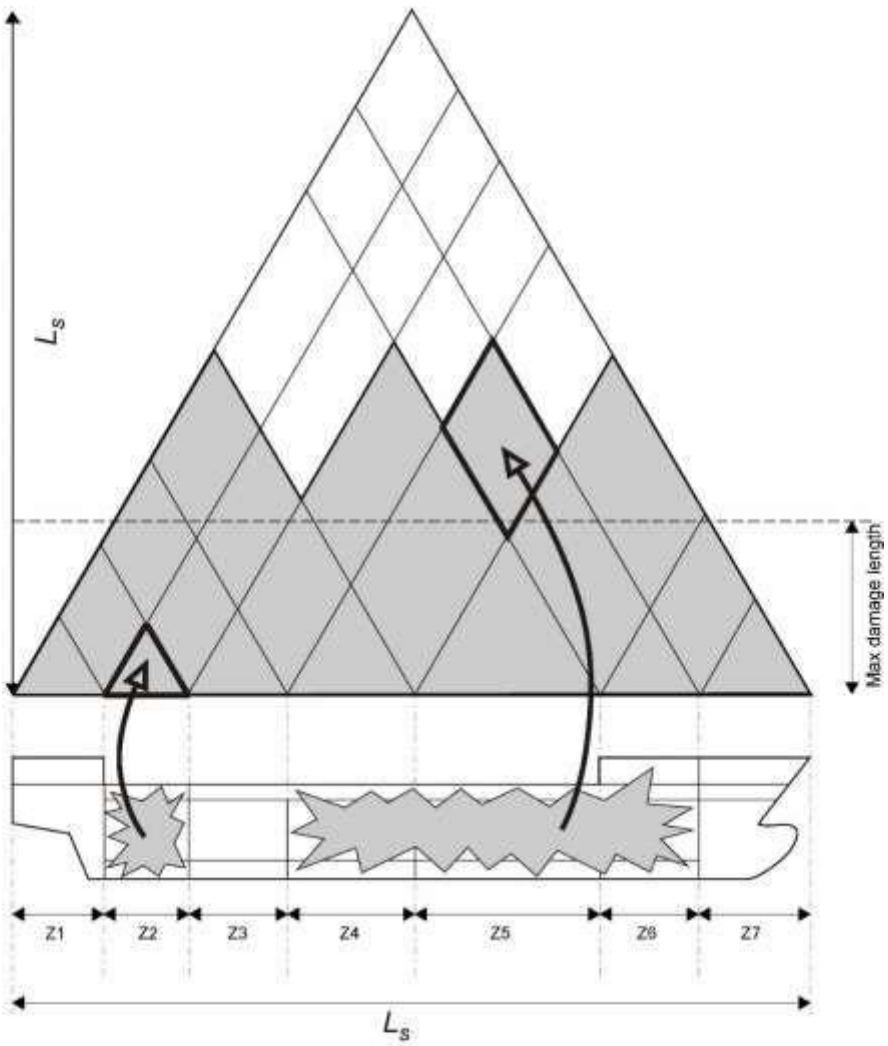
5 In the second example the zones have been placed in accordance with the watertight arrangement, including minor subdivision (as in double bottom, etc.). In this case there is a much better chance of obtaining higher s-factors.

6 Where transverse corrugated bulkheads are fitted, they may be treated as equivalent plane bulkheads, provided the corrugation depth is of the same order as the stiffening structure.

7 Pipes and valves directly adjacent or situated as close as practicable to a transverse bulkhead can be considered to be part of the bulkhead, provided the separation distance on either side of the bulkhead is of the same order as the bulkhead stiffening structure. The same applies for small recesses, drain wells, etc.

8 For cases where the pipes and valves cannot be considered as being part of the transverse bulkhead, when they present a risk of progressive flooding to other watertight compartments that will have influence on the overall attained index *A*, they should be handled either by introducing a new damage zone and accounting for the progressive flooding to associated compartments or by introducing a gap.

9 The triangle in the figure below illustrates the possible single and multiple zone damages in a ship with a watertight arrangement suitable for a seven-zone division. The triangles at the bottom line indicate single zone damages and the parallelograms indicate adjacent zones damages.



10 As an example, the triangle illustrates a damage opening the rooms in zone 2 to the sea and the parallelogram illustrates a damage where rooms in zones 4, 5 and 6 are flooded simultaneously.

11 The shaded area illustrates the effect of the maximum absolute damage length. The *p*-factor for a combination of three or more adjacent zones equals zero if the length of the combined adjacent damage zones minus the length of the foremost and the aft most damage zones in the combined damage zone is greater than the maximum damage length. Having this in mind when subdividing L_s could limit the number of zones defined to maximize the attained index *A*.

12 As the *p*-factor is related to the watertight arrangement by the longitudinal limits of damage zones and the transverse distance from the ship side to any longitudinal barrier in the zone, the following indices are introduced:

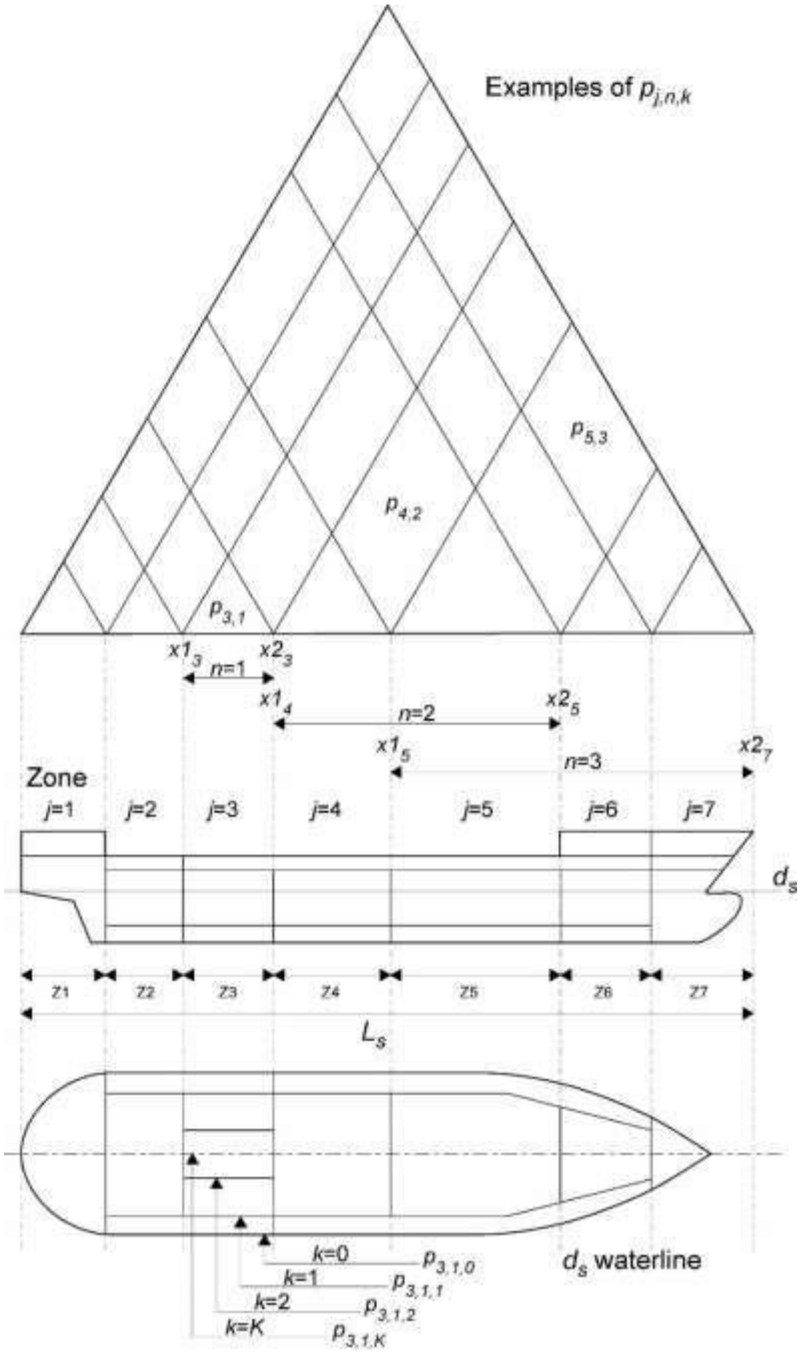
j: the damage zone number starting with No.1 at the stern;

n: the number of adjacent damage zones in question where *j* is the aft zone;

k: the number of a particular longitudinal bulkhead as a barrier for transverse penetration in a damage zone counted from shell towards the centreline. The shell has No. 0;

K: total number of transverse penetration boundaries;

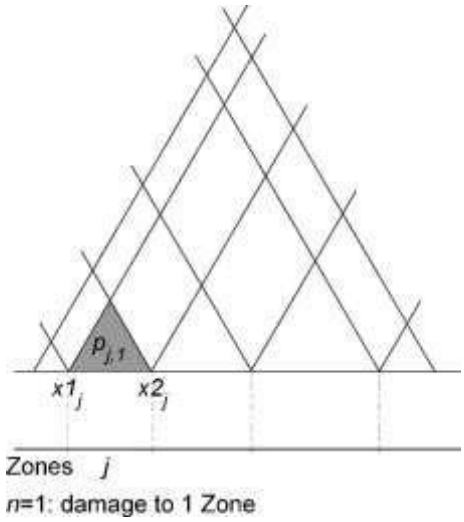
$p_{j,n,k}$: the *p*-factor for a damage in zone *j* and next (*n*-1) zones forward of *j* damaged to the longitudinal bulkhead *k*.



Pure longitudinal subdivision

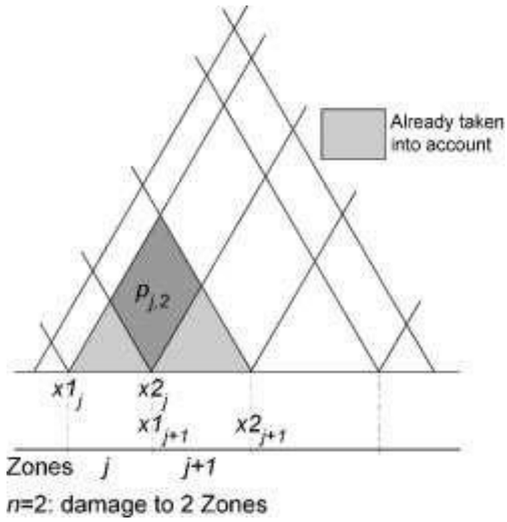
Single damage zone, pure longitudinal subdivision:

$p_{j,1} = p(x1_j,x2_j)$



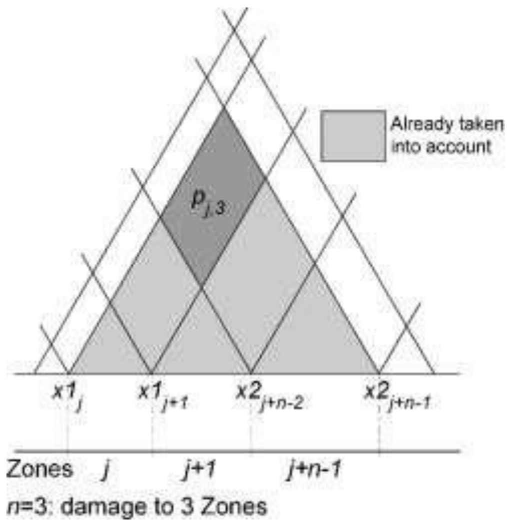
Two adjacent zones, pure longitudinal subdivision:

$p_{j,2} = p(x1_j,x2_{j+1}) - p(x1_j,x2_j) - p(x1_{j+1},x2_{j+1})$



Three or more adjacent zones, pure longitudinal subdivision:

$p_{j,n} = p(x1_j,x2_{j+n-1}) - p(x1_j,x2_{j+n-2}) - p(x1_{j+1},x2_{j+n-1}) + p(x1_{j+1},x2_{j+n-2})$



Regulation 7-1.1.2

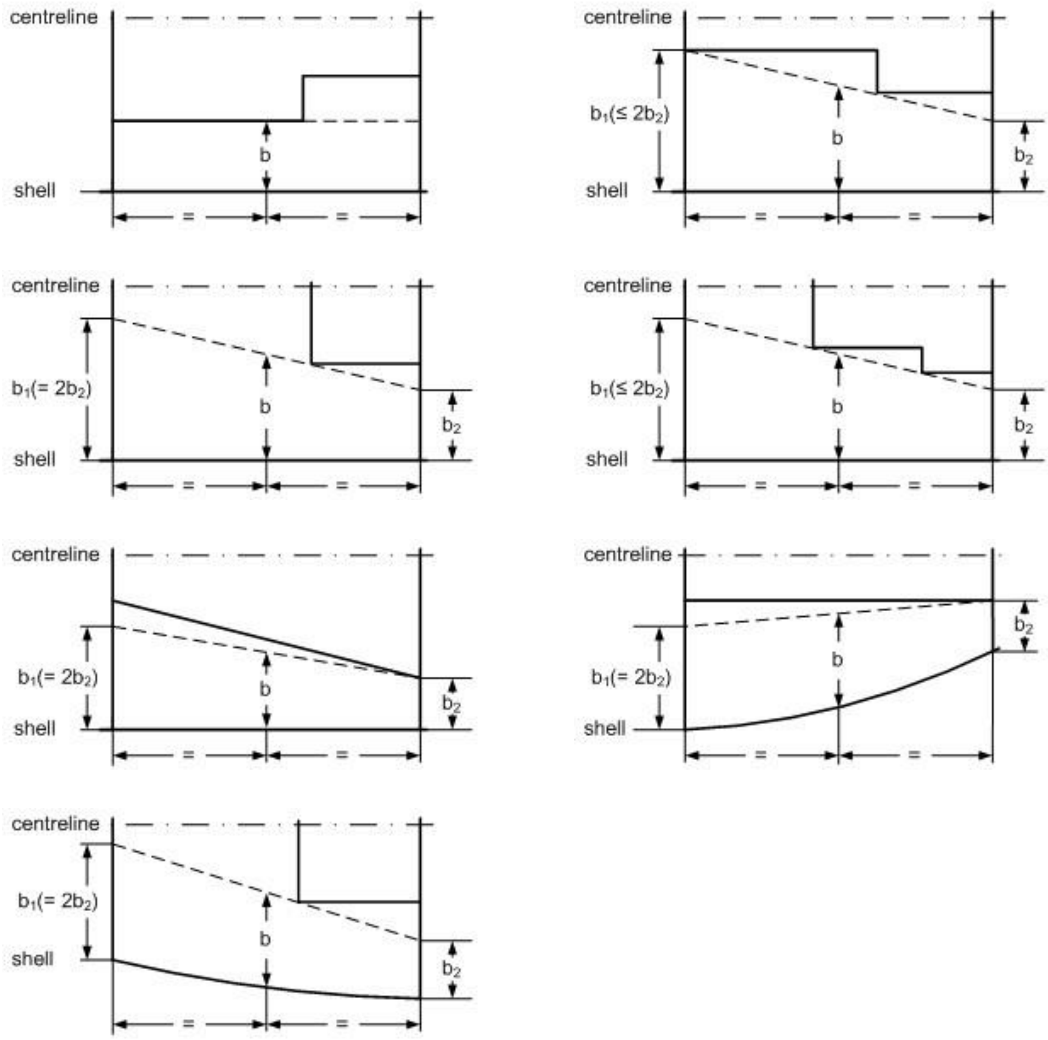
Transverse subdivision in a damage zone

1 Damage to the hull in a specific damage zone may just penetrate the ship's watertight hull or penetrate further towards the centreline. To describe the probability of penetrating only a wing compartment, a probability factor *r* is used, based mainly on the penetration depth *b*. The value of *r* is equal to 1, if the penetration depth is *B/2* where *B* is the maximum breadth of the ship at the deepest subdivision draught d_s, and $r = 0$ if $b = 0$.

2 The penetration depth *b* is measured at level deepest subdivision draught d_s as a transverse distance from the ship side right-angled to the centreline to a longitudinal barrier.

3 Where the actual watertight bulkhead is not a plane parallel to the shell, *b* should be determined by means of an assumed line, dividing the zone to the shell in a relationship b_1/b_2 with $1/2 \leq b_1/b_2 \leq 2$.

4 Examples of such assumed division lines are illustrated in the figure below. Each sketch represents a single damage zone at a water line plane level d_s and the longitudinal bulkhead represents the outermost bulkhead position below d_s + 12.5 m.



4.1 If a transverse subdivision intercepts the deepest subdivision draught waterline within the extent of the zone, *b* is equal to zero in that zone for that transverse subdivision [see figure 1]. A non-zero *b* can be obtained by including an additional zone, see figure 2.

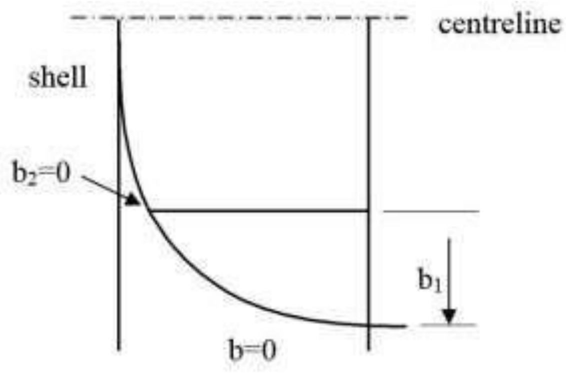


Figure 1

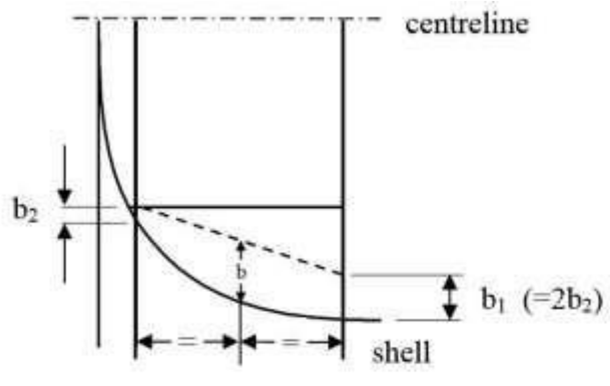


Figure 2

4.2 If the deepest subdivision draught waterline on the side of a single hull ship includes a part where multiple transverse (y) coordinates occur for a longitudinal (x) location, a straightened reference waterline can be used for the calculation of *b*. If this approach is chosen, the original waterline is replaced by an envelope curve including straight parts perpendicular to the centreline where multiple transverse coordinates occur [see figures 1 to 4]. The maximum transverse damage extent *B/2* should then be calculated from waterline or the reference waterline, if applicable, at the deepest subdivision draught.

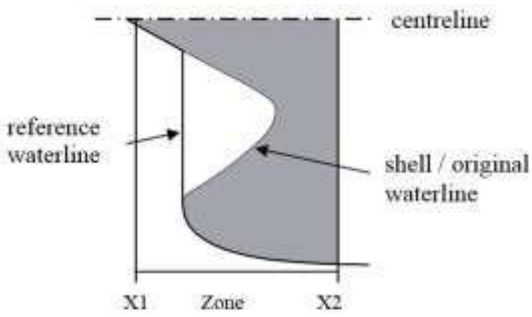


Figure 1

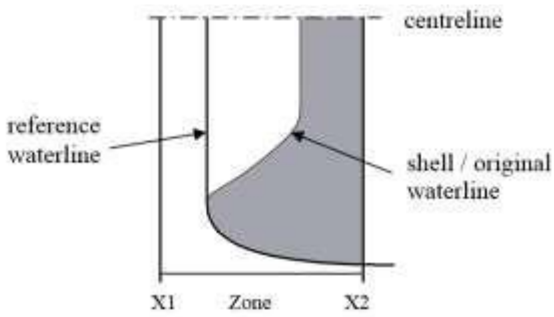


Figure 2

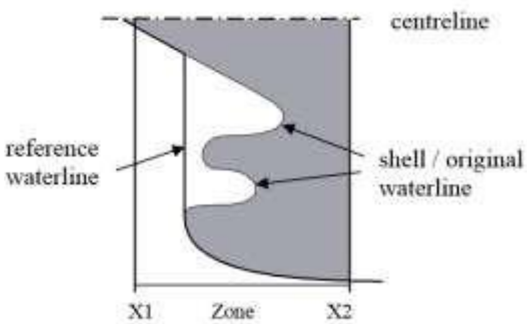


Figure 3

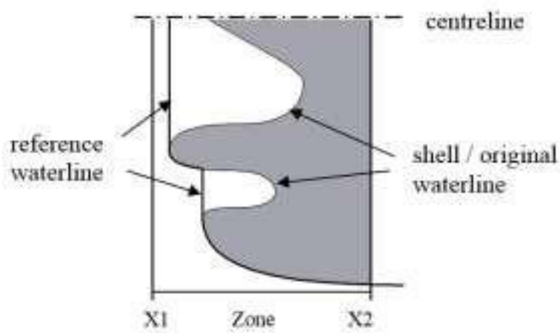


Figure 4

5 In calculating *r*-values for a group of two or more adjacent compartments, the *b*-value is common for all compartments in that group, and equal to the smallest *b*-value in that group:

$b = min\{b_1, b_2, ..., b_n\}$

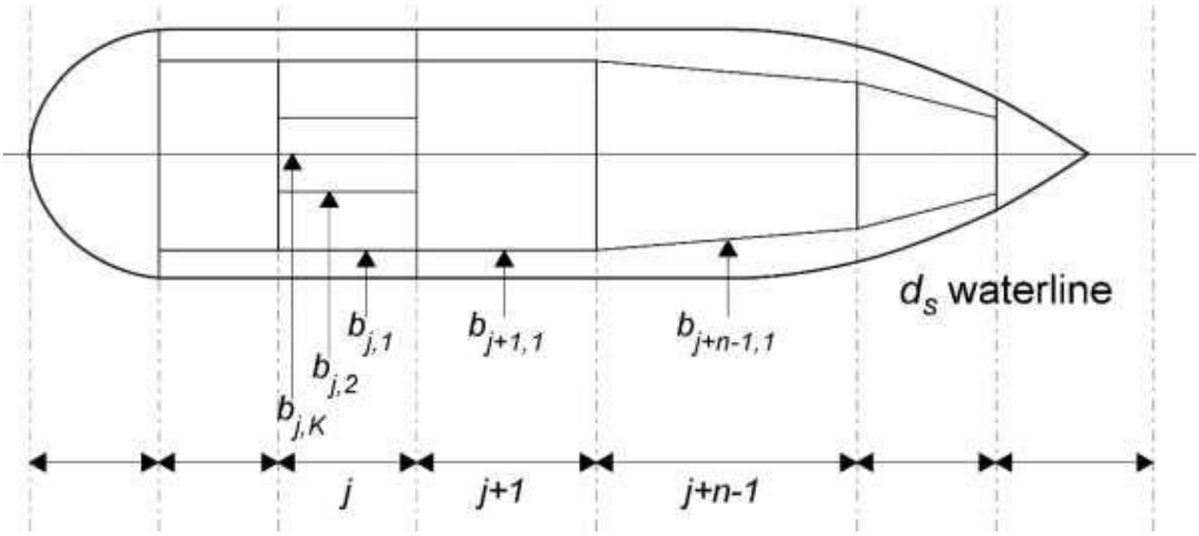
where: n = number of wing compartments in that group;
$b_1 b_2, \ldots, b_n$ = mean values of b for individual wing compartments contained in the group.

Accumulating p

6 The accumulated value of *p* for one zone or a group of adjacent zones is determined by:

$$p_{j,n} = \sum_{k=1}^{k=K_{j,n}} p_{j,n,k}$$

where $K_{j,n} = \sum_{j}^{j+n-1} K_j$ the total number of b_K's for the adjacent zones in question.



7 The figure above illustrates *b*'s for adjacent zones. The zone *j* has two penetration limits and one to the centre, the zone *j+1* has one *b* and the zone *j+n-1* has one value for *b*. The multiple zones will have (2+1+1) four values of *b*, and sorted in increasing order they are:

$(b_{j,1} ; b_{j+1,1} ; b_{j+n-1,1} ; b_{j,2} ; b_K)$

8 Because of the expression for *r(x1, x2, b)* only one b_K should be considered. To minimize the number of calculations, *b*'s of the same value may be deleted.

As $b_{j,1} = b_{j+1,1}$ the final *b*'s will be $(b_{j,1} ; b_{j+n-1,1} ; b_{j,2} ; b_K)$

Examples of multiple zones having a different b

9 Examples of combined damage zones and damage definitions are given in the figures below. Compartments are identified by R10, R12, etc.

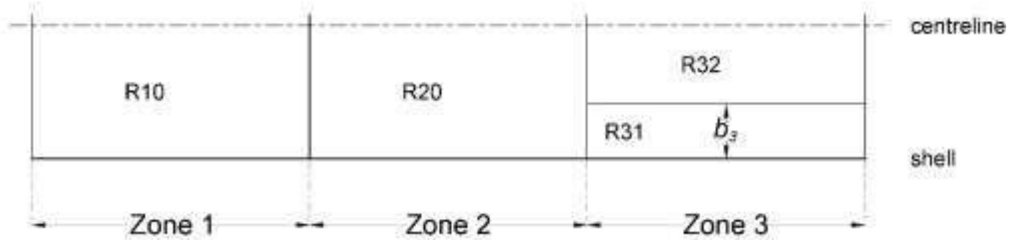


Figure: Combined damage of zones 1 + 2 + 3 includes a limited penetration to b_3, taken into account generating two damages:

1) to b_3 with R10, R20 and R31 damaged;
2) to *B/2* with R10, R20, R31 and R32 damaged.

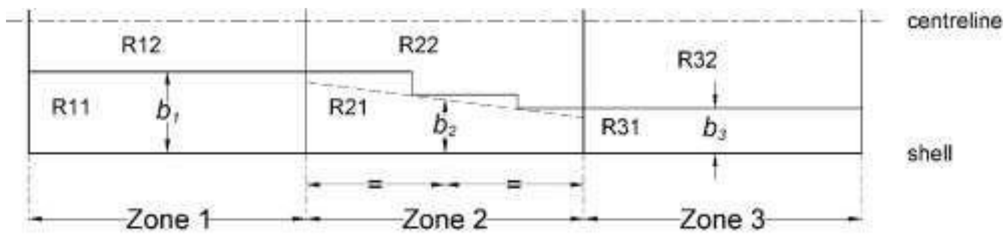


Figure: Combined damage of zones 1 + 2 + 3 includes 3 different limited damage penetrations generating four damages:

1) to b_3 with R11, R21 and R31 damaged;
2) to b_2 with R11, R21, R31 and R32 damaged;
3) to b_1 with R11, R21, R31, R32, and R22 damaged;
4) to *B/2* with R11, R21, R31, R32, R22 and R12 damaged.

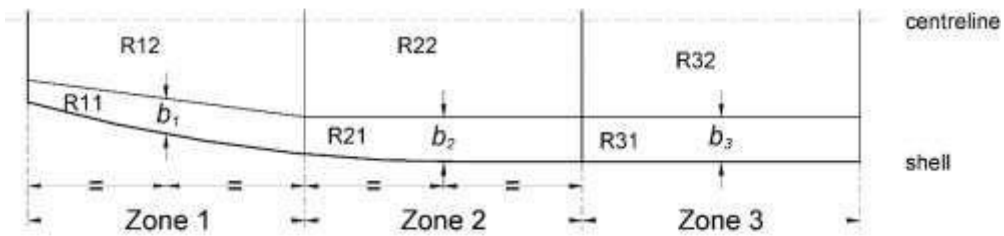
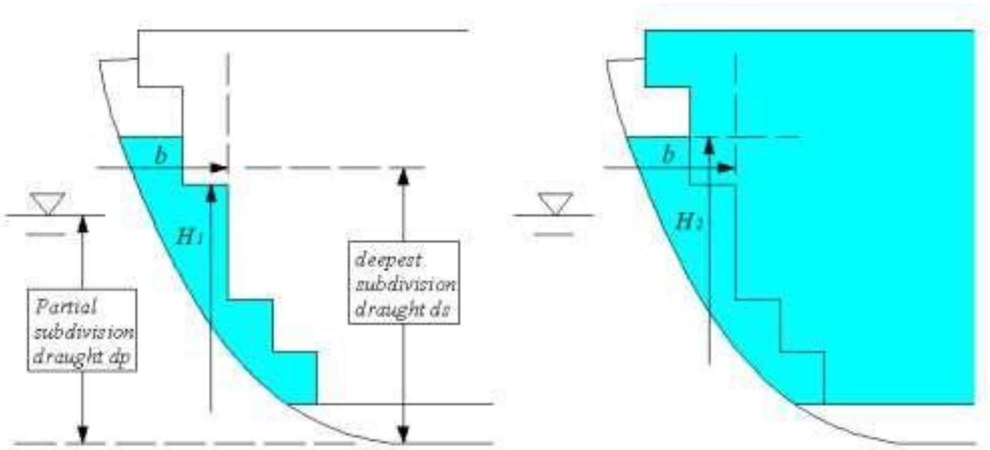


Figure: Combined damage of zone 1 + 2 + 3 including 2 different limited damage penetrations ($b_1 < b_2 = b_3$) generating three damages:

1) to b_1 with R11, R21 and R31 damaged;
2) to b_2 with R11, R21, R31 and R12 damaged;
3) to *B/2* with R11, R21, R31, R12, R22 and R32 damaged.

10 A damage having a transverse extent *b* and a vertical extent H_2 leads to the flooding of both wing compartment and hold; for *b* and H_1 only the wing compartment is flooded. The figure below illustrates a partial subdivision draught d_p damage.



11 The same is valid if b-values are calculated for arrangements with sloped walls.

12 Pipes and valves directly adjacent or situated as close as practicable to a longitudinal bulkhead can be considered to be part of the bulkhead, provided the separation distance on either side of the bulkhead is of the same order as the bulkhead stiffening structure. The same applies for small recesses, drain wells, etc.

REGULATION 7-2 – CALCULATION OF THE FACTOR s_i

General

1 Initial condition – an intact loading condition to be considered in the damage analysis described by the mean draught, vertical centre of gravity and the trim; or alternative parameters from where the same may be determined (e.g. displacement, *GM* and trim). There are three initial conditions corresponding to the three draughts d_s, d_p and d_l.

2 Immersion limits – immersion limits are an array of points that are not to be immersed at various stages of flooding as indicated in regulations 7-2.5.2 and 7-2.5.3.

3 Openings – all openings need to be defined: both weathertight and unprotected. Openings are the most critical factor to preventing an inaccurate index *A*. If the final waterline immerses the lower edge of any opening through which progressive flooding takes place, the factor "*s*" may be recalculated taking such flooding into account. However, in this case the *s* value should also be calculated without taking into account progressive flooding and corresponding opening. The smallest *s* value should be retained for the contribution to the attained index.

Regulation 7-2.1

1 In cases where the *GZ* curve may include more than one "range" of positive righting levers for a specific stage of flooding, only one continuous positive "range" of the *GZ* curve may be used within the allowable range/heel limits for calculation purposes. Different stages of flooding may not be combined in a single *GZ* curve.

Figure 1

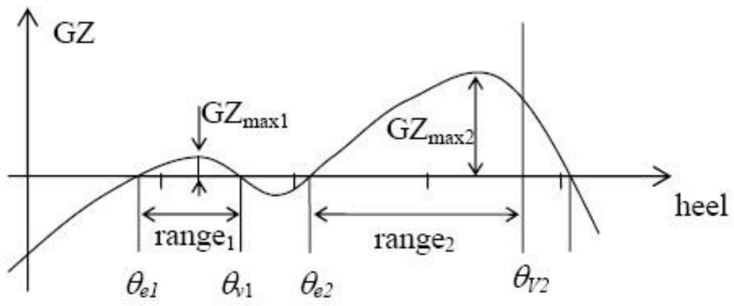
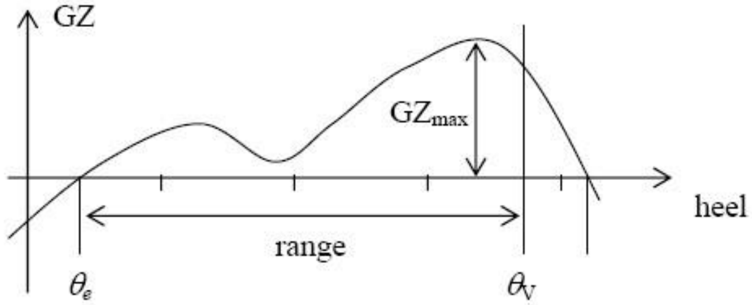


Figure 2



2 In figure 1, the *s*-factor may be calculated from the heel angle, range and corresponding GZ_{max} of the first or second "range" of positive righting levers. In figure 2, only one *s*-factor can be calculated.

Regulation 7-2.2

Intermediate stages of flooding

1 The case of instantaneous flooding in unrestricted spaces in way of the damage zone does not require intermediate stage flooding calculations. Where intermediate stages of flooding calculations are necessary in connection with progressive flooding, flooding through non-watertight boundaries or cross-flooding, they should reflect the sequence of filling as well as filling level phases. Calculations for intermediate stages of flooding should be performed whenever equalization is not instantaneous, i.e. equalization is of a duration greater than 60 s. Such calculations consider the progress through one or more floodable (non-watertight) spaces, or cross-flooded spaces. Bulkheads surrounding refrigerated spaces, incinerator rooms and longitudinal bulkheads fitted with non-watertight doors are typical examples of structures that may significantly slow down the equalization of main compartments.

Flooding boundaries

2 If a compartment contains decks, inner bulkheads, structural elements and doors of sufficient tightness and strength to seriously restrict the flow of water, for intermediate stage flooding calculation purposes it should be divided into corresponding non-watertight spaces. It is assumed that the non-watertight divisions considered in the calculations are limited to "A" class fire-rated bulkheads and decks, and do not apply to "B" class fire-rated bulkheads normally used in accommodation areas (e.g. cabins and corridors). This guidance also relates to regulation 4.5. For spaces in the double bottom, in general, only main longitudinal structures with a limited number of openings have to be considered as flooding boundaries.

Sequential flooding computation

3 For each damage scenario, the damage extent and location determine the initial stage of flooding. Calculations should be performed in stages, each stage comprising at least two intermediate filling phases in addition to the full phase per flooded space. Unrestricted spaces in way of damage should be considered as flooded immediately. Every subsequent stage involves all connected spaces being flooded simultaneously until an impermeable boundary or final equilibrium is reached. Unless the flooding process is simulated using time-domain methods, when a flooding stage leads to both a self-acting cross-flooding device and a non-watertight boundary, the self-acting cross-flooding device is assumed to act immediately and occur before the non-watertight boundary is breached. If due to the configuration of the subdivision in the ship it is expected that other intermediate stages of flooding are more onerous, then those should be investigated.

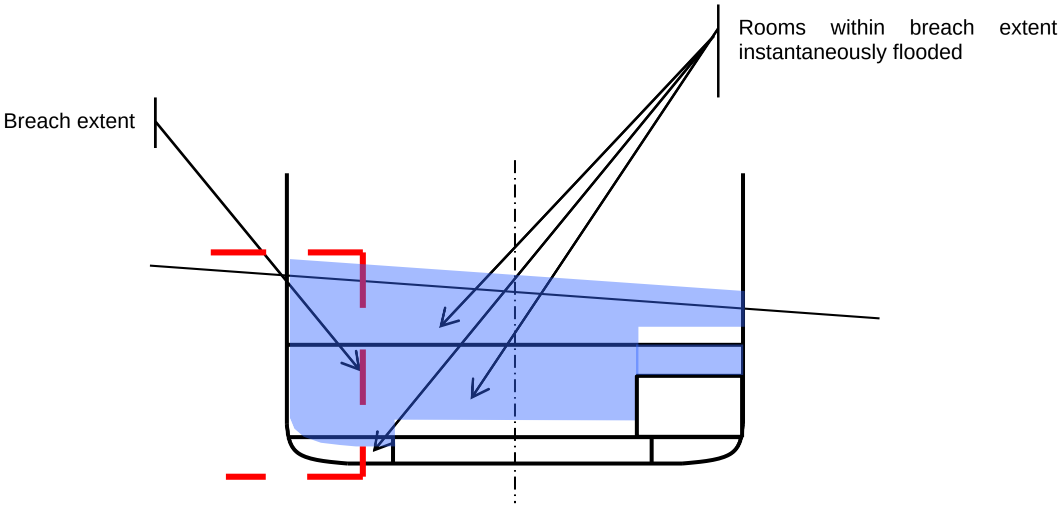
3.1 For each phase of a flooding stage (except the final full phase), the instantaneous transverse moment of this floodwater is calculated by assuming a constant volume of water at each heeling angle. The *GZ* curve is calculated with a constant intact displacement at all stages of flooding. Only one free surface needs to be assumed for water in spaces flooded during the current stage.

3.2 In the final full phase of each stage, the water level in rooms flooded during this stage reaches the outside sea level, so the lost buoyancy method can be used. The same method applies for every successive stage (added volume of water with a constant intact displacement for all phases before the final full phase of the stage in consideration), while each of the previous stages at the final full phase can be calculated with the lost buoyancy method.

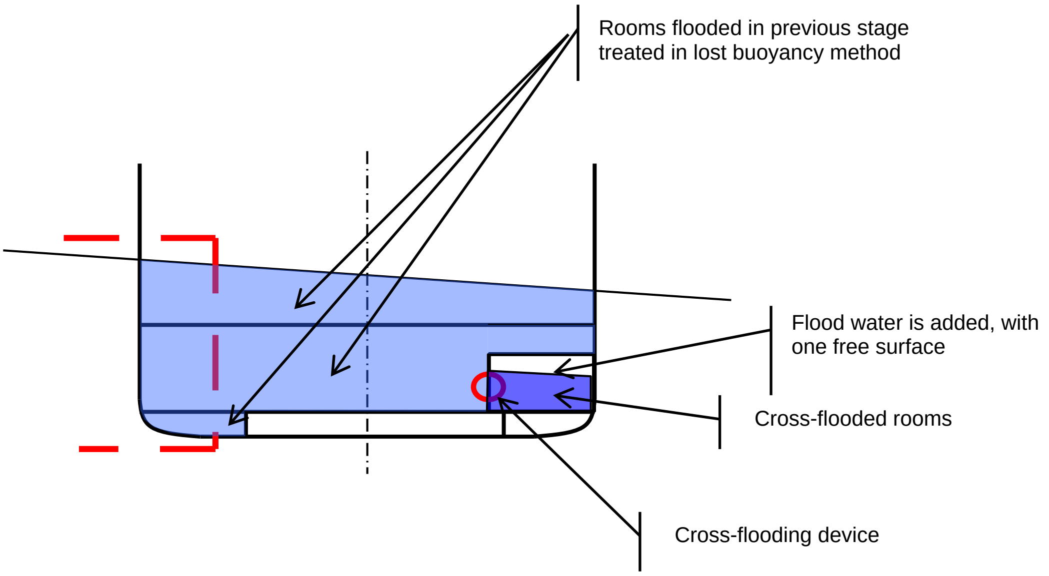
3.3 The examples below present a simplified, sequential approach to intermediate stage down-flooding and cross-flooding. Because simultaneous down-flooding and cross-flooding is not accounted for, any time-to-flood calculated with this sequential approach should be conservative. Alternative approaches, such as time-domain flooding simulation, are also acceptable.

Example 1: Major damage with cross-flooding device

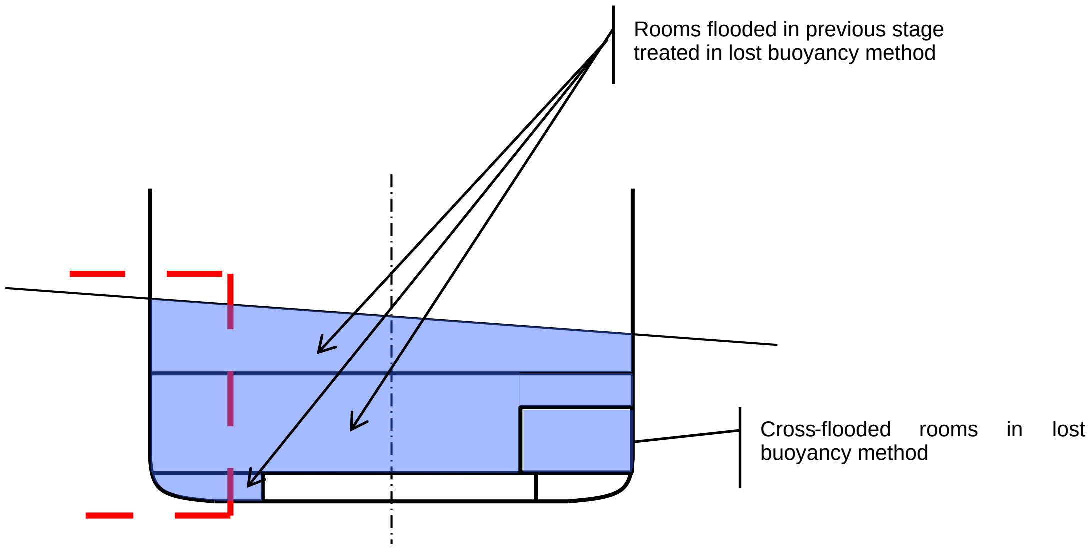
Stage 0: Unrestricted spaces in way of damage should be considered as flooded immediately (intermediate phases are not considered). The lost buoyancy method is applied as this is a full (final) phase. Provided the ship does not capsize and remains at a floating position from which cross-flooding can proceed, stage 0 need not be taken into account for the s_{factor} calculation as the first intermediate stage to be calculated is after 60 s. See cross-flooding/equalization explanatory note 5 below.



Stage 1: Cross-flooding of opposite room



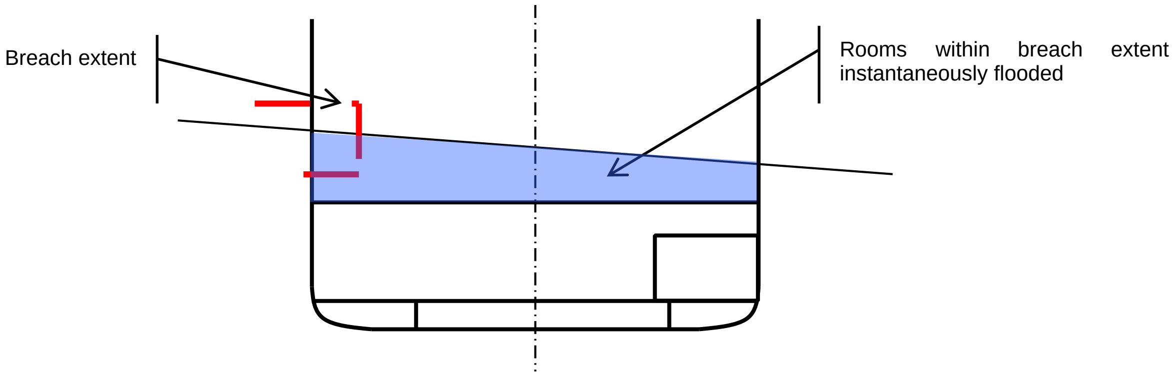
An intermediate phase



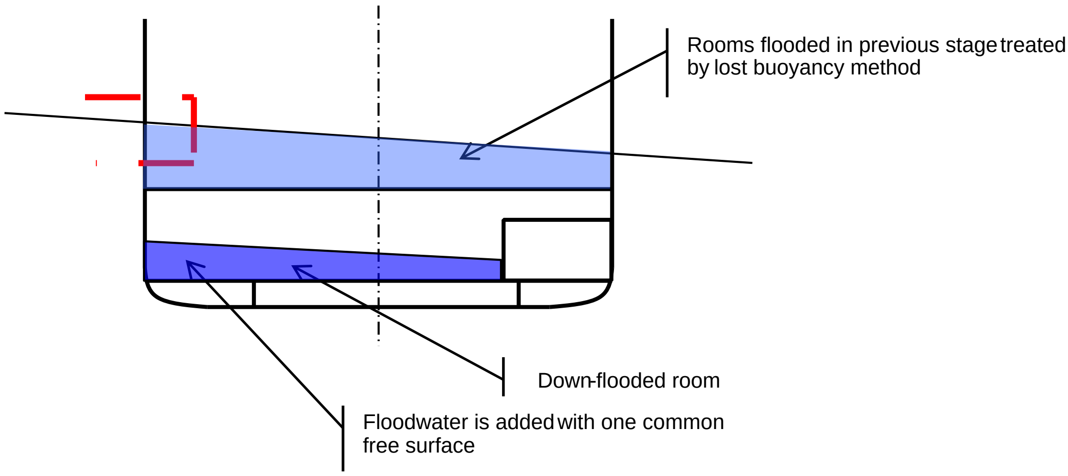
Full (final) phase of flooding stage 1

Example 2: Minor damage with down-flooding and cross-flooding

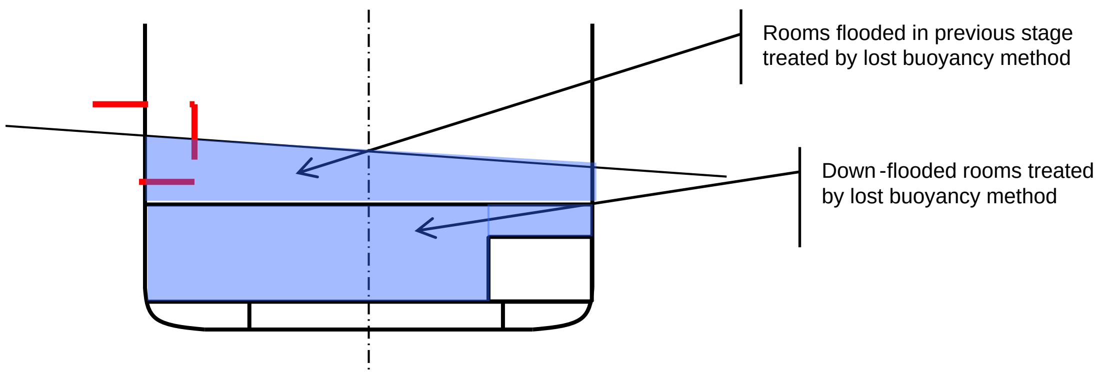
Stage 0: Unrestricted spaces in way of damage should be considered as flooded immediately (intermediate phases are not considered). The lost buoyancy method is applied as this is a full (final) phase. Provided the ship does not capsize and remains at a floating position from which cross-flooding can proceed, stage 0 need not be taken into account for the s_{factor} calculation as the first intermediate stage to be calculated is after 60 s. See cross-flooding/equalization explanatory note 5 below.



STAGE 1: DOWN-FLOODING THROUGH NON-WATERTIGHT DECK

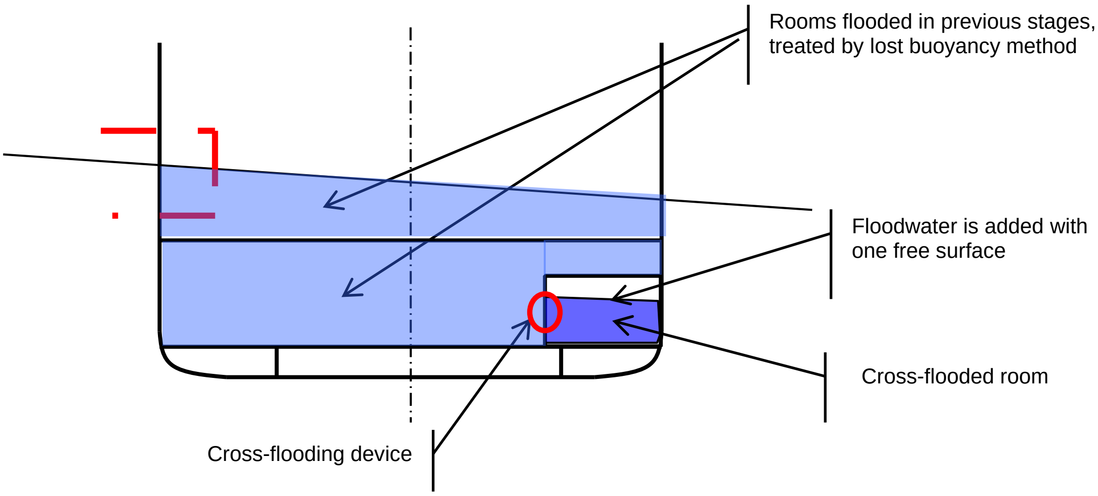


An intermediate phase

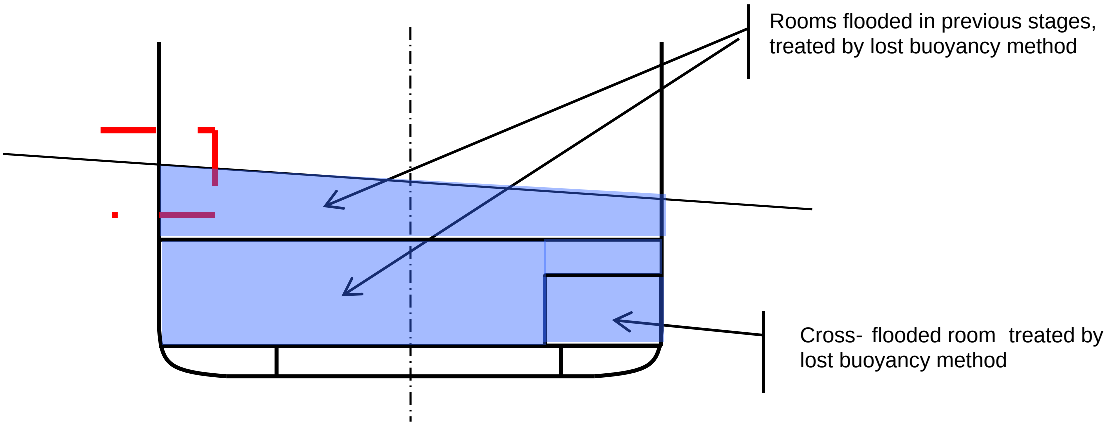


Final (full) phase of stage 1

STAGE 2: CROSS-FLOODING



An intermediate phase



Full (final) phase of stage 2

Cross-flooding/equalization

4 In general, cross-flooding is flooding of an undamaged space of the ship to reduce the heel in the final equilibrium condition.

5 The cross-flooding time should be calculated in accordance with the *Revised recommendation on a standard method for evaluating cross-flooding arrangements* (resolution MSC.362(92)). If complete fluid equalization occurs in 60 s or less, it should be treated as instantaneous and no further calculations need to be carried out. Additionally, in cases where s_{final} = 1 is achieved in 60 s or less, but equalization is not complete, instantaneous flooding may also be assumed if s_{final} will not become reduced. In any cases where complete fluid equalization exceeds 60 s, the value of $s_{\text{intermediate}}$ after 60 s is the first intermediate stage to be considered. Only self-acting open cross-flooding arrangements without valves should be considered effective for instantaneous flooding cases.

6 Provided that the ship has a *GZ* greater than 0 and remains in a position from which cross-flooding can proceed, stage 0 need not be taken into account for the s_{factor} calculation as the first intermediate stage to be calculated is after 60 s.

7 Only cross-flooding devices which are sufficiently submerged below the external waterline at stage 0 are to be used in the calculation for cross-flooding according to resolution MSC.362(92).

8 If complete fluid equalization can be finalized in 10 min or less, the assessment of survivability is carried out using the formula in regulation 7-2.1.1 (i.e. as the smallest value of $s_{intermediate}$ or $s_{final} \cdot s_{mom}$)

9 In case the equalization time is longer than 10 min, s_{final} is calculated for the floating position achieved after 10 min of equalization. This floating position is computed by calculating the amount of flood water according to resolution MSC.362(92) using interpolation, where the equalization time is set to 10 min, i.e. the interpolation of the flood water volume is made between the case before equalization (T=0) and the total calculated equalization time. For damage cases involving different cross-flooding devices serving different spaces, when the interpolation between the case before equalization ($T=0$) and the total calculated equalization time is needed for flood water volume calculation after 60 s or 10 min, the total equalization time is to be calculated separately for each cross-flooding device.

10 In any cases where complete fluid equalization exceeds 10 min, the value of s_{final} used in the formula in regulation 7-2.1.1 should be the minimum of s_{final} at 10 min or at final equalization.

11 The factor $s_{intermediate,i}$ may be used for cross-flooding stages if they are intermediate stages which are followed by other subsequent flooding stages (e.g. the flooding stages of non-watertight compartments).

Alternatives

12 As an alternative to the procedure described above in the explanatory notes for regulation 7-2.2, direct calculation using computational fluid dynamics (CFD), time-domain flooding simulations or model testing may be used to analyse intermediate stages of flooding and determine the time for equalization.

Regulation 7-2.3

1 The formulation of $s_{final,i}$ is based on target values for *GZ* and *Range* to achieve s = 1. These values are defined as TGZ_{max} and *TRange*.

2 If ro-ro spaces are damaged there might be the possibility of water accumulation on these deck spaces. To account for this, in any damage case where the ro-ro space is damaged the higher values for TGZ_{max} and *TRange* are to be applied for the calculation of s_i.

Regulation 7-2.4.1.2

The parameter *A* (projected lateral area) used in this paragraph does not refer to the attained subdivision index.

Regulation 7-2.5.2.1

Unprotected openings

1 The flooding angle will be limited by immersion of such an opening. It is not necessary to define a criterion for non-immersion of unprotected openings at equilibrium, because if it is immersed, the range of positive *GZ* limited to flooding angle will be zero so "s" will be equal to zero.

2 An unprotected opening connects two rooms or one room and the outside. An unprotected opening will not be taken into account if the two connected rooms are flooded or none of these rooms are flooded. If the opening is connected to the outside, it will not be taken into account if the connected compartment is flooded. An unprotected opening does not need to be taken into account if it connects a flooded room or the outside to an undamaged room, if this room will be considered as flooded in a subsequent stage.

Openings fitted with a weathertight means of closing ("weathertight openings")

3 The survival "*s*" factor will be "0" if any such point is submerged at a stage which is considered as "final". Such points may be submerged during a stage or phase which is considered as "intermediate", or within the range beyond equilibrium.

4 If an opening fitted with a weathertight means of closure is submerged at equilibrium during a stage considered as intermediate, it should be demonstrated that this weathertight means of closure can sustain the corresponding head of water and that the leakage rate is negligible.

5 These points are also defined as connecting two rooms or one room and the outside, and the same principle as for unprotected openings is applied to take them into account or not. If several stages have to be considered as "final", a "weathertight opening" does not need to be taken into account if it connects a flooded room or the outside to an undamaged room if this room will be considered as flooded in a successive "final" stage.

Regulation 7-2.5.2.2

1 Partial immersion of the bulkhead deck may be accepted at final equilibrium. This provision is intended to ensure that evacuation along the bulkhead deck to the vertical escapes will not be impeded by water on that deck. A "horizontal evacuation route" in the context of this regulation means a route on the bulkhead deck connecting spaces located on and under this deck with the vertical escapes from the bulkhead deck required for compliance with SOLAS chapter II-2.

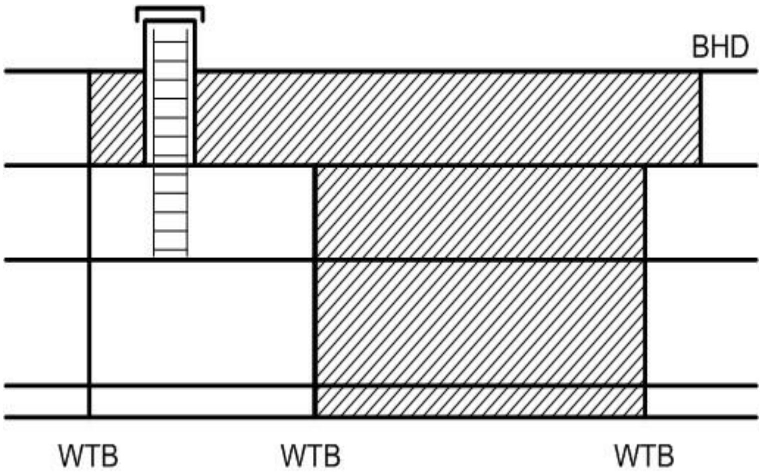
2 Horizontal evacuation routes on the bulkhead deck include only escape routes (designated as category 2 stairway spaces according to SOLAS regulation II-2/9.2.2.3 or as category 4 stairway spaces according to SOLAS regulation II-2/9.2.2.4 for passenger ships carrying not more than 36 passengers) used for the evacuation of undamaged spaces. Horizontal evacuation routes do not include corridors (designated as category 3 corridor spaces according to SOLAS regulation II-2/9.2.2.3 or as category 2 corridor spaces according to SOLAS regulation II-2/9.2.2.4 for passenger ships carrying not more than 36 passengers) or escape routes within a damaged zone. No part of a horizontal evacuation route serving undamaged spaces should be immersed.

3 s_i = 0 where it is not possible to access a stair leading up to the embarkation deck from an undamaged space as a result of flooding to the "stairway" or "horizontal stairway" on the bulkhead deck.

Regulation 7-2.5.3.1

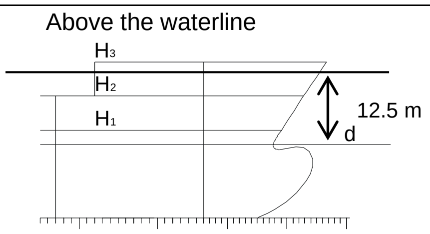
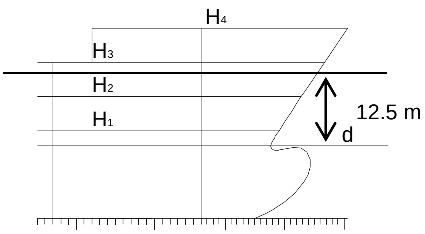
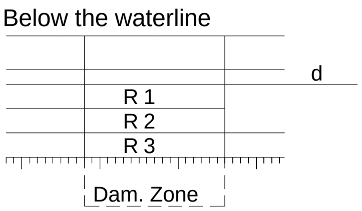
1 The purpose of this paragraph is to provide an incentive to ensure that evacuation through a vertical escape will not be obstructed by water from above. The paragraph is intended for smaller emergency escapes, typically hatches, where fitting of a watertight or weathertight means of closure would otherwise exclude them from being considered as flooding points.

2 Since the probabilistic regulations do not require that the watertight bulkheads be carried continuously up to the bulkhead deck, care should be taken to ensure that evacuation from intact spaces through flooded spaces below the bulkhead deck will remain possible, for instance by means of a watertight trunk.



Regulation 7-2.6

The sketches in the figure illustrate the connection between position of watertight decks in the reserve buoyancy area and the use of factor *v* for damages below these decks.

	In this example, there are 3 horizontal subdivisions to be taken into account as the vertical extent of damage. The example shows the maximum possible vertical extent of damage *d* + 12.5 m is positioned between H_2 and H_3. H_1 with factor v_1, H_2 with factor $v_2 > v_1$ but $v_2 < 1$ and H_3 with factor $v_3 = 1$.
	The factors v_1 and v_2 are the same as above. The reserve buoyancy above H_3 should be taken undamaged in all damage cases.
	The combination of damages into the rooms R1, R2 and R3 positioned below the initial water line should be chosen so that the damage with the lowest *s*-factor is taken into account. That often results in the definition of alternative damages to be calculated and compared. If the deck taken as lower limit of damage is not watertight, down flooding should be considered.

Regulation 7-2.6.1

The parameters x_1 and x_2 are the same as parameters *x1* and *x2* used in regulation 7-1.

REGULATION 7-3 – PERMEABILITY

Regulation 7-3.2

1 The following additional cargo permeabilities may be used:

Spaces	Permeability at draught d_s	Permeability at draught d_p	Permeability at draught d_l
Timber cargo in holds	0.35	0.7	0.95
Wood chip cargo	0.6	0.7	0.95

2 Reference is made to MSC/Circ.998 (*IACS unified interpretation regarding timber deck cargo in the context of damage stability requirements*) regarding timber deck cargo.

Regulation 7-3.3

1 Concerning the use of other figures for permeability "if substantiated by calculations", such permeabilities should reflect the general conditions of the ship throughout its service life rather than specific loading conditions.

2 This paragraph allows for the recalculation of permeabilities. This should only be considered in cases where it is evident that there is a major discrepancy between the values shown in the regulation and the real values. It is not designed for improving the attained value of a deficient ship of regular type by the modification of chosen spaces in the ship that are known to provide significantly onerous results. All proposals should be considered on a case-by-case basis by the Administration and should be justified with adequate calculations and arguments.

REGULATION 8 – SPECIAL REQUIREMENTS CONCERNING PASSENGER SHIP STABILITY

Regulation 8.1

This regulation is intended to ensure a sufficient safety level if a large compartment is located aft of the collision bulkhead.

REGULATION 8-1 – SYSTEM CAPABILITIES AND OPERATIONAL INFORMATION AFTER A FLOODING CASUALTY ON PASSENGER SHIPS

Regulation 8-1.2

1 In the context of this regulation, "compartment" has the same meaning as defined under regulation 7-1 of these Explanatory Notes (i.e. an onboard space within watertight boundaries).

2 The purpose of the paragraph is to prevent any flooding of limited extent from immobilizing the ship. This principle should be applied regardless of how the flooding might occur. Only flooding below the bulkhead deck need be considered.

REGULATION 9 – DOUBLE BOTTOMS IN PASSENGER SHIPS AND CARGO SHIPS OTHER THAN TANKERS

Regulation 9.1

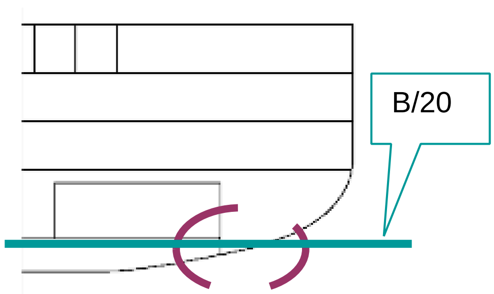
1 This regulation is intended to minimize the impact of flooding from a minor grounding. Special attention should be paid to the vulnerable area at the turn of the bilge. When justifying a deviation from fitting an inner bottom an assessment of the consequences of allowing a more extensive flooding than reflected in the regulation should be provided.

2 The determination regarding the requirement to fit a double bottom "as far as this is practicable and compatible with the design and proper working of the ship" is made, or should be accepted by, the Administration or a recognized organization acting on its behalf.

3 Compliance with the damage stability requirement in regulation 9.8 should not be considered as an equivalent optional requirement to the fitting of a dimensionally compliant double bottom. This is because a flooded watertight compartment, such as an engine-room, that complies with the damage stability requirement in regulation 9.8 is not equivalent to a flooded double bottom below that compartment. Compliance with the damage stability requirement in regulation 9.8 is intended to provide a minimum level of safety in cases when the fitting of a double bottom is not practicable or compatible with the design and proper working of the ship.

Regulation 9.2

1 Except as provided in regulations 9.3 and 9.4, parts of the double bottom not extended for the full width of the ship as required by regulation 9.2 should be considered an unusual arrangement for the purpose of this regulation and should be handled in accordance with regulation 9.7. An example is provided below.



2 If an inner bottom is located higher than the partial subdivision draught d_p, this should be considered an unusual arrangement and is to be handled in accordance with regulation 9.7.

Regulations 9.3.2.2, 9.6 and 9.7

For cargo ships of less than 80 m in length (L), the alternative arrangements to provide a level of safety satisfactory to the Administration should be limited to compartments not having a double bottom, having an unusual bottom arrangement, or having an "other well" extending below the required double bottom height that is greater than the h/2 or 500 mm limit indicated in regulation 9.3.2.1. In these cases compliance with the bottom damage standard in regulation 9.8 should be demonstrated assuming that the damage will only occur between the transverse watertight bulkheads in compartments not having a double bottom, having an unusual bottom arrangement, or having an "other well" extending below the required double bottom height that is greater than the *h*/2 or 500 mm limit indicated in regulation 9.3.2.1.

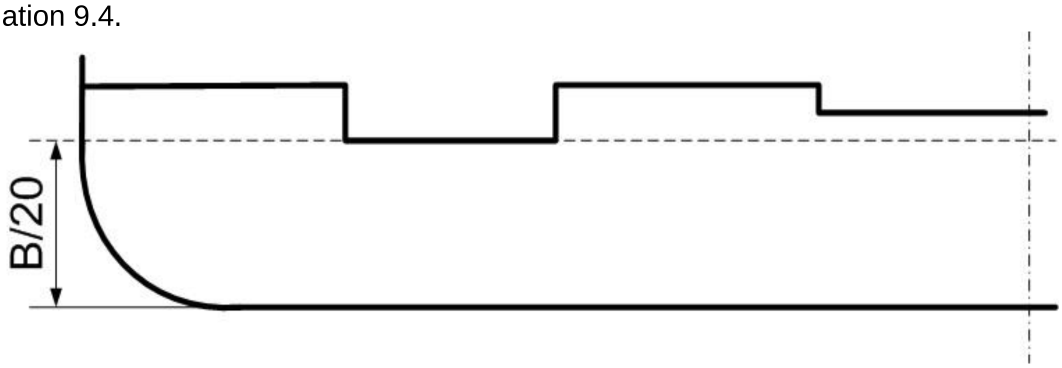
Regulation 9.6

1 Any part of a passenger ship or a cargo ship of 80 m in length (*L*) and upwards where a double bottom is omitted in accordance with regulation 9.1, 9.4 or 9.5 shall be capable of withstanding bottom damages, as specified in regulation 9.8. The intent of this provision is to specify the circumstances under which the Administration should require calculations, which damage extents to assume and what survival criteria to apply when double bottoms are not fitted.

2 The definition of "watertight" in regulation 2.17 implies that the strength of inner bottoms and other boundaries assumed to be watertight should be verified if they are to be considered effective in this context.

Regulation 9.7

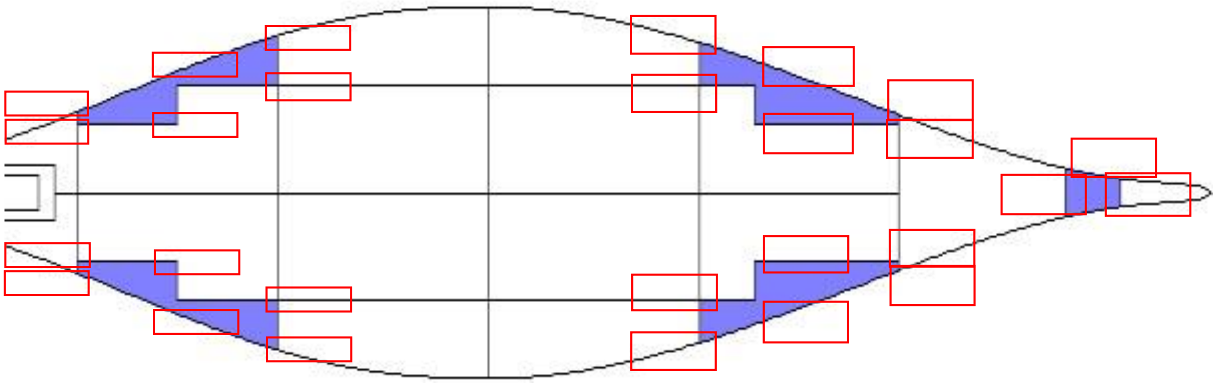
The reference to a "plane" in regulation 9.2 does not imply that the surface of the inner bottom may not be stepped in the vertical direction. Minor steps and recesses need not be considered unusual arrangements for the purpose of this paragraph as long as no part of the inner bottom is located below the reference plane. Discontinuities in way of wing tanks are covered by regulation 9.4.



Regulation 9.8

1 For ships to which the probabilistic damage stability requirements of part B-1 apply, the term "all service conditions" used in this paragraph means the three loading conditions with all trims used to calculate the attained subdivision index *A*. For ships not subject to the probabilistic damage stability requirements in part B-1, such as cargo ships that comply with the subdivision and damage stability requirements of other instruments as allowed by regulation II-1/4.2.1.2 and cargo ships of less than 80 m in length (*L*), "all service conditions" means that the limit curves or tables required by regulation 5-1.2.1 should include values calculated for the same draught and trim range(s) as for the other applicable stability requirements.

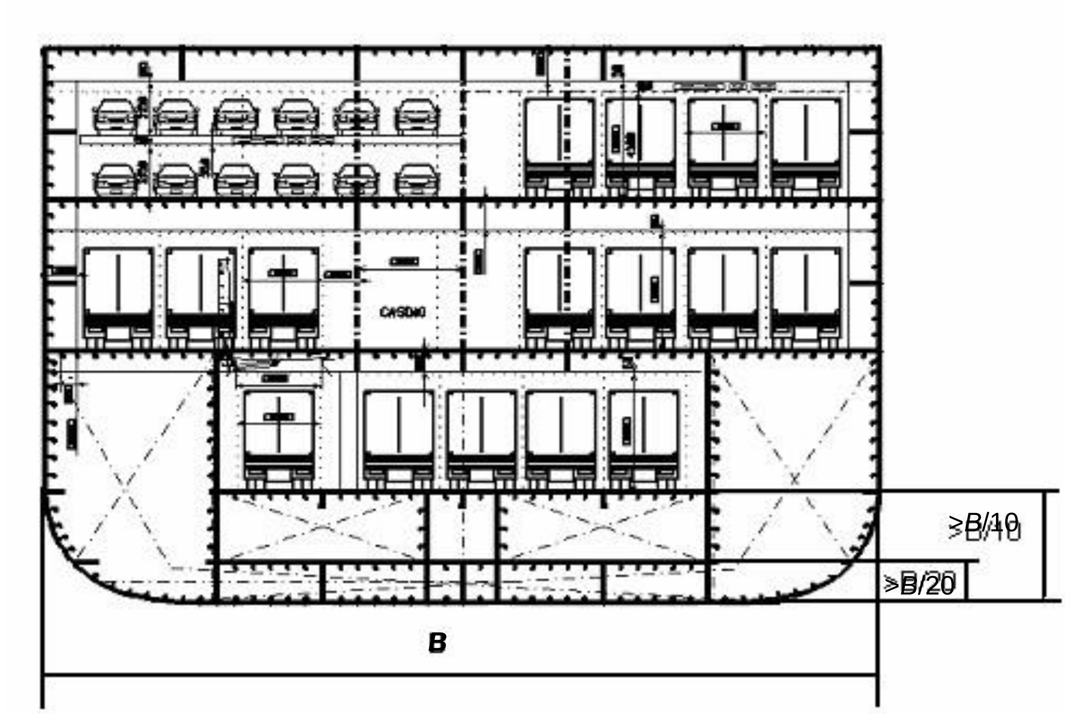
2 The damage extents specified in this paragraph should be applied to all parts of the ship where no double bottom is fitted, as permitted by regulations 9.1, 9.4 or 9.5, and include any adjacent spaces located within the extent of damage. Small wells in accordance with regulation 9.3.1 do not need to be considered damaged even if within the extent of the damage. Possible positions of the damages are shown in an example below (parts of the ship not fitted with a double bottom are shaded; the damages to be assumed are indicated by boxes).



Regulation 9.9

1 For the purpose of identifying "large lower holds", horizontal surfaces having a continuous deck area greater than approximately 30% in comparison with the waterplane area at subdivision draught should be taken to be located anywhere in the affected area of the ship. For the alternative bottom damage calculation, a vertical extent of *B*/10 or 3 m, whichever is less, should be assumed.

2 The increased minimum double bottom height of not more than *B*/10 or 3 m, whichever is less, for passenger ships with large lower holds, is applicable to holds in direct contact with the double bottom. Typical arrangements of ro-ro passenger ships may include a large lower hold with additional tanks between the double bottom and the lower hold, as shown in the figure below. In such cases, the vertical position of the double bottom required to be *B*/10 or 3 m, whichever is less, should be applied to the lower hold deck, maintaining the required double bottom height of *B*/20 or 2 m, whichever is less (but not less than 760 mm). The figure below shows a typical arrangement of a modern ro-ro passenger ferry.



REGULATION 10 – CONSTRUCTION OF WATERTIGHT BULKHEADS

Regulation 10.1

For the treatment of steps in the bulkhead deck of passenger ships see explanatory notes for regulation 13. For the treatment of steps in the freeboard deck of cargo ships see explanatory notes for regulation 13-1.

REGULATION 12 – PEAK AND MACHINERY SPACE BULKHEADS, SHAFT TUNNELS, ETC.

Regulation 12.6.1

For cargo ships, the following figures show examples of suitable butterfly valve arrangements:

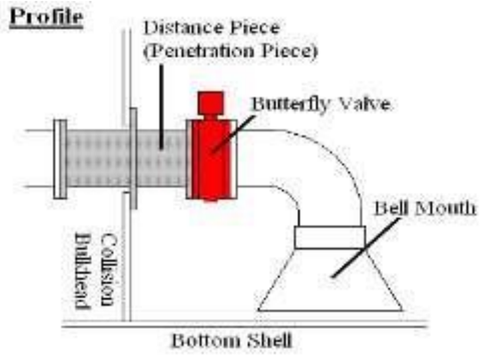


Figure 1

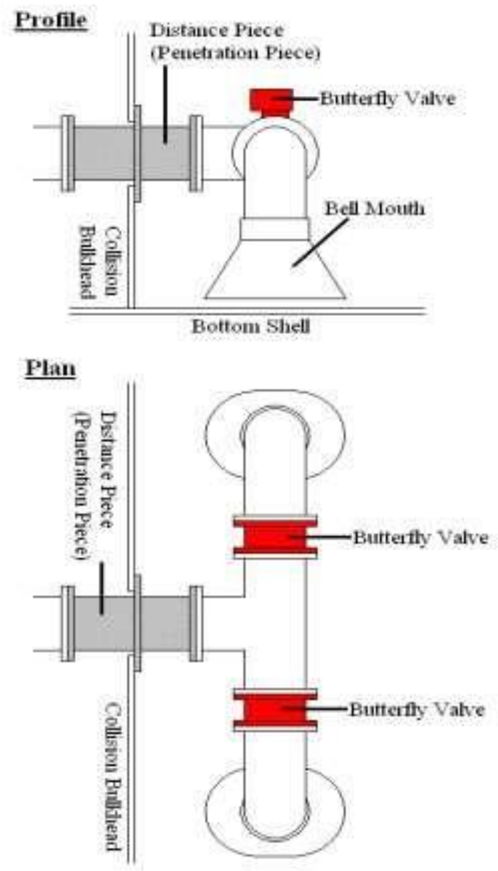


Figure 2

As butterfly valves must be capable of being remotely operated the following shall apply:

.1 the actuator shall be of a double acting type;

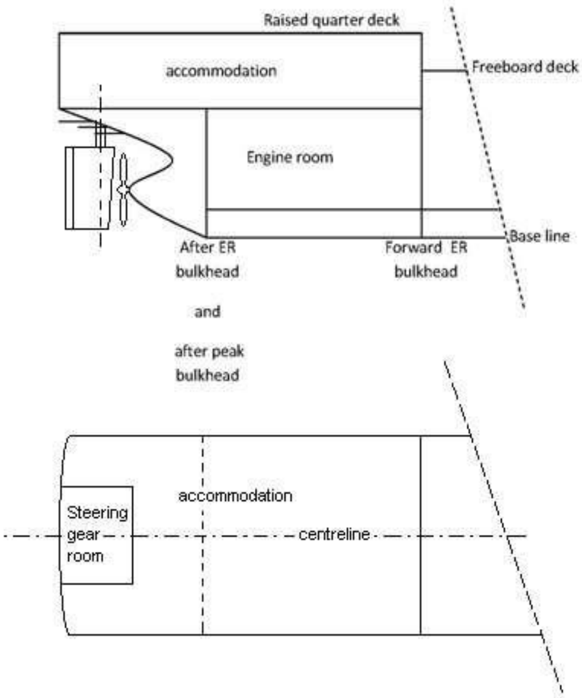
.2 when subject to loss of power, the actuator shall remain in its current position; and

.3 when subject to loss of power, the valve shall be able to be manually operated.

Regulation 12.10

1 In cargo ships the after engine-room bulkhead can be regarded as the afterpeak bulkhead provided that the after peak adjoins the engine-room.

2 In cargo ships with a raised quarter deck, it may be impracticable to extend the afterpeak bulkhead to the freeboard deck as the freeboard deck does not extend to the aft perpendicular. Provided that the afterpeak bulkhead extends above the deepest load line, and that all rudderstock bearings are housed in a watertight compartment without open connection to spaces located in front of the afterpeak bulkhead, termination of the afterpeak bulkhead on a watertight deck lower than the freeboard deck can be accepted by the Administration.



Regulation 12.11

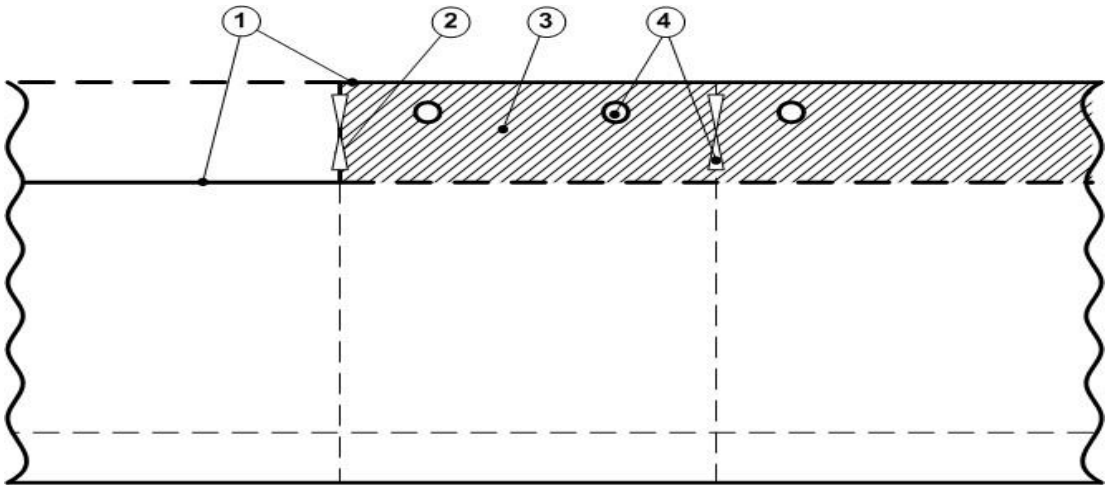
In cargo ships a stern tube enclosed in a watertight space of moderate volume, such as an afterpeak tank, where the inboard end of the stern tube extends through the afterpeak/engine-room watertight bulkhead into the engine-room, is considered to be an acceptable solution satisfying the requirement of this regulation, provided the inboard end of the stern tube is effectively sealed at the afterpeak/engine-room bulkhead by means of an approved watertight/oiltight gland system.

REGULATION 13 – OPENINGS IN WATERTIGHT BULKHEADS BELOW THE BULKHEAD DECK IN PASSENGER SHIPS

General – Steps in the bulkhead deck

1 If the transverse watertight bulkheads in a region of the ship are carried to a higher deck which forms a vertical step in the bulkhead deck, openings located in the bulkhead at the step may be considered as being located above the bulkhead deck. Such openings should then comply with regulation 17 and should be taken into account when applying regulation 7-2.

2 All openings in the shell plating below the upper deck throughout that region of the ship should be treated as being below the bulkhead deck and the provisions of regulation 15 should be applied. See figure below.



1 Bulkhead deck 2 Considered as located above the bulkhead deck
3 Ship's side 4 Considered as located below the bulkhead deck

Regulation 13.2.3

1 For closed piping systems compliance with this regulation is achieved if approved pipe penetrations are fitted at the crossing of watertight bulkheads to ensure that heat-sensitive pipes outside the space affected by the fire remain intact, so that any flooding of the fire affected space does not cause progressive flooding through the piping or pipe penetration.

1.1 For open piping systems compliance with this regulation is achieved if approved pipe penetrations are fitted at the crossing of watertight bulkheads as are required for closed piping systems, and additionally each pipe connection to a watertight compartment is fitted with an isolation or non-return valve, as appropriate, to prevent progressive flooding through the piping system after a fire. As an alternative to fitting an isolation or non-return valve, pipes may be routed above the damaged waterline in such a way that progressive flooding is prevented, taking into account the dynamic movements of the ship in a damaged condition.

1.2 However, progressive flooding may be taken into account in accordance with SOLAS regulation 7-2.5.4 instead.

2 For the purpose of this explanatory note the following definitions apply:

A *closed piping system* is a piping system without openings in multiple watertight compartments.

An *open piping system* is a piping system with openings in multiple watertight compartments.

3 Materials used in systems which penetrate watertight bulkheads should be of sufficient strength after exposure to heat or be considered as part of an open piping system.

3.1 Closing devices using intumescent material (swelling when exposed to heat) for open piping systems should not be considered equivalent to the fitting of a valve, since the fire might be located too far from the device to create a watertight seal.

4 Approval of pipe penetrations fitted to ensure the watertight integrity of a bulkhead or deck where heat-sensitive materials are used should include a prototype test of watertightness after having undergone the standard fire test appropriate for the location in which the penetrations are to be installed[2].

4.1 The fire tested pipe penetration should then be tested to a test pressure of not less than 1.5 times the design pressure as defined in regulation 2.18. The pressure should be applied to the same side of the division as the fire test.

4.2 The fire tested pipe penetration should be tested for a period of at least 30 min under hydraulic pressure equal to the test pressure, but minimum 1.0 bar. There should be no leakage during this test.

4.3 The fire tested pipe penetration should continue to be tested for a further 30 min with the test pressure. The quantity of water leakage is not to exceed a total of 1 litre.

4.4 The prototype test should be considered valid only for the pipe typology (e.g. thermoplastic and multilayer), pressure classes, the maximum/minimum dimensions tested, and the type and fire rating of the division tested.

5 The pressure test need not be carried out on the hot penetration arrangement. Ample time may be given to prepare for the pressure test, i.e. dismantling the fire testing equipment and rigging the pressure test equipment.

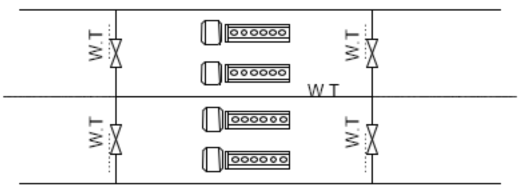
5.1 The pressure test should be carried out with the pipe section used in the fire test still in place.

5.2 Any pipe insulation fitted for the purpose of the fire test may be removed before the pressure test.

5.3 Prototype testing need not be carried out if the pipe penetration is made of steel or equivalent material having a thickness of 3 mm or greater and a length of not less than 900 mm (preferably 450 mm on each side of the division), and there are no openings. Such penetrations shall be suitably insulated by extension of the insulation at the same level of the division. See also regulation II-2/9.3.1 with respect to piping. However, the penetration must still comply with the watertight integrity requirement in regulation 2.17.

Regulation 13.4

In cases where main and auxiliary propulsion machinery spaces, including boilers serving the needs for propulsion, are divided by watertight longitudinal bulkheads in order to comply with redundancy requirements (e.g. according to regulation 8-1.2), one watertight door in each watertight bulkhead may be permitted, as shown in the figure below.



2 Refer to the requirements for A-class division set out in part 3 of annex 1 to the 2010 FTP Code.

REGULATION 13-1 – OPENINGS IN WATERTIGHT BULKHEADS AND INTERNAL DECKS IN CARGO SHIPS

Regulation 13-1.1

1 If the transverse watertight bulkheads in a region of the ship are carried to a higher deck than in the remainder of the ship, openings located in the bulkhead at the step may be considered as being located above the freeboard deck.

2 All openings in the shell plating below the upper deck throughout that region of the ship should be treated as being below the freeboard deck, similar to the bulkhead deck for passenger ships (see relevant figure under regulation 13 above), and the provisions of regulation 15 should be applied.

REGULATION 15 – OPENINGS IN THE SHELL PLATING BELOW THE BULKHEAD DECK OF PASSENGER SHIPS AND THE FREEBOARD DECK OF CARGO SHIPS

General – Steps in the bulkhead deck and freeboard deck

For the treatment of steps in the bulkhead deck of passenger ships see explanatory notes for regulation 13. For the treatment of steps in the freeboard deck of cargo ships see explanatory notes for regulation 13-1.

REGULATION 15-1 – EXTERNAL OPENINGS IN CARGO SHIPS

Regulations 15-1.1 to 15-1.3 apply to cargo ships which are subject to the damage stability analysis required in part B-1 or other IMO instruments.

Regulation 15-1.1

With regard to air-pipe closing devices, they should be considered weathertight closing devices (not watertight). This is consistent with their treatment in regulation 7-2.5.2.1. However, in the context of regulation 15-1, "external openings" are not intended to include air-pipe openings.

REGULATION 16 – CONSTRUCTION AND INITIAL TESTS OF WATERTIGHT CLOSURES

General

These requirements are only to establish a general design standard for watertight closures. They are not intended to require any non-watertight hatches to be watertight, nor do they override the requirements of the International Convention on Load Lines.

Regulation 16.2

Large doors, hatches or ramps on passenger and cargo ships, of a design and size that would make pressure testing impracticable, may be exempted from regulation 16.2, provided it is demonstrated by calculations that the doors, hatches or ramps maintain watertightness at design pressure with a proper margin of resistance. Where such doors utilize gasket seals, a prototype pressure test to confirm that the compression of the gasket material is capable of accommodating any deflection, revealed by the structural analysis, should be carried out. After installation every such door, hatch or ramp should be tested by means of a hose test or equivalent.

Note: See explanatory notes for regulation 13 for additional information regarding the treatment of steps in the bulkhead deck of passenger ships. See explanatory notes for regulation 13-1 for additional information regarding the treatment of steps in the freeboard deck of cargo ships.

REGULATION 17 – INTERNAL WATERTIGHT INTEGRITY OF PASSENGER SHIPS ABOVE THE BULKHEAD DECK

General – Steps in the bulkhead deck

For the treatment of steps in the bulkhead deck of passenger ships see explanatory notes for regulation 13.

Regulation 17.1

1 Sliding watertight doors with a reduced pressure head that are located above the bulkhead deck and which are immersed in the final or during any intermediate stage of flooding should comply fully with the requirements of regulation 13. These types of sliding watertight doors tested with reduced pressure head must not be immersed at any stage of flooding by a head of water higher than the tested pressure head. See figure 1 below. These sliding watertight doors shall be kept closed during navigation in compliance with the requirements of regulation 22 and this should be clearly indicated in the damage control information required by regulation 19.

2 If watertight doors are located above the worst final and above the worst intermediate waterline in damage cases contributing to the attained subdivision index *A*, but within the area where the door becomes intermittently immersed (fully or partly) at angles of heel in the required range of positive stability beyond the equilibrium position, such doors are to be power-operated and remotely controlled sliding semi-watertight doors complying with the requirements of regulation 13, except that the scantlings and sealing requirements could be reduced to the maximum head of water caused by the waterline being intermittently immersed (see figure 1 below). These doors should be closed in case of damage and this should be clearly indicated in the damage control information required by regulation 19.

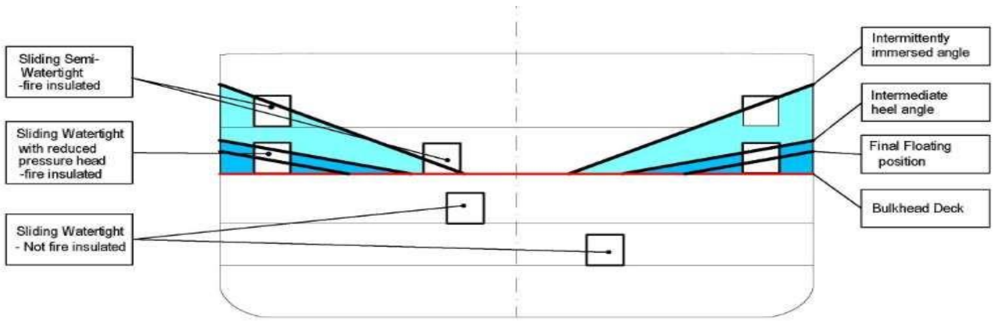


Figure 1

3 The use of watertight sliding doors above the bulkhead deck affects the escape provisions of regulation II-2/13. When such doors are used above the bulkhead deck, there should 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 should be independent of watertight doors and at least one of which should give access to a stairway forming a vertical escape. Sliding watertight doors that will be used frequently by passengers must not create a tripping hazard.

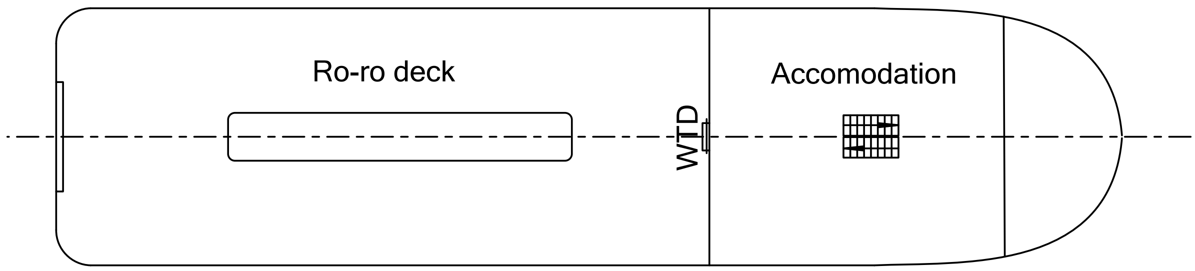
4 Doors fitted above the bulkhead deck which are required to meet both fire protection and watertight requirements should comply with the fire requirements in regulation II-2/9.4.1.1 and the watertight requirements in paragraphs 1 and 2 above. Notwithstanding the ultimate sentence of regulation II-2/9.4.1.1.2, watertight doors fitted above the bulkhead deck should be insulated to the standard required by table 9.1 and regulation II-2/9.2.2.1.1.1 or by table 9.3 and regulation II-2/9.2.2.1.1.2 as appropriate. The door must be capable of operation using both the remote fire door control circuit and the remote watertight door control circuit. If two doors are fitted, they must be capable of independent operation. The operation of either door separately must not preclude closing of the other door. Both doors must be capable of being operated from either side of the bulkhead.

Regulation 17.3

This paragraph is intended to ensure that progressive flooding through air pipes of volumes located above a horizontal division in the superstructure, which is considered as a watertight boundary when applying regulation 7-2.6.1.1, will be taken into consideration if a side or bottom damage would cause flooding via tanks or spaces located below the waterline.

REGULATION 17-1 – INTEGRITY OF THE HULL AND SUPERSTRUCTURE, DAMAGE PREVENTION AND CONTROL ON RO-RO PASSENGER SHIPS

Regulations 17-1.1.1 and 17-1.1.3 apply only to direct accesses from a ro-ro space to spaces located below the bulkhead deck. The operation of doors in bulkheads separating a ro-ro space and other spaces should be limited to compliance with regulation 23.3.



REGULATION 22 – PREVENTION AND CONTROL OF WATER INGRESS, ETC.

The word "port" used in this regulation includes all berths and sheltered locations where loading and/or discharging may take place.

APPENDIX

GUIDELINES FOR THE PREPARATION OF SUBDIVISION AND DAMAGE STABILITY CALCULATIONS

GENERAL

1.1 Purpose of the Guidelines

1.1.1 These Guidelines serve the purpose of simplifying the process of the damage stability analysis, as experience has shown that a systematic and complete presentation of the particulars results in considerable saving of time during the approval process.

1.1.2 A damage stability analysis serves the purpose of providing proof of the damage stability standard required for the respective ship type. At present, two different calculation methods, the deterministic concept and the probabilistic concept are applied.

1.2 Scope of analysis and documentation on board

1.2.1 The scope of subdivision and damage stability analysis is determined by the required damage stability standard and aims at providing the ship's master with clear intact stability requirements. In general, this is achieved by determining *KG*-respective *GM*-limit curves, containing the admissible stability values for the draught range to be covered.

1.2.2 Within the scope of the analysis thus defined, all potential or necessary damage conditions will be determined, taking into account the damage stability criteria, in order to obtain the required damage stability standard. Depending on the type and size of ship, this may involve a considerable amount of analyses.

1.2.3 Referring to SOLAS chapter II-1, regulation 19, the necessity to provide the crew with the relevant information regarding the subdivision of the ship is expressed, therefore plans should be provided and permanently exhibited for the guidance of the officer in charge. These plans should clearly show for each deck and hold the boundaries of the watertight compartments, the openings therein with means of closure and position of any controls thereof, and the arrangements for the correction of any list due to flooding. In addition, Damage Control Booklets containing the aforementioned information should be available.

DOCUMENTS FOR SUBMISSION

2.1 Presentation of documents

The documentation should begin with the following details: principal dimensions, ship type, designation of intact conditions, designation of damage conditions and pertinent damaged compartments, *KG*-respective *GM*-limit curve.

2.2 General documents

For the checking of the input data, the following should be submitted:

.1 main dimensions;

.2 lines plan, plotted or numerical;

.3 hydrostatic data and cross curves of stability (including drawing of the buoyant hull);

.4 definition of sub-compartments with moulded volumes, centres of gravity and permeability;

.5 layout plan (watertight integrity plan) for the sub-compartments with all internal and external opening points including their connected sub-compartments, and particulars used in measuring the spaces, such as general arrangement plan and tank plan. The subdivision limits, longitudinal, transverse and vertical, should be included;

.6 light service condition;

.7 load line draught;

.8 coordinates of opening points with their level of tightness (e.g. weathertight, unprotected);

.9 watertight door location with pressure calculation;

.10 side contour and wind profile;

.11 cross and down flooding devices and the calculations thereof according to resolution MSC.362(92) with information about diameter, valves, pipe lengths and coordinates of inlet/outlet;

.12 pipes in damaged area when the destruction of these pipes results in progressive flooding; and

.13 damage extensions and definition of damage cases.

2.3 Special documents

The following documentation of results should be submitted.

2.3.1 Documentation

2.3.1.1 Initial data:

.1 subdivision length L_s;

.2 initial draughts and the corresponding *GM*-values;

.3 required subdivision index *R*; and

.4 attained subdivision index *A* with a summary table for all contributions for all damaged zones.

2.3.1.2 Results for each damage case which contributes to the index *A*:

.1 draught, trim, heel, *GM* in damaged condition;

.2 dimension of the damage with probabilistic values *p*, *v* and *r*;

.3 righting lever curve (including GZ_{max} and range) with factor of survivability *s*;

.4 critical weathertight and unprotected openings with their angle of immersion; and

.5 details of sub-compartments with amount of in-flooded water/lost buoyancy with their centres of gravity.

2.3.1.3 In addition to the requirements in paragraph 2.3.1.2, particulars of non-contributing damages (s_i = 0 and p_i > 0.00) should also be submitted for passenger ships and ro-ro ships fitted with long lower holds including full details of the calculated factors.

2.3.2 Special consideration

For intermediate conditions, as stages before cross-flooding or before progressive flooding, an appropriate scope of the documentation covering the aforementioned items is needed in addition.

***

ANNEX 12

RESOLUTION MSC.429(98)/REV.2
(adopted on 11 November 2020)

REVISED EXPLANATORY NOTES TO THE SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the function of the Committee,

RECALLING ALSO that, by resolution MSC.216(82), it adopted the regulations on subdivision and damage stability as contained in SOLAS chapter II-1 which are based on the probabilistic concept, using the probability of survival after collision as a measure of ships' safety in a damaged condition,

NOTING that, at its eighty-second session, it approved *Interim explanatory notes to the SOLAS chapter II-1 subdivision and damage stability regulations* (MSC.1/Circ.1226), to assist Administrations in the uniform interpretation and application of the aforementioned subdivision and damage stability regulations,

NOTING ALSO that, at its eighty-fifth session, it adopted the *Explanatory notes to the SOLAS chapter II-1 subdivision and damage stability regulations* (resolution MSC.281(85)),

NOTING FURTHER that, by resolution MSC.421(98), it adopted amendments to regulations on subdivision and damage stability, as contained in SOLAS chapter II-1, and in conjunction with the adoption of the aforementioned amendments, adopted the Revised Explanatory Notes to the SOLAS chapter II-1 subdivision and damage stability regulations, by resolution MSC.429(98),

NOTING that, by resolution MSC.474(102), it adopted additional amendments to regulations on subdivision and damage stability, as contained in SOLAS chapter II-1,

RECOGNIZING that the consolidated Revised Explanatory Notes should be adopted in conjunction with the adoption of the aforementioned amendments to subdivision and damage stability regulations,

RECOGNIZING ALSO that the appropriate application of the Revised Explanatory Notes is essential for ensuring the uniform application of the SOLAS chapter II-1 subdivision and damage stability regulations,

HAVING CONSIDERED, at its 102nd session, the recommendations made by the Sub-Committee on Ship Design and Construction, at its seventh session,

1 ADOPTS the consolidated *Revised explanatory notes to the SOLAS chapter II-1 subdivision and damage stability regulations* set out in the annex to the present resolution;

2 URGES Contracting Governments and all parties concerned to utilize the consolidated Revised Explanatory Notes when applying the SOLAS chapter II-1 subdivision and damage stability regulations adopted by resolution MSC.216(82), as amended;

3 INVITES Contracting Governments to note that these consolidated Revised Explanatory Notes should take effect on 1 January 2024 and should apply to ships as defined in SOLAS regulation II-1/1.1.1.1;

4 REVOKES resolution MSC.429(98)/Rev.1 on 1 January 2024.

ANNEX

REVISED EXPLANATORY NOTES TO THE SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS

Contents

PART A

INTRODUCTION

1 The harmonized SOLAS regulations on subdivision and damage stability, as contained in SOLAS chapter II-1, are based on a probabilistic concept which uses the probability of survival after collision as a measure of ships' safety in a damaged condition. This probability is referred to as the "attained subdivision index *A*" in the regulations. It can be considered an objective measure of ships' safety and, ideally, there would be no need to supplement this index by any deterministic requirements.

2 The philosophy behind the probabilistic concept is that two different ships with the same attained index are of equal safety and, therefore, there is no need for special treatment of specific parts of the ship, even if they are able to survive different damages. The only areas which are given special attention in the regulations are the forward and bottom regions, which are dealt with by special subdivision rules provided for cases of ramming and grounding.

3 Only a few deterministic elements, which were necessary to make the concept practicable, have been included. It was also necessary to include a deterministic "minor damage" on top of the probabilistic regulations for passenger ships to avoid ships being designed with what might be perceived as unacceptably vulnerable spots in some part of their length.

4 It is easily recognized that there are many factors that will affect the final consequences of hull damage to a ship. These factors are random and their influence is different for ships with different characteristics. For example, it would seem obvious that in ships of similar size carrying different amounts of cargo, damages of similar extents may lead to different results because of differences in the range of permeability and draught during service. The mass and velocity of the ramming ship is obviously another random variable.

5 Owing to this, the effect of a three-dimensional damage to a ship with given watertight subdivision depends on the following circumstances:

.1 which particular space or group of adjacent spaces is flooded;

.2 the draught, trim and intact metacentric height at the time of damage;

.3 the permeability of affected spaces at the time of damage;

.4 the sea state at the time of damage; and

.5 other factors such as possible heeling moments owing to unsymmetrical weights.

6 Some of these circumstances are interdependent and the relationship between them and their effects may vary in different cases. Additionally, the effect of hull strength on penetration will obviously have some effect on the results for a given ship. Since the location and size of the damage is random, it is not possible to state which part of the ship becomes flooded. However, the probability of flooding a given space can be determined if the probability of occurrence of certain damages is known from experience, that is, damage statistics. The probability of flooding a space is then equal to the probability of occurrence of all such damages which just open the considered space to the sea.

7 For these reasons and because of mathematical complexity as well as insufficient data, it would not be practicable to make an exact or direct assessment of their effect on the probability that a particular ship will survive a random damage if it occurs. However, accepting some approximations or qualitative judgments, a logical treatment may be achieved by using the probability approach as the basis for a comparative method for the assessment and regulation of ship safety.

8 It may be demonstrated by means of probability theory that the probability of ship survival should be calculated as the sum of probabilities of its survival after flooding each single compartment, each group of two, three, etc., adjacent compartments multiplied, respectively, by the probabilities of occurrence of such damages leading to the flooding of the corresponding compartment or group of compartments.

9 If the probability of occurrence for each of the damage scenarios the ship could be subjected to is calculated and then combined with the probability of surviving each of these damages with the ship loaded in the most probable loading conditions, we can determine the attained index *A* as a measure for the ship's ability to sustain a collision damage.

10 It follows that the probability that a ship will remain afloat without sinking or capsizing as a result of an arbitrary collision in a given longitudinal position can be broken down to:

.1 the probability that the longitudinal centre of damage occurs in just the region of the ship under consideration;

.2 the probability that this damage has a longitudinal extent that only includes spaces between the transverse watertight bulkheads found in this region;

.3 the probability that the damage has a vertical extent that will flood only the spaces below a given horizontal boundary, such as a watertight deck;

.4 the probability that the damage has a transverse penetration not greater than the distance to a given longitudinal boundary; and

.5 the probability that the watertight integrity and the stability throughout the flooding sequence is sufficient to avoid capsizing or sinking.

11 The first three of these factors are solely dependent on the watertight arrangement of the ship, while the last two depend on the ship's shape. The last factor also depends on the actual loading condition. By grouping these probabilities, calculations of the probability of survival, or attained index *A*, have been formulated to include the following probabilities:

.1 the probability of flooding each single compartment and each possible group of two or more adjacent compartments; and

.2 the probability that the stability after flooding a compartment or a group of two or more adjacent compartments will be sufficient to prevent capsizing or dangerous heeling due to loss of stability or to heeling moments in intermediate or final stages of flooding.

12 This concept allows a rule requirement to be applied by requiring a minimum value of *A* for a particular ship. This minimum value is referred to as the "required subdivision index *R*" in the present regulations and can be made dependent on ship size, number of passengers or other factors legislators might consider important.

13 Evidence of compliance with the rules then simply becomes:

$$A \geq R$$

13.1 As explained above, the attained subdivision index *A* is determined by a formula for the entire probability as the sum of the products for each compartment or group of compartments of the probability that a space is flooded, multiplied by the probability that the ship will not capsize or sink due to flooding of the considered space. In other words, the general formula for the attained index can be given in the form:

$$A = \Sigma p_i s_i$$

13.2 Subscript "i" represents the damage zone (group of compartments) under consideration within the watertight subdivision of the ship. The subdivision is viewed in the longitudinal direction, starting with the aftmost zone/compartment.

13.3 The value of "p_i" represents the probability that only the zone "i" under consideration will be flooded, disregarding any horizontal subdivision, but taking transverse subdivision into account. Longitudinal subdivision within the zone will result in additional flooding scenarios, each with its own probability of occurrence.

13.4 The value of "s_i" represents the probability of survival after flooding the zone "i" under consideration.

14 Although the ideas outlined above are very simple, their practical application in an exact manner would give rise to several difficulties if a mathematically perfect method were to be developed. As pointed out above, an extensive but still incomplete description of the damage will include its longitudinal and vertical location as well as its longitudinal, vertical and transverse extent. Apart from the difficulties in handling such a five-dimensional random variable, it is impossible to determine its probability distribution very accurately with the presently available damage statistics. Similar limitations are true for the variables and physical relationships involved in the calculation of the probability that a ship will not capsize or sink during intermediate stages or in the final stage of flooding.

15 A close approximation of the available statistics would result in extremely numerous and complicated computations. In order to make the concept practicable, extensive simplifications are necessary. Although it is not possible to calculate the exact probability of survival on such a simplified basis, it has still been possible to develop a useful comparative measure of the merits of the longitudinal, transverse and horizontal subdivision of a ship.

PART B

GUIDANCE ON INDIVIDUAL SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS

REGULATION 1 – APPLICATION

Regulation 1.3

1 If a passenger ship built before 1 January 2009 undergoes alterations or modifications of major character, it may still remain under the damage stability regulations applicable to ships built before 1 January 2009.

2 If a passenger ship constructed on or after 1 January 2009 but before the applicable dates in regulation 1.1.1.1[1] undergoes alterations or modifications of major character that do not impact the watertight subdivision of the ship, or only have a minor impact, it may still remain under the damage stability regulations that were applicable when it was constructed. However, if alterations or modifications of major character significantly impact the watertight subdivision of the ship, it should comply with the damage stability regulations in part B-1 applicable when the alterations or modifications of major character are carried out unless the Administration determines that this is not reasonable and practicable, in which case the attained subdivision index *A* should be raised above the original construction required subdivision index *R* as much as practical.

3 Application of MSC.1/Circ.1246 is limited to cargo ships constructed before 1 January 2009.

4 A cargo ship constructed on or after 1 January 2009 of less than 80 m in length that is later lengthened beyond that limit should fully comply with the damage stability regulations according to its type and length.

5 If a passenger ship that has been in domestic service only and never been issued a SOLAS Passenger Ship Safety Certificate is converted to international service, for purposes of the stability requirements in parts B, B-1, B-2, B-3 and B-4 it should be treated as a passenger ship constructed on the date on which such a conversion commences.

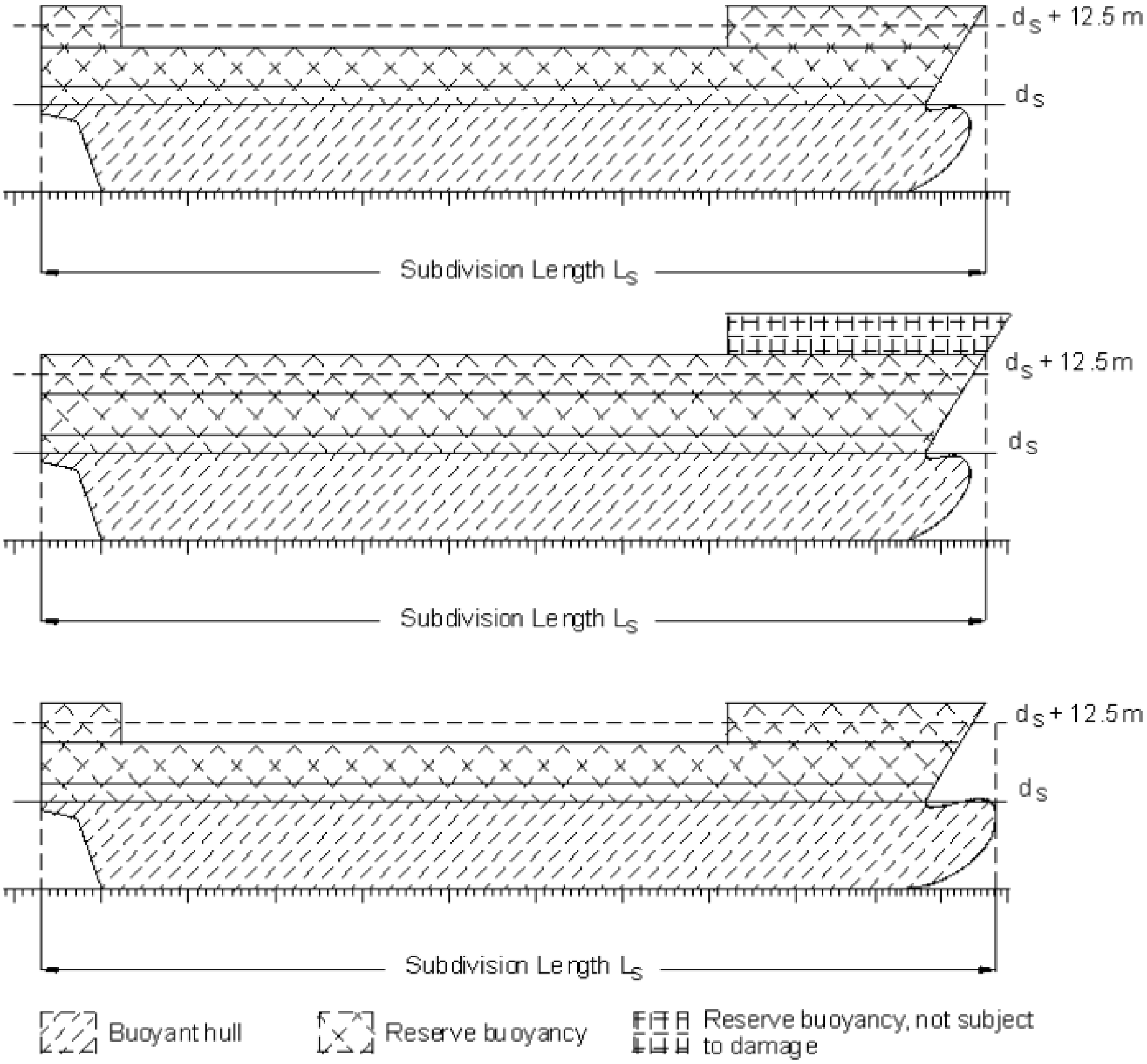
REGULATION 2 – DEFINITIONS

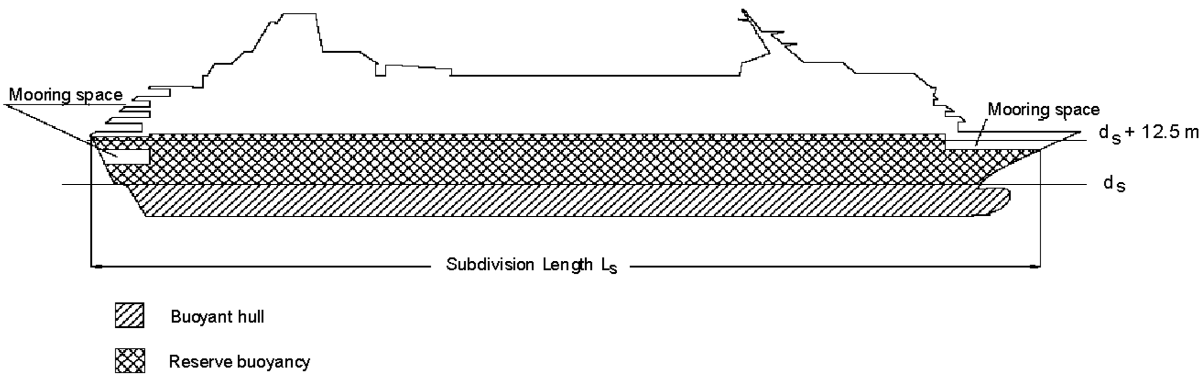
Regulation 2.1

Subdivision length (L_s) – Different examples of L_s showing the buoyant hull and the reserve buoyancy are provided in the figures below. The limiting deck for the reserve buoyancy may be partially watertight.

The maximum possible vertical extent of damage above the baseline is d_s + 12.5 metres.

[1] References to regulations in this Guidance are to regulations of SOLAS chapter II-1, unless expressly provided otherwise.





Regulation 2.6

Freeboard deck – See explanatory notes for regulation 13-1 for the treatment of a stepped freeboard deck with regard to watertightness and construction requirements.

Regulation 2.11

Light service draught (d_l) – The light service draught (d_l) corresponds, in general, to the ballast arrival condition with 10% consumables for cargo ships. For passenger ships it corresponds, in general, to the arrival condition with 10% consumables, a full complement of passengers and crew and their effects, and ballast as necessary for stability and trim. Any temporary ballast water exchange conditions for compliance with the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 or any non-service conditions, such as dry-docking, should not be taken as d_l.

Regulation 2.19

Bulkhead deck – See explanatory notes for regulation 13 for the treatment of a stepped bulkhead deck with regard to watertightness and construction requirements.

REGULATION 4 – GENERAL

Regulation 4.5

See explanatory notes for regulation 7-2.2, for information and guidance related to these provisions.

REGULATION 5 – INTACT STABILITY

Regulation 5.2

1 For the purpose of this regulation, a sister ship means a cargo ship built by the same shipyard from the same plans.

2 For any new sister ship with known differences from the lead sister ship that do not exceed the lightship displacement and longitudinal centre of gravity deviation limits specified in regulation 5.2, a detailed weights and centres of gravity calculation to adjust the lead sister ship's lightship properties should be carried out. These adjusted lead sister ship lightship properties are then used for comparison to the new sister ship's lightweight survey results. However, in cases when the known differences from the lead sister ship exceed lightship displacement or longitudinal centre of gravity deviation limits specified in regulation 5.2, the ship should be inclined.

3 When the lightweight survey results do not exceed the specified deviation limits, the lightship displacement and the longitudinal and transverse centres of gravity obtained from the lightweight survey should be used in conjunction with the higher of either the lead sister ship's vertical centre of gravity or the calculated, adjusted value.

4 Regulation 5.2 may be applied to the SPS Code ships certified to carry less than 240 persons.

Regulation 5.4

1 When alterations are made to a ship in service that result in calculable differences in the lightship properties, a detailed weights and centres of gravity calculation to adjust the lightship properties should be carried out. If the adjusted lightship displacement or longitudinal centre of gravity, when compared to the approved values, exceeds one of the deviation limits specified in regulation 5.5, the ship should be re-inclined. In addition, if the adjusted lightship vertical centre of gravity, when compared to the approved value, exceeds 1%, the ship should be re-inclined. The lightship transverse centre of gravity is not subject to a deviation limit.

2 When a ship does not exceed the deviation limits specified in explanatory note 1 above, amended stability information should be provided to the master using the new calculated lightship properties if any of the following deviations from the approved values are exceeded:

.1 1% of the lightship displacement; or

.2 0.5% of L for the longitudinal centre of gravity; or

.3 0.5% of the vertical centre of gravity.

However, in cases when these deviation limits are not exceeded, it is not necessary to amend the stability information supplied to the master.

3 When multiple alterations are made to a ship in service over a period of time and each alteration is within the deviation limits specified above, the cumulative total changes to the lightship properties from the most recent inclining also should not exceed the deviation limits specified above or the ship should be re-inclined.

Regulation 5.5

When the lightweight survey results do not exceed the specified deviation limits, the lightship displacement and the longitudinal and transverse centres of gravity obtained from the lightweight survey should be used in conjunction with the vertical centre of gravity derived from the most recent inclining in all subsequent stability information supplied to the master.

REGULATION 5-1 – STABILITY INFORMATION TO BE SUPPLIED TO THE MASTER

Regulation 5-1.3

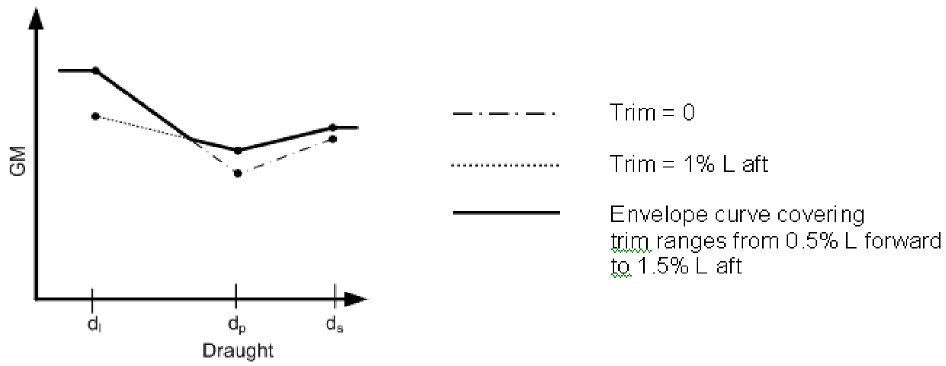
The requirement that applied trim values shall coincide in all stability information intended for use on board is intended to address initial stability calculations as well as those that may be necessary during the service life of the ship.

Regulation 5-1.4 (see also regulation 7.2)

1 Linear interpolation of the limiting values between the draughts d_s, d_p and d_l is only applicable to minimum *GM* values. If it is intended to develop curves of maximum permissible *KG*, a sufficient number of KM_T values for intermediate draughts should be calculated to ensure that the resulting maximum *KG* curves correspond with a linear variation of *GM*. When light service draught is not with the same trim as other draughts, KM_T for draughts between partial and light service draught should be calculated for trims interpolated between trim at partial draught and trim at light service draught.

2 In cases where the operational trim range is intended to exceed ±0.5% of *L*, the original *GM* limit line should be designed in the usual manner with the deepest subdivision draught and partial subdivision draught calculated at level trim and estimated service trim used for the light service draught. Then additional sets of *GM* limit lines should be constructed on the basis of the operational range of trims which is covered by loading conditions for each of the three draughts d_s, d_p and d_l ensuring that intervals of 1% *L* are not exceeded. The sets of *GM* limit lines are combined to give a single envelope limiting *GM* curve. The effective trim range of the curve should be clearly stated.

3 If multiple *GM* limiting curves are obtained from damage stability calculations of differing trims in accordance with regulation 7, an envelope curve covering all calculated trim values should be developed. Calculations covering different trim values should be carried out in steps not exceeding 1% of *L*. The whole range including intermediate trims should be covered by the damage stability calculations. Refer to the example showing an envelope curve obtained from calculations of 0 trim and 1% of *L*.

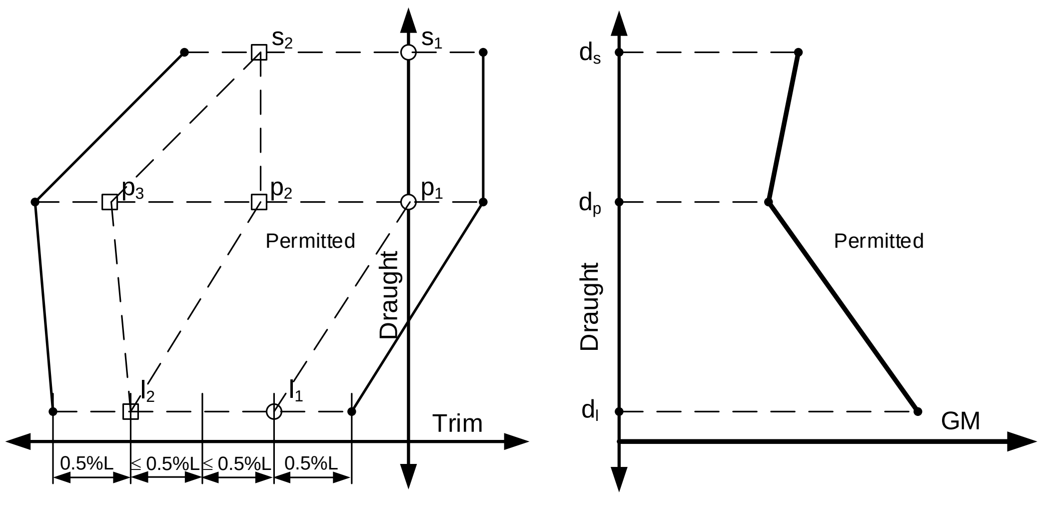


4 Temporary loading conditions may occur with a draught less than the light service draught d_l due to ballast water exchange requirements, etc. In these cases, for draughts below d_l, the *GM* limit value at d_l is to be used.

5 Ships may be permitted to sail at draughts above the deepest subdivision draught d_s according to the International Convention on Load Lines, e.g. using the tropical freeboard. In these cases, for draughts above d_s the *GM* limit value at d_s is to be used.

Regulation 5-1.5

There could be cases where it is desirable to expand the trim range, for instance around d_p. This approach is based on the principle that it is not necessary that the same number of trims be used when the *GM* is the same throughout a draught and when the steps between trims do not exceed 1% of *L*. In these cases there will be three *A* values based on draughts s_1, p_1, l_1 and s_2, p_2, l_2 and s_2, p_3, l_2. The lowest value of each partial index A_s, A_p and A_l across these trims should be used in the summation of the attained subdivision index *A*.



Trim limit diagram **GM limit curve**

Regulation 5-1.6

This provision is intended to address cases where an Administration approves an alternative means of verification.

REGULATION 6 – REQUIRED SUBDIVISION INDEX *R*

Regulation 6.1

To demonstrate compliance with these provisions, see the *Guidelines for the preparation of subdivision and damage stability calculations*, set out in the appendix, regarding the presentation of damage stability calculation results.

REGULATION 7 – ATTAINED SUBDIVISION INDEX *A*

Regulation 7.1

1 The probability of surviving after collision damage to the ship's hull is expressed by the index *A*. Producing an index *A* requires calculation of various damage scenarios defined by the extent of damage and the initial loading conditions of the ship before damage. Three loading conditions should be considered and the result weighted as follows:

$$A = 0.4A_s + 0.4A_p + 0.2A_l$$

where the indices *s*, *p* and *l* represent the three loading conditions and the factor to be multiplied to the index indicates how the index *A* from each loading condition is weighted.

2 The method of calculating *A* for a loading condition is expressed by the formula:

$$A_c = \sum_{i=1}^{i=t} p_i \left[v_i s_i \right]$$

2.1 The index *c* represents one of the three loading conditions, the index *i* represents each investigated damage or group of damages and *t* is the number of damages to be investigated to calculate A_c for the particular loading condition.

2.2 To obtain a maximum index *A* for a given subdivision, *t* has to be equal to *T*, the total number of damages.

3 In practice, the damage combinations to be considered are limited either by significantly reduced contributions to *A* (i.e. flooding of substantially larger volumes) or by exceeding the maximum possible damage length.

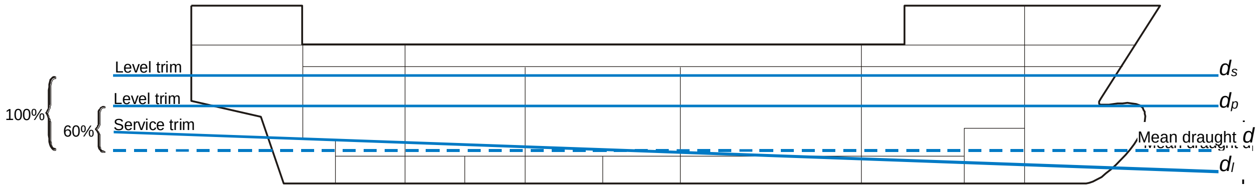
4 The index *A* is divided into partial factors as follows:

p_i The *p* factor is solely dependent on the geometry of the watertight arrangement of the ship.

v_i The *v* factor is dependent on the geometry of the watertight arrangement (decks) of the ship and the draught of the initial loading condition. It represents the probability that the spaces above the horizontal subdivision will not be flooded.

s_i The *s* factor is dependent on the calculated survivability of the ship after the considered damage for a specific initial condition.

5 Three initial loading conditions should be used for calculating each index *A.* The loading conditions are defined by their mean draught *d,* trim and *GM (*or *KG).* The mean draught and trim are illustrated in the figure below.



6 The *GM* (or *KG*) values for the three loading conditions could, as a first attempt, be taken from the intact stability *GM* (or *KG*) limit curve. If the required index *R* is not obtained, the *GM* (or *KG*) values may be increased (or reduced), implying that the intact loading conditions from the intact stability book must now meet the *GM* (or *KG*) limit curve from the damage stability calculations derived by linear interpolation between the three *GM*s.

7 For a series of new passenger or cargo ships built from the same plans each of which have the same draughts d_s, d_p and d_l as well as the same *GM* and trim limits, the attained subdivision index *A* calculated for the lead ship may be used for the other ships. In addition, small differences in the draught d_l (and the subsequent change in the draught d_p) are acceptable if they are due to small differences in the lightship characteristics that do not exceed the deviation limits specified in regulation 5.2. For cases where these conditions are not met, a new attained subdivision index *A* should be calculated.

"Built from the same plans" means that the watertight and weathertight aspects of the hull, bulkheads, decks, openings and other parts of a ship that impact the attained subdivision index *A* calculation remain exactly the same.

8 For a passenger or cargo ship in service which undergoes alterations that materially affect the stability information supplied to the master and require it to be re-inclined in accordance with regulation 5.4, a new attained subdivision index *A* should be calculated. However, for alteration cases where a re-inclining is not required and the alterations do not change the watertight and weathertight arrangements of the ship that impact the attained subdivision index *A*, if d_s and the *GM* and trim limits remain the same then a new attained subdivision index *A* is not required.

9 For passenger ships subject to lightweight surveys every 5 years, if the lightweight survey results are within the limits specified in regulation 5.5, and d_s and the *GM* and trim limits remain the same, a new attained subdivision index *A* is not required. However, if the lightweight survey results exceed either limit specified in regulation 5.5, a new attained subdivision index *A* should be calculated.

10 For any new passenger or cargo ship for which the deviation in lightship characteristics between the preliminary and the as built values are within the limits specified in regulation 5.2 and d_s is unchanged, then the preliminary attained subdivision index *A* calculation may be approved as the final attained subdivision index *A* calculation. However, for cases where these conditions are not met, then a new attained subdivision index *A* should be calculated.

Regulation 7.2

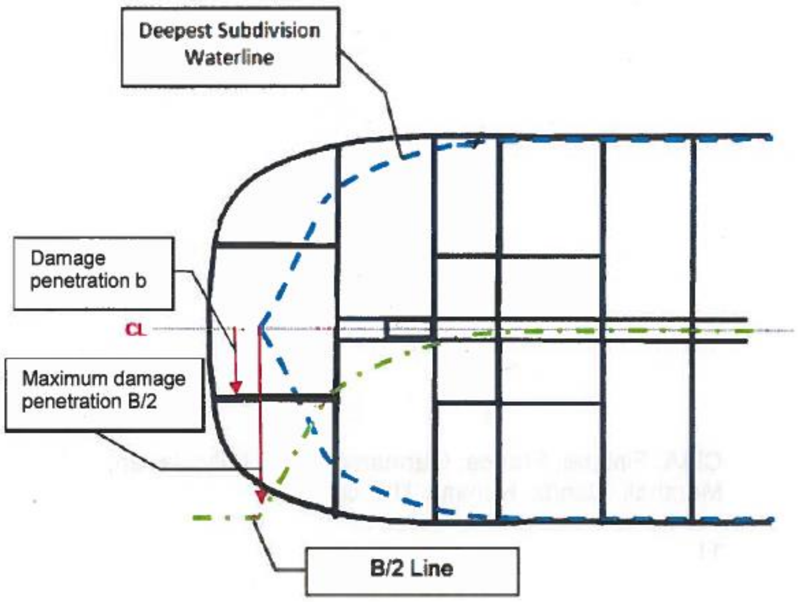
When additional calculations of *A* are performed for different trims, for a given set of calculations the difference between trim values for d_s, d_p and d_l may not exceed 1% *L*.

Regulation 7.5

1 With the same intent as wing tanks, the summation of the attained index *A* should reflect effects caused by all watertight bulkheads and flooding boundaries within the damaged zone. It is not correct to assume damage only to one half of the ship's breadth *B* and ignore changes in subdivision that would reflect lesser contributions.

2 In the forward and aft ends of the ship where the sectional breadth is less than the ship's breadth *B*, transverse damage penetration can extend beyond the centreline bulkhead. This application of the transverse extent of damage is consistent with the methodology to account for the localized statistics which are normalized on the greatest moulded breadth *B* rather than the local breadth.

3 Where, at the extreme ends of the ship, the subdivision exceeds the waterline at the deepest subdivision draught, the damage penetration *b* or *B*/2 is to be taken from centreline. The figure below illustrates the shape of the *B*/2 line.



4 Where longitudinal corrugated bulkheads are fitted in wing compartments or on the centreline, they may be treated as equivalent plane bulkheads provided the corrugation depth is of the same order as the stiffening structure. The same principle may also be applied to transverse corrugated bulkheads.

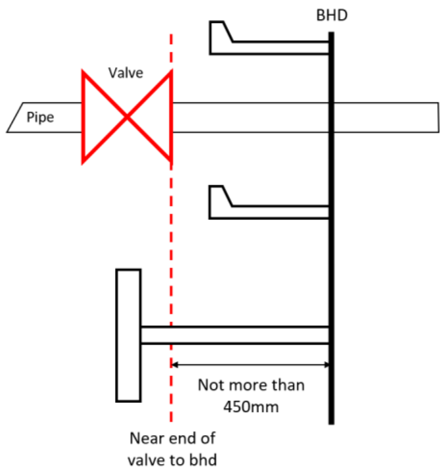
Regulation 7.6

Refer to the explanatory notes for regulation 7-2.2 for the treatment of free surfaces during all stages of flooding.

Regulation 7.7

1 *This explanatory note only applies to ships for which the building contract is placed on or after 1 January 2020 and which are constructed before 1 January 2024.* Pipes and valves directly adjacent or situated as close as practicable to a bulkhead or to a deck can be considered to be part of the bulkhead or deck, provided the separation distance on either side of the bulkhead or deck is of the same order as the bulkhead or deck stiffening structure. The same applies for small recesses, drain wells, etc.

2 *This explanatory note only applies to ships constructed on or after 1 January 2024.* Pipes and valves directly adjacent or situated as close as practicable to a bulkhead or to a deck can be considered to be part of the bulkhead or deck, provided the separation distance on either side of the bulkhead or deck is of the same order as the bulkhead or deck stiffening structure. The same applies for small recesses, drain wells, etc. In no case should the separation distance on either side of the bulkhead or deck be more than 450 mm measured from the valve's near end to the bulkhead or deck.



3 For ships up to L = 150 m the provision for allowing "minor progressive flooding" should be limited to pipes penetrating a watertight subdivision with a total cross-sectional area of not more than 710 mm^2 between any two watertight compartments. For ships of L = 150 m and upwards the total cross-sectional area of pipes should not exceed the cross-sectional area of one pipe with a diameter of L/5000 m.

REGULATION 7-1 – CALCULATION OF THE FACTOR p_i

General

1 The definitions below are intended to be used for the application of part B-1 only.

2 In regulation 7-1, the words "compartment" and "group of compartments" should be understood to mean "zone" and "adjacent zones".

3 Zone – a longitudinal interval of the ship within the subdivision length.

4 Room – a part of the ship, limited by bulkheads and decks, having a specific permeability.

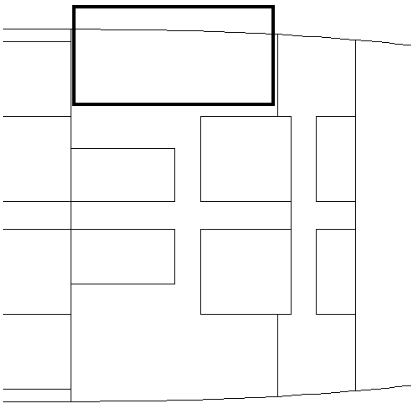
5 Space – a combination of rooms.

6 Compartment – a space within watertight boundaries.

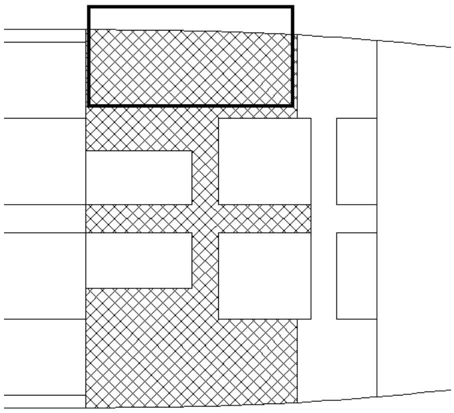
7 Damage – the three-dimensional extent of the breach in the ship.

8 For the calculation of *p*, *v*, *r* and *b* only the damage should be considered, for the calculation of the *s*-value the flooded space should be considered. The figures below illustrate the difference.

Damage shown as the bold square:



Flooded space shown below:



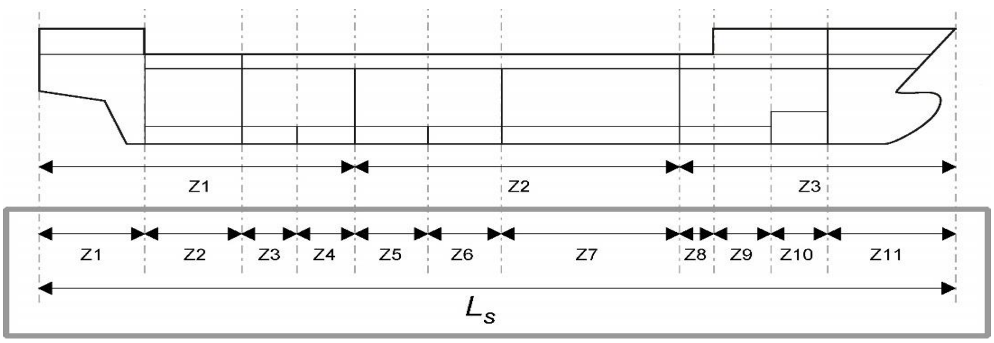
Regulation 7-1.1.1

1 The coefficients b_{11}, b_{12}, b_{21} and b_{22} are coefficients in the bi-linear probability density function on normalized damage length (*J*). The coefficient b_{12} is dependent on whether L_s is greater or less than L^* (i.e. 260 m); the other coefficients are valid irrespective of L_s.

Longitudinal subdivision

2 In order to prepare for the calculation of index *A*, the ship's subdivision length L_s is divided into a fixed discrete number of damage zones. These damage zones will determine the damage stability investigation in the way of specific damages to be calculated.

3 There are no specific rules for longitudinally subdividing the ship, except that the length L_s defines the extremities of the zones. Zone boundaries need not coincide with physical watertight boundaries. However, it is important to consider a strategy carefully to obtain a good result (that is a large attained index *A*). All zones and combination of adjacent zones may contribute to the index *A*. In general it is expected that the more zone boundaries the ship is divided into the higher the attained index will be, but this benefit should be balanced against extra computing time. The figure below shows different longitudinal zone divisions of the length L_s.



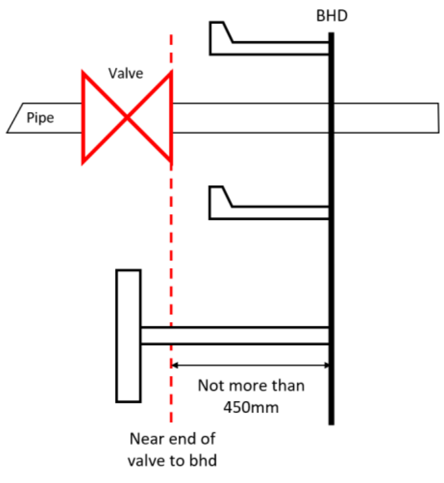
4 The first example is a very rough division into three zones of approximately the same size with limits where longitudinal subdivision is established. The probability that the ship will survive a damage in one of the three zones is expected to be low (i.e. the *s*-factor is low or zero) and, therefore, the total attained index *A* will be correspondingly low.

5 In the second example the zones have been placed in accordance with the watertight arrangement, including minor subdivision (as in double bottom, etc.). In this case there is a much better chance of obtaining higher *s*-factors.

6 Where transverse corrugated bulkheads are fitted, they may be treated as equivalent plane bulkheads, provided the corrugation depth is of the same order as the stiffening structure.

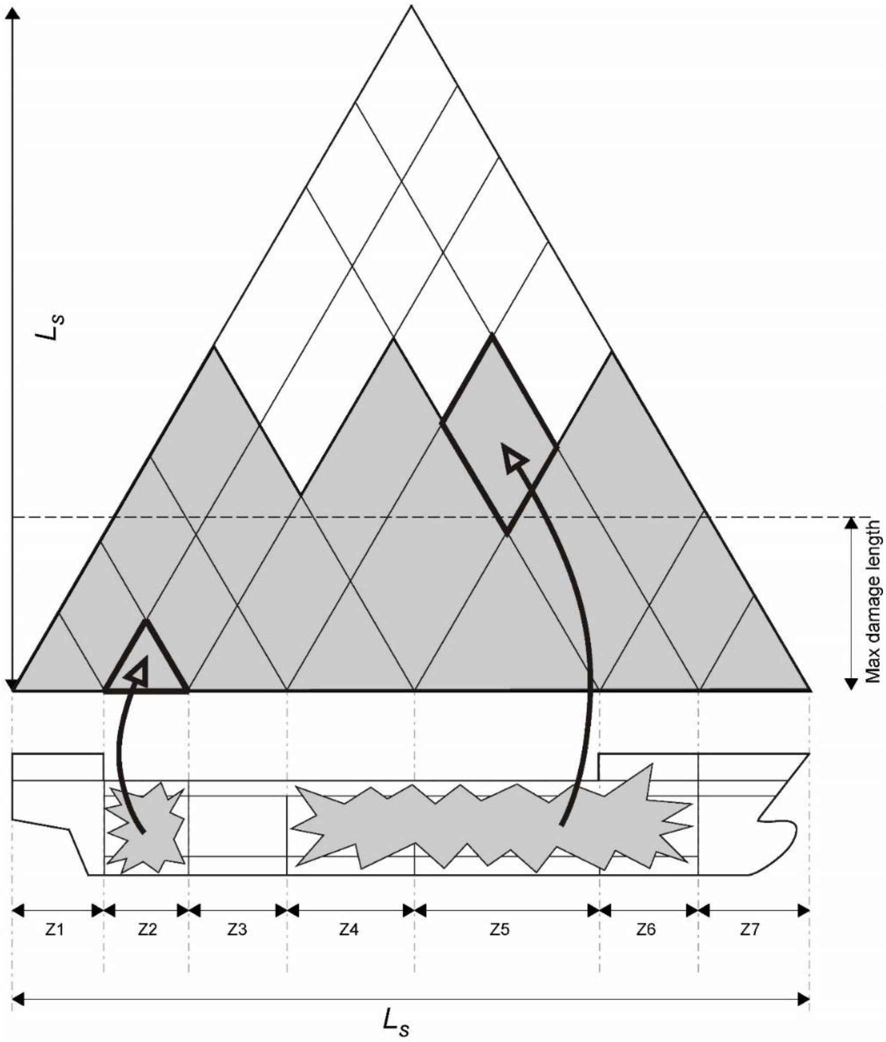
7 *This explanatory note only applies to ships for which the building contract is placed on or after 1 January 2020 and which are constructed before 1 January 2024.* Pipes and valves directly adjacent or situated as close as practicable to a transverse bulkhead can be considered to be part of the bulkhead, provided the separation distance on either side of the bulkhead is of the same order as the bulkhead stiffening structure. The same applies for small recesses, drain wells, etc.

8 *This explanatory note only applies to ships constructed on or after 1 January 2024.* Pipes and valves directly adjacent or situated as close as practicable to a transverse bulkhead can be considered to be part of the bulkhead, provided the separation distance on either side of the bulkhead is of the same order as the bulkhead stiffening structure. The same applies for small recesses, drain wells, etc. In no case should the separation distance on either side of the bulkhead or deck be more than 450 mm measured from the valve's near end to the bulkhead or deck.



9 For cases where the pipes and valves cannot be considered as being part of the transverse bulkhead, when they present a risk of progressive flooding to other watertight compartments that will have influence on the overall attained index *A*, they should be handled either by introducing a new damage zone and accounting for the progressive flooding to associated compartments or by introducing a gap.

10 The triangle in the figure below illustrates the possible single and multiple zone damages in a ship with a watertight arrangement suitable for a seven-zone division. The triangles at the bottom line indicate single zone damages and the parallelograms indicate adjacent zones damages.



11 As an example, the triangle illustrates a damage opening the rooms in zone 2 to the sea and the parallelogram illustrates a damage where rooms in zones 4, 5 and 6 are flooded simultaneously.

12 The shaded area illustrates the effect of the maximum absolute damage length. The *p*-factor for a combination of three or more adjacent zones equals zero if the length of the combined adjacent damage zones minus the length of the foremost and the aft most damage zones in the combined damage zone is greater than the maximum damage length. Having this in mind when subdividing L_s could limit the number of zones defined to maximize the attained index *A*.

13 As the *p*-factor is related to the watertight arrangement by the longitudinal limits of damage zones and the transverse distance from the ship side to any longitudinal barrier in the zone, the following indices are introduced:

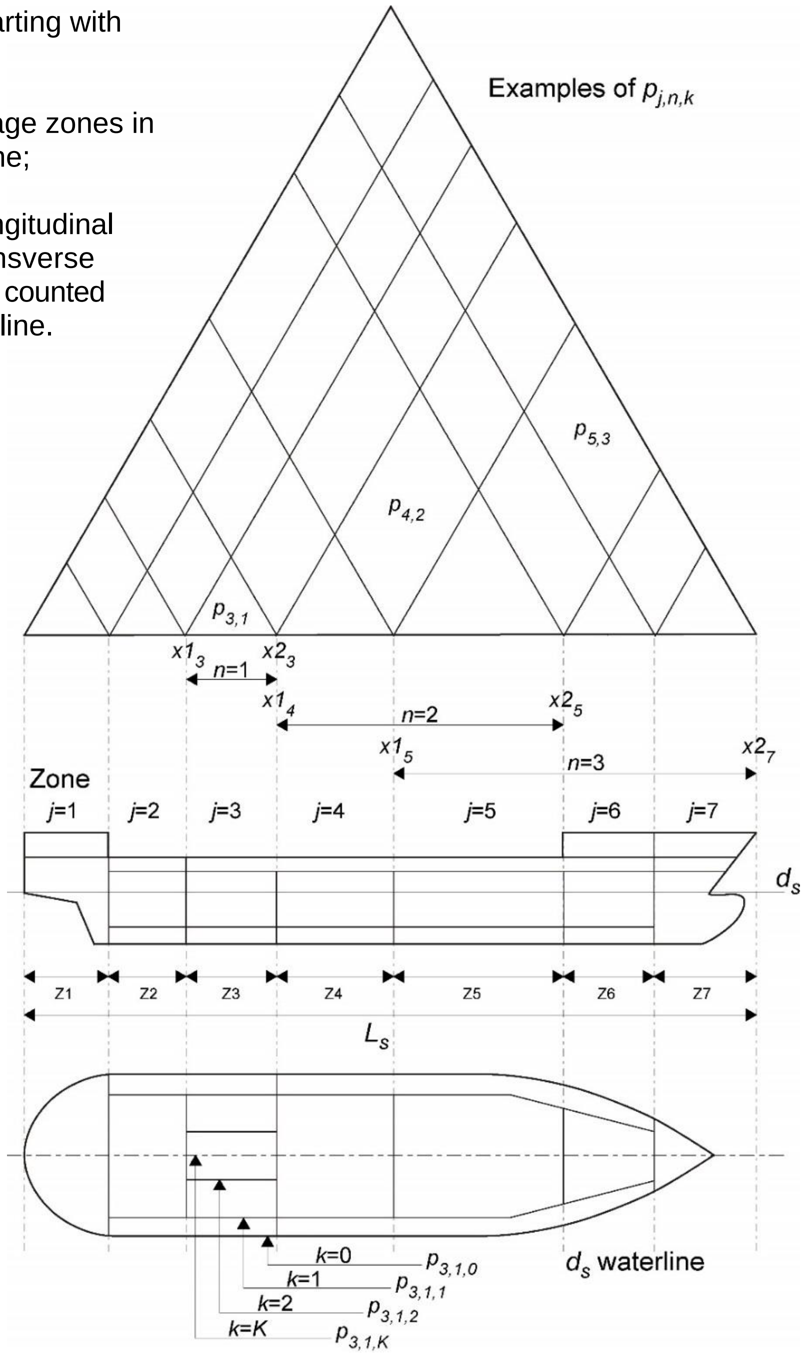
j: the damage zone number starting with No.1 at the stern;

n: the number of adjacent damage zones in question where *j* is the aft zone;

k: the number of a particular longitudinal bulkhead as a barrier for transverse penetration in a damage zone counted from shell towards the centreline. The shell has No.0;

K: total number of transverse penetration boundaries;

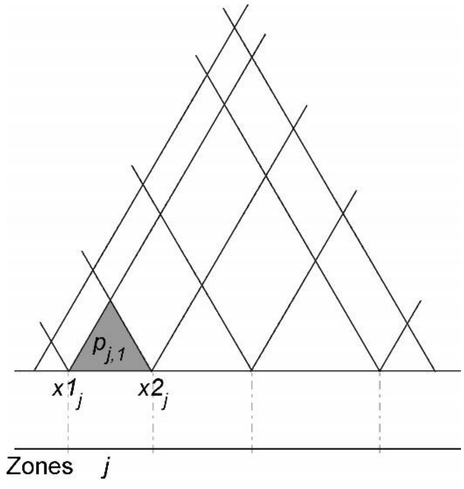
$p_{j,n,k}$: the *p*-factor for a damage in zone *j* and next (*n*-1) zones forward of *j* damaged to the longitudinal bulkhead *k*.



Pure longitudinal subdivision

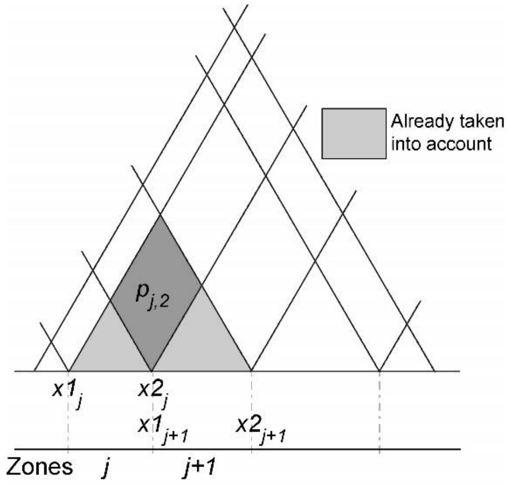
Single damage zone, pure longitudinal subdivision:

$p_{j,1} = p(x1_j, x2_j)$



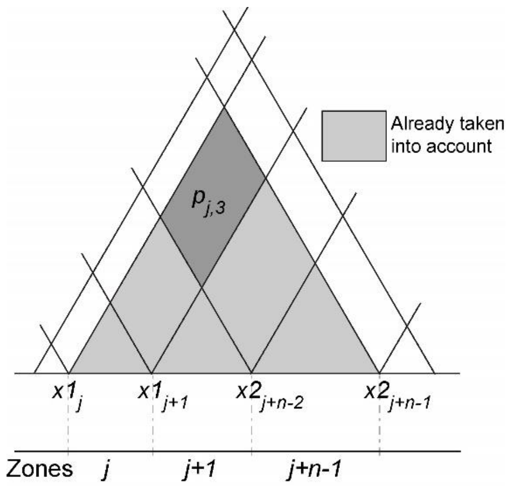
Two adjacent zones, pure longitudinal subdivision:

$p_{j,2} = p(x1_j, x2_{j+1}) - p(x1_j, x2_j) - p(x1_{j+1}, x2_{j+1})$



Three or more adjacent zones, pure longitudinal subdivision:

$p_{j,n} = p(x1_j, x2_{j+n-1}) - p(x1_j, x2_{j+n-2}) - p(x1_{j+1}, x2_{j+n-1}) + p(x1_{j+1}, x2_{j+n-2})$



Regulation 7-1.1.2

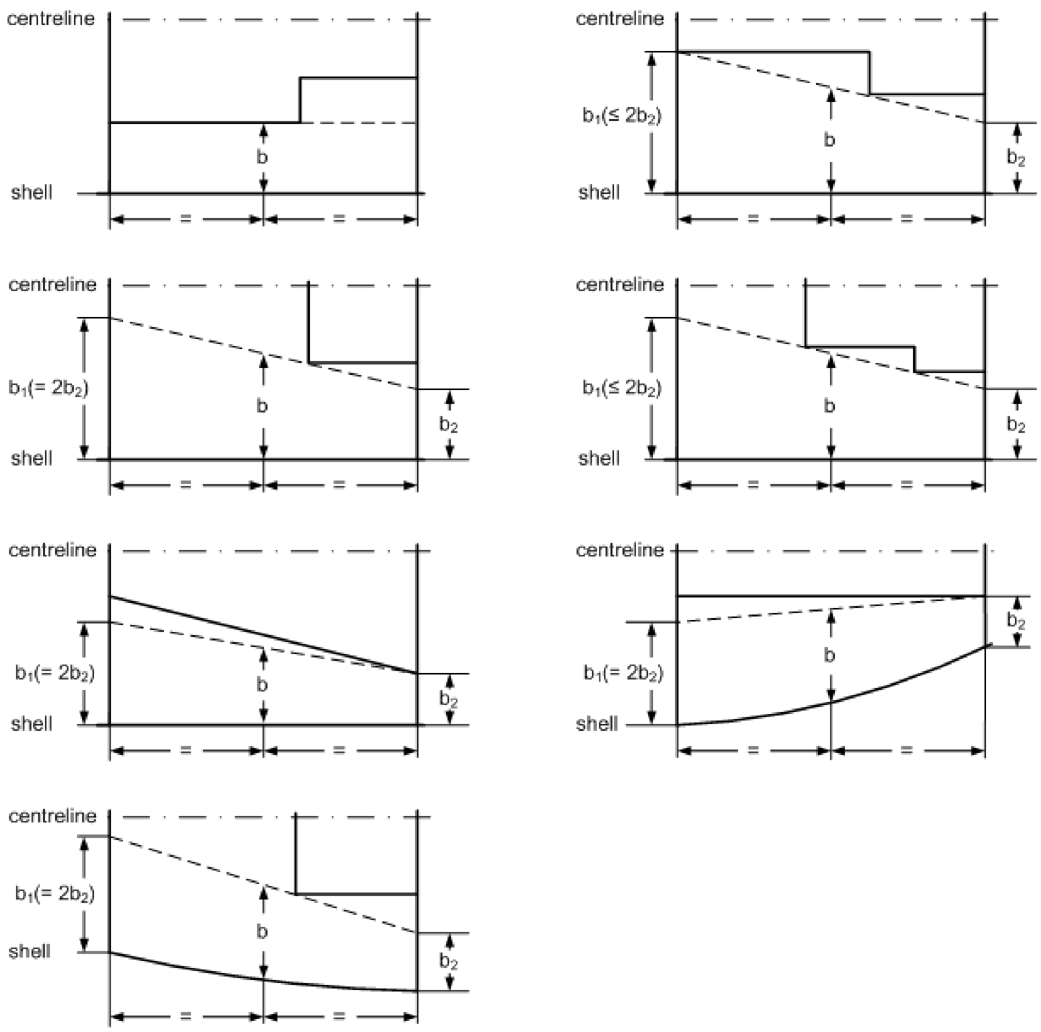
Transverse subdivision in a damage zone

1 Damage to the hull in a specific damage zone may just penetrate the ship's watertight hull or penetrate further towards the centreline. To describe the probability of penetrating only a wing compartment, a probability factor *r* is used, based mainly on the penetration depth *b*. The value of *r* is equal to 1, if the penetration depth is *B/2* where *B* is the maximum breadth of the ship at the deepest subdivision draught d_s, and $r = 0$ if $b = 0$.

2 The penetration depth *b* is measured at level deepest subdivision draught d_s as a transverse distance from the ship side right-angled to the centreline to a longitudinal barrier.

3 Where the actual watertight bulkhead is not a plane parallel to the shell, *b* should be determined by means of an assumed line, dividing the zone to the shell in a relationship b_1/b_2 with $1/2 \leq b_1/b_2 \leq 2$.

4 Examples of such assumed division lines are illustrated in the figure below. Each sketch represents a single damage zone at a water line plane level d_s and the longitudinal bulkhead represents the outermost bulkhead position below d_s + 12.5 m.



4.1 If a transverse subdivision intercepts the deepest subdivision draught waterline within the extent of the zone, *b* is equal to zero in that zone for that transverse subdivision [see figure 1]. A non-zero *b* can be obtained by including an additional zone, see figure 2.

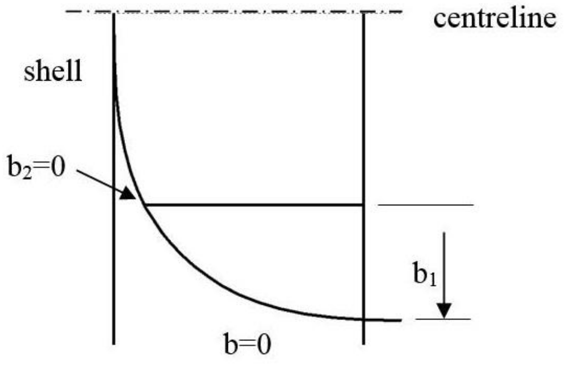


Figure 1

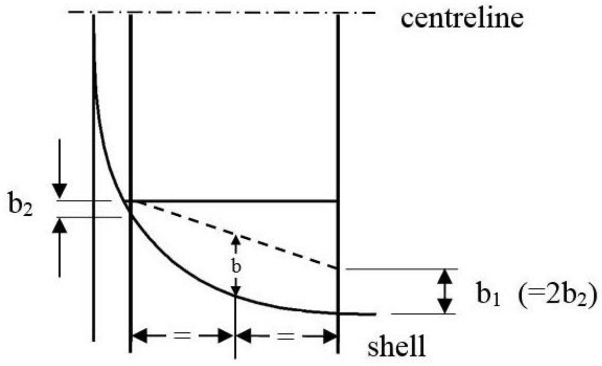


Figure 2

4.2 If the deepest subdivision draught waterline on the side of a single hull ship includes a part where multiple transverse (y) coordinates occur for a longitudinal (x) location, a straightened reference waterline can be used for the calculation of *b*. If this approach is chosen, the original waterline is replaced by an envelope curve including straight parts perpendicular to the centreline where multiple transverse coordinates occur [see figures 1 to 4]. The maximum transverse damage extent *B/2* should then be calculated from waterline or the reference waterline, if applicable, at the deepest subdivision draught.

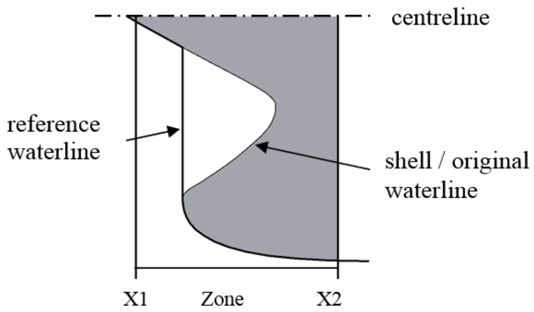


Figure 1

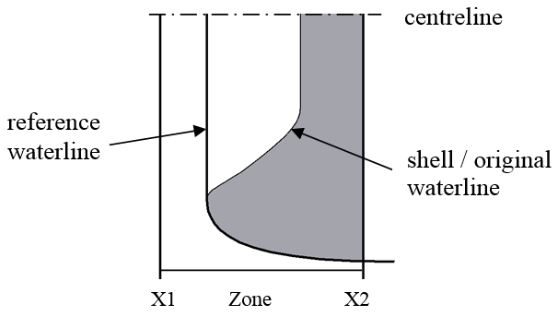


Figure 2

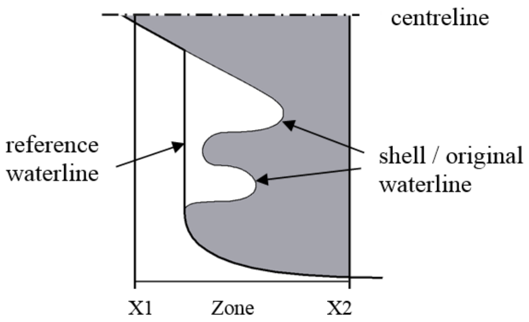


Figure 3

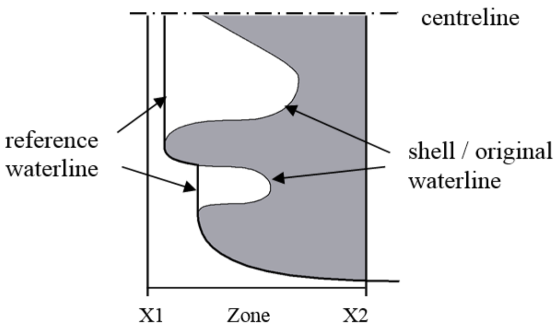


Figure 4

5 In calculating *r*-values for a group of two or more adjacent compartments, the *b*-value is common for all compartments in that group, and equal to the smallest *b*-value in that group:

$$b = \min\{b_1, b_2, \ldots, b_n\}$$

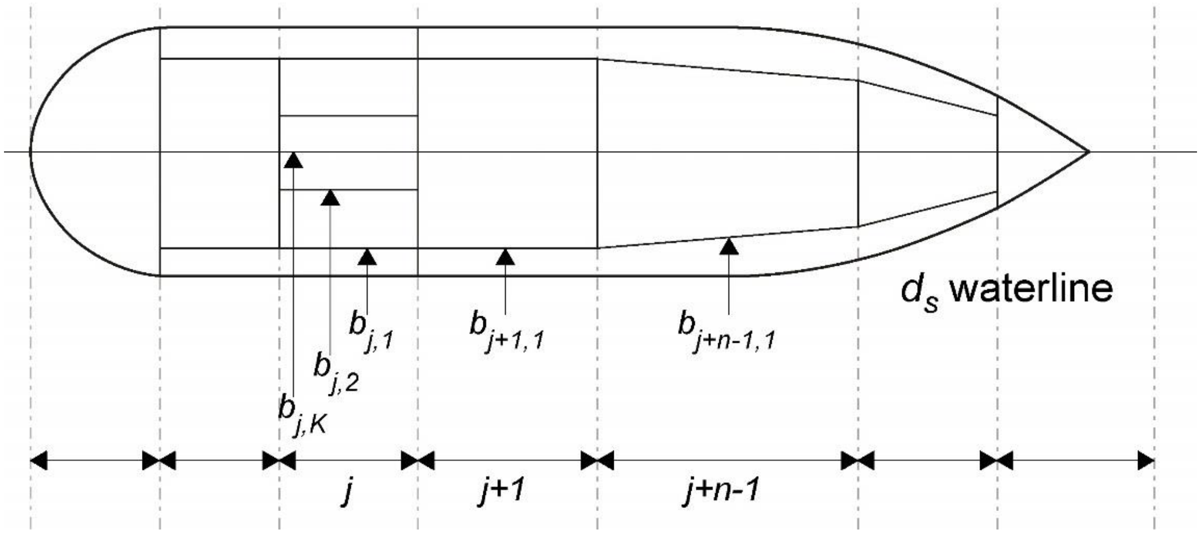
where: $n =$ number of wing compartments in that group;
$b_1, b_2, \ldots, b_n =$ mean values of *b* for individual wing compartments contained in the group.

Accumulating p

6 The accumulated value of *p* for one zone or a group of adjacent zones is determined by:

$$p_{j,n} = \sum_{k=1}^{k=K_{j,n}} p_{j,n,k}$$

where $K_{j,n} = \sum_{j}^{j+n-1} K_j$ the total number of b_k's for the adjacent zones in question.



7 The figure above illustrates *b*'s for adjacent zones. The zone *j* has two penetration limits and one to the centre, the zone *j+1* has one *b* and the zone *j+n-1* has one value for *b*. The multiple zones will have (2+1+1) four values of *b*, and sorted in increasing order they are:

$(b_{j,1}\,;\ b_{j+1,1}\,;\ b_{j+n-1,1}\,;\ b_{j,2}\,;\ b_K)$

8 Because of the expression for *r(x1, x2, b)* only one b_K should be considered. To minimize the number of calculations, *b*'s of the same value may be deleted.

As $b_{j,1} = b_{j+1,1}$ the final *b*'s will be $(b_{j,1}\,;\ b_{j+n-1,1}\,;\ b_{j,2}\,;\ b_K)$

Examples of multiple zones having a different b

9 Examples of combined damage zones and damage definitions are given in the figures below. Compartments are identified by R10, R12, etc.

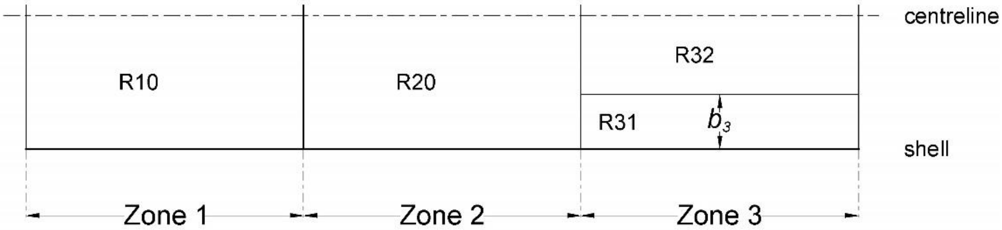


Figure: Combined damage of zones 1 + 2 + 3 includes a limited penetration to b_3, taken into account generating two damages:

1) to b_3 with R10, R20 and R31 damaged;
2) to *B/2* with R10, R20, R31 and R32 damaged.

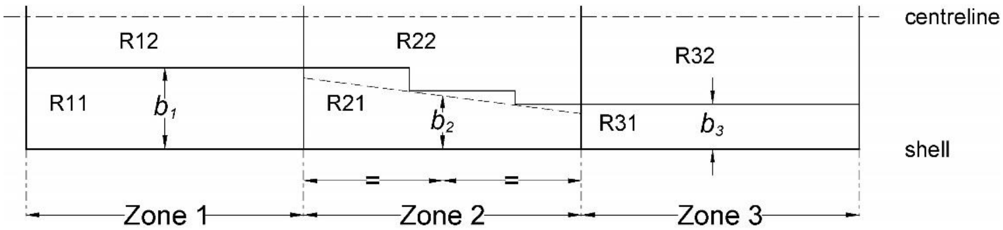


Figure: Combined damage of zones 1 + 2 + 3 includes 3 different limited damage penetrations generating four damages:

1) to b_3 with R11, R21 and R31 damaged;
2) to b_2 with R11, R21, R31 and R32 damaged;
3) to b_1 with R11, R21, R31, R32, and R22 damaged;
4) to *B/2* with R11, R21, R31, R32, R22 and R12 damaged.

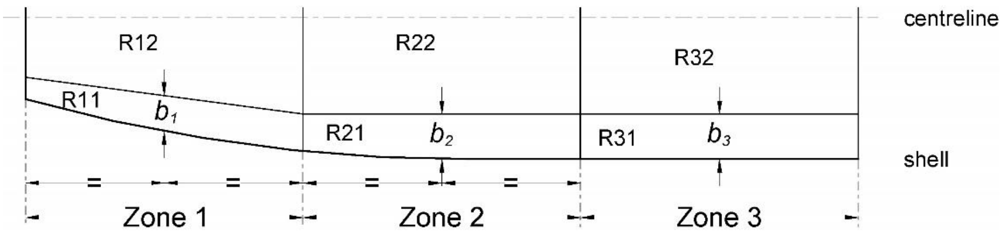
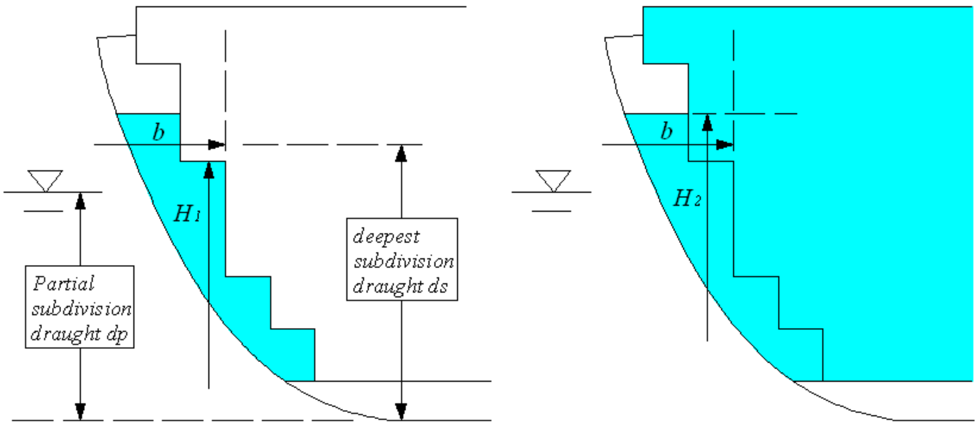


Figure: Combined damage of zone 1 + 2 + 3 including 2 different limited damage penetrations ($b_1 < b_2 = b_3$) generating three damages:

1) to b_1 with R11, R21 and R31 damaged;
2) to b_2 with R11, R21, R31 and R12 damaged;
3) to *B/2* with R11, R21, R31, R12, R22 and R32 damaged.

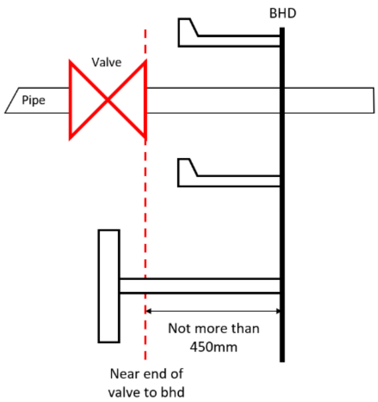
10 A damage having a transverse extent *b* and a vertical extent H_2 leads to the flooding of both wing compartment and hold; for *b* and H_1 only the wing compartment is flooded. The figure below illustrates a partial subdivision draught d_p damage.



11 The same is valid if *b*-values are calculated for arrangements with sloped walls.

12 *This explanatory note only applies to ships for which the building contract is placed on or after 1 January 2020 and which are constructed before 1 January 2024.* Pipes and valves directly adjacent or situated as close as practicable to a longitudinal bulkhead can be considered to be part of the bulkhead, provided the separation distance on either side of the bulkhead is of the same order as the bulkhead stiffening structure. The same applies for small recesses, drain wells, etc.

13 *This explanatory note only applies to ships constructed on or after 1 January 2024.* Pipes and valves directly adjacent or situated as close as practicable to a longitudinal bulkhead can be considered to be part of the bulkhead, provided the separation distance on either side of the bulkhead is of the same order as the bulkhead stiffening structure. The same applies for small recesses, drain wells, etc. In no case should the separation distance on either side of the bulkhead or deck be more than 450 mm measured from the valve's near end to the bulkhead or deck.



REGULATION 7-2 – CALCULATION OF THE FACTOR s_i

General

1 Initial condition – an intact loading condition to be considered in the damage analysis described by the mean draught, vertical centre of gravity and the trim; or alternative parameters from where the same may be determined (e.g. displacement, *GM* and trim). There are three initial conditions corresponding to the three draughts d_s, d_p and d_l.

2 Immersion limits – immersion limits are an array of points that are not to be immersed at various stages of flooding as indicated in regulations 7-2.5.2 and 7-2.5.3.

3 Openings – all openings need to be defined: both weathertight and unprotected. Openings are the most critical factor to preventing an inaccurate index *A*. If the final waterline immerses the lower edge of any opening through which progressive flooding takes place, the factor "*s*" may be recalculated taking such flooding into account. However, in this case the *s* value should also be calculated without taking into account progressive flooding and corresponding opening. The smallest *s* value should be retained for the contribution to the attained index.

Regulation 7-2.1

1 In cases where the *GZ* curve may include more than one "range" of positive righting levers for a specific stage of flooding, only one continuous positive "range" of the *GZ* curve may be used within the allowable range/heel limits for calculation purposes. Different stages of flooding may not be combined in a single *GZ* curve.

Figure 1

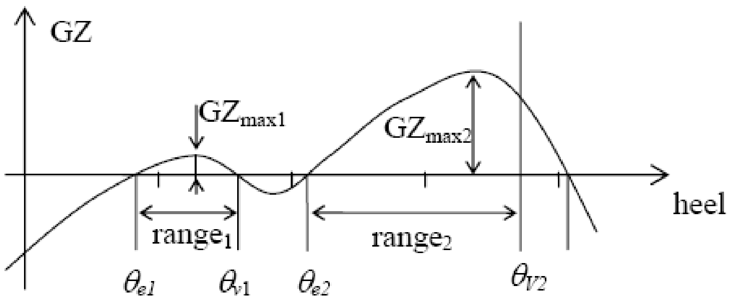
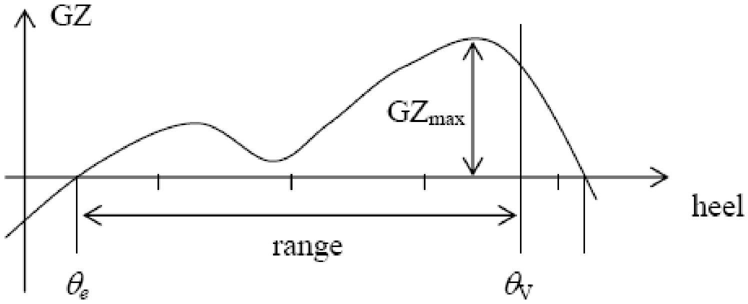


Figure 2



2 In figure 1, the *s*-factor may be calculated from the heel angle, range and corresponding GZ_{max} of the first or second "range" of positive righting levers. In figure 2, only one *s*-factor can be calculated.

Regulation 7-2.2

Intermediate stages of flooding

1 The case of instantaneous flooding in unrestricted spaces in way of the damage zone does not require intermediate stage flooding calculations. Where intermediate stages of flooding calculations are necessary in connection with progressive flooding, flooding through non-watertight boundaries or cross-flooding, they should reflect the sequence of filling as well as filling level phases. Calculations for intermediate stages of flooding should be performed whenever equalization is not instantaneous, i.e. equalization is of a duration greater than 60 s. Such calculations consider the progress through one or more floodable (non-watertight)

spaces, or cross-flooded spaces. Bulkheads surrounding refrigerated spaces, incinerator rooms and longitudinal bulkheads fitted with non-watertight doors are typical examples of structures that may significantly slow down the equalization of main compartments.

Flooding boundaries

2 If a compartment contains decks, inner bulkheads, structural elements and doors of sufficient tightness and strength to seriously restrict the flow of water, for intermediate stage flooding calculation purposes it should be divided into corresponding non-watertight spaces. It is assumed that the non-watertight divisions considered in the calculations are limited to "A" class fire-rated bulkheads and decks, and do not apply to "B" class fire-rated bulkheads normally used in accommodation areas (e.g. cabins and corridors). This guidance also relates to regulation 4.5. For spaces in the double bottom, in general, only main longitudinal structures with a limited number of openings have to be considered as flooding boundaries.

Sequential flooding computation

3 For each damage scenario, the damage extent and location determine the initial stage of flooding. Calculations should be performed in stages, each stage comprising at least two intermediate filling phases in addition to the full phase per flooded space. Unrestricted spaces in way of damage should be considered as flooded immediately. Every subsequent stage involves all connected spaces being flooded simultaneously until an impermeable boundary or final equilibrium is reached. Unless the flooding process is simulated using time-domain methods, when a flooding stage leads to both a self-acting cross-flooding device and a non-watertight boundary, the self-acting cross-flooding device is assumed to act immediately and occur before the non-watertight boundary is breached. If due to the configuration of the subdivision in the ship it is expected that other intermediate stages of flooding are more onerous, then those should be investigated.

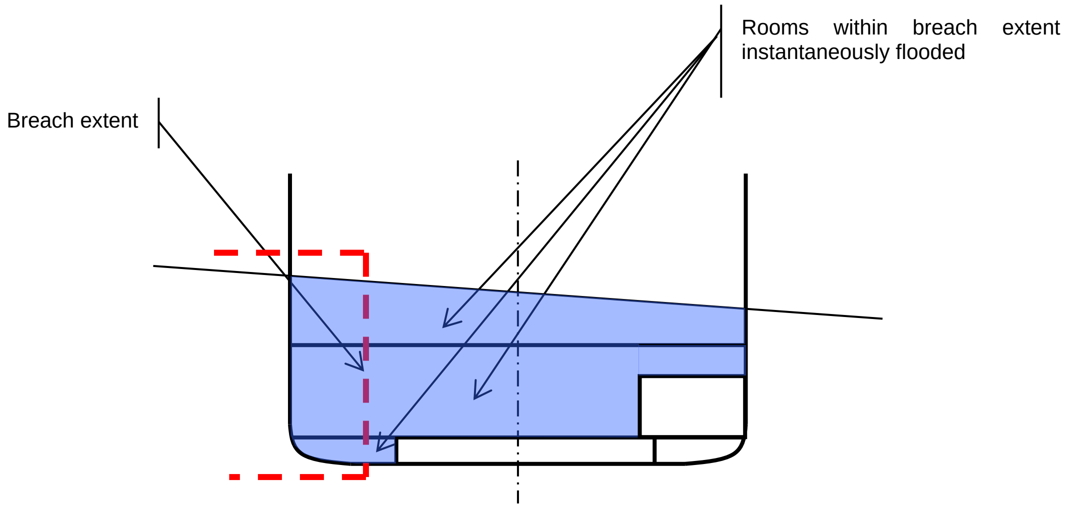
3.1 For each phase of a flooding stage (except the final full phase), the instantaneous transverse moment of this floodwater is calculated by assuming a constant volume of water at each heeling angle. The *GZ* curve is calculated with a constant intact displacement at all stages of flooding. Only one free surface needs to be assumed for water in spaces flooded during the current stage.

3.1.1 In the final full phase of each stage, the water level in rooms flooded during this stage reaches the outside sea level, so the lost buoyancy method can be used. The same method applies for every successive stage (added volume of water with a constant intact displacement for all phases before the final full phase of the stage in consideration), while each of the previous stages at the final full phase can be calculated with the lost buoyancy method.

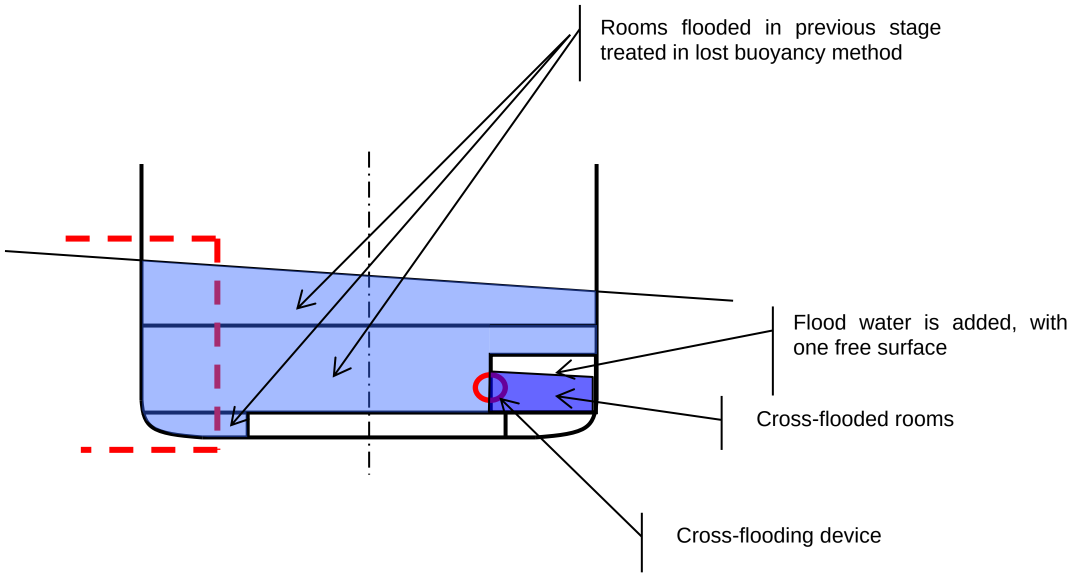
3.1.2 The examples below present a simplified, sequential approach to intermediate stage downflooding and cross-flooding. Because simultaneous downflooding and cross-flooding is not accounted for, any time-to-flood calculated with this sequential approach should be conservative. Alternative approaches, such as time-domain flooding simulation, are also acceptable.

Example 1: Major damage with cross-flooding device

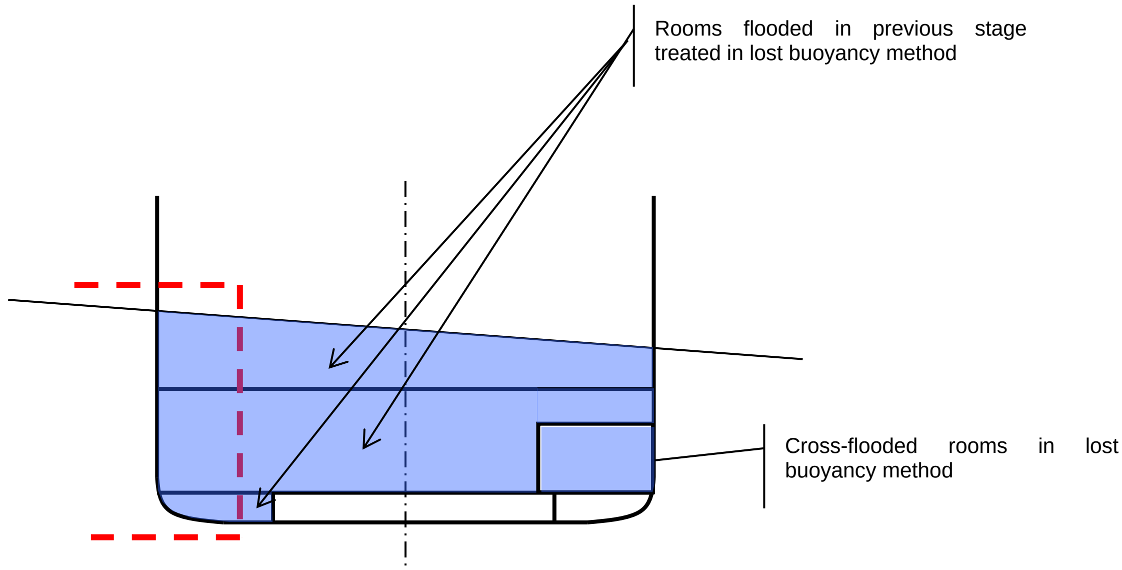
Stage 0: Unrestricted spaces in way of damage should be considered as flooded immediately (intermediate phases are not considered). The lost buoyancy method is applied as this is a full (final) phase. Provided the ship does not capsize and remains at a floating position from which cross-flooding can proceed, stage 0 need not be taken into account for the s_{factor} calculation as the first intermediate stage to be calculated is after 60 s. See cross-flooding/equalization explanatory note 5 below.



Stage 1: Cross-flooding of opposite room



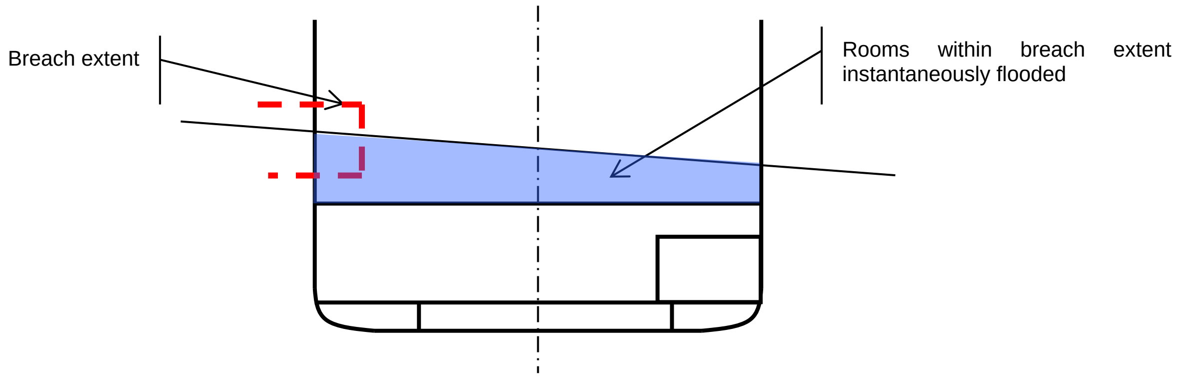
An intermediate phase



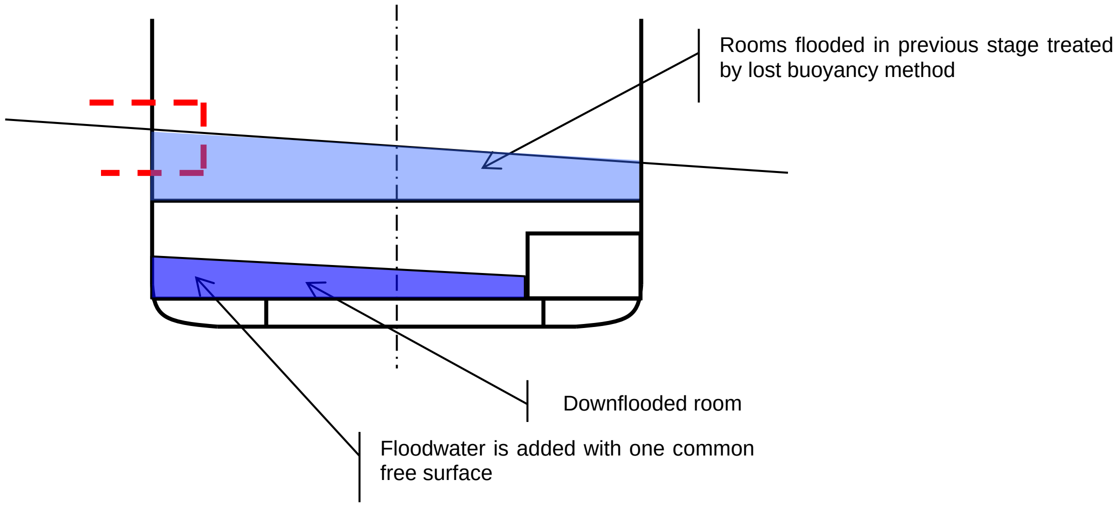
Full (final) phase of flooding stage 1

Example 2: Minor damage with downflooding and cross-flooding

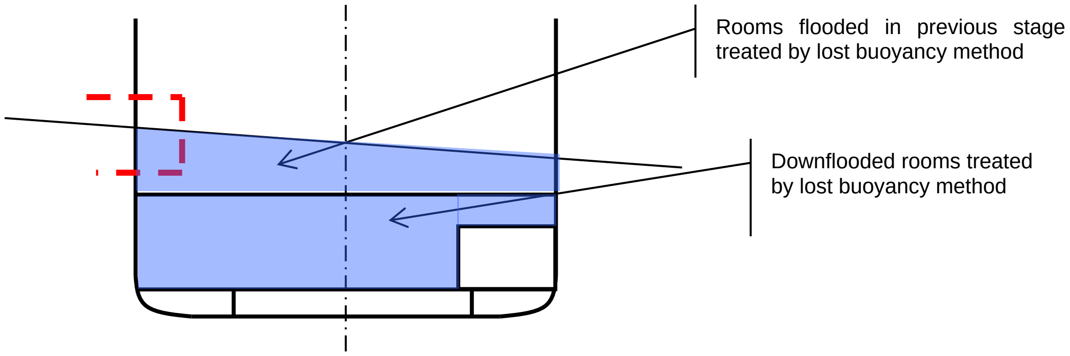
Stage 0: Unrestricted spaces in way of damage should be considered as flooded immediately (intermediate phases are not considered). The lost buoyancy method is applied as this is a full (final) phase. Provided the ship does not capsize and remains at a floating position from which cross-flooding can proceed, stage 0 need not be taken into account for the s_{factor} calculation as the first intermediate stage to be calculated is after 60 s. See cross-flooding/equalization explanatory note 5 below.



Stage 1: Downflooding through non-watertight deck

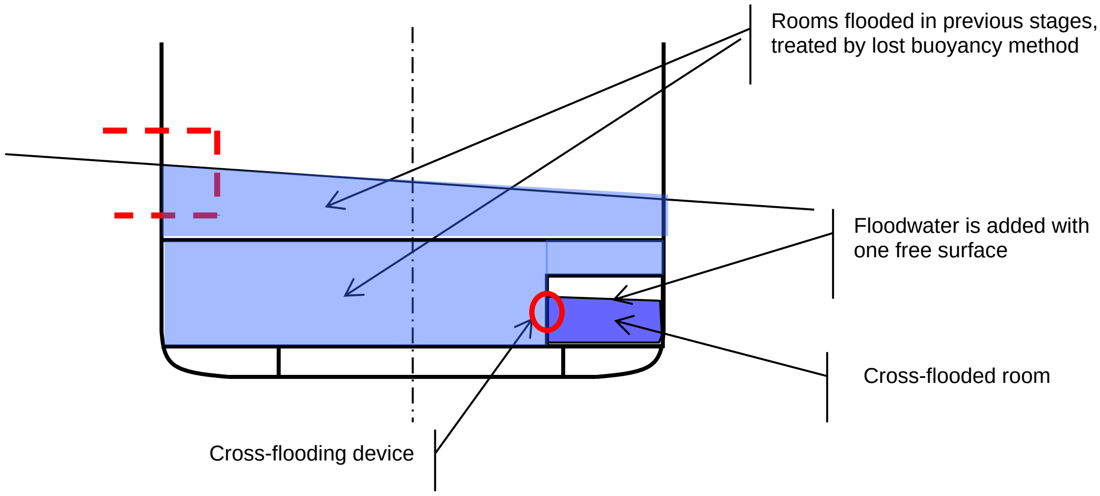


An intermediate phase

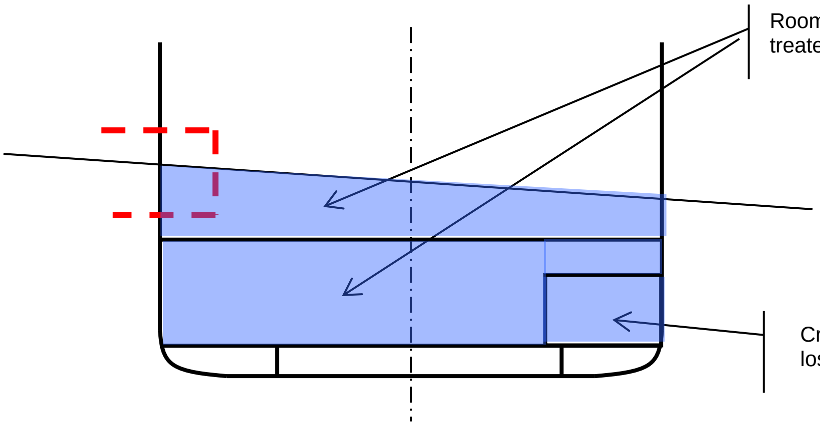


Final (full) phase of stage 1

Stage 2: Cross-flooding



An intermediate phase



Full (final) phase of stage 2

Cross-flooding/equalization

4 In general, cross-flooding is flooding of an undamaged space of the ship to reduce the heel in the final equilibrium condition.

5 The cross-flooding time should be calculated in accordance with the *Revised recommendation on a standard method for evaluating cross-flooding arrangements* (resolution MSC.362(92)). If complete fluid equalization occurs in 60 s or less, it should be treated as instantaneous and no further calculations need to be carried out. Additionally, in cases where $s_{\text{final}} = 1$ is achieved in 60 s or less, but equalization is not complete, instantaneous flooding may also be assumed if s_{final} will not become reduced. In any cases where complete fluid equalization exceeds 60 s, the value of $s_{\text{intermediate}}$ after 60 s is the first intermediate stage to be considered. Only self-acting open cross-flooding arrangements without valves should be considered effective for instantaneous flooding cases.

6 Provided that the ship has a *GZ* greater than 0 and remains in a position from which cross-flooding can proceed, stage 0 need not be taken into account for the s_{factor} calculation as the first intermediate stage to be calculated is after 60 s.

7 Only cross-flooding devices which are sufficiently submerged below the external waterline at stage 0 are to be used in the calculation for cross-flooding according to resolution MSC.362(92).

8 If complete fluid equalization can be finalized in 10 min or less, the assessment of survivability is carried out using the formula in regulation 7-2.1.1 (i.e. as the smallest value of $s_{\text{intermediate}}$ or $s_{\text{final}} \cdot s_{\text{mom}}$)

9 In case the equalization time is longer than 10 min, s_{final} is calculated for the floating position achieved after 10 min of equalization. This floating position is computed by calculating the amount of flood water according to resolution MSC.362(92) using interpolation, where the equalization time is set to 10 min, i.e. the interpolation of the flood water volume is made between the case before equalization (*T*=0) and the total calculated equalization time. For damage cases involving different cross-flooding devices serving different spaces, when the interpolation between the case before equalization (*T=0*) and the total calculated equalization time is needed for flood water volume calculation after 60 s or 10 min, the total equalization time is to be calculated separately for each cross-flooding device.

10 In any cases where complete fluid equalization exceeds 10 min, the value of s_{final} used in the formula in regulation 7-2.1.1 should be the minimum of s_{final} at 10 min or at final equalization.

11 The factor $s_{intermediate,i}$ may be used for cross-flooding stages if they are intermediate stages which are followed by other subsequent flooding stages (e.g. the flooding stages of non-watertight compartments).

Alternatives

12 As an alternative to the procedure described above in the explanatory notes for regulation 7-2.2, direct calculation using computational fluid dynamics (CFD), time-domain flooding simulations or model testing may be used to analyse intermediate stages of flooding and determine the time for equalization.

Regulation 7-2.3

1 The formulation of $s_{final,i}$ is based on target values for *GZ* and *Range* to achieve *s* = 1. These values are defined as TGZ_{max} and *TRange*.

2 If ro-ro spaces are damaged there might be the possibility of water accumulation on these deck spaces. To account for this, in any damage case where the ro-ro space is damaged the higher values for TGZ_{max} and *TRange* are to be applied for the calculation of s_i.

Regulation 7-2.4.1.2

The parameter *A* (projected lateral area) used in this paragraph does not refer to the attained subdivision index.

Regulation 7-2.5.2.1 and 7-2.5.2.3

Unprotected openings

1 The flooding angle will be limited by immersion of such an opening. It is not necessary to define a criterion for non-immersion of unprotected openings at equilibrium, because if it is immersed, the range of positive *GZ* limited to flooding angle will be zero so "*s*" will be equal to zero.

2 An unprotected opening connects two rooms or one room and the outside. An unprotected opening will not be taken into account if the two connected rooms are flooded or none of these rooms are flooded. If the opening is connected to the outside, it will not be taken into account if the connected compartment is flooded. An unprotected opening does not need to be taken into account if it connects a flooded room or the outside to an undamaged room, if this room will be considered as flooded in a subsequent stage.

Openings fitted with a weathertight means of closing ("weathertight openings")

Applies to passenger ships for which the building contract is placed on or after 1 January 2020 and which are constructed before 1 January 2024, and to cargo ships.

3 The survival "*s*" factor will be "0" if any such point is submerged at a stage which is considered as "final". Such points may be submerged during a stage or phase which is considered as "intermediate", or within the range beyond equilibrium.

4 If an opening fitted with a weathertight means of closure is submerged at equilibrium during a stage considered as intermediate, it should be demonstrated that this weathertight means of closure can sustain the corresponding head of water and that the leakage rate is negligible.

5 These points are also defined as connecting two rooms or one room and the outside, and the same principle as for unprotected openings is applied to take them into account or not. If several stages have to be considered as "final", a "weathertight opening" does not need to be taken into account if it connects a flooded room or the outside to an undamaged room if this room will be considered as flooded in a successive "final" stage.

Regulation 7-2.5.2.2

1 Partial immersion of the bulkhead deck may be accepted at final equilibrium. This provision is intended to ensure that evacuation along the bulkhead deck to the vertical escapes will not be impeded by water on that deck. A "horizontal evacuation route" in the context of this regulation means a route on the bulkhead deck connecting spaces located on and under this deck with the vertical escapes from the bulkhead deck required for compliance with SOLAS chapter II-2.

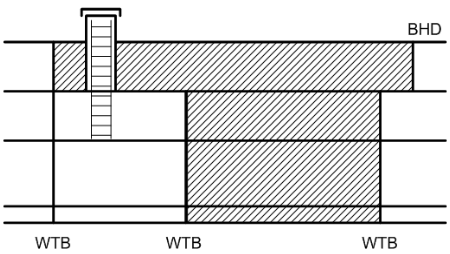
2 Horizontal evacuation routes on the bulkhead deck include only escape routes (designated as category 2 stairway spaces according to SOLAS regulation II-2/9.2.2.3 or as category 4 stairway spaces according to SOLAS regulation II-2/9.2.2.4 for passenger ships carrying not more than 36 passengers) used for the evacuation of undamaged spaces. Horizontal evacuation routes do not include corridors (designated as category 3 corridor spaces according to SOLAS regulation II-2/9.2.2.3 or as category 2 corridor spaces according to SOLAS regulation II-2/9.2.2.4 for passenger ships carrying not more than 36 passengers) or escape routes within a damaged zone. No part of a horizontal evacuation route serving undamaged spaces should be immersed.

3 s_i = 0 where it is not possible to access a stair leading up to the embarkation deck from an undamaged space as a result of flooding to the "stairway" or "horizontal stairway" on the bulkhead deck.

Regulation 7-2.5.3.1

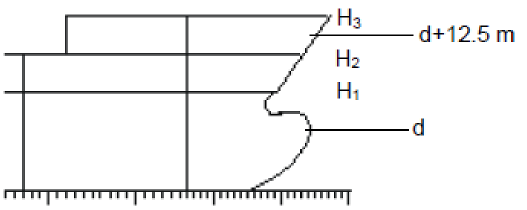
1 The purpose of this paragraph is to provide an incentive to ensure that evacuation through a vertical escape will not be obstructed by water from above. The paragraph is intended for smaller emergency escapes, typically hatches, where fitting of a watertight or weathertight means of closure would otherwise exclude them from being considered as flooding points.

2 Since the probabilistic regulations do not require that the watertight bulkheads be carried continuously up to the bulkhead deck, care should be taken to ensure that evacuation from intact spaces through flooded spaces below the bulkhead deck will remain possible, for instance by means of a watertight trunk.



Regulation 7-2.6

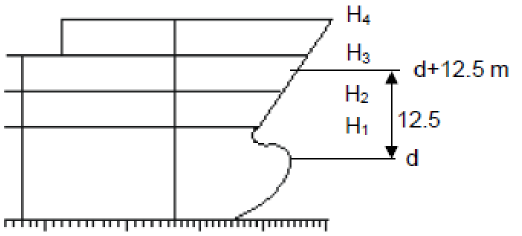
The sketches in the figure illustrate the connection between position of watertight decks in the reserve buoyancy area and the use of factor *v* for damages below these decks.



Example 1: vertical extent of damage above the waterline

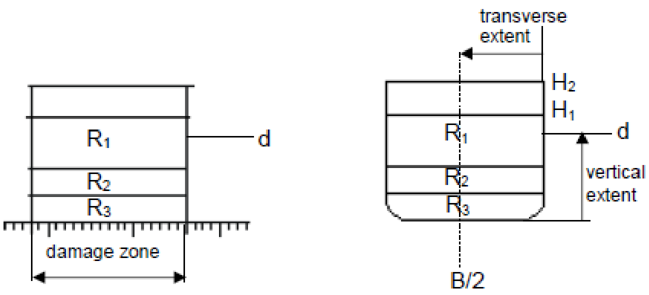
In example 1, there are 3 horizontal subdivisions (H_1, H_2 and H_3) to be taken into account as the vertical extent of damage.

The example shows the maximum possible vertical extent of damage *d* + 12.5 m is positioned between H_2 and H_3. H_1 with factor v_1, H_2 with factor $v_2 > v_1$ but $v_2 < 1$ and H_3 with factor $v_3 = 1$.



Example 2: vertical extent of damage above the waterline

In example 2, the factors v_1 and v_2 are the same as above. The reserve buoyancy above H_3 should be taken undamaged in all damage cases.



Example 3: vertical extent of damage below the waterline

In example 3, the combination of damages into the rooms R_1, R_2 and R_3 positioned below the initial water line should be chosen so that the damage with the lowest *s*-factor is taken into account. That often results in the definition of alternative damages to be calculated and compared within a damage zone taking into account the vertical and the transverse extent. If the deck taken as the lower limit of damage is not watertight, down flooding should be considered.

Regulation 7-2.6.1

The parameters x_1 and x_2 are the same as parameters *x1* and *x2* used in regulation 7-1.

REGULATION 7-3 – PERMEABILITY

Regulation 7-3.2

1 The following additional cargo permeabilities may be used:

Spaces	Permeability at draught d_s	Permeability at draught d_p	Permeability at draught d_l
Timber cargo in holds	0.35	0.7	0.95
Wood chip cargo	0.6	0.7	0.95

2 Reference is made to MSC/Circ.998 (*IACS Unified Interpretation regarding timber deck cargo in the context of damage stability requirements*) regarding timber deck cargo.

Regulation 7-3.3

1 Concerning the use of other figures for permeability "if substantiated by calculations", such permeabilities should reflect the general conditions of the ship throughout its service life rather than specific loading conditions.

2 This paragraph allows for the recalculation of permeabilities. This should only be considered in cases where it is evident that there is a major discrepancy between the values shown in the regulation and the real values. It is not designed for improving the attained value of a deficient ship of regular type by the modification of chosen spaces in the ship that are known to provide significantly onerous results. All proposals should be considered on a case-by-case basis by the Administration and should be justified with adequate calculations and arguments.

REGULATION 8 – SPECIAL REQUIREMENTS CONCERNING PASSENGER SHIP STABILITY

Regulation 8.1

This regulation is intended to ensure a sufficient safety level if a large compartment is located aft of the collision bulkhead.

REGULATION 8-1 – SYSTEM CAPABILITIES AND OPERATIONAL INFORMATION AFTER A FLOODING CASUALTY ON PASSENGER SHIPS

Regulation 8-1.2

1 In the context of this regulation, "compartment" has the same meaning as defined under regulation 7-1 of these explanatory notes (i.e. an onboard space within watertight boundaries).

2 The purpose of the paragraph is to prevent any flooding of limited extent from immobilizing the ship. This principle should be applied regardless of how the flooding might occur. Only flooding below the bulkhead deck need be considered.

REGULATION 9 – DOUBLE BOTTOMS IN PASSENGER SHIPS AND CARGO SHIPS OTHER THAN TANKERS

Regulation 9.1

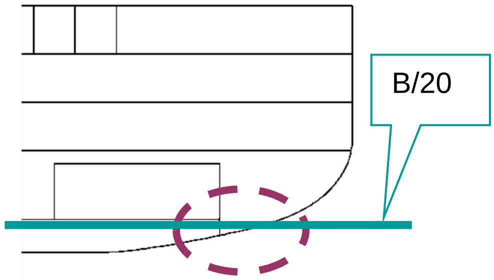
1 This regulation is intended to minimize the impact of flooding from a minor grounding. Special attention should be paid to the vulnerable area at the turn of the bilge. When justifying a deviation from fitting an inner bottom, an assessment of the consequences of allowing a more extensive flooding than reflected in the regulation should be provided.

2 The determination regarding the requirement to fit a double bottom "as far as this is practicable and compatible with the design and proper working of the ship" is made, or should be accepted by, the Administration or a recognized organization acting on its behalf.

3 Compliance with the damage stability requirement in regulation 9.8 should not be considered as an equivalent optional requirement to the fitting of a dimensionally compliant double bottom. This is because a flooded watertight compartment, such as an engine-room, that complies with the damage stability requirement in regulation 9.8 is not equivalent to a flooded double bottom below that compartment. Compliance with the damage stability requirement in regulation 9.8 is intended to provide a minimum level of safety in cases when the fitting of a double bottom is not practicable or compatible with the design and proper working of the ship.

Regulation 9.2

1 Except as provided in regulations 9.3 and 9.4, parts of the double bottom not extended for the full width of the ship as required by regulation 9.2 should be considered an unusual arrangement for the purpose of this regulation and should be handled in accordance with regulation 9.7. An example is provided below.



2 If an inner bottom is located higher than the partial subdivision draught d_p, this should be considered an unusual arrangement and is to be handled in accordance with regulation 9.7.

Regulations 9.3.2.2, 9.6 and 9.7

For cargo ships of less than 80 m in length (*L*), the alternative arrangements to provide a level of safety satisfactory to the Administration should be limited to compartments not having a double bottom, having an unusual bottom arrangement, or having an "other well" extending below the required double bottom height that is greater than the *h*/2 or 500 mm limit indicated in regulation 9.3.2.1. In these cases compliance with the bottom damage standard in regulation 9.8 should be demonstrated assuming that the damage will only occur between the transverse watertight bulkheads in compartments not having a double bottom, having an unusual bottom arrangement, or having an "other well" extending below the required double bottom height that is greater than the *h*/2 or 500 mm limit indicated in regulation 9.3.2.1.

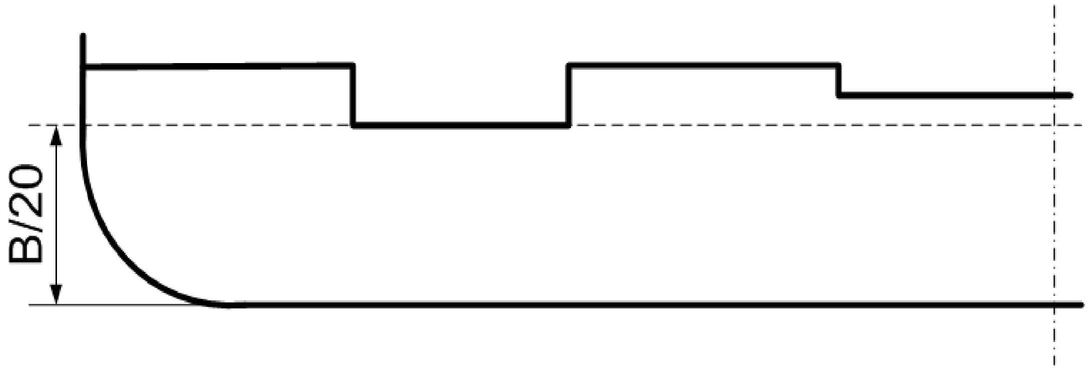
Regulation 9.6

1 Any part of a passenger ship or a cargo ship of 80 m in length (*L*) and upwards where a double bottom is omitted in accordance with regulation 9.1, 9.4 or 9.5 shall be capable of withstanding bottom damages, as specified in regulation 9.8. The intent of this provision is to specify the circumstances under which the Administration should require calculations, which damage extents to assume and what survival criteria to apply when double bottoms are not fitted.

2 The definition of "watertight" in regulation 2.17 implies that the strength of inner bottoms and other boundaries assumed to be watertight should be verified if they are to be considered effective in this context.

Regulation 9.7

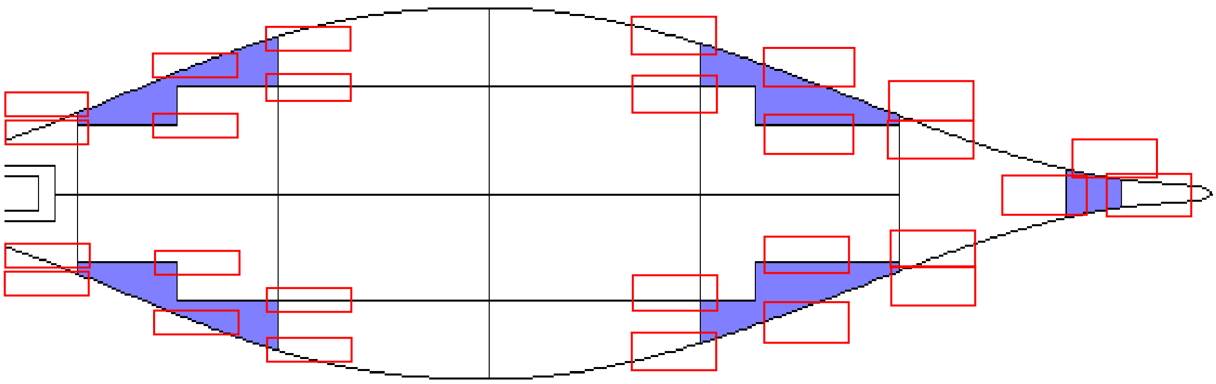
The reference to a "plane" in regulation 9.2 does not imply that the surface of the inner bottom may not be stepped in the vertical direction. Minor steps and recesses need not be considered unusual arrangements for the purpose of this paragraph as long as no part of the inner bottom is located below the reference plane. Discontinuities in way of wing tanks are covered by regulation 9.4.



Regulation 9.8

1 For ships to which the probabilistic damage stability requirements of part B-1 apply, the term "all service conditions" used in this paragraph means the three loading conditions with all trims used to calculate the attained subdivision index *A*. For ships not subject to the probabilistic damage stability requirements in part B-1, such as cargo ships that comply with the subdivision and damage stability requirements of other instruments as allowed by regulation II-1/4.2.1.2 and cargo ships of less than 80 m in length (*L*), "all service conditions" means that the limit curves or tables required by regulation 5-1.2.1 should include values calculated for the same draught and trim range(s) as for the other applicable stability requirements.

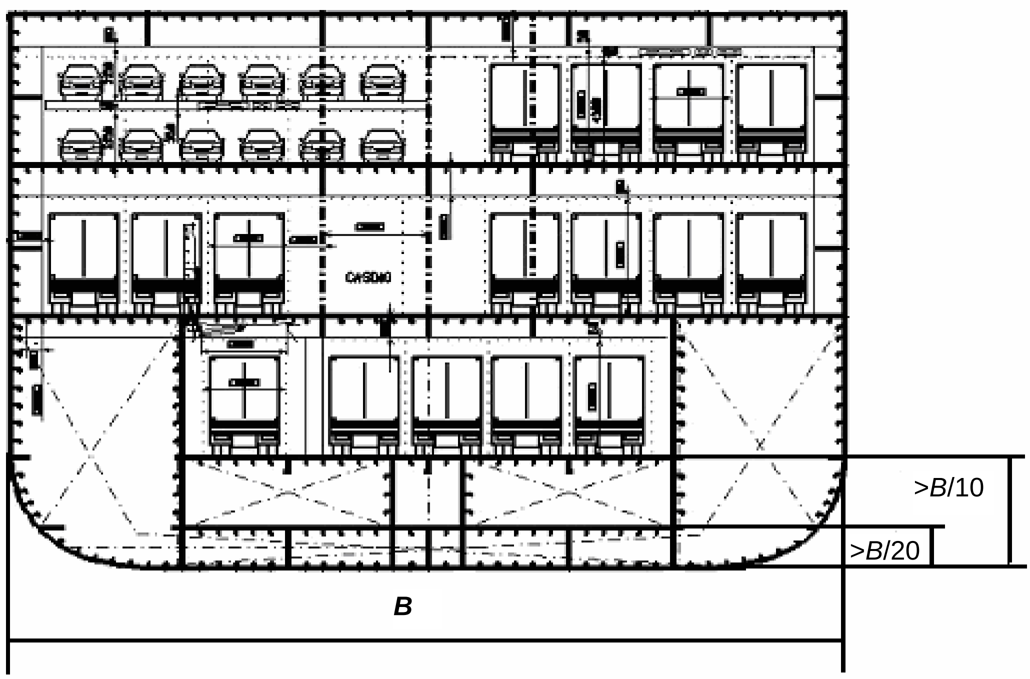
2 The damage extents specified in this paragraph should be applied to all parts of the ship where no double bottom is fitted, as permitted by regulations 9.1, 9.4 or 9.5, and include any adjacent spaces located within the extent of damage. Small wells in accordance with regulation 9.3.1 do not need to be considered damaged even if within the extent of the damage. Possible positions of the damages are shown in an example below (parts of the ship not fitted with a double bottom are shaded; the damages to be assumed are indicated by boxes).



Regulation 9.9

1 For the purpose of identifying "large lower holds", horizontal surfaces having a continuous deck area greater than approximately 30% in comparison with the waterplane area at subdivision draught should be taken to be located anywhere in the affected area of the ship. For the alternative bottom damage calculation, a vertical extent of *B*/10 or 3 m, whichever is less, should be assumed.

2 The increased minimum double bottom height of not more than *B*/10 or 3 m, whichever is less, for passenger ships with large lower holds, is applicable to holds in direct contact with the double bottom. Typical arrangements of ro-ro passenger ships may include a large lower hold with additional tanks between the double bottom and the lower hold, as shown in the figure below. In such cases, the vertical position of the double bottom required to be *B*/10 or 3 m, whichever is less, should be applied to the lower hold deck, maintaining the required double bottom height of *B*/20 or 2 m, whichever is less (but not less than 760 mm). The figure below shows a typical arrangement of a modern ro-ro passenger ferry.



REGULATION 10 – CONSTRUCTION OF WATERTIGHT BULKHEADS

Regulation 10.1

For the treatment of steps in the bulkhead deck of passenger ships see explanatory notes for regulation 13. For the treatment of steps in the freeboard deck of cargo ships see explanatory notes for regulation 13-1.

REGULATION 12 – PEAK AND MACHINERY SPACE BULKHEADS, SHAFT TUNNELS, ETC.

Regulation 12.6.1

For cargo ships, for which the building contract is placed on or after 1 January 2020 and which are constructed before 1 January 2024, the following figures show examples of suitable butterfly valve arrangements:

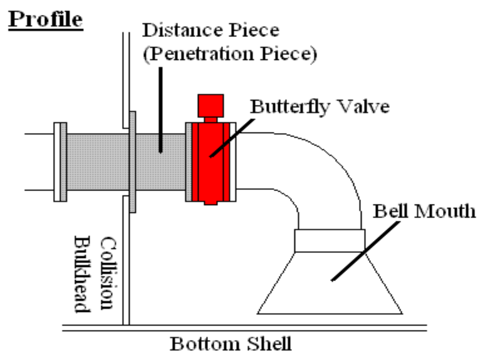


Figure 1

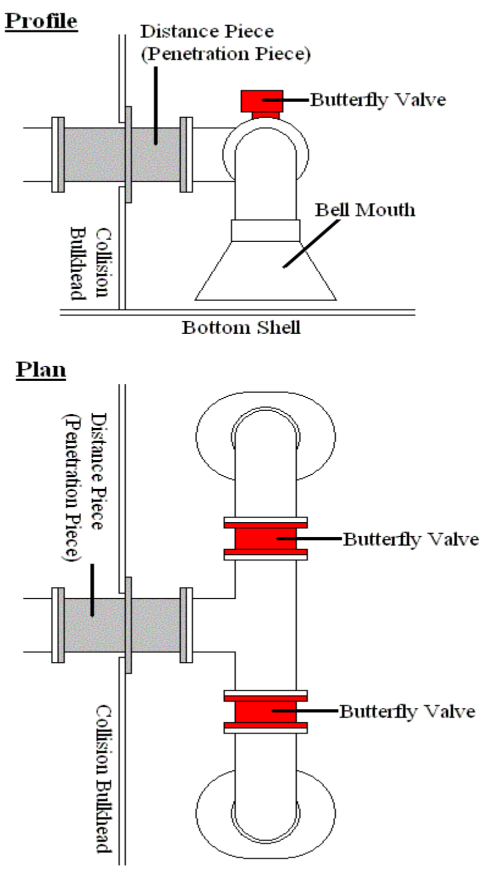


Figure 2

As butterfly valves must be capable of being remotely operated the following shall apply:

.1 the actuator shall be of a double acting type;

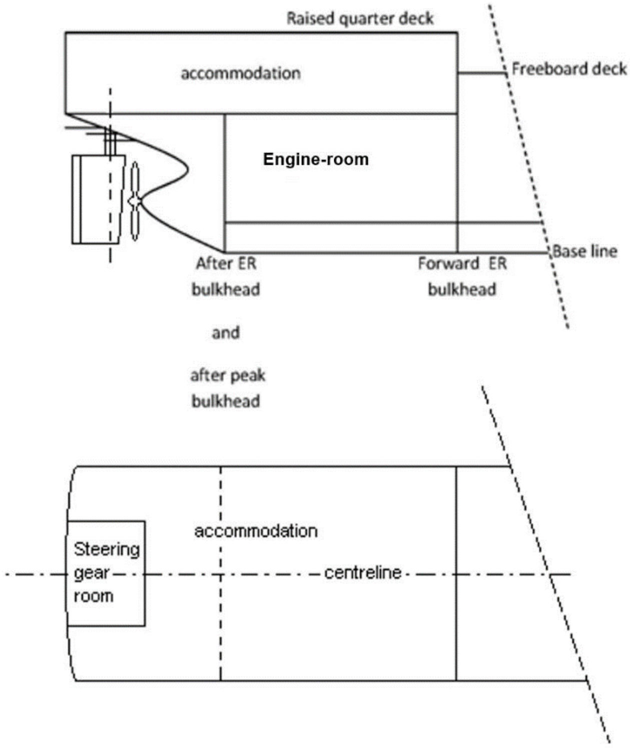
.2 when subject to loss of power, the actuator shall remain in its current position; and

.3 when subject to loss of power, the valve shall be able to be manually operated.

Regulation 12.10

1 In cargo ships the after engine-room bulkhead can be regarded as the afterpeak bulkhead provided that the after peak adjoins the engine-room.

2 In cargo ships with a raised quarter deck, it may be impracticable to extend the afterpeak bulkhead to the freeboard deck as the freeboard deck does not extend to the aft perpendicular. Provided that the afterpeak bulkhead extends above the deepest load line, and that all rudderstock bearings are housed in a watertight compartment without open connection to spaces located in front of the afterpeak bulkhead, termination of the afterpeak bulkhead on a watertight deck lower than the freeboard deck can be accepted by the Administration.



Regulation 12.11

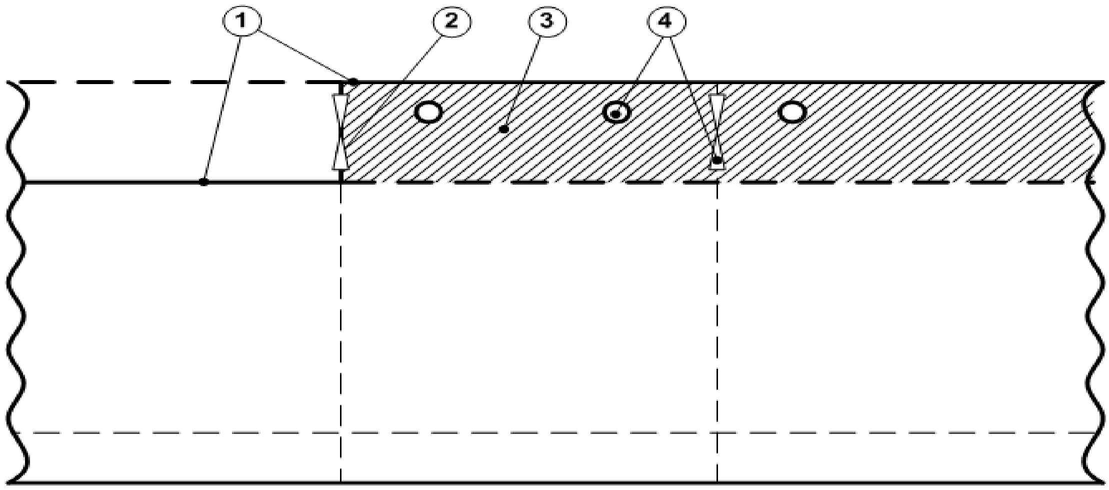
In cargo ships a stern tube enclosed in a watertight space of moderate volume, such as an afterpeak tank, where the inboard end of the stern tube extends through the afterpeak/engine-room watertight bulkhead into the engine-room, is considered to be an acceptable solution satisfying the requirement of this regulation, provided the inboard end of the stern tube is effectively sealed at the afterpeak/engine-room bulkhead by means of an approved watertight/oiltight gland system.

REGULATION 13 – OPENINGS IN WATERTIGHT BOUNDARIES BELOW THE BULKHEAD DECK IN PASSENGER SHIPS

General – Steps in the bulkhead deck

1 If the transverse watertight bulkheads in a region of the ship are carried to a higher deck which forms a vertical step in the bulkhead deck, openings located in the bulkhead at the step may be considered as being located above the bulkhead deck. Such openings should then comply with regulation 17 and should be taken into account when applying regulation 7-2.

2 All openings in the shell plating below the upper deck throughout that region of the ship should be treated as being below the bulkhead deck and the provisions of regulation 15 should be applied. See figure below.



1 Bulkhead deck 2 Considered as located above the bulkhead deck
3 Ship's side 4 Considered as located below the bulkhead deck

Regulation 13.2.3

1 For closed piping systems compliance with this regulation is achieved if approved pipe penetrations are fitted at the crossing of watertight boundaries to ensure that heat-sensitive pipes outside the space affected by the fire remain intact, so that any flooding of the fire affected space does not cause progressive flooding through the piping or pipe penetration.

1.1 For open piping systems compliance with this regulation is achieved if approved pipe penetrations are fitted at the crossing of watertight boundaries as are required for closed piping systems, and additionally each pipe connection to a watertight compartment is fitted with an isolation or non-return valve, as appropriate, to prevent progressive flooding through the piping system after a fire. As an alternative to fitting an isolation or non-return valve, pipes may be routed above the damaged waterline in such a way that progressive flooding is prevented, taking into account the dynamic movements of the ship in a damaged condition.

1.2 However, progressive flooding may be taken into account in accordance with regulation 7-2.5.4 instead.

2 For the purpose of this explanatory note the following definitions apply:

A *closed piping system* is a piping system without openings in multiple watertight compartments.

An *open piping system* is a piping system with openings in multiple watertight compartments.

3 Materials used in systems which penetrate watertight boundaries should be of sufficient strength after exposure to heat or be considered as part of an open piping system. Closing devices using intumescent material (swelling when exposed to heat) for open piping systems should not be considered equivalent to the fitting of a valve, since the fire might be located too far from the device to create a watertight seal.

4 Approval of pipe penetrations fitted to ensure the watertight integrity of a bulkhead or deck where heat-sensitive materials are used should include a prototype test of watertightness after having undergone the standard fire test appropriate for the location in which the penetrations are to be installed.[2]

4.1 The fire tested pipe penetration should then be tested to a test pressure of not less than 1.5 times the design pressure as defined in regulation 2.18. The pressure should be applied to the same side of the division as the fire test.

4.2 The fire tested pipe penetration should be tested for a period of at least 30 min under hydraulic pressure equal to the test pressure, but minimum 1.0 bar. There should be no leakage during this test.

4.3 The fire tested pipe penetration should continue to be tested for a further 30 min with the test pressure. The quantity of water leakage is not to exceed a total of 1 litre.

4.4 The prototype test should be considered valid only for the pipe typology (e.g. thermoplastic and multilayer), pressure classes, the maximum/minimum dimensions tested, and the type and fire rating of the division tested.

5 The pressure test need not be carried out on the hot penetration arrangement. Ample time may be given to prepare for the pressure test, i.e. dismantling the fire testing equipment and rigging the pressure test equipment.

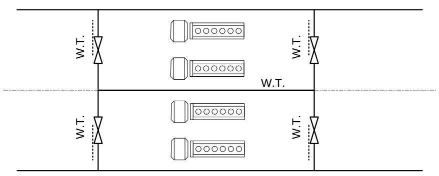
5.1 The pressure test should be carried out with the pipe section used in the fire test still in place.

5.2 Any pipe insulation fitted for the purpose of the fire test may be removed before the pressure test.

5.3 Prototype testing need not be carried out if the pipe penetration is made of steel or equivalent material having a thickness of 3 mm or greater and a length of not less than 900 mm (preferably 450 mm on each side of the division), and there are no openings. Such penetrations shall be suitably insulated by extension of the insulation at the same level of the division. See also regulation II-2/9.3.1 with respect to piping. However, the penetration must still comply with the watertight integrity requirement in regulation 2.17.

Regulation 13.4

In cases where main and auxiliary propulsion machinery spaces, including boilers serving the needs for propulsion, are divided by watertight longitudinal bulkheads in order to comply with redundancy requirements (e.g. according to regulation 8-1.2), one watertight door in each watertight bulkhead may be permitted, as shown in the figure below.



2 Refer to the requirements for A-class division set out in part 3 of annex 1 to the 2010 FTP Code.

REGULATION 13-1 – OPENINGS IN WATERTIGHT BULKHEADS AND INTERNAL DECKS IN CARGO SHIPS

Regulation 13-1.1

1 If the transverse watertight bulkheads in a region of the ship are carried to a higher deck than in the remainder of the ship, openings located in the bulkhead at the step may be considered as being located above the freeboard deck.

2 All openings in the shell plating below the upper deck throughout that region of the ship should be treated as being below the freeboard deck, similar to the bulkhead deck for passenger ships (see relevant figure under regulation 13 above), and the provisions of regulation 15 should be applied.

REGULATION 15 – OPENINGS IN THE SHELL PLATING BELOW THE BULKHEAD DECK OF PASSENGER SHIPS AND THE FREEBOARD DECK OF CARGO SHIPS

General – Steps in the bulkhead deck and freeboard deck

For the treatment of steps in the bulkhead deck of passenger ships see explanatory notes for regulation 13. For the treatment of steps in the freeboard deck of cargo ships see explanatory notes for regulation 13-1.

REGULATION 15-1 – EXTERNAL OPENINGS IN CARGO SHIPS

Regulations 15-1.1 to 15-1.3 apply to cargo ships which are subject to the damage stability analysis required in part B-1 or other IMO instruments.

Regulation 15-1.1

With regard to air-pipe closing devices, they should be considered weathertight closing devices (not watertight). This is consistent with their treatment in regulation 7-2.5.2.1. However, in the context of regulation 15-1, "external openings" are not intended to include air-pipe openings.

REGULATION 16 – CONSTRUCTION AND INITIAL TESTS OF WATERTIGHT CLOSURES

General

These requirements are only to establish a general design standard for watertight closures. They are not intended to require any non-watertight hatches to be watertight, nor do they override the requirements of the International Convention on Load Lines.

Regulation 16.2

Large doors, hatches or ramps on passenger and cargo ships, of a design and size that would make pressure testing impracticable, may be exempted from regulation 16.2, provided it is demonstrated by calculations that the doors, hatches or ramps maintain watertightness at design pressure with a proper margin of resistance. Where such doors utilize gasket seals, a prototype pressure test to confirm that the compression of the gasket material is capable of accommodating any deflection, revealed by the structural analysis, should be carried out. After installation every such door, hatch or ramp should be tested by means of a hose test or equivalent.

Note: See explanatory notes for regulation 13 for additional information regarding the treatment of steps in the bulkhead deck of passenger ships. See explanatory notes for regulation 13-1 for additional information regarding the treatment of steps in the freeboard deck of cargo ships.

REGULATION 17 – INTERNAL WATERTIGHT INTEGRITY OF PASSENGER SHIPS ABOVE THE BULKHEAD DECK

General – Steps in the bulkhead deck

For the treatment of steps in the bulkhead deck of passenger ships see explanatory notes for regulation 13.

Regulation 17.1

This explanatory note only applies to passenger ships for which the building contract is placed on or after 1 January 2020 and which are constructed before 1 January 2024.

1 Sliding watertight doors with a reduced pressure head that are located above the bulkhead deck and which are immersed in the final or during any intermediate stage of flooding should comply fully with the requirements of regulation 13. These types of sliding watertight doors tested with reduced pressure head must not be immersed at any stage of flooding by a head of water higher than the tested pressure head. See figure 1 below. These sliding watertight doors shall be kept closed during navigation in compliance with the requirements of regulation 22 and this should be clearly indicated in the damage control information required by regulation 19.

2 If watertight doors are located above the worst final and above the worst intermediate waterline in damage cases contributing to the attained subdivision index *A*, but within the area where the door becomes intermittently immersed (fully or partly) at angles of heel in the required range of positive stability beyond the equilibrium position, such doors are to be power-operated and remotely controlled sliding semi-watertight doors complying with the requirements of regulation 13, except that the scantlings and sealing requirements could be reduced to the maximum head of water caused by the waterline being intermittently immersed (see figure 1 below). These doors should be closed in case of damage and this should be clearly indicated in the damage control information required by regulation 19.

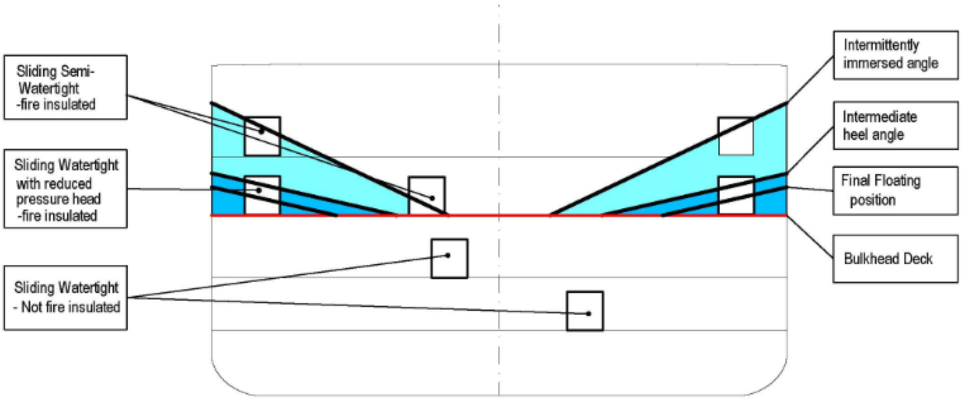


Figure 1

3 The use of sliding watertight doors above the bulkhead deck affects the escape provisions of regulation II-2/13. When such doors are used above the bulkhead deck, there should 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 should be independent of watertight doors and at least one of which should give access to a stairway forming a vertical escape. Sliding watertight doors that will be used frequently by passengers must not create a tripping hazard.

4 Doors fitted above the bulkhead deck which are required to meet both fire protection and watertight requirements should comply with the fire requirements in regulation II-2/9.4.1.1 and the watertight requirements in paragraphs 1 and 2 above. Notwithstanding regulation II-2/9.4.1.1.3, watertight doors fitted above the bulkhead deck should be insulated to the standard required by table 9.1 and regulation II-2/9.2.2.1.1.1 or by table 9.3 and regulation II-2/9.2.2.1.1.2 as appropriate. The door must be capable of operation using both the remote fire door control circuit and the remote watertight door control circuit. If two doors are fitted, they must be capable of independent operation. The operation of either door separately must not preclude closing of the other door. Both doors must be capable of being operated from either side of the bulkhead.

Regulation 17.2

This explanatory note only applies to passenger ships constructed on or after 1 January 2024.

1 Doors fitted in internal watertight subdivision boundaries located above the bulkhead deck that are immersed at either the final equilibrium or worst intermediate stage of flooding waterlines should be sliding watertight doors that comply fully with the requirements of regulation 13. They should not be immersed at any stage of flooding by a head of water higher than their design scantlings or their tested pressure head. These sliding watertight doors should be kept closed during navigation in accordance with the requirements of regulation 22 and this should be clearly indicated in the damage control information required by regulation 19.

2 The use of sliding watertight doors above the bulkhead deck affects the escape provisions of regulation II-2/13. When such doors are used above the bulkhead deck, there should 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 should be independent of watertight doors and at least one of which should give access to a stairway forming a vertical escape. Sliding watertight doors that will be used frequently by passengers must not create a tripping hazard.

3 Doors fitted above the bulkhead deck which are required to meet both fire protection and watertight requirements should comply with the fire requirements in regulation II-2/9.4.1.1 and the watertight requirements in paragraph 1 above. Notwithstanding regulation II-2/9.4.1.1.3, watertight doors fitted above the bulkhead deck should be insulated to the standard required by table 9.1 and regulation II-2/9.2.2.1.1.1 or by table 9.3 and regulation II-2/9.2.2.1.1.2 as appropriate. The door must be capable of operation using both the remote fire door control circuit and the remote watertight door control circuit. If two doors are fitted, they must be capable of independent operation. The operation of either door separately must not preclude closing of the other door. Both doors must be capable of being operated from either side of the bulkhead.

Regulation 17.3

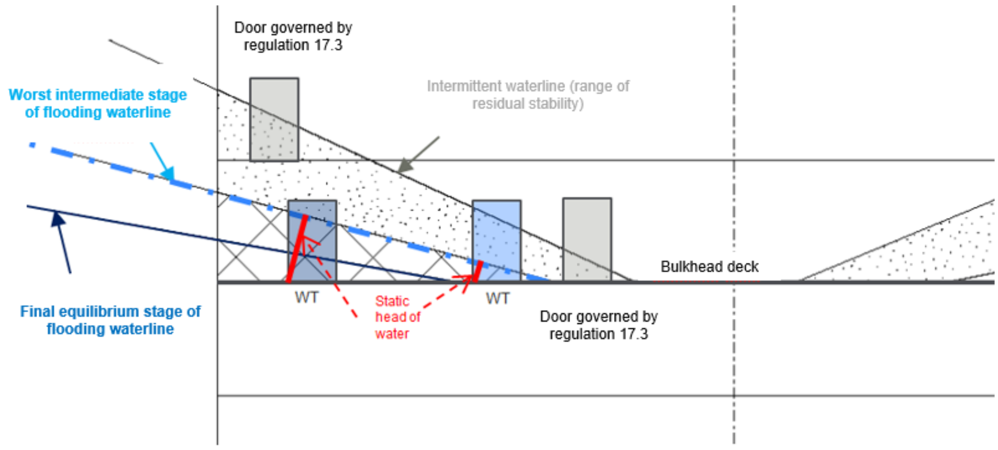
This explanatory note only applies to passenger ships constructed on or after 1 January 2024.

1 To be considered capable of preventing the passage of water when intermittently immersed in the required range of positive stability, these doors should meet a watertight standard for a minimum 1 m head of water. These doors may be hinged or sliding, provided they comply with the design requirements applied from both sides of the door. Consideration

should be given to the opening direction for hinged doors, so that they do not open against the intended direction of escape. These doors should be closed in case of damage and this should be clearly indicated in the damage control information required by regulation 19.

2 These doors are required to meet the fire protection requirements in chapter II-2. Because these doors are not watertight doors that comply with the requirements in regulation 13, the exclusions for watertight doors in chapter II-2 do not apply. In addition to operation using the fire door control circuit, these doors should be provided with a separate remote closure control circuit located on the navigation bridge with the central operating console for the power-operated sliding watertight doors that is required by regulation 13.7.1. A diagram showing the location of each door, with visual indicators to show whether each door is open or closed, should also be at the central operating console. A red light should indicate a door is fully open and a green light should indicate a door is fully closed. When the door is closed remotely, the red light should indicate the intermediate position by flashing. The indicating circuit should be independent of the control circuit for each door. Indication should also be provided to the onboard stability computer, if installed in accordance with regulation 8-1.3.1.

3 These doors should also be capable of being remotely closed with the ship listed 15 degrees either way.



	Situation/waterlines	Type	Structural and functional scantling	Use at sea
Watertight door according to regulations 17.2 and 13	Immersed at the final equilibrium stage of flooding waterline or the worst intermediate stage of flooding waterline	Sliding	According to Revised MSC.1/Circ.1572	Closed during navigation
Door according to regulation 17.3	Above the worst intermediate and final equilibrium waterlines but within the area where the door becomes intermittently immersed (fully or partially) at angles of heel in the required range of positive stability beyond the equilibrium position	Hinged or Sliding		Doors that are remotely operated should be closed in case of damage

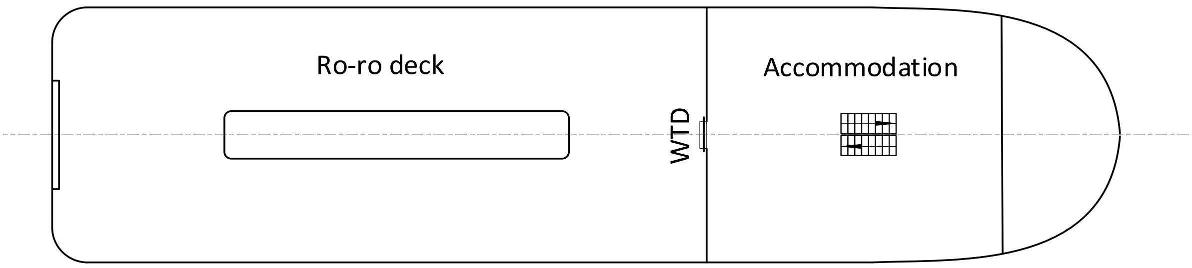
Regulation 17.5

For passenger ships for which the building contract is placed on or after 1 January 2020 and which are constructed before 1 January 2024, this is regulation 17.3.

This paragraph is intended to ensure that progressive flooding through air pipes of volumes located above a horizontal division in the superstructure, which is considered as a watertight boundary when applying regulation 7-2.6.1.1, will be taken into consideration if a side or bottom damage would cause flooding via tanks or spaces located below the waterline.

REGULATION 17-1 – INTEGRITY OF THE HULL AND SUPERSTRUCTURE, DAMAGE PREVENTION AND CONTROL ON RO-RO PASSENGER SHIPS

Regulations 17-1.1.1 and 17-1.1.3 apply only to direct accesses from a ro-ro space to spaces located below the bulkhead deck. The operation of watertight doors in bulkheads separating a ro-ro space and other spaces as per regulation 13.8.1 should be limited to compliance with regulation 23.3.



Regulation 17-1.1.2

If a non-watertight vehicle ramp closure is assumed to restrict the flow of water during the calculation of the attained subdivision index *A*, the vehicle ramp opening should comply with regulation 7-2.5.3.4.

REGULATION 22 – PREVENTION AND CONTROL OF WATER INGRESS, ETC.

The word "port" used in this regulation includes all berths and sheltered locations where loading and/or discharging may take place.

Regulation 22.3

Regarding the requirement that Administrations authorize watertight doors that may be opened during navigation only after careful consideration of the impact on ship operations and survivability taking into account guidance issued by the Organization, no prescribed guidance with respect to stability survivability is considered necessary for cargo ships. For cargo ships, these authorizations are left to the discretion of the Administration.

Regulation 22.7

This provision applies to any hatches that are considered watertight in the damage stability calculations, whether fitted above or below the bulkhead deck of passenger ships or the freeboard deck of cargo ships.

REGULATION 23 – SPECIAL REQUIREMENTS FOR RO-RO PASSENGER SHIPS

Regulation 23.6

In the context of this paragraph, the movement of cargo during navigation should not be considered "the essential working of the ship".

APPENDIX

GUIDELINES FOR THE PREPARATION OF SUBDIVISION AND DAMAGE STABILITY CALCULATIONS

1 GENERAL

1.1 Purpose of the Guidelines

1.1.1 These Guidelines serve the purpose of simplifying the process of the damage stability analysis, as experience has shown that a systematic and complete presentation of the particulars results in considerable saving of time during the approval process.

1.1.2 A damage stability analysis serves the purpose of providing proof of the damage stability standard required for the respective ship type. At present, two different calculation methods, the deterministic concept and the probabilistic concept, are applied.

1.2 Scope of analysis and documentation on board

1.2.1 The scope of subdivision and damage stability analysis is determined by the required damage stability standard and aims at providing the ship's master with clear intact stability requirements. In general, this is achieved by determining *KG*-respective *GM*-limit curves, containing the admissible stability values for the draught range to be covered.

1.2.2 Within the scope of the analysis thus defined, all potential or necessary damage conditions will be determined, taking into account the damage stability criteria, in order to obtain the required damage stability standard. Depending on the type and size of ship, this may involve a considerable amount of analyses.

1.2.3 Referring to SOLAS chapter II-1, regulation 19, the necessity to provide the crew with the relevant information regarding the subdivision of the ship is expressed, therefore plans should be provided and permanently exhibited for the guidance of the officer in charge. These plans should clearly show for each deck and hold the boundaries of the watertight compartments, the openings therein with means of closure and position of any controls thereof, and the arrangements for the correction of any list due to flooding. In addition, Damage Control Booklets containing the aforementioned information should be available.

2 DOCUMENTS FOR SUBMISSION

2.1 Presentation of documents

The documentation should begin with the following details: principal dimensions, ship type, designation of intact conditions, designation of damage conditions and pertinent damaged compartments, *KG*-respective *GM*-limit curve.

2.2 General documents

For the checking of the input data, the following should be submitted:

.1 main dimensions;

.2 lines plan, plotted or numerical;

.3 hydrostatic data and cross curves of stability (including drawing of the buoyant hull);

.4 definition of sub-compartments with moulded volumes, centres of gravity and permeability;

.5 layout plan (watertight integrity plan) for the sub-compartments with all internal and external opening points including their connected sub-compartments, and particulars used in measuring the spaces, such as general arrangement plan and tank plan. The subdivision limits, longitudinal, transverse and vertical, should be included;

.6 light service condition;

.7 load line draught;

.8 coordinates of opening points with their level of tightness (e.g. weathertight, unprotected);

.9 watertight door location with pressure calculation;

.10 side contour and wind profile;

.11 cross and downflooding devices and the calculations thereof according to resolution MSC.362(92) with information about diameter, valves, pipe lengths and coordinates of inlet/outlet;

.12 pipes in damaged area when the destruction of these pipes results in progressive flooding; and

.13 damage extensions and definition of damage cases.

2.3 Special documents

The following documentation of results should be submitted.

2.3.1 Documentation

2.3.1.1 Initial data:

.1 subdivision length L_s;

.2 initial draughts and the corresponding *GM*-values;

.3 required subdivision index *R*; and

.4 attained subdivision index *A* with a summary table for all contributions for all damaged zones.

2.3.1.2 Results for each damage case which contributes to the index *A*:

.1 draught, trim, heel, *GM* in damaged condition;

.2 dimension of the damage with probabilistic values *p*, *v* and *r*;

.3 righting lever curve (including GZ_{max} and range) with factor of survivability *s*;

.4 critical weathertight and unprotected openings with their angle of immersion; and

.5 details of sub-compartments with amount of in-flooded water/lost buoyancy with their centres of gravity.

2.3.1.3 In addition to the requirements in paragraph 2.3.1.2, particulars of non-contributing damages (s_i = 0 and p_i > 0.00) should also be submitted for passenger ships and ro-ro ships fitted with long lower holds including full details of the calculated factors.

2.3.2 Special consideration

For intermediate conditions, as stages before cross-flooding or before progressive flooding, an appropriate scope of the documentation covering the aforementioned items is needed in addition.

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ANNEX 14

DRAFT AMENDMENTS TO SOLAS CHAPTERS II-1 AND III*

CHAPTER II-1
CONSTRUCTION – STRUCTURE, SUBDIVISION AND STABILITY, MACHINERY AND ELECTRICAL INSTALLATIONS

PART A-1
STRUCTURE OF SHIPS

Regulation 2 – Definitions

1 The following new paragraphs are added after existing paragraph 29:

"30 *Lifting appliance* means any load-handling ship's equipment:

.1 used for cargo loading, transfer or discharge;

.2 used for raising and lowering hold hatch covers or moveable bulkheads;

.3 used as engine-room cranes;

.4 used as stores cranes;

.5 used as hose handling cranes;

.6 used for launch and recovery of tender boats and similar applications; and

.7 used as personnel handling cranes.

31 *Anchor handling winch* means any winch for the purpose of deploying, recovering and repositioning anchors and mooring lines in subsea operations.

32 *Loose gear* means an article of ship's equipment by means of which a load can be attached to a lifting appliance or an anchor handling winch but which does not form an integral part of the appliance or load.

33 The expression *appliances installed on or after [date]*, as provided in regulation 3-13 means:

.1 for ships the keel of which is laid or which is at a similar stage of construction on or after [*date*], appliances on board those ships; or

.2 for ships other than those specified in .1, including those constructed before 1 January 2009, appliances having a contractual delivery date to the ship on or after [*date+ six months*] or, in the absence of a contractual delivery date to the ship, actually delivered to the ship on or after [*date+ 4 years*]."

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* Modifications to existing text is shown in grey shading. Draft amendments to regulations 2 and 3-13 of SOLAS chapter II-1 were approved in principle by the Committee and they will be circulated for adoption in conjunction with the approval of the associated draft guidelines for lifting appliances and the draft guidelines for anchor handling winches, once finalized.

2 The following new regulation is added after existing regulation II-1/3-12, together with the associated footnotes:

"**Regulation 3-13**
Lifting appliances and anchor handling winches

1 Application

1.1 Unless expressly provided otherwise, this regulation shall apply to lifting appliances and anchor handling winches, and loose gear utilized with the lifting appliances and the anchor handling winches.

1.2 Notwithstanding the above, this regulation does not apply to:

.1 lifting appliances on ships certified as MODUs;[1]

.2 lifting appliances used on offshore construction ships, such as pipe/cable laying/repair or offshore installation vessels, including ships for decommissioning work, which comply with standards acceptable to the Administration;

.3 integrated mechanical equipment for opening and closing hold hatch covers; and

.4 life-saving launching appliances complying with the LSA Code.

1.3 The Administration shall determine to what extent the provisions of regulations 3-13.2.1 and 3-13.2.4 do not apply to lifting appliances which have a safe working load below 1,000 kg.

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1 Ships certified as MODUs are those subject to the MODU Code and which carry a MODU Code Certificate on board issued by the Administration or a recognized organization. The carriage of this certificate includes authorized electronic versions available on board.

2 Design, construction and installation

2.1 Lifting appliances installed on or after [*date*] shall be:

.1 designed, constructed and installed in accordance with the requirements of a classification society which is recognized by the Administration in accordance with the provisions of regulation XI-1/1 or standards acceptable to the Administration which provide an equivalent level of safety; and

.2 load tested and thoroughly examined after installation and before being taken into use for the first time and after repairs, modifications or alterations of major character.

2.2 Anchor handling winches installed on or after [*date*] shall be designed, constructed, installed and tested to the satisfaction of the Administration, based on the Guidelines developed by the Organization.[2]

2.3 Lifting appliances installed on or after [*date*] shall be permanently marked and provided with documentary evidence for the safe working load (SWL).

2.4 Lifting appliances installed before [*date*] shall be tested and thoroughly examined, based on the Guidelines developed by the Organization[3] and comply with regulation 3-13.2.3 no later than the date of the first renewal survey on or after [*date*].

2.5 Anchor handling winches installed before [*date*] shall be tested and thoroughly examined, based on the Guidelines developed by the Organization[2] no later than the date of the first renewal survey on or after [*date*].

[2] Refer to the *Guidelines for anchor handling winches* (MSC.1/Circ.[…]).

3 Maintenance, operation, inspection and testing

All lifting appliances and anchor handling winches, regardless of installation date, and all loose gear utilized with any lifting appliances and anchor handling winches, shall be operationally tested, thoroughly examined, inspected, operated and maintained, based on the Guidelines developed by the Organization.[3]

[3] Refer to the *Guidelines for lifting appliances* (MSC.1/Circ.[…]).

4 Inoperative lifting appliances and anchor handling winches

Except as provided in regulations I/11(c), while all reasonable steps shall be taken to maintain lifting appliances, anchor handling winches and loose gear to which this regulation applies in working order, malfunctions of that equipment shall not be assumed as making the ship unseaworthy or as a reason for delaying the ship in ports, provided that action has been taken by the master to take the inoperative lifting appliance or anchor handling winch into account in planning and executing a safe voyage. [2 3]"

PART B-4
STABILITY MANAGEMENT

3 The following new regulation 25-1 is added after existing regulation 25 with the associated footnote:

"Regulation 25-1

Water level detectors on multiple hold cargo ships other than bulk carriers and tankers

1 Multiple hold cargo ships other than bulk carriers and tankers constructed on or after [1 January 2024] shall be fitted with water level detectors* in each cargo hold intended for dry cargoes. Water level detectors are not required for cargo holds located entirely above the freeboard deck.

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* Refer to the *Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers* (resolution MSC.188(79)).

2 The water level detectors required by paragraph 1 shall:

.1 give audible and visual alarms at the navigation bridge, one when the water level above the bottom of the cargo hold reaches a height of not less than 0.3 m, and another at a height not less than 15% of the depth of the cargo hold but not more than 2 m; and

.2 be fitted in the aft end of the cargo holds. For cargo holds which are occasionally used for water ballast, an alarm overriding device may be installed. The visual alarms shall clearly discriminate between the two different water levels detected in each hold.

3 As an alternative to the water level detector at a height of not less than 0.3 m, a bilge level alarm sensor may be fitted, located in the cargo hold bilge wells or other suitable location in the aft end of the cargo holds, serving the bilge pumping arrangements required by regulation 35-1 and giving audible and visual alarms at the navigation bridge."

CHAPTER III
LIFE-SAVING APPLIANCES AND ARRANGEMENTS

PART B
REQUIREMENTS FOR SHIPS AND LIFE-SAVING APPLIANCES

Regulation 33 – Survival craft embarkation and launching arrangements

4 Paragraph 33.2 is replaced, as follows:

".2 On cargo ships of 20,000 gross tonnage and upwards, davit-launched lifeboats shall be capable of being launched, where necessary utilizing painters, with the ship making headway at speeds up to 5 knots in calm water."

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ANNEX 15

DRAFT AMENDMENTS TO THE 2011 ESP CODE*

THE INTERNATIONAL CODE ON THE ENHANCED PROGRAMME OF INSPECTIONS DURING SURVEYS OF BULK CARRIERS AND OIL TANKERS, 2011 (2011 ESP CODE)

ANNEX B

CODE ON THE ENHANCED PROGRAMME OF INSPECTIONS DURING SURVEYS OF OIL TANKERS

PART A

CODE ON THE ENHANCED PROGRAMME OF INSPECTIONS DURING SURVEYS OF DOUBLE-HULL OIL TANKERS

1 The column entitled "Renewal Survey No.1" in annex 2 of part A of annex B of the 2011 ESP Code, as amended by resolution MSC.461(101), is amended as follows:

"1 ~~One section of deck plating for the full beam of the ship within the cargo area~~

~~2 Measurements, for general assessment and recording of corrosion pattern, of those structural members subject to close-up survey according to annex 1~~

~~3~~ Suspect areas"

***

* Tracked changes are created using "strikeout" for deleted text and "grey shading" to highlight all modifications and new insertions, including deleted text.

ANNEX 16

DRAFT AMENDMENTS TO THE 1988 LL PROTOCOL*

1 Regulation 27(13)(a) is replaced by the following:

"(13) The condition of equilibrium after flooding shall be regarded as satisfactory provided:

(a) the final waterline after flooding, taking into account sinkage, heel and trim, is below the lower edge of any opening through which progressive downflooding may take place. Such openings shall include air pipes, ventilators (even if they comply with regulation 19(4)) and openings which are closed by means of weathertight doors (even if they comply with regulation 12) or hatch covers (even if they comply with regulation 16(1) through (5)), and may exclude those openings closed by means of manhole covers and flush scuttles (which comply with regulation 18), cargo hatch covers of the type described in regulation 27(2), *remotely operated sliding watertight doors*, hinged watertight access doors with open/closed indication locally and at the navigation bridge, of the quick-acting or single-action type that are normally closed at sea, hinged watertight doors that are permanently closed at sea, and sidescuttles of the non-opening type (which comply with regulation 23). ~~However,~~ ~~i~~In the case of doors separating a main machinery space from a steering gear compartment, watertight doors may be of a hinged, quick-acting type kept closed at sea whilst not in use, provided also that the lower sill of such doors is above the summer load waterline."

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* Tracked changes are indicated using "strikeout" for deleted text and "grey shading" to highlight all modifications and new insertions, including deleted text.

ANNEX 17

DRAFT AMENDMENTS TO THE IBC CODE*

CHAPTER 2

SHIP SURVIVAL CAPABILITY AND LOCATION OF CARGO TANKS

1 The existing paragraph 2.9.2.1 is replaced by the following:

"2.9.2 In any stage of flooding:

.1 the waterline, taking into account sinkage, heel and trim, shall be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings shall include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated sliding watertight ~~sliding~~ doors, hinged watertight access doors with open/closed indication locally and at the navigation bridge, of the quick-acting or single-action type that are normally closed at sea, hinged watertight doors that are permanently closed at sea, and sidescuttles of the non-opening type;"

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* Tracked changes are indicated using "strikeout" for deleted text and "grey shading" to highlight all modifications and new insertions, including deleted text.

ANNEX 18

DRAFT AMENDMENTS TO THE IGC CODE*

CHAPTER 2

SHIP SURVIVAL CAPABILITY AND LOCATION OF CARGO TANKS

1 The existing text of paragraph 2.7.1.1 is replaced by the following:

"**2.7.1 In any stage of flooding:**

.1 the waterline, taking into account sinkage, heel and trim, shall be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings shall include air pipes and openings that are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers that maintain the high integrity of the deck, remotely operated sliding watertight ~~sliding~~ doors, hinged watertight access doors with open/closed indication locally and at the navigation bridge, of the quick-acting or single-action type that are normally closed at sea, hinged watertight doors that are permanently closed at sea, and sidescuttles of the non-opening type;"

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* Tracked changes are indicated using "strikeout" for deleted text and "grey shading" to highlight all modifications and new insertions, including deleted text.

ANNEX 20

DRAFT AMENDMENTS TO THE INTERNATIONAL CODE FOR FIRE SAFETY SYSTEMS (FSS CODE)

CHAPTER 9
FIXED FIRE DETECTION AND FIRE ALARM SYSTEMS

2 Engineering specifications

2.1 General requirements

1 The following new paragraph 2.1.8 is inserted after existing paragraph 2.1.7:

"2.1.8 In cargo ships and on passenger ship cabin balconies, where an individually identifiable system is fitted, notwithstanding the provisions in paragraph 2.1.6.1, isolator modules need not be provided at each fire detector if the system is arranged in such a way that the number and location of individually identifiable fire detectors rendered ineffective due to a fault would not be larger than an equivalent section in a section identifiable system, arranged in accordance with paragraph 2.4.1."

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ANNEX 21*

DRAFT AMENDMENTS TO THE INTERNATIONAL LIFE-SAVING APPLIANCES CODE (LSA CODE)

CHAPTER IV
SURVIVAL CRAFT

4.4 General requirements for lifeboats

1 Paragraph 4.4.1.3.2 is replaced as follows:

".2 except for free-fall lifeboats, be capable of being launched and towed when the ship is making headway at ~~a~~ speeds of up to 5 knots in calm water."

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* Grey shading highlights new or amended text.

ANNEX 22

DRAFT MSC RESOLUTION

AMENDMENTS TO THE REVISED RECOMMENDATION ON TESTING OF LIFE-SAVING APPLIANCES (RESOLUTION MSC.81(70)) *

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO that the Assembly, when adopting resolution A.689(17) on *Testing of life-saving appliances*, authorized the Committee to keep the annexed *Recommendation on testing of life-saving appliances* under review and to adopt, when appropriate, amendments thereto,

RECALLING FURTHER that, since the adoption of resolution A.689(17), the Committee has amended the Recommendation annexed thereto by resolutions MSC.54(66) and MSC.81(70), and by circulars MSC/Circ.596, MSC/Circ.615 and MSC/Circ.809,

RECOGNIZING the need to ensure that the references in the *Revised recommendation on testing of life-saving appliances* (resolution MSC.81(70)) are kept up to date,

1 ADOPTS the *Amendments to the Revised recommendation on testing of life-saving appliances (MSC.81(70))*, set out in the annex to the present resolution;

2 INVITES Contracting Governments to the SOLAS Convention to bring the above amendments to the attention of all parties concerned.

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* Shaded strikeouts denote deleted text and shading highlights new or amended text.

ANNEX

DRAFT AMENDMENTS TO THE REVISED RECOMMENDATION ON TESTING OF LIFE-SAVING APPLIANCES (RESOLUTION MSC.81(70))

Part 2 – Production and installation tests

5 SURVIVAL CRAFT

5.4 Launch test

1 Paragraph 5.4 is replaced, as follows:

"Except in the case of a free-fall lifeboat, it ~~It~~ should be demonstrated that the fully equipped lifeboat on cargo ships of 20,000 gross ~~tons or more~~ tonnage and upwards and rescue boat can be launched from a ship proceeding ahead at a speed of not less than 5 knots in calm water and on an even keel. There should be no damage to the lifeboat or the rescue boat or their equipment as a result of this test."

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MSC.1/Circ.1619
11 December 2020

GUIDELINES ON THE DESIGN OF MOORING ARRANGEMENTS AND THE SELECTION OF APPROPRIATE MOORING EQUIPMENT AND FITTINGS FOR SAFE MOORING

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), having considered a proposal by the Sub-Committee on Ship Design and Construction, at its sixth session (4 to 8 February 2019), and recognizing the importance of design of mooring arrangements and the selection of appropriate mooring equipment and fittings for safe mooring operations, with a view to ensuring a uniform approach towards the application of the provisions of SOLAS regulation II-1/3-8, as amended by resolution MSC.473(102), which is expected to become effective on 1 January 2024, approved the *Guidelines on the design of mooring arrangements and the selection of appropriate mooring equipment and fittings for safe mooring*, as set out in the annex.

2 Member States are invited to bring the annexed Guidelines to the attention of ship designers, shipyards, shipowners, ship managers, bareboat charterers and other organizations or persons responsible for design of mooring arrangements and the selection of appropriate mooring equipment and fittings.

3 Member States are also invited to bring the annexed Guidelines to the attention of shipmasters, ships' officers and crew, and all other parties concerned.

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ANNEX

GUIDELINES ON THE DESIGN OF MOORING ARRANGEMENTS AND THE SELECTION OF APPROPRIATE MOORING EQUIPMENT AND FITTINGS FOR SAFE MOORING

1 Introduction

1.1 Historical evolution in ship designs, especially the design of large ships, has resulted in optimized performance and a greater degree of complexity; this has not been extended to the design of ships' mooring arrangements. These Guidelines support the application of the provisions of SOLAS for mooring arrangements and encourage greater consideration of the occupational safety and safe mooring of the ship when designing new ships. Improving the design of mooring arrangements should enhance usability and safety during towing and mooring operations.

1.2 Regulations II-1/3-8.7 and II-1/3-8.8 of the International Convention for the Safety of Life at Sea (SOLAS), as amended, require that for ships of 3,000 gross tonnage and above constructed on or after 1 January 2024, the mooring arrangement shall be designed, and the mooring equipment including lines shall be selected, in order to ensure occupational safety and safe mooring of the ship; and ships of less than 3,000 gross tonnage constructed on or after 1 January 2024 should comply with these requirements as far as reasonably practicable, or with applicable national standards of the Administration.

1.3 These Guidelines provide an approach to the design of mooring arrangements, and the selection of mooring equipment and fittings, which should be applied in conjunction with principles of ergonomics and usability.

2 Definitions

For the purposes of these Guidelines:

2.1 *Line Design Break Force (LDBF)* means the minimum force that a new, dry, spliced, mooring line will break at. This is for all synthetic cordage materials.

2.2 *Mooring area* refers to the dedicated area on a ship where mooring equipment is installed and line-handling takes place. It also includes areas where there is a risk of personnel injury in event of snap-back or other failure of mooring equipment. There may be multiple mooring areas on a ship.

2.3 *Mooring arrangements* means the configuration of the mooring equipment and fittings and other design features of the ships related to the mooring operation, i.e. lighting and communication equipment.

2.4 *Mooring equipment and fittings* means items such as mooring winches, capstans, bollards, bitts, fairleads, rollers, chocks, etc. and also includes mooring lines.

2.5 *Mooring lines* means ropes, wires and combinations used for mooring operations other than messenger lines but including tails.

2.6 *Mooring operations* means normal mooring and unmooring of the ship, including associated in-harbour towing movements.

2.7 *Mooring personnel* means personnel tasked to assist in the activity of mooring and unmooring ships, either ashore or from mooring boats, carried out within the framework of port marine services.

2.8 *Shipboard personnel* means personnel assigned duties for supervising or working in mooring areas during mooring operations.

2.9 *Ship Design Minimum Breaking Load (MBL_{SD})* means the minimum breaking load of new, dry, mooring lines for which shipboard fittings and supporting hull structures are designed in order to meet mooring restraint requirements.

2.10 *Supervising personnel* means shipboard personnel assigned duties for supervising mooring areas during mooring operations.

2.11 *Towing and mooring arrangements plan* means the plan as described in section 5 of the annex to the *Revised guidance on shipboard towing and mooring equipment* (MSC.1/Circ.1175/Rev.1). This plan presents specific information regarding the towing and mooring fittings aboard the vessel, the mooring lines, as well as the arrangement of mooring lines and the acceptable environmental conditions for mooring.

2.12 *Working Load Limit (WLL)* means the maximum load that a mooring line should be subjected to in operational service, calculated from the relevant environmental mooring restraint requirement.

3 Goals

The equipment selection and mooring arrangement design safety objectives should be to facilitate safe mooring operations and reduce the risk to shipboard personnel and mooring personnel caused by inappropriate selection and arrangement of equipment and fittings.

4 Functional objectives

4.1 A ship should be provided with mooring equipment and fittings appropriate for its type and size. In addition, a ship should be provided with mooring lines appropriate for the equipment and fittings installed on board. In order to achieve the goals for the correct equipment selection and mooring arrangement design safety objectives set out in section 3, the following functional objectives should be applied.

4.2 Mooring equipment and fittings should be:

.1 arranged to minimize obstructed access to and operation of the mooring equipment;

.2 arranged to minimize obstructed access to working space and minimize obstructed view of the mooring area;

.3 arranged to minimize the need for complex mooring line configurations during the normal operation of the ship;

.4 selected and arranged to minimize the need for manual handling of mooring lines under load; and

.5 selected and arranged to minimize the exposure of personnel involved in mooring operations to the dynamic loads of mooring lines.

5 Achievement of the functional objectives

To meet the functional objectives, the following design and equipment features should be considered from the earliest stage in the design process.

Selection of equipment, fittings and mooring lines should not be undertaken independently. To facilitate safe mooring operations, it is necessary for mooring equipment, fittings and mooring lines to be considered as a complete system within which all components are compatible.

The guidance on the design of mooring arrangements and the selection of equipment and fittings should be read in conjunction with MSC.1/Circ.1175/Rev.1.

This section should be implemented to the extent permitted by the size and purpose of the ship.

5.1 Design of mooring arrangements

5.1.1 To minimize the need for complex mooring line configurations during the normal operation of the ship, mooring winches and fairleads should be positioned to allow the use of direct, unobstructed leads from the mooring winch to the fairlead for each of the mooring lines described in the towing and mooring arrangements plan. It is preferable to provide a dedicated fairlead for each mooring line.

5.1.2 Where a straight lead is not possible:

.1 the deviation from a straight lead should be by means of pedestal fairleads, rolling fairleads or similar means that will reduce friction between line/fitting and reduce bend losses. Steel fittings such as horns or bollards without chafe protection should be avoided;

.2 the line should traverse the mooring area from winch to the fairlead by the shortest route; and

.3 changes of direction of mooring line should be minimized to prevent reductions in mooring line strength due to bend loss and introduction of complex snap-back areas.

5.1.3 To provide for the oversight and supervision of the mooring operations, the mooring area should be designed to give supervising personnel an unobstructed view of the installed mooring equipment and fittings. This should include the provision for a platform, or other appropriate means, by which supervising personnel can obtain an unobstructed view of the mooring area and berth arrangements planned to be used from a position clear of hazards.

5.1.4 The mooring arrangements should be designed to provide unobstructed views between shipboard personnel, and of lines being worked, within the mooring area.

5.1.5 The winch operator should be provided with mooring winch controls that are positioned so that the winch operator has a direct view of the line in the mooring area being worked without stepping away from the winch controls. Winch controls should be positioned clear of hazards.

5.1.6 Deck illumination should provide a clear view of the mooring area and the equipment and lines being worked during hours of darkness or in conditions of limited visibility.

5.1.7 The design of mooring arrangements and mooring areas should take into account the following constraints:

.1 anticipated variations in shore-based mooring arrangements and the need to preserve flexibility in mooring line configurations to achieve an appropriate restraining capacity;

.2 ships' structural elements, including accommodation, ventilation exhausts, cargo equipment or similar obstacles, on access; and

.3 special requirements for the location and selection of mooring equipment and fittings, for example special requirements for canal transits.

5.1.8 Unless the size and special features of the ship do not permit it, equipment and fittings in mooring areas should be positioned to provide shipboard personnel with unobstructed access to the following during mooring operations:

.1 mooring winches and winch controls;

.2 mooring fittings;

.3 mooring lines and mooring line stowage; and

.4 the space between shipside fairleads and winches to permit mooring personnel to safely apply stoppers to mooring lines when necessary.

5.1.9 The mooring arrangements should be designed to avoid the exposure of the shipboard personnel to lines under tension through snap-back or sudden movements of mooring lines. In this respect the following measures should be considered:

.1 locate winches close to shipside fairleads. The position of winches should not result in inappropriate mooring line orientations, or block or otherwise interfere with the use of shipside fairleads for additional mooring lines, connecting up of tugs for towage during mooring operations or the ability to safely moor the ship;

.2 enclosing the mooring line(s) behind barrier(s) provided that such enclosures do not adversely affect the performance of the mooring system and do not prevent effective inspection and maintenance of equipment, fittings and mooring lines;

.3 alternative design(s) where crew members do not need to work close to or have to pass mooring lines under tension or potentially under tension;

.4 use of appropriate, alternative means to moor the ship, including but not limited to automated mooring systems; or

.5 permanently fix mooring lines to a mooring winch.

5.1.10 Mooring areas should be considered as potential snap-back zones and signage should be provided to indicate that this is the case.

5.1.11 To minimize the need for manual handling of towing and mooring lines, the following measures should be considered:

.1 equipment and fitting arrangements should minimize the distance over which any mooring line may need to be handled;

.2 the use of fixed or dedicated mooring lines, taking into account the need to avoid inappropriate mooring line orientations, or block or otherwise interfere with the use of shipside fairleads for additional mooring lines, connecting up of tugs for towage during mooring operations or the ability to safely moor the ship;

.3 the layout to be designed to prevent manual intervention in transfer of the mooring line from storage drum to mooring winch drum and vice versa;

.4 use of spooling equipment;

.5 additional mooring lines should be available for immediate use, provided that their stowage does not interfere with the safe operation of the mooring equipment; and

.6 a sufficient number of mooring winches so that, during mooring operations, manual use of warping ends, stoppers, capstans and bitts is minimized, as far as possible.

5.1.12 The mooring arrangement design should take into account the principles for effective mooring arrangements included in appropriate industry guidance on mooring equipment and fittings.

5.2 Selection of equipment, fittings and mooring lines

5.2.1 The selection of winches should take into account:

.1 the availability of winches with alternative drum arrangements, including split drum arrangements, which can reduce the need for manual handling of mooring lines during mooring operations;

.2 the positioning of winch controls, including the availability of remote controls for winches to improve the line of sight and reduce operator exposure to snap-back;

.3 the availability of constant tension winches and their appropriateness for the normal operation of the ship; and

.4 limiting noise levels to ensure proper communication during mooring operations.

5.2.2 The selection of fittings should take into account:

.1 the type of mooring line with which the fitting is designed to be used. The design or selection of the fitting and the design of its hull supporting structure should be done in accordance with MSC.1/Circ.1175/Rev.1;

.2 the diameter D of surfaces of mooring fittings that are in contact with the mooring line in relation to the mooring line diameter d (D/d ratio) to reduce or mitigate bend loss of strength; and

.3 the need for the load-bearing surfaces of fittings to minimize damage from chafing and abrasion.

5.2.3 The selection of mooring lines should take into account:

.1 the guidance on mooring restraint as per appendix A of MSC.1/Circ.1175/Rev.1;

.2 the diameter D of surfaces of mooring fittings that are in contact with the mooring line in relation to the mooring line diameter d (D/d ratio) to reduce or mitigate bend loss of strength;

.3 the compatibility of the MBL_{SD} of mooring lines and the brake capacity of the mooring winches installed on board;

.4 the Line Design Break Force (LDBF) to be 100% to 105% of the MBL_{SD};

.5 the characteristics and limitations of mooring lines including material properties and environmental operating conditions anticipated during normal operation of the ship;

.6 the anticipated behaviour of the mooring line in the event of failure;

.7 the influence on stored energy and the potential for snap-back of high stiffness mooring lines caused by the use of tails; and

.8 as far as possible, but at least for lines in the same service (e.g. headlines, breast lines or springs), mooring lines of the same diameter and type (i.e. material) should be used.

5.2.4 To avoid overload on mooring winches, fittings and mooring lines, consideration should be given to select mooring winches with brake capacity of less than the ship design minimum breaking load of the mooring line or with adjustable brake capacity.

5.2.5 Fittings, particularly shipside fairleads, should be positioned to minimize the potential for chafing of mooring lines during the normal operation of the ship.

5.2.6 The selection of equipment and fittings including lines should take into account the principles for effective mooring arrangements included in appropriate industry guidance.

5.2.7 The mooring equipment, fittings and the mooring lines should at all times be compatible in design, diameter, strength, suitability, etc. and maintained with the original purpose and concept of the mooring arrangement.

5.2.8 Load limits

5.2.8.1 Notwithstanding the definitions in paragraph 2.1, LDBF of mooring lines made of nylon should be tested under wet and spliced conditions.

5.2.8.2 All components of a ship's mooring system, within defined tolerances, should be selected based on MBL_{SD}.

5.2.8.3 When selecting lines, the LDBF should be 100% to 105% of the MBL_{SD}.

5.2.8.4 The WLL of mooring lines should be used as user operating limiting values, not to be exceeded. The WLL is expressed as a percentage of MBL_{SD} and should be used as a limiting value in operational mooring analyses. Steel wires have a WLL of 55% of MBL_{SD} and all other cordage (synthetic) have a WLL of 50% of the MBL_{SD}.

6 Documentation on deviation

6.1 A supplement to the "Towing and mooring arrangements plan" should record the deviations if any, in relation to the following paragraphs:

.1 5.1.2 (where a straight lead is not possible);

.2 5.1.4 (unobstructed views);

.3 5.1.5 (protection of winch operators);

.4 5.1.8 (access to mooring equipment and fitting);

.5 5.1.9 (exposure of the shipboard personnel to lines under tension); and

.6 5.1.11 (minimize the need for manual handling of towing and mooring lines).

6.2 The documentation should include justification for such deviations and suitable safety measures, if any.

6.3 A reference to the supplement should be included in the towing and mooring arrangement plan so as to make the shipboard personnel aware of the safety measures which need to be considered during mooring operations.

7 References

(1) Oil Companies International Marine Forum (OCIMF), *Mooring Equipment Guidelines, 4th Edition 2018*, ISBN: 978-1-85609-771-0.

(2) Ian. C. Clark BSc, MSc, Master Mariner, MNI, *The Nautical Institute, Mooring and Anchoring Ships Vol.1, Principle and Practice*, ISBN: 9781906915934, 2009.

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MSC.1/Circ.1620
24 December 2020

GUIDELINES FOR INSPECTION AND MAINTENANCE OF MOORING EQUIPMENT INCLUDING LINES

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), having considered a proposal by the Sub-Committee on Ship Design and Construction, at its sixth session, and recognizing the importance of inspection and maintenance of mooring equipment including lines, approved the *Guidelines for inspection and maintenance of mooring equipment including lines*, as set out in the annex.

2 Member States are invited to bring the annexed Guidelines to the attention of shipowners, ship managers, bareboat charterers and other organizations or persons responsible for operation of ships.

3 Member States are also invited to bring the annexed Guidelines to the attention of shipmasters, ships' officers and crew and all other parties concerned, for providing guidance on inspection and maintenance of mooring equipment including mooring lines.

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ANNEX

GUIDELINES FOR INSPECTION AND MAINTENANCE OF MOORING EQUIPMENT INCLUDING LINES

1 General

1.1 Purpose

The purpose of these Guidelines is to provide recommendations and guidance for maintenance and in-service inspections of mooring equipment including lines and tails, criteria for identifying worn-out lines and tails for removal from service before failure, and criteria for selection of replacement mooring lines and tails.

1.2 Application

These Guidelines apply to all ships. Certain provisions are intended for reference by shipboard personnel, and other provisions are intended for Company personnel responsible for selecting and procuring replacement mooring lines.

2 Definitions

For the purpose of these Guidelines:

2.1 *Bend radius (D/d ratio)* means the diameter, D, of a mooring fitting divided by the diameter, d, of a mooring line that is led around or through the fitting. The D/d ratio is used by mooring line manufacturers to specify the minimum radius of a fitting around or through which a mooring line of diameter "d" should be led, in order to reduce or mitigate bend loss of strength of the mooring line.

2.2 *Company* means company, as defined in SOLAS regulation IX/1.2.

2.3 *Line Design Break Force* (LDBF) means the minimum force that a new, dry, spliced, mooring line will break at. This is for all synthetic cordage materials.

2.4 *Mooring arrangement* means the configuration of the mooring equipment and fittings and other design features of the ship related to the mooring operation, i.e. lighting and communication equipment.

2.5 *Mooring boat* means the boat handling mooring lines between the ship and ashore mooring facilities during mooring and unmooring operations and does not include harbour ship assist tugs (see the *Guidelines on minimum training and education of mooring personnel* (FAL.6/Circ.11/Rev.1)).

2.6 *Mooring equipment and fittings* means items such as winches, capstans, bollards, bitts, fairleads, rollers, chocks, etc. and also includes mooring lines.

2.7 *Mooring line configuration* means all components of an individual mooring line, including tails, eye splices, etc. Any change or replacement of a component is a change to the line's configuration, unless a component is replaced by a part having the same specification as in the original configuration.

2.8 *Mooring operations* means normal mooring and unmooring of the ship, including associated in-harbour towing movements.

2.9 *Mooring personnel* means personnel tasked to assist in the activity of mooring and unmooring ships, either ashore or from mooring boats, carried out within the framework of port marine services.

2.10 *Rotation of mooring lines* means periodical change of mooring lines for respective mooring drums to equalize the wear of mooring lines.

2.11 *Ship Design Minimum Breaking Load* (MBL_{SD}) means the minimum breaking load of new, dry, mooring lines for which shipboard fittings and supporting hull structures are designed in order to meet mooring restraint requirements.

2.12 *Towing and mooring arrangements plan* means the plan as described in section 5 of the annex to the *Revised guidance on shipboard towing and mooring equipment* (MSC.1/Circ.1175/Rev.1). This plan presents specific information regarding the towing and mooring fittings aboard the vessel, the mooring lines, as well as the arrangement of mooring lines and the acceptable environmental conditions for mooring.

3 Safe use of mooring equipment

3.1 Safe use of mooring equipment and fittings

Throughout its operational life, mooring equipment should be maintained and operated in accordance with the original design concept, if available, including when replacing parts and lines. In order to ensure all mooring equipment functions as designed, the Company should establish procedures for mooring operations, inspection and maintenance of mooring equipment, including mooring lines, taking into account appropriate references listed in paragraph 7 of these Guidelines.

3.2 Protection and storage of mooring lines

To preserve the design life of mooring lines, the following practices should be followed during mooring operations:

.1 smooth contacts at turn-off points with large angles and/or eye splices; and
.2 using covers/mats at ship side to protect against any friction damage.

3.3 Control of mooring lines

3.3.1 The Company should establish procedures to allow the identification and control of mooring lines, tails and associated attachments when on board and to facilitate inspection and maintenance of mooring lines. Such procedures should include:

.1 providing a means of recording the number, type and location of mooring lines, tails and associated attachments. Such records may be included in either the towing and mooring arrangements plan or with records of inspection and maintenance or an alternative established by the requirements of the Company; and

.2 providing a means of linking specific mooring lines, tails and associated attachments to the relevant records and a manufacturer's certificate, if available.

3.3.2 Any defect discovered to the mooring lines during mooring operations should be immediately reported to the Master by all parties concerned including shore-based mooring personnel. If no actions are taken as appropriate the competent authorities should be informed, as necessary.

4 Inspection and maintenance of mooring lines

4.1 Inspection of mooring lines

4.1.1 To prevent the deterioration of mooring lines to a condition which may result in the failure of the line during mooring operations, the periodic inspection of mooring lines, mooring line tails and associated attachments should be included in the onboard maintenance plan or equivalent maintenance management system. The maintenance plan may be computer based.

4.1.2 The requirements for inspection of individual mooring lines will be specific to the type of mooring line used on board. In general, onboard inspection of mooring lines will be based on manufacturer recommendations and by visual inspection of the outside of the mooring line to identify excessive wear or damage, e.g. external abrasion, external cut, kink, heat damage such as fusion and slackening or fraying of eye splices. Such visual inspections should be based on:

.1 the recommendations of the mooring line and/or tail manufacturer, particularly the criteria provided for the assessment of mooring line condition;

.2 operational experience regarding the performance of the mooring line and/or mooring line tail during previous mooring operations; and

.3 the environmental conditions to which the mooring lines and/or mooring line tails are routinely exposed.

4.1.3 In the case of jacketed synthetic fibre mooring lines, detailed visual inspection of the condition of the synthetic fibre line may not be possible. The condition of the external jacket is not an accurate indicator of the condition of the load-bearing synthetic fibre material within the mooring line.

4.2 Maintenance of mooring lines

The Company should establish the maintenance procedures as required in paragraph 3.1 of these Guidelines. The maintenance procedures should specify replacement of in-service mooring lines and may include the rotation of mooring lines.

4.3 Criteria for condemning worn-out mooring lines

4.3.1 The replacement of in-service mooring lines which have been assessed as no longer suitable for use should be based on the removal prior to failure and in accordance with criteria provided by the manufacturer.

4.3.2 For visual inspection and replacement of mooring lines, additional advice is provided in industry guidance on mooring line and mooring line tail inspections.

4.4 Inspection and maintenance of equipment and fittings

4.4.1 Equipment and fittings should be properly inspected and maintained, based on the manufacturer's recommendations. Mooring equipment and fittings should be included in the onboard maintenance plan or equivalent maintenance management system. The maintenance plan may be computer based.

4.4.2 Maintenance should include the preservation, by appropriate means, of the clear marking of information on equipment and fittings, including Safe Working Load (SWL) and winch control instructions.

4.4.3 Records of inspection and maintenance of equipment and fittings should be available on board.

4.4.4 Records of the original design concept, equipment, arrangement and specifications should be retained on board through the life cycle of the ship.

4.4.5 To preserve the design life of mooring lines and reduce the potential for failure during mooring operations any storage provided for additional (loose) mooring lines should minimize the exposure to harmful environments (e.g. UV light, water, chemicals, cargo, extreme temperature).

5 Selection of replacement mooring lines

5.1 When replacing mooring lines, compatibility with the mooring equipment and fittings on board, as specified in the mooring arrangement plan, should be taken into account. This should be achieved by selecting a replacement mooring line which meets the designed specifications. In cases where this is not possible, the following properties should be taken into consideration and the towing and mooring arrangement plan updated accordingly:

.1 breaking strength;
.2 environmental conditions to be used (e.g. temperature);
.3 linear density;
.4 tenacity;
.5 D/d ratios;
.6 compression fatigue; and
.7 stiffness.

5.2 Any increase in LDBF for the mooring lines above the limits specified, i.e. 100% to 105% of the MBL_{SD}, may require a review of the operating parameters and load limits of mooring equipment and fitting as well as of their hull supporting structures.

5.3 It should be noted that, when selecting replacement mooring lines, over time in service their strength will decay due to varying environmental conditions and thus the original service life expectations may not be achieved. Therefore, the Company should ensure that the condition of mooring lines is tracked throughout their service with the objective to replace the line before failure.

5.4 For wire ropes, corrosion protection should be considered.

5.5 For both wire and fibre mooring lines, the acceptable minimum bend radius (D/d ratio) recommended by the manufacturer should be taken into consideration as strength and life expectancy of these lines are directly related to the bend radius they are exposed to in service.

5.6 Where the acceptable minimum bend radius recommendations for a particular mooring line are not achievable, the service life of the line may be less than that stated by the manufacturer and therefore the line may need to be replaced before the end of the service life recommended by the manufacturer. The condition of lines regularly exposed to below the acceptable minimum bend radius should be subject to particular attention during inspections.

5.7 When selecting replacement mooring lines with high stiffness, including wire and high modulus synthetic lines, consideration should be given to the use of synthetic tails in order to reduce peak loading when the ship is secured alongside.

5.8 Consideration of the use of synthetic tails on high stiffness mooring lines should take into account industry and manufacturer guidance and the potential effects of synthetic tails on the stored energy of mooring lines under tension. The use of tails can change the characteristics of a mooring line and its behaviour in the event of failure. High stiffness mooring lines may exert significant dynamic force and have significant snap-back zones when used with synthetic tails that have a low stiffness.

6 Updating of ship documents and record-keeping

6.1 Records of inspection and maintenance of mooring equipment and inspection and replacement of mooring lines should be retained on board. Such records should be kept for a period determined by the Company, but in any event the records should be kept until completion of the next annual survey.

6.2 Consideration should be given to control and certification of mooring lines, wires, tails and associated attachments. Manufacturers' test certificates for mooring lines, joining shackles and synthetic tails should be kept on board and properly linked back to the equipment.

6.3 The items to be recorded during inspection and maintenance should be determined, taking into account the recommendations of the manufacturers of the mooring lines.

6.4 Any change of mooring line configuration requires updating of the towing and mooring arrangements plan.

7 References

(1) Oil Companies International Marine Forum (OCIMF), *Mooring Equipment Guidelines, 4th Edition 2018*, ISBN: 978-1-85609-771-0.

(2) Ian. C. Clark BSc, MSc, Master Mariner, MNI, *The Nautical Institute, Mooring and Anchoring Ships Vol.1, Principle and Practice*, ISBN: 9781906915934, 2009.

(3) Walter Vervloesem AMNI, *The Nautical Institute, Mooring and Anchoring Ships Vol.2, Inspection and Maintenance*, ISBN: 9781870077941, 2009.

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MSC.1/Circ.1623
7 December 2020

AMENDMENTS TO THE CODE OF SAFE PRACTICE FOR CARGO STOWAGE AND SECURING (CSS CODE)

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), approved amendments to the *Code of Safe Practice for Cargo Stowage and Securing* (CSS Code), as prepared by the Sub-Committee on Carriage of Cargoes and Containers, at its sixth session (9 to 13 September 2019), as set out in the annex.

2 Member States are invited to bring the amendments to the attention of shipowners, ship operators, ship masters and crews and all parties concerned.

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ANNEX

AMENDMENTS TO THE CODE OF SAFE PRACTICE FOR CARGO STOWAGE AND SECURING (CSS CODE)

ANNEX 13

Methods to assess the efficiency of securing arrangements
For semi-standardized and non-standardized cargo

The complete text of annex 13, together with its four appendices, is replaced by the following:

"**1 Scope of application**

1.1 The methods described in this annex should be applied to semi-standardized and non-standardized cargo including very heavy and/or very large cargo items. Standardized stowage and securing systems, in particular containers on containerships, are excluded.

1.2 Cargoes carried on towed barges should be secured according to the provisions of this annex except that the assumed external forces may be determined using an alternative method acceptable to the Administration instead of that described in section 7.1 of this annex.

1.3 Very heavy and/or very large cargo items as addressed in chapter 1.8 of this Code may require provisions and considerations beyond the general scope of this annex. Examples of such provisions and considerations are given in appendix 3 of this annex.

1.4 Semi-standardized cargoes, for which the securing arrangements are often designed based on worst case assumptions on cargo properties, lashing angles and stowage positions on board, may require provisions and considerations beyond the general scope of this annex. Examples of such provisions and considerations are given in appendix 4 of this annex.

1.5 Notwithstanding the general principles contained in this annex, the adequacy of cargo securing may be demonstrated by means of detailed engineering calculations based upon the general principles and encompassing the additional provisions and considerations shown in appendix 3 of this annex. Computer programs used for that purpose should be validated against a suitable range of model tests or full-scale results in irregular seas. When using new software for new and unconventional applications, the validation should be documented.

1.6 The application of the methods described in this annex is supplementary to the principles of good seamanship and should not replace experience in stowage and securing practice.

2 Purpose of the methods

The methods should:

.1 provide guidance for the preparation of Cargo Securing Manuals and the examples therein;

.2 assist ship's staff in assessing the securing of cargo items not covered by the Cargo Securing Manual;

.3 assist qualified shore personnel in assessing the securing of cargo items not covered by the Cargo Securing Manual; and

.4 serve as a reference for maritime and port-related education and training.

3 Presentation of the methods

The methods are presented in a universally applicable and flexible way. It is recommended that designers of Cargo Securing Manuals convert this presentation into a format suiting the particular ship, its securing equipment and the cargo carried. This format may include applicable diagrams, tables or calculated examples.

4 Strength of securing equipment

4.1 Manufacturers of securing equipment should at least supply information on the nominal breaking strength of the equipment in kilonewtons (kN).[1]

4.2 "Maximum securing load" (MSL) is a term used to define the load capacity for a device used to secure cargo to a ship. "Safe working load" (SWL) may be substituted for MSL for securing purposes, provided this is equal to or exceeds the strength defined by MSL.

Where practicable, the MSL should preferably be marked on the securing equipment.

The MSLs for different securing devices are given in table 1 if not given under 4.3.

The MSL of timber should be taken as 0.3 kN/cm2 normal to the grain.

Table 1 – Determination of MSL from breaking strength

Material	MSL
Shackles, rings, deckeyes, turnbuckles of mild steel	50% of breaking strength
Fibre rope	33% of breaking strength
Web lashing	50% of breaking strength
Wire rope (single use)	80% of breaking strength
Wire rope (re-useable)	30% of breaking strength
Steel band (single use)	70% of breaking strength
Chains	50% of breaking strength

4.3 Particular securing devices (e.g. fibre straps with tensioners or special equipment for securing containers) may be marked with a permissible working load, as prescribed by an appropriate authority. This may be taken as the MSL.

4.4 When the components of a lashing device are connected in series (e.g. a wire to a shackle to a deckeye), the minimum MSL in the series should apply to that device.

4.5 Where temporary welded fittings are used, they should be designed to be adequate for the expected loading, and installed by qualified welders in accordance with established welding procedures. The design and placement of these fittings should be such as to minimize bending.

[1] 1 kN ≈ 100 kg.

4.6 Simple stoppers may be used to provide securing against sliding. These are generally welded to a surface by fillet welds, characterized by thickness (*a*) and length (*l*). A face plate should be provided against the cargo piece so that welds are not loaded by a shear force at right angles to the weld direction or by significant bending forces. As a simple rule of thumb for welded steel stoppers, the MSL of single-lay weld leg can then be approximated as 4 kN/cm (*l*) normal to the face plate, assuming 5 mm weld thickness (*a*). For a triple-lay weld leg, MSL can be taken as 10 kN/cm normal to the face plate.

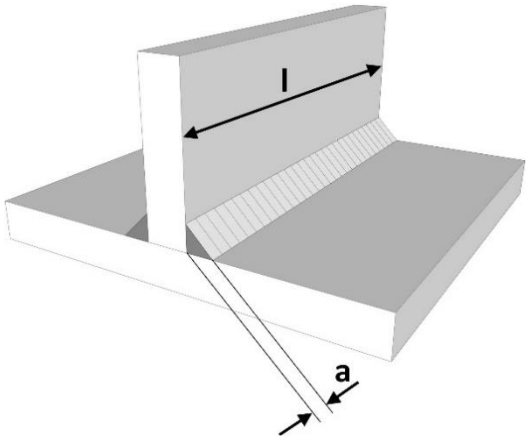


Figure 16.1 – Welding of steel stoppers

4.7 All securing devices to be accounted for in the balance calculations described in this annex should be capable of transferring forces directly from the vessel to the cargo or vice versa, in order to reflect their MSLs. For that purpose, lashings should be attached to fixed securing points or strong supporting structures marked on the cargo item or advised as being suitable, or taken as a loop around the item with both ends secured to the same side as shown in figure 7 in annex 5 of the Code. Lashings going over the top of the cargo item, whose only function is to increase friction by their pre-tension, cannot be credited in the evaluation of securing arrangements under this annex.

5 Rule-of-thumb method

5.1 The total of the MSL values of the securing devices on each side of a cargo item (port as well as starboard) should equal the weight of the item.[2]

5.2 This method, which implies a transverse acceleration of 1g (9.81 m/s^2), applies to nearly any size of ship, regardless of the location of stowage, stability and loading condition, season and area of operation. The method, however, takes into account neither the adverse effects of lashing angles and non-homogeneous distribution of forces among the securing devices nor the favourable effect of friction.

5.3 Transverse lashing angles to the deck should not be greater than 60° and it is important that adequate friction is provided by the use of suitable material. Additional lashings at angles of greater than 60° may be desirable to prevent tipping but are not to be counted in the number of lashings under the rule of thumb.

6 Safety factor

6.1 When using balance calculation methods for assessing the strength of the securing devices, a safety factor is used to take account of the possibility of uneven distribution of forces among the devices or reduced capability due to the improper assembly of the devices or other

[2] The weight of the unit should be taken in kN.

reasons. This safety factor is used in the formula to derive the calculated strength (*CS*) from the MSL and shown in the relevant method used.

$$CS = \frac{MSL}{safety\ factor}$$

6.2 Notwithstanding the introduction of such a safety factor, care should be taken to use securing elements of similar material and length in order to provide a uniform elastic behaviour within the arrangement.

6.3 If securing devices of different elasticity are used in the same direction, e.g. welded bottom stoppers and fibre belts or long wire lashings, the more flexible securing devices in such an arrangement should be excluded if they, due to their elongation, do not contribute to preventing initial movement of the cargo.

7 Advanced calculation method

7.1 Assumption of external forces

7.1.1 External forces to a cargo item in longitudinal, transverse and vertical directions should be obtained using the formula:

$$F_{(x,y,z)} = m \cdot a_{(x,y,z)} + F_{w(x,y)} + F_{s(x,y)}$$

where

$F_{(x,y,z)}$ = longitudinal, transverse and vertical forces
m = mass of the item
$a_{(x,y,z)}$ = longitudinal, transverse and vertical accelerations (see table 2 below)
$F_{w(x,y)}$ = longitudinal and transverse forces by wind pressure
$F_{s(x,y)}$ = longitudinal and transverse forces by sea sloshing.

The basic acceleration data are presented in table 2.

Table 2 – Basic acceleration data

	Transverse acceleration a_y in m/s²									Longitudinal acceleration a_x in m/s²
on deck, high	7.1	6.9	6.8	6.7	6.7	6.8	6.9	7.1	7.4	3.8
on deck, low	6.5	6.3	6.1	6.1	6.1	6.1	6.3	6.5	6.7	2.9
'tween-deck	5.9	5.6	5.5	5.4	5.4	5.5	5.6	5.9	6.2	2.0
lower hold	5.5	5.3	5.1	5.0	5.0	5.1	5.3	5.5	5.9	1.5
0 … L	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
Vertical acceleration a_z in m/s²										
	7.6	6.2	5.0	4.3	4.3	5.0	6.2	7.6	9.2	

Remarks:

The given transverse acceleration figures include components of gravity, pitch and heave parallel to the deck. The given vertical acceleration figures do not include the static weight component.

7.1.2 The basic acceleration data are to be considered as valid under the following operational conditions:[3]

.1 operation in unrestricted area;

.2 operation during the whole year;

.3 length of ship is 100 m;

.4 service speed is 15 knots; and

.5 $B/GM \geq 13$ (B = moulded breadth of ship, GM = metacentric height).

7.1.3 For operation in a restricted area, reduction factors for accelerations may be considered, taking into account the season of the year, the accuracy of the weather forecast affecting the wave heights during the intended voyage and the duration of the voyage. Restricted area means any sea area in which the weather can be forecast for the entire sea voyage or shelter can be found during the voyage.

7.1.4 Reduction factors, f_R, may be applied to significant wave heights[4], H_s, not exceeding 12 m for the design of securing arrangements in any of the following cases:

.1 The required securing arrangement is calculated for the maximum expected 20-year significant wave height in a particular restricted area and the cargo is always secured according to the designed arrangement when operating in that area.

.2 The maximum significant wave height that a particular securing arrangement can withstand is calculated and the vessel is limited to operating only in significant wave heights up to the maximum calculated. Procedures for ensuring that any operational limitation is not exceeded should be developed and followed and documented in the ship's approved Cargo Securing Manual.

.3 Required securing arrangements are designed for different significant wave heights and the securing arrangement is selected according to the maximum expected wave height for each voyage for which an accurate weather forecast is available. Thus, the duration of the voyage should not exceed 72 hours or a duration as accepted by the Administration.

7.1.5 The basic acceleration data in table 2 may be multiplied by the following reduction factor:

$f_R = 1 - (H_s - 13)^2 / 240$, where H_s is:

.1 the maximum expected 20-year significant wave height in the area according to ocean wave statistics; or

.2 the maximum predicted significant wave height on which the operational limitations are based; or

[3] The acceleration values in table 2 are calculated according to the guidance formulae for acceleration components in the IGC Code (resolution MSC.5(48)) and reduced to a probability level of 25 days.

[4] Arithmetic mean of the highest one third of waves measured from trough to crest.

.3 for voyages not exceeding 72 hours the maximum predicted significant wave height according to weather forecasts.

7.1.6 When weather-dependent lashing is applied, operational procedures for the following activities should be developed, followed and documented in the ship's approved Cargo Securing Manual, or otherwise included in the ship's safety management system:

.1 decision on the level of cargo securing based on the length of the voyage and the weather forecast;

.2 communication to all concerned parties of the decided level of cargo securing for the intended voyage;

.3 execution and supervision of appropriate cargo securing efforts in accordance with the Cargo Securing Manual; and

.4 monitoring of environmental conditions and ship motions to ensure that the applied level of cargo securing is not exceeded.

7.1.7 For ships of a length other than 100 m and a service speed other than 15 knots, the acceleration figures should be multiplied by a correction factor given in table 3.

Table 3 – Correction factors for length and service speed

Length (m) / Speed (kn)	**50**	**60**	**70**	**80**	**90**	**100**	**120**	**140**	**160**	**180**	**200**
9	1.20	1.09	1.00	0.92	0.85	0.79	0.70	0.63	0.57	0.53	0.49
12	1.34	1.22	1.12	1.03	0.96	0.90	0.79	0.72	0.65	0.60	0.56
15	1.49	1.36	1.24	1.15	1.07	1.00	0.89	0.80	0.73	0.68	0.63
18	1.64	1.49	1.37	1.27	1.18	1.10	0.98	0.89	0.82	0.76	0.71
21	1.78	1.62	1.49	1.38	1.29	1.21	1.08	0.98	0.90	0.83	0.78
24	1.93	1.76	1.62	1.50	1.40	1.31	1.17	1.07	0.98	0.91	0.85

7.1.8 For length/speed combinations not directly tabulated, the following formula may be used to obtain the correction factor with v = speed in knots and L = length between perpendiculars in metres:

$$\text{correction factor} = (0.345 \cdot v/\sqrt{L}) + (58.62 \cdot L - 1034.5)/L^2$$

This formula should not be used for ship lengths less than 50 m or more than 300 m.

In addition, for ships with B/GM less than 13, the transverse acceleration figures should be multiplied by the correction factor given in table 4.

Table 4 – Correction factors for B/GM

B/GM	3	4	5	6	7	8	9	10	11	12	13 or above
on deck, high	2.64	2.28	1.98	1.74	1.56	1.40	1.27	1.19	1.11	1.05	1.00
on deck, low	2.18	1.93	1.72	1.55	1.42	1.30	1.21	1.14	1.09	1.04	1.00
'tween deck	1.62	1.51	1.41	1.33	1.26	1.19	1.14	1.09	1.06	1.03	1.00
lower hold	1.24	1.23	1.20	1.18	1.15	1.12	1.09	1.06	1.04	1.02	1.00

7.1.9 The following should be observed:

.1 In the case of marked roll resonance with amplitudes above ±30°, the given figures of transverse acceleration may be exceeded. Effective measures should be taken to avoid this condition.

.2 In the case of heading into the seas at high speed with marked slamming impacts, the given figures of longitudinal and vertical acceleration may be exceeded. An appropriate reduction of speed should be considered.

.3 In the case of running before large stern or quartering seas with a stability which does not amply exceed the accepted minimum requirements, large roll amplitudes must be expected with transverse accelerations greater than the figures given. An appropriate change of heading should be considered.

.4 Forces by wind and sea to cargo items above the weather deck should be accounted for by a simple approach:

.1 force by wind pressure = 1 kN per m^2

.2 force by sea sloshing = 1 kN per m^2

.5 The wind force may be reduced by the same principles as the accelerations, i.e. multiplying it with a reduction factor, f_R, based on the expected significant wave height.

.6 Sloshing by sea can induce forces much greater than the figure given above. This figure should be considered as remaining unavoidable after adequate measures to prevent overcoming seas.

.7 Sea sloshing forces need only be applied to a height of deck cargo up to 2 m above the weather deck or hatch top.

.8 For voyages in a restricted area and with forecast wave heights for which no sea sloshing is expected, sea sloshing forces may be neglected.

7.2 Balance of forces and moments

7.2.1 The balance calculation should preferably be carried out for:

.1 transverse sliding in port and starboard directions;

.2 transverse tipping in port and starboard directions; and

.3 longitudinal sliding under conditions of reduced friction in forward and aft directions.

7.2.2 In the case of symmetrical securing arrangements, one appropriate calculation for each case above is sufficient.

7.2.3 Friction contributes towards prevention of sliding. The following friction coefficients (μ) should be applied.

Table 5 – Friction coefficients

Materials in contact	Friction coefficient (μ)
Timber–timber, wet or dry	0.4
Steel–timber or steel-rubber	0.3
Steel–steel, dry	0.1
Steel–steel, wet	0.0

A friction increasing material or deck coating with higher friction coefficients may be used assuming a certified conservative friction coefficient and the endurable shear stress of the material under repeated loads, as they occur in heavy weather at sea. The applicability of these data should be reviewed with due consideration of the prevailing conditions in terms of moisture, dust, greasy dirt, frost, ice or snow as well as the local pressure applied (weight per area) to the material. Specific advice on this matter as well as instructions for maintenance of coatings should be included in the ship's Cargo Securing Manual, if appropriate.

7.2.4 Transverse sliding

7.2.4.1 The balance calculation should meet the following condition (see also figure 17):

$$F_y \leq \mu \cdot m \cdot g + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$$

Where:

n is the number of lashings being calculated
F_y is transverse force from load assumption (kN)
μ is friction coefficient
m is mass of the cargo item (t)
g is gravity acceleration of earth = 9.81 m/s^2
CS is calculated strength of transverse securing devices (kN)
$CS = \frac{MSL}{1.5}$
f is a function of μ and the vertical securing angle α (see table 6).

7.2.4.2 A vertical securing angle α greater than 60° will reduce the effectiveness of this particular securing device in respect to sliding of the item. Disregarding of such devices from the balance of forces should be considered, unless the necessary load is gained by the imminent tendency to tipping or by a reliable pre-tensioning of the securing device and maintaining the pre-tension throughout the voyage.

7.2.4.3 Any horizontal securing angle, i.e. deviation from the transverse direction, should not exceed 30°, otherwise an exclusion of this securing device from the transverse sliding balance should be considered.

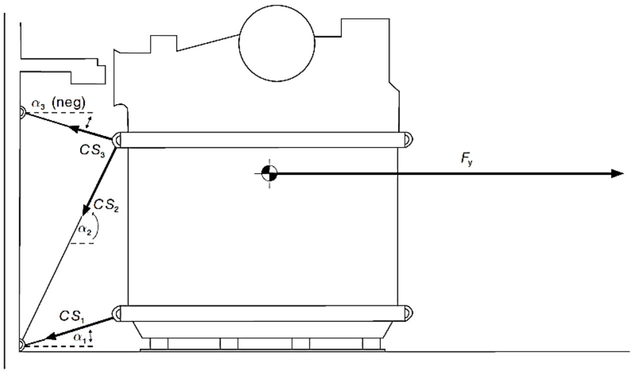


Figure 17 – Balance of transverse forces

Table 6 – f values as a function of α and μ

α / μ	–30°	–20°	–10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
0.3	0.72	0.84	0.93	1.00	1.04	1.04	1.02	0.96	0.87	0.76	0.62	0.47	0.30
0.1	0.82	0.91	0.97	1.00	1.00	0.97	0.92	0.83	0.72	0.59	0.44	0.27	0.10
0.0	0.87	0.94	0.98	1.00	0.98	0.94	0.87	0.77	0.64	0.50	0.34	0.17	0.00

Remark: $f = \mu \cdot \sin \alpha + \cos \alpha$

7.2.4.4 As an alternative to using table 6 to determine the forces in a securing arrangement, the method outlined in paragraph 7.3 can be used to take account of transverse and longitudinal components of lashing forces.

7.2.5 Transverse tipping

This balance calculation should meet the following condition (see also figure 18):

$$F_y \cdot a \leq b \cdot m \cdot g + CS_1 \cdot c_1 + CS_2 \cdot c_2 + \ldots + CS_n \cdot c_n$$

where
F_y, m, g, CS, n are as explained under 7.2.1

a is lever-arm of tipping (m) (see figure 18)
b is lever-arm of stableness (m) (see figure 18)
c is lever-arm of securing force (m) (see figure 18)

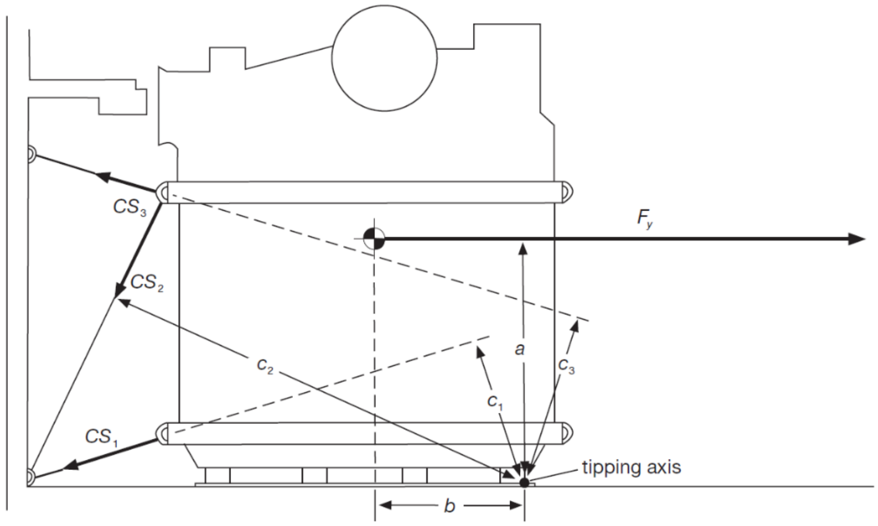


Figure 18 – Balance of transverse moments

7.2.6 Longitudinal sliding

7.2.6.1 Under normal conditions the transverse securing devices provide sufficient longitudinal components to prevent longitudinal sliding. If in doubt, a balance calculation should meet the following condition:

$$F_x \leq \mu \cdot (m \cdot g - f_z \cdot F_z) + CS_1 \cdot f_1 + CS_2 \cdot f_2 + \ldots + CS_n \cdot f_n$$

where
F_x is longitudinal force from load assumption (kN)
μ, m, g, f, n are as explained under 7.2.1
F_z is vertical force from load assumption (kN)
f_z is a correction factor for the vertical force, depending on friction as indicated below:

μ	0.0	0.1	0.2	0.3	0.4	0.6
f_z	0.20	0.50	0.70	0.80	0.85	0.90

7.2.6.2 *CS* is calculated strength of longitudinal securing devices (kN)

$$CS = \frac{MSL}{1.5}$$

Remark*:* Longitudinal components of transverse securing devices should not be assumed greater than 0.5 · *CS*.

7.2.6.3 Instead of service speed, a reduced operational speed is allowed to be used when the correction factor for length and speed is calculated according to table 3 for the correction of the longitudinal and vertical accelerations. The longitudinal acceleration calculated using table 3 in this annex should be verified by monitoring during the voyage. When necessary the speed should be further reduced in order to ensure that the calculated acceleration is not exceeded. In the Cargo Securing Manual, it should be noted that the speed has to be reduced in heavy head seas to avoid longitudinal shifting of cargo. It should also be noted for which speed the accelerations in longitudinal direction have been calculated.

Note: Correction factors for speeds less than the service speed are not allowed for the correction of transverse accelerations.

7.2.7 Calculated example

A calculated example for this method is shown in appendix 1 of annex 13.

7.3 Balance of forces – alternative method

7.3.1 The balance of forces described in paragraph 7.2.4 and 7.2.6 will normally furnish a sufficiently accurate determination of the adequacy of the securing arrangement. However, this alternative method allows a more precise consideration of horizontal securing angles.

7.3.2 Securing devices usually do not have a pure longitudinal or transverse direction in practice but have an angle *β* in the horizontal plane. This horizontal securing angle *β* is defined in this annex as the angle of deviation from the transverse direction. The angle *β* is to be scaled in the quadrantal mode, i.e. between 0° and 90°.

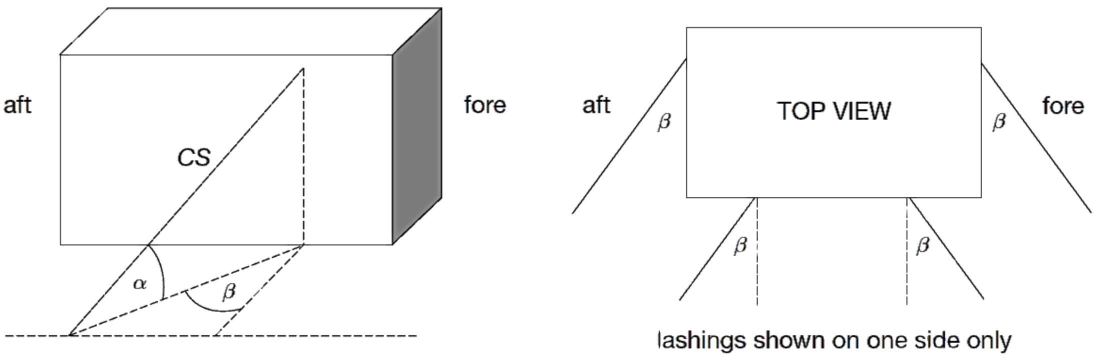


Figure 19 – Definition of the vertical and horizontal securing angles α and β

7.3.3 A securing device with an angle *β* develops securing effects both in longitudinal and transverse direction, which can be expressed by multiplying the calculated strength *CS* with the appropriate values of f_x or f_y. The values of f_x and f_y can be obtained from table 7.

7.3.4 Table 7 consists of five sets of figures, one each for the friction coefficients μ = 0.4, 0.3, 0.2, 0.1 and 0. Each set of figures is obtained by using the vertical angle α and horizontal angle *β*. The value of f_x is obtained when entering the table with *β* from the right while f_y is obtained when entering with *β* from the left, using the nearest tabular value for *α* and *β*. Interpolation is not required but may be used.

The balance calculations are made in accordance with the following formulae:

Transverse sliding: $F_y \leq \mu \cdot m \cdot g + f_{y1} \cdot CS_1 + \ldots + f_{yn} \cdot CS_n$
Longitudinal sliding: $F_x \leq \mu \cdot (m \cdot g - f_z \cdot F_z) + f_{x1} \cdot CS_1 + \ldots + f_{xn} \cdot CS_n$
Transverse tipping: $F_y \cdot a \leq b \cdot m \cdot g + 0.9 \cdot (CS_1 \cdot c_1 + CS_2 \cdot c_2 + \ldots + CS_n \cdot c_n)$

Caution:

Securing devices which have a vertical angle *α* of less than 45° in combination with horizontal angle *β* greater than 45° should not be used in the balance of transverse tipping in the above formula. All symbols used in these formulae have the same meaning as defined in paragraph 7.2 except f_y and f_x, obtained from table 7, and *CS* is as follows:

$$CS = \frac{MSL}{1.35}$$

A calculated example for this method is shown in appendix 1 of annex 13.

Table 7 – *f_x values and f_y values as a function of α, β and μ*

Table 7.1 for μ = 0.4

β for f_y	α														*β* for f_x
	–30	**–20**	**–10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0.67	0.80	0.92	1.00	1.05	1.08	1.07	1.02	0.99	0.95	0.85	0.72	0.57	0.40	**90**
10	0.65	0.79	0.90	0.98	1.04	1.06	1.05	1.01	0.98	0.94	0.84	0.71	0.56	0.40	**80**
20	0.61	0.75	0.86	0.94	0.99	1.02	1.01	0.98	0.95	0.91	0.82	0.70	0.56	0.40	**70**
30	0.55	0.68	0.78	0.87	0.92	0.95	0.95	0.92	0.90	0.86	0.78	0.67	0.54	0.40	**60**
40	0.46	0.58	0.68	0.77	0.82	0.86	0.86	0.84	0.82	0.80	0.73	0.64	0.53	0.40	**50**
50	0.36	0.47	0.56	0.64	0.70	0.74	0.76	0.75	0.74	0.72	0.67	0.60	0.51	0.40	**40**
60	0.23	0.33	0.42	0.50	0.56	0.61	0.63	0.64	0.64	0.63	0.60	0.55	0.48	0.40	**30**
70	0.10	0.18	0.27	0.34	0.41	0.46	0.50	0.52	0.52	0.53	0.52	0.49	0.45	0.40	**20**
80	–0.05	0.03	0.10	0.17	0.24	0.30	0.35	0.39	0.41	0.42	0.43	0.44	0.42	0.40	**10**
90	–0.20	–0.14	–0.07	0.00	0.07	0.14	0.20	0.26	0.28	0.31	0.35	0.38	0.39	0.40	**0**

Table 7.2 for μ = 0.3

β for f_y	Α														*β* for f_x
	–30	**–20**	**–10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0.72	0.84	0.93	1.00	1.04	1.04	1.02	0.96	0.92	0.87	0.76	0.62	0.47	0.30	**90**
10	0.70	0.82	0.92	0.98	1.02	1.03	1.00	0.95	0.91	0.86	0.75	0.62	0.47	0.30	**80**
20	0.66	0.78	0.87	0.94	0.98	0.99	0.96	0.91	0.88	0.83	0.73	0.60	0.46	0.30	**70**
30	0.60	0.71	0.80	0.87	0.90	0.92	0.90	0.86	0.82	0.79	0.69	0.58	0.45	0.30	**60**
40	0.51	0.62	0.70	0.77	0.81	0.82	0.81	0.78	0.75	0.72	0.64	0.54	0.43	0.30	**50**
50	0.41	0.50	0.58	0.64	0.69	0.71	0.71	0.69	0.67	0.64	0.58	0.50	0.41	0.30	**40**
60	0.28	0.37	0.44	0.50	0.54	0.57	0.58	0.58	0.57	0.55	0.51	0.45	0.38	0.30	**30**
70	0.15	0.22	0.28	0.34	0.39	0.42	0.45	0.45	0.45	0.45	0.43	0.40	0.35	0.30	**20**
80	0.00	0.06	0.12	0.17	0.22	0.27	0.30	0.33	0.33	0.34	0.35	0.34	0.33	0.30	**10**
90	–0.15	–0.10	–0.05	0.00	0.05	0.10	0.15	0.19	0.21	0.23	0.26	0.28	0.30	0.30	**0**

Table 7.3 for μ = 0.2

β for f_y	Α														*β* for f_x
	–30	**–20**	**–10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0.77	0.87	0.95	1.00	1.02	1.01	0.97	0.89	0.85	0.80	0.67	0.53	0.37	0.20	**90**
10	0.75	0.86	0.94	0.98	1.00	0.99	0.95	0.88	0.84	0.79	0.67	0.52	0.37	0.20	**80**
20	0.71	0.81	0.89	0.94	0.96	0.95	0.91	0.85	0.81	0.76	0.64	0.51	0.36	0.20	**70**
30	0.65	0.75	0.82	0.87	0.89	0.88	0.85	0.79	0.75	0.71	0.61	0.48	0.35	0.20	**60**
40	0.56	0.65	0.72	0.77	0.79	0.79	0.76	0.72	0.68	0.65	0.56	0.45	0.33	0.20	**50**
50	0.46	0.54	0.60	0.64	0.67	0.67	0.66	0.62	0.60	0.57	0.49	0.41	0.31	0.20	**40**
60	0.33	0.40	0.46	0.50	0.53	0.54	0.53	0.51	0.49	0.47	0.42	0.36	0.28	0.20	**30**

β for f_y	A														*β* for f_x
	–30	**–20**	**–10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
70	0.20	0.25	0.30	0.34	0.37	0.39	0.40	0.39	0.38	0.37	0.34	0.30	0.26	0.20	**20**
80	0.05	0.09	0.14	0.17	0.21	0.23	0.25	0.26	0.26	0.26	0.26	0.25	0.23	0.20	**10**
90	–	–	–	0.00	0.03	0.07	0.10	0.13	0.14	0.15	0.17	0.19	0.20	0.20	**0**

Table 7.4 for μ = 0.1

β for f_y	A														*β* for f_x
	–30	**–20**	**–10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0.82	0.91	0.97	1.00	1.00	0.97	0.92	0.83	0.78	0.72	0.59	0.44	0.27	0.10	**90**
10	0.80	0.89	0.95	0.98	0.99	0.96	0.90	0.82	0.77	0.71	0.58	0.43	0.27	0.10	**80**
20	0.76	0.85	0.91	0.94	0.94	0.92	0.86	0.78	0.74	0.68	0.56	0.42	0.26	0.10	**70**
30	0.70	0.78	0.84	0.87	0.87	0.85	0.80	0.73	0.68	0.63	0.52	0.39	0.25	0.10	**60**
40	0.61	0.69	0.74	0.77	0.77	0.75	0.71	0.65	0.61	0.57	0.47	0.36	0.23	0.10	**50**
50	0.51	0.57	0.62	0.64	0.65	0.64	0.61	0.56	0.53	0.49	0.41	0.31	0.21	0.10	**40**
60	0.38	0.44	0.48	0.50	0.51	0.50	0.48	0.45	0.42	0.40	0.34	0.26	0.19	0.10	**30**
70	0.25	0.29	0.32	0.34	0.35	0.36	0.35	0.33	0.31	0.30	0.26	0.21	0.16	0.10	**20**
80	0.10	0.13	0.15	0.17	0.19	0.20	0.20	0.20	0.19	0.19	0.17	0.15	0.13	0.10	**10**
90	–0.05	–0.03	–0.02	0.00	0.02	0.03	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.10	**0**

Table 7.5 for μ = 0.0

β for f_y	A														*β* for f_x
	–30	**–20**	**–10**	**0**	**10**	**20**	**30**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	
0	0.87	0.94	0.98	1.00	0.98	0.94	0.87	0.77	0.71	0.64	0.50	0.34	0.17	0.00	**90**
10	0.85	0.93	0.97	0.98	0.97	0.93	0.85	0.75	0.70	0.63	0.49	0.34	0.17	0.00	**80**
20	0.81	0.88	0.93	0.94	0.93	0.88	0.81	0.72	0.66	0.60	0.47	0.32	0.16	0.00	**70**
30	0.75	0.81	0.85	0.87	0.85	0.81	0.75	0.66	0.61	0.56	0.43	0.30	0.15	0.00	**60**
40	0.66	0.72	0.75	0.77	0.75	0.72	0.66	0.59	0.54	0.49	0.38	0.26	0.13	0.00	**50**
50	0.56	0.60	0.63	0.64	0.63	0.60	0.56	0.49	0.45	0.41	0.32	0.22	0.11	0.00	**40**
60	0.43	0.47	0.49	0.50	0.49	0.47	0.43	0.38	0.35	0.32	0.25	0.17	0.09	0.00	**30**
70	0.30	0.32	0.34	0.34	0.34	0.32	0.30	0.26	0.24	0.22	0.17	0.12	0.06	0.00	**20**
80	0.15	0.16	0.17	0.17	0.17	0.16	0.15	0.13	0.12	0.11	0.09	0.06	0.03	0.00	**10**
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0**

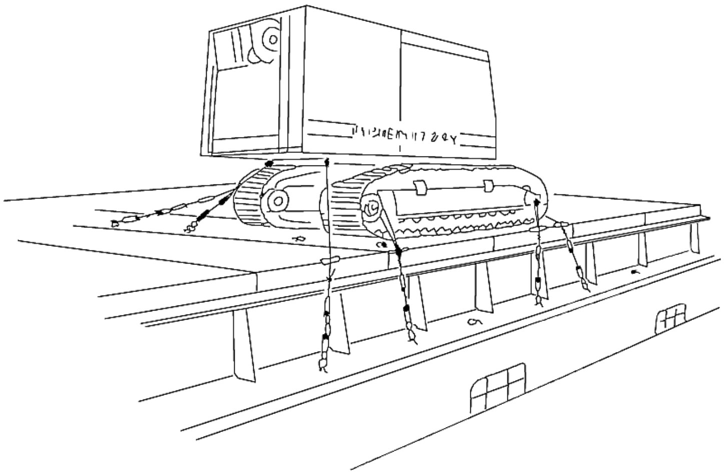
Remark: $f_y = \cos\alpha \cdot \cos\beta + \mu \cdot \sin\alpha$ $f_x = \cos\alpha \cdot \sin\beta + \mu \cdot \sin\alpha$.

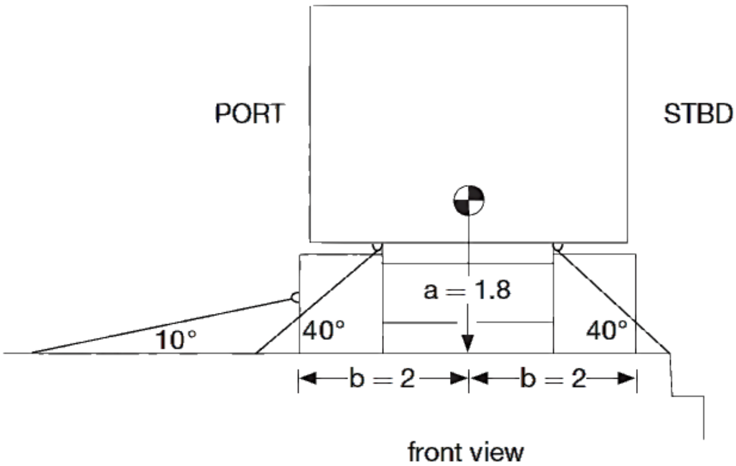
APPENDIX 1

CALCULATED EXAMPLE 1

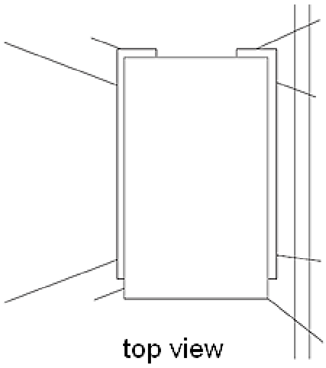
(refer to paragraph 7.2, Balance of forces and moments)

Ship: L = 120 m; B = 20 m; GM = 1.4 m; speed = 15 knots
Cargo: m = 62 t; dimensions = 6 × 4 × 4 m;
stowage at 0.7L on deck, low





front view



top view

Securing material:

wire rope (single use): breaking strength = 125 kN; *MSL* = 100 kN
shackles, turnbuckles, deck rings: breaking strength = 180 kN; *MSL* = 90 kN
stowage on dunnage boards: μ = 0.3; *CS* = 90/1.5 = 60 kN

Securing arrangement:

side	*n*	*CS*	α	*f*	*c*
STBD	4	60 kN	40°	0.96	–
PORT	2	60 kN	40°	0.96	–
PORT	2	60 kN	10°	1.04	–

External forces:

$F_X = 2.9 \times 0.89 \times 62 + 16 + 8 = 184$ kN
$F_Y = 6.3 \times 0.89 \times 62 + 24 + 12 = 384$ kN
$F_Z = 6.2 \times 0.89 \times 62 = 342$ kN

Balance of forces (STBD arrangement):

384 < 0.3 × 62 × 9.81 + 4 × 60 × 0.96
384 < 412 this is OK!

Balance of forces (PORT arrangement):

384 < 0.3 × 62 × 9.81 + 2 × 60 × 0.96 + 2 × 60 × 1.04
384 < 422 this is OK!

Balance of moments:

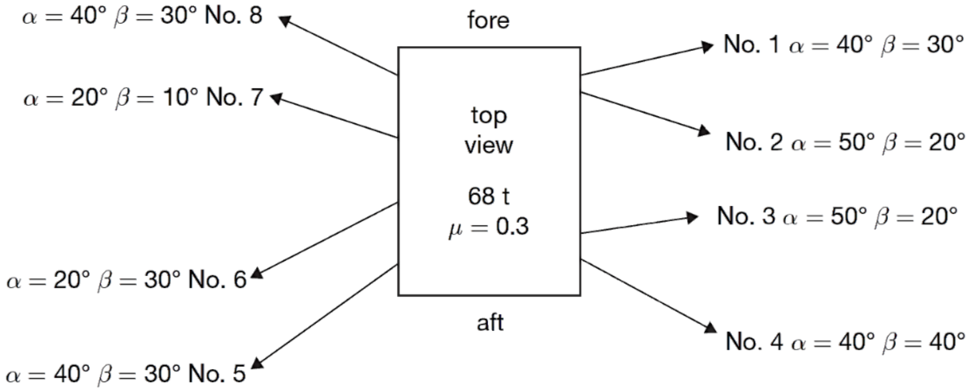
384 × 1.8 < 2 × 62 × 9.81
691 < 1216 no tipping, even without lashings!

Calculated example 2

(refer to section 7.3, Balance of forces – alternative method)

A cargo item of 68 t mass is stowed on timber (μ = 0.3) in the 'tween deck at 0.7*L* of a vessel.
L = 160 m, *B* = 24 m, *v* = 18 knots and GM = 1.5 m.
Dimensions of the cargo item are height = 2.4 m and width = 1.8 m.
The external forces are: F_x = 112 kN, F_y = 312 kN, F_z = 346 kN, f_z= 0.8 and $f_z \cdot F_z$ = 276.8 kN

The top view shows the overall securing arrangement with eight lashings.



Calculation of balance of forces:

No.	MSL (kN)	CS (kN)	*α*	*β*	f_y	$CS \times f_y$	f_x	$CS \times f_x$
1	108	80	40° stbd	30° fwd	0.86	68.8 stbd	0.58	46.4 fwd
2	90	67	50° stbd	20° aft	0.83	55.6 stbd	0.45	30.2 aft
3	90	67	50° stbd	20° fwd	0.83	55.6 stbd	0.45	30.2 fwd
4	108	80	40° stbd	40° aft	0.78	62.4 stbd	0.69	55.2 aft
5	108	80	40° port	30° aft	0.86	68.8 port	0.58	46.4 aft
6	90	67	20° port	30° aft	0.92	61.6 port	0.57	38.2 aft
7	90	67	20° port	10° fwd	1.03	69.0 port	0.27	18.1 fwd
8	108	80	40° port	30° fwd	0.86	68.8 port	0.58	46.4 fwd

Transverse balance of forces (STBD arrangement) Nos. 1, 2, 3 and 4:

$312 < 0.3 \times 68 \times 9.81 + 68.8 + 55.6 + 55.6 + 62.4$

$312 < 443$ this is OK!

Transverse balance of forces (PORT arrangement) Nos. 5, 6, 7 and 8:

$312 < 0.3 \times 68 \times 9.81 + 68.8 + 61.6 + 69.0 + 68.8$

$312 < 468$ this is OK!

Longitudinal balance of forces (FWD arrangement) Nos. 1, 3, 7 and 8:

$112 < 0.3\ (68 \times 9.81 – 276.8) + 46.4 + 30.2 + 18.1 + 46.4$

$112 < 258$ this is OK!

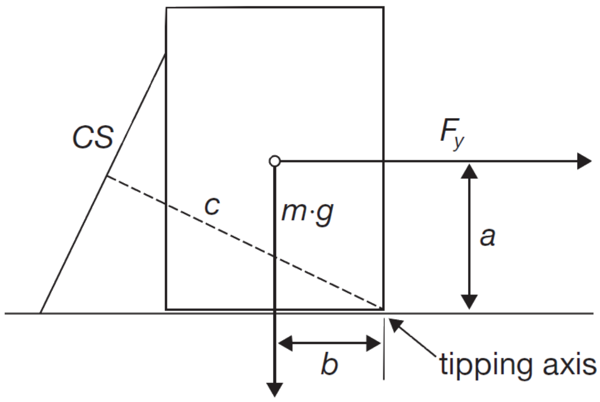
Longitudinal balance of forces (AFT arrangement) Nos. 2, 4, 5 and 6:

$112 < 0.3\ (68 \times 9.81 – 276.8) + 30.2 + 55.2 + 46.4 + 38.2$

$112 < 287$ this is OK!

Transverse tipping

Unless specific information is provided, the vertical centre of gravity of the cargo item can be assumed to be at one half the height and the transverse centre of gravity at one half the width. Also, if the lashing is connected as shown in the sketch, instead of measuring *c*, the length of the lever from the tipping axis to the lashing *CS*, it is conservative to assume that it is equal to the width of the cargo item.



$F_y \cdot a \quad \leq b \cdot m \cdot g + 0.9 \cdot (CS_1 \cdot c_1 + CS_2 \cdot c_2 + CS_3 \cdot c_3 + CS_4 \cdot c_4)$

312 × 2.4/2 < 1.8/2 × 68 × 9.81 + 0.9 × 1.8 × (80 + 67 + 67 + 80)
374 < 600 + 476
374 < 1076 this is OK!

APPENDIX 2

EXPLANATIONS AND INTERPRETATION OF METHODS TO ASSESS THE EFFICIENCY OF SECURING ARRANGEMENTS

1 The acceleration figures given in table 2, in combination with the correction factors, represent peak values on a 25-day voyage. This does not imply that peak values in *x*, *y* and *z* directions occur simultaneously with the same probability. It can be generally assumed that peak values in the transverse direction will appear in combination with less than 60% of the peak values in longitudinal and vertical directions.

2 Peak values in longitudinal and vertical directions may be associated more closely because they have the common source of pitching and heaving.

3 The advanced calculation method uses the "worst case approach". That is expressed clearly by the transverse acceleration figures, which increase to forward and aft in the ship and thereby show the influence of transverse components of simultaneous vertical accelerations. Consequently, there is no need to consider vertical accelerations separately in the balances of transverse forces and moments. These simultaneously acting vertical accelerations create an apparent increase of weight of the item and thus increase the effect of the friction in the balance of forces and the moment of stableness in the balance of moments. For this reason there is no reduction of the force $m \cdot g$ normal to the deck due to the presence of an angle of heel.

4 The situation is different for the longitudinal sliding balance. The worst case would be a peak value of the longitudinal force F_x accompanied by an extreme reduction of weight through the vertical force F_z.

5 The friction coefficients shown in the tables of this annex are generally lower than the ones given in other publications, such as the CTU Code. The reason for this can be seen in various influences which may appear in practical shipping, such as: vibration of the ship, moisture, grease, oil, dust and other residues.

6 There are certain stowage materials available which are said to increase friction considerably. Extended experience with these materials may bring additional coefficients into practical use.

7 The principal way of calculating forces within the securing elements of a complex securing arrangement should necessarily include the consideration of:

.1 load-elongation behaviour (elasticity);

.2 geometrical arrangement (angles, length); and

.3 pre-tension, of each individual securing element.

8 This approach would require a large volume of information and a complex, iterative calculation. The results would still be doubtful due to uncertain parameters.

9 Therefore, the simplified approach was chosen with the assumption that the elements take an even load of *CS* (calculated strength) which is reduced against the MSL (maximum securing load) by the safety factor.

10 When employing the advanced calculation method, the way of collecting data should be followed as shown in the calculated example. It is acceptable to estimate securing angles, to take average angles for a set of lashings and similarly to arrive at reasonable figures of the levers *a*, *b* and *c* for the balance of moments.

11 It should be borne in mind that this annex contains a number of assumptions based on approximations. Even though safety factors are also incorporated, there is no clear-cut borderline between safety and non-safety. If in doubt, the arrangement should be improved.

APPENDIX 3

ADVANCED PROVISIONS AND CONSIDERATIONS APPLICABLE TO VERY HEAVY AND/OR VERY LARGE CARGO ITEMS

This appendix contains additional advice that may be considered for the stowage and securing of cargo with unusual characteristics, as referenced in chapter 1.8 of this Code and may include items of exceptional mass and/or dimension. However, the listed considerations do not claim to be complete.

1 Longitudinal tipping

For the securing of large and tall cargo items in longitudinal direction, the balance calculation should also consider longitudinal tipping and meet the following condition:

$$F_x \cdot a \leq b \cdot (m \cdot g - f_z \cdot F_z) + CS_1 \cdot c_1 + CS_2 \cdot c_2 + ... + CS_n \cdot c_n \; [kNm]$$

Where:

F_x, m, g, F_z, CS, n are as explained under 7.2.1 of this annex.

a is lever-arm of tipping (m) (see figure 18)
b is lever-arm of stableness (m) (see figure 18)
c is lever-arm of securing force (m) (see figure 18)

The factor f_Z is obtained by the applicable relation of b/a as shown below:

b/a	0.1	0.2	0.3	0.4	0.6	1.0	2.0	3.0
f_Z	0.50	0.70	0.80	0.85	0.90	0.94	0.98	1.00

2 Rotational inertia of large cargo items

2.1 The algorithm used in 7.2.2 of this annex and section 1 above for defining the tipping moment acting on a distinct cargo item replaces the physical extent of the item by its centre of gravity. The tipping moment is then declared as the determined horizontal force F_x or F_y, multiplied by the vertical distance "*a*" of this centre of gravity to the edge of the footprint, i.e. the tipping axis of the item. This is sufficiently accurate, as long as the spatial dimensions of the item remain below about 6 metres.

2.2 Larger items, however, will develop a substantial additional tipping moment by their rotational inertia against the rotational acceleration of the ship in rolling or pitching motions. The additional tipping moment is independent from the stowage position of the item in the ship and always positive, i.e. intensifying the tipping impulse. This phenomenon requires additional securing measures and, therefore, should be included in tipping balances for large cargo items by the use of a simple algorithm.

2.3 Transverse tipping balance

2.3.1 For cargo items of width *w* (measured athwartships) and height *h*, where $(w^2 + h^2) > 50\ m^2$, the additional tipping moment $k \cdot J$ due to rotational inertia of the cargo item should be added to the ordinary tipping moment $F_y \cdot a$ in the transverse tipping balance.

2.3.2 The appropriate figure of the moment of rotational inertia J should be supplied by the shipper related to the centre of gravity of the item for the plane of transverse tipping. If such information is not available, an estimated figure may be used by:

$J = m \cdot \left(\frac{w^2+h^2}{12}\right)$ $[tm^2]$ for homogeneous distribution of mass in the item

$J = m \cdot \left(\frac{(w+h)^2}{12}\right)$ $[tm^2]$ for an item with peripheral concentration of mass.

The reverse angular acceleration k may be taken as $k = \frac{36 \cdot GM}{B^2}$ $[s^{-2}]$.

2.4 Longitudinal tipping balance

2.4.1 For cargo items of length *l* (measured fore and aft) and height h, where $(l^2 + h^2) > 50\ m^2$, the additional tipping moment $k \cdot J$ due to rotational inertia of the cargo item should be added to the ordinary tipping moment $F_x \cdot a$ in the longitudinal tipping balance.

2.4.2 The appropriate figure of the moment of rotational inertia J should be supplied by the shipper related to the centre of gravity of the item for the plane of longitudinal tipping. If such information is not available, an estimated figure may be used by:

$J = m \cdot \left(\frac{l^2+h^2}{12}\right)$ $[tm^2]$ for homogeneous distribution of mass in the item

$J = m \cdot \left(\frac{(l+h)^2}{12}\right)$ $[tm^2]$ for an item with peripheral concentration of mass

The reverse angular acceleration k may be taken as $k = \frac{25}{L}$ $[s^{-2}]$.

3 Separate consideration of wind and sea sloshing

3.1 The algorithm used in this annex for defining the horizontal force F_x or F_y, acting on a cargo item stowed on deck, combines horizontal weight components, inertia forces and wind/sloshing forces for reasons of simplification. This is correct for the balance of sliding; however, it is an approximation only for the balance of tipping. Particularly, high deck cargo items with their major wind exposed area well above the centre of gravity should be given a separate compilation of moments from wind forces, sea sloshing forces and gravity/inertia forces in order to get a more realistic tipping moment. The inertia forces strike on the centre of gravity of the cargo item, the sea sloshing strikes on the cargo area not more than 2 m above the weather deck and the wind forces strike on the lateral area of the cargo item exposed to wind.

Example: The figures of the tipping lever "*a*" relate to a large portal harbour crane shipped on deck of a heavy lift ship. The centres of attack by wind and spray deviate considerably from the centre of gravity. A separate compilation of the longitudinal tipping moment reads:

	F_x	a	$F_x \cdot a$
Gravity/inertia	1373 kN	13.0 m	17849 kNm
Wind	170 kN	20.0 m	3400 kNm
Spray	4 kN	1.0 m	4 kNm
Total	**1547 kN**		**21253 kNm**

3.2 The conventionally computed tipping moment would be only:

Total	**1547 kN**	**13.0 m**	**20111 kNm**

3.3 The surplus over the conventional tipping moment here is about 6%. The potential additional tipping moment by rotational inertia has not been reflected in this example.

4 Interpretation of "on deck high"

4.1 The stowage level "on deck high" in table 2 of annex 13 has been positioned at a distance above the water line of about two thirds of the ship's breadth. With extremely large cargo items this level can easily be exceeded. In order to avoid uncertainties in the determination of transverse and longitudinal accelerations in such cases, it is recommended to use the original mathematical model, which has been the basis for acceleration tables in annex 13. This model may easily be programmed, e.g. in a suitable spreadsheet.

4.2 The shown mathematical model is identical to that used in the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code) (resolution MSC. 5(48)). However, while in the IGC Code the probability level of accelerations refers to the lifetime of a ship of 10^4 days, annex 13, in order to remain within the scope of practical cargo securing experience, applies a reduction factor of 0.74, corresponding to the 25-day significant wave height in the North Atlantic. Furthermore, the model has been expanded to supply reasonable *K*-parameters for *B/GM*-relations less than 7, applicable to ships with exceptional large *GM*-values.

Mathematical model of the acceleration tables 2 to 4

4.3 The longitudinal, transverse and vertical accelerations acting on a cargo item may be obtained alternatively by the set of formulas as follows:

$$a_x = c_1 \cdot c_2 \cdot c_3 \cdot a_{x0} \cdot g \; [m/s^2]$$
$$a_y = c_1 \cdot c_2 \cdot c_3 \cdot a_{y0} \cdot g \; [m/s^2]$$
$$a_z = c_1 \cdot c_2 \cdot c_3 \cdot a_{z0} \cdot g \; [m/s^2]$$

a_x: longitudinal acceleration (gravity component of pitch included)
a_y: transverse acceleration (gravity component of roll included)
a_z: vertical acceleration (component due to static weight not included)
c_1: correction factor for navigation area, taken as 1.0 worldwide in annex 13
c_2: correction factor for season, taken as 1.0 for whole year in the annex 13
c_3: correction factor for 25 navigation days, taken as $0.6 + 0.1 \cdot \log_{10} 25 = 0.74$ in annex 13

$$a_{x0} = \pm a_0 \cdot \sqrt{0.06 + A^2 - 0.25 \cdot A}$$

$$a_{y0} = \pm a_0 \cdot \sqrt{0.6 + 2.5 \cdot \left(\frac{x}{L} + 0.05\right)^2 + K \cdot \left(1 + 0.6 \cdot K \cdot \frac{z}{B}\right)^2}$$

$$a_{z0} = \pm a_0 \cdot \sqrt{1 + \left(5.3 - \frac{45}{L}\right)^2 \cdot \left(\frac{x}{L} + 0.05\right)^2 \cdot \left(\frac{0.6}{C_b}\right)^{3/2}}$$

therein:

$$a_0 = 0.2 \cdot \frac{v}{\sqrt{L}} + \frac{34 - 600/L}{L}$$

$$A = \left(0.7 - \frac{L}{1200} + \frac{5 \cdot z}{L}\right) \cdot \left(\frac{0.6}{C_b}\right)$$

$K = R \cdot \frac{13 \cdot GM}{B}$, but never less than 1.0

$R = \left(\frac{B}{7 \cdot GM}\right)^{\left(\frac{GM}{B}\right)}$, but never greater than 1.0

L = length between perpendiculars [m]
B = moulded breadth of ship [m]
GM = metacentric height of ship [m]
C_b = block coefficient of ship
x = longitudinal distance from amidships to calculating point, positive forward [m]
z = vertical distance from actual waterline to calculating point, positive upward [m]
v = service speed [knots]
g = gravity acceleration = 9.81 [m/s^2]

5 Structural strength assessment

5.1 Dry cargo ships are typically designed on the assumption that cargo is homogeneously distributed. The maximum permissible surface load is usually specified in the ship's documentation and given in t/m^2 for all relevant stowage areas, i.e. double bottom (tank top), top of stepped side tanks, 'tween deck pontoons, weather deck and weather deck hatch covers.

5.2 Heavy cargo items tend to produce concentrated strip or point loads rather than homogeneous loads. Then care should be taken that the stress parameters, corresponding to the maximum permissible homogeneous load, are not exceeded by the load induced by the heavy item. The essential parameters for stresses in deck sections, hatch covers and 'tween deck pontoons or panels are shear forces and bending moments. Suitable steel or timber beams or equivalent panel structures should be used to transfer the strip or point load to the primary members of the load-bearing structure.

5.3 Where a loading situation appears to be too complex to be safely examined by manual calculation or where stress parameters obtained by a manual calculation method come close to the applicable limit of the supporting structure, utilization of finite element analysis should be considered.

6 Weather routeing

6.1 Utilizing weather routeing services may significantly contribute to performing a safe passage. Care should be taken that the engaged service complies with the recommendations laid down in MSC/Circ.1063 on *Participation of ships in weather routeing services*.

6.2 In case of transporting heavy and/or large cargo items, where safe securing is an essential requirement, the routeing decisions should be oriented to the avoidance of severe ship motions rather than to other criteria, such as swift passage or fuel economy. However, the engagement of a weather routeing service does not eliminate the need for the application of securing measures as required in this annex.

7 Other considerations

When planning the transport of very heavy and/or very large cargo items on deck of a vessel, particular consideration should be given to:

.1 the observation of sight line requirements as stipulated in SOLAS regulation V/22, and, in case of non-compliance, the conditions for a temporary exemption by the Flag State Administration;

.2 the provision of unimpeded radar transmission with due observation of resolution MSC.192(79) on *Revised performance standards for radar equipment* and SN.1/Circ.271 on *Guidelines for the installation of shipborne radar equipment*; and

.3 the provision of visibility of navigations light as required by annex I of International Regulations for Preventing Collisions at Sea and specified in resolution MSC.253(83) *on Performance standards for navigation lights, navigation light controllers and associated equipment*.

APPENDIX 4

ADVANCED PROVISIONS AND CONSIDERATIONS APPLICABLE TO SEMI-STANDARDIZED CARGOES

This appendix contains advice that may be considered for the stowage and securing of semi-standardized cargoes in addition to the other provisions of chapter 4, annex 4 and annex 13 of this Code.

The provisions in section 1 below may be used for the following conditions:

.1 worst case accelerations are used for the design of securing arrangements of semi-standardized cargoes, i.e. the most severe external forces within the particular deck or otherwise defined region of the vessel are applied;

.2 uniform securing arrangements are used for types of cargo items considering stepped weight classes, whereby arrangements always cover the highest weight within a class and the most unfavourable position of the centre of gravity;

.3 the range of lashing angles is well defined by the pattern of securing points in the vessel, as well as on vehicles. The assessment uses worst case angles, i.e. the worst combination of vertical and horizontal angles within the given ranges; and

.4 securing equipment is regularly inspected when used for recurrent application.

1 Performance factor for short voyages

For cargo securing arrangements considered in section 7.1 case .3 (short duration voyages up to 72 hours), the forces and moments on the right side of the balance equations in section 7.3 may be multiplied by the F_P performance factor of 1.15, as illustrated below:

Transverse sliding: $F_y \leq (\mu \cdot m \cdot g + f_{y1} \cdot CS_1 + \ldots + f_{yn} \cdot CS_n) \cdot F_P$

Longitudinal sliding: $F_x \leq (\mu \cdot (m \cdot g - f_z \cdot F_z) + f_{x1} \cdot CS_1 + \ldots + f_{xn} \cdot CS_n) \cdot F_P$

Transverse tipping: $F_y \cdot a \leq (b \cdot m \cdot g + 0.9 \cdot (CS_1 \cdot c_1 + CS_2 \cdot c_2 + \ldots + CS_n \cdot c_n)) \cdot F_P$

2 Asymmetrical securing arrangements

For asymmetrical lashing arrangements and for cargoes resting on supports with different coefficients of friction, separate sliding of the item's fore and aft ends should be considered in the transverse direction. The calculations for each end should be based on the part of the item's weight resting on each support and the characteristics of the cargo securing devices attached to each end.

3 Safety factor

In the case of elementary securing arrangements, where no more than two devices per impact direction are used and loads are evenly distributed by proper orientation to the centre of gravity of the cargo item, the calculated *CS* of securing devices may be obtained by:

$$CS = \frac{MSL}{1.2}$$

The specific conditions for the use of the reduced safety factor should be outlined in the ship's Cargo Securing Manual.

4 Friction coefficients

In addition to the friction coefficients in table 5 in section 7.2, the following friction coefficients (μ) may be applied.

Table 8 – Additional friction coefficients

Materials in contact	Friction coefficient (μ)
Steel–rubber tyre, dirty, wet or dry	0.3
Steel–solid rubber tyre, dry and clean[5]	0.3
Steel–air rubber tyre, wet and clean[5]	0.4
Steel–air rubber tyre, dry and clean[5]	0.45

5 Effect of parking brake and wheel chocks

For wheel-based cargoes, the effect of parking brakes as well as the effect of wheel chocks may be taken into account when dimensioning securing arrangements against movement in the rolling direction. Usually parking brakes have a braking capacity corresponding to a force equal to $0.2 \cdot g \cdot GVM$ (kN), where GVM is the gross vehicle mass of the item in tonnes and in most cases the parking brake is applied on one axle only. If a wheel is chocked it can be considered not to roll and the friction in the rolling direction should be taken as the lesser of the friction between the tyre and the ship's deck, and the chock and the ship's deck."

5 Conditions of cleanliness as defined in the ship's Cargo Securing Manual.

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MSC.1/Circ.1624
7 December 2020

AMENDMENTS TO THE CODE OF SAFE PRACTICE FOR SHIPS CARRYING TIMBER DECK CARGOES, 2011 (2011 TDC CODE)

1 The Assembly, at its twenty-seventh session (November 2011), adopted, by resolution A.1048(27), the *Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011* (2011 TDC Code).

2 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), approved amendments to the *Code Of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011* (2011 TDC Code), as prepared by the Sub-Committee on Carriage of Cargoes and Containers, at its sixth session (9 to 13 September 2019), as set out in the annex.

3 Member States are invited to bring the amendments to the attention of shipowners, ship operators, shipmasters and crews, and all parties concerned.

***

ANNEX

Part B
Design of cargo securing arrangements

Chapter 6
Alternative design principles

6.2 Accelerations and forces acting on the cargo

1 Paragraph 6.2.1 is replaced by the following:

"The cargo securing arrangement should be designed for accelerations, as well as forces by wind and sea, calculated in accordance with annex 13 of the CSS Code."

2 Paragraphs 6.2.2 up to and including 6.2.5 are deleted.

Annex B
Samples of stowage and securing arrangements

B.5 Example calculation – Uprights for round wood

Example B.5.3 – Uprights for round wood on a 6,000 DWT ship on the Baltic Sea

3 The text under figure B.7 is replaced by the following:

"The ship is trading in the Baltic Sea with a weather forecast predicting a significant wave height up to 5.5 meters. Thus, the reduction factor for operation in restricted waters is taken as:

$$f_R = 1 - (H_s - 13)^2 / 240 = 1 - (5.5 - 13)^2 / 240 = 0.76"$$

B.6 Example calculation – Frictional securing of transversely stowed round wood

Example B.6.1 – Frictional securing of round wood on a 6,000 DWT ship

4 The last paragraph under figure B.8 is replaced by the following:

"The maximum allowed significant wave height H_S with this stowage arrangement is calculated as 2.4 m according to the following:

$$a_t = a_{t\ basic} \cdot f_{R1} \cdot f_{R2} \cdot f_R$$

$$f_R = \frac{a_t}{a_{t\ basic} \cdot f_{R1} \cdot f_{R2}} = \frac{3.2}{6.5 \cdot 0.93 \cdot 1.00} = 0.53$$

$$f_R = 1 - (H_S - 13)^2 / 240$$

$$H_S = 13 - \sqrt{((1-0.53) \cdot 240)} = 2.4 \text{ m"}$$

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MSC.1/Circ.1625
8 December 2020

UNIFIED INTERPRETATIONS OF THE IGC CODE (AS AMENDED BY RESOLUTION MSC.370(93))

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), with a view to providing more specific guidance for the application of the relevant requirements of the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk* (IGC Code), as amended by resolution MSC.370(93), approved unified interpretations of the IGC Code prepared by the Sub-Committee on Carriage of Cargoes and Containers, at its sixth session, as set out in the annex.

2 Member States are invited to use the annexed unified interpretation as guidance when applying the relevant provisions of the IGC Code and to bring the unified interpretations to the attention of all parties concerned.

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ANNEX

UNIFIED INTERPRETATIONS OF THE IGC CODE (AS AMENDED BY RESOLUTION MSC.370(93))

1 Tee welds in type A or type B independent tanks (paragraph 4.20.1.1)

1.1 Paragraph 4.20.1.1 is applicable to independent tanks of type A or type B, primarily constructed of plane surfaces. This includes the tank corners which are constructed using bent plating which is aligned with the tank surfaces and connected with in-plane welds.

1.2 The applicability of the expression "For dome-to-shell connections only" is clarified as follows:

.1 welded corners (i.e. corners made of weld metal) should not be used in the main tank shell construction, i.e. corners between shell side (sloped plane surfaces parallel to hopper or top side inclusive if any) and bottom or top of the tank, and between tank end transverse bulkheads and bottom, top or shell sides (sloped plane surfaces inclusive if any) of the tank. Instead, tank corners which are constructed using bent plating aligned with the tank surfaces and connected with in-plane welds should be used; and

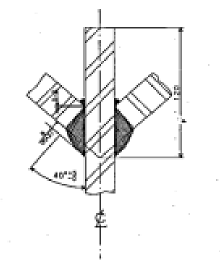
.2 tee welds can be accepted for other localized constructions of the shell such as suction well, sump and dome, where tee welds of full penetration type should also be used.

2 Welds of type C independent bi-lobe tank with centreline bulkhead (paragraph 4.20.1.2)

2.1 Paragraph 4.20.1.2 is applicable to type C independent tanks including bi-lobe tanks, primarily constructed of curved surfaces fitted with a centreline bulkhead.

2.2 The applicability of the expression "Other edge preparations" is clarified as follows:

Cruciform full penetration welded joints in a bi-lobe tank with centreline bulkhead can be accepted for the tank structure construction at tank centreline welds with bevel preparation subject to the approval of the Administration or recognized organization acting on its behalf, based on the results of the tests carried out at the approval of the welding procedure. (See example below.)



3 Outer duct in gas fuel piping systems (paragraphs 5.4.4 and 5.13.2.4)

3.1 The expression "design pressure of the outer pipe or duct" in 5.4.4 is:

.1 the maximum pressure that can act on the outer pipe or equipment enclosure after the inner pipe rupture as documented by suitable calculations taking into account the venting arrangements; or

.2 for gas fuel systems with inner pipe working pressure greater than 1 MPa, the "maximum built-up pressure arising in the annular space", after the inner pipe rupture, which should be calculated in accordance with paragraph 9.8.2 of the IGF Code as adopted by MSC.391(95).

3.2 The expression "maximum pressure at gas pipe rupture" in 5.13.2.4 is the maximum pressure to which the outer pipe or duct is subjected after the inner pipe rupture and for testing purposes it is the same as the design pressure used in 5.4.4.

4 Cargo sampling (paragraphs 5.6.5 and 18.9)

4.1 These requirements should only be applicable if such a sampling system is fitted on board. Connections used for control of atmosphere in cargo tanks during inerting or gassing up should not be considered as cargo sampling connections.

5 Cargo filters (paragraph 5.6.6)

5.1 Means to indicate that filters are becoming blocked and filter maintenance is required should be provided for fixed in-line filter arrangement and portable filter installations where dedicated filter housing piping is provided.

5.2 Where portable filters for fitting to manifold presentation flanges are used without dedicated filter housing, and these can be visually inspected after each loading and discharging operation, no additional arrangements for indicating blockage or facilitating drainage should be required.

6 Cargo piping insulation (paragraph 5.12.3.1)

6.1 The expression "a thermal insulation system as required to minimize heat leak into the cargo during transfer operations" means that properties of the piping insulation should be taken into consideration when calculating the heat balance of the containment system and capacity of the pressure/temperature control system.

6.2 The expression "cargo piping systems shall be provided with a thermal insulation system as required ... to protect personnel from direct contact with cold surfaces" means that surfaces of cargo piping systems with which personnel are likely to have contact under normal conditions should be protected by a thermal insulation, with the exception of the following examples:

.1 surfaces of cargo piping systems which are protected by physical screening measures to prevent such direct contact;

.2 surfaces of manual valves having extended spindles that protect the operator from the cargo temperature; and

.3 surfaces of cargo piping systems whose design temperature (to be determined from inner fluid temperature) is above minus 10°C.

7 Type testing requirements for valves (paragraph 5.13.1.1.2)

7.1 The expression "Each type of valve…shall be certified to a recognized standard" means that:

.1 for pressure relief valves (PRVs) that are subject to IGC Code paragraph 8.2.5, the flow or capacity should be certified by the Administration or recognized organization acting on its behalf; and

.2 for other types of valves, the manufacturer should certify the flow properties of the valves based on tests carried out according to recognized standards.

8 Guidance for sizing pressure relief systems for interbarrier spaces (paragraph 8.1)

8.1 General

8.1.1 The formula for determining the relieving capacity given in section 2 is for interbarrier spaces surrounding independent type A cargo tanks, where the thermal insulation is fitted to the cargo tanks.

8.1.2 The relieving capacity of pressure relief devices of interbarrier spaces surrounding independent type B cargo tanks may be determined on the basis of the method given in section 2; however, the leakage rate should be determined in accordance with 4.7.2 of the IGC Code.

8.1.3 The relieving capacity of pressure relief devices for interbarrier spaces of membrane and semi-membrane tanks should be evaluated on the basis of specific membrane/semi-membrane tank design.

8.1.4 The relieving capacity of pressure relief devices for interbarrier spaces adjacent to integral type cargo tanks may, if applicable, be determined as for type A independent cargo tanks.

8.2 Size of pressure relief devices

8.2.1 The combined relieving capacity of the pressure relief devices for interbarrier spaces surrounding type A independent cargo tanks where the insulation is fitted to the cargo tanks may be determined by the following formula:

$$Q_{sa} = 3{,}4 \,.\, A_c \frac{\rho}{\rho_v} \sqrt{h} \quad (m^3/s)$$

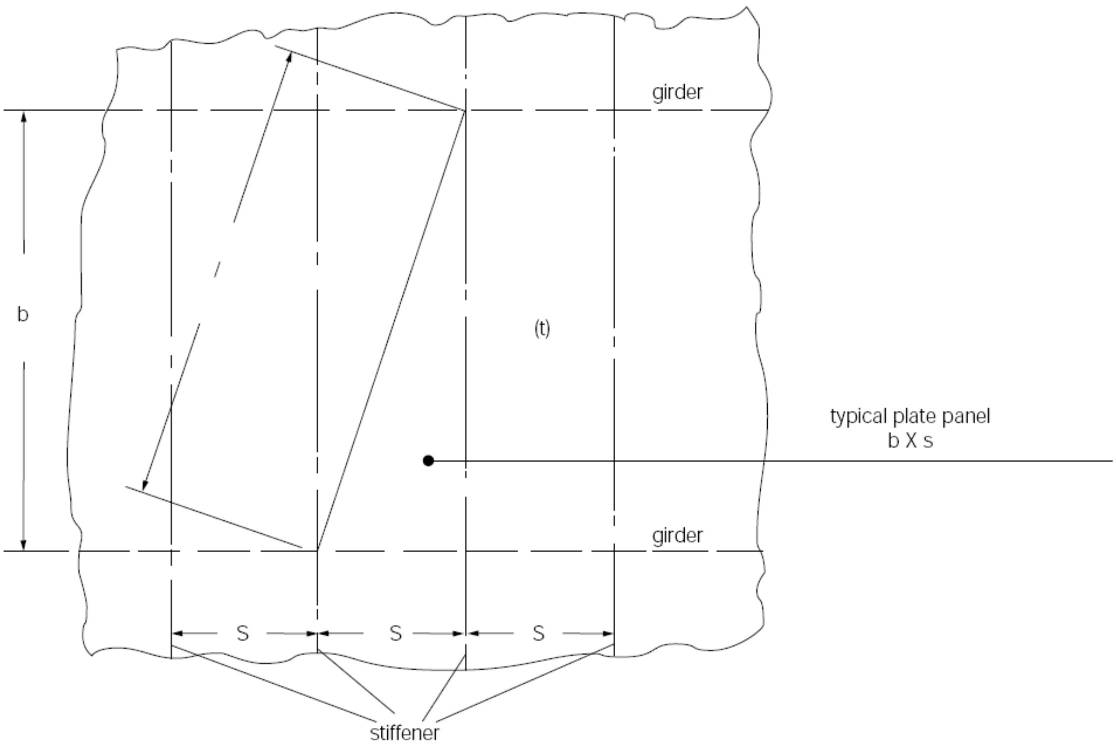
where:

Q_{sa} = minimum required discharge rate of air at standard conditions of 273 K and 1.013 bar

A_c = design crack opening area (m^2)

$$A_c = \frac{\pi}{4} \delta \,.\, 1 \ (m^2)$$

δ	=	max, crack opening width (m)
δ	=	0.2t (m)
t	=	thickness of tank bottom plating (m)
l	=	design crack length (m) equal to the diagonal of the largest plate panel of the tank bottom, see sketch below.
H	=	max liquid height above tank bottom plus 10.MARVS (m)
ρ	=	density of product liquid phase (kg/m^3) at the set pressure of the interbarrier space relief device
ρ_v	=	density of product vapour phase (kg/m^3) at the set pressure of the interbarrier space relief device and a temperature of 273 K
MARVS	=	max allowable relief valve setting of the cargo tank (bar).



9 Emergency fire pump (paragraphs 11.2 and 11.3.4)

9.1 In paragraph 11.3.4 the term "fire pumps" where not qualified by the word "emergency" refers to the fire pumps required in accordance with SOLAS regulation II-2/10.2.2.2.2.

9.2 If all the fire pumps mentioned in paragraph 1 above supplying the water spray system (for covering the superstructures and deckhouses) are disabled due to a fire in any one compartment, then the emergency fire pump should be sized to cover:

.1 the water spray system for the boundaries of the superstructures and deckhouses, and lifeboats, liferafts and muster areas facing the cargo area, (as per paragraph 11.3.4); and

.2 two fire hydrants (as per paragraph 11.2).

9.3 When the ship is also fitted with a total flooding high expansion foam system protecting the engine-room (to comply with SOLAS regulations II-2/10.4.1.1.2 and 10.5.1.1) and the emergency fire pump is intended to supply sea water to this system, then the emergency fire pump should also be sized to cover the foam system for dealing with an engine-room fire, when the main fire pumps are disabled.

9.4 On the basis of the principle of dealing with one single fire incident at a time, the emergency fire pump does not need to be sized to cover all three systems in 2 and 3 above (i.e. water spray, hydrants and foam) at the same time and should only need to be sized to cover the most demanding area and required systems, as follows:

.1 the foam system + two hydrants; or

.2 the water spray system + two hydrants; whichever is greater.

10 Fire pumps used as spray pumps (paragraph 11.3.4)

10.1 In cases where the emergency fire pump is used to meet this requirement, its capacity, in addition to being capable of maintaining two jets of water as required by paragraph 12.2.2.1.1 of the FSS Code, should be increased taking into account the spray application rates stated in paragraph 11.3.2.1, but limiting coverage to boundaries of normally manned superstructures and deckhouses, survival crafts and their muster areas.

10.2 The expression "one of the fire pumps or emergency fire pump" is related to fire pumps required by SOLAS regulation II-2/10.2.2 installed outside the space where spray pump(s) are located.

10.3 The expression "fire in one compartment" means a compartment provided with A-class boundaries in which is located the fire pump(s), or the source of power of the fire pump(s), serving the water-spray system in accordance with paragraph 11.3.3.

11 Level indicators for cargo tanks (paragraph 13.2.2)

11. 1 In order to assess whether or not only one level gauge is acceptable in relation to the aforesaid sentence, the expression "can be maintained" means that any part of the level gauge other than passive parts can be overhauled while the cargo tank is in service.

Note: passive parts are those parts assumed not subject to failures under normal service conditions.

12 Inhibition of cargo pump operation and opening of manifold ESD valves with level alarms overridden (table 18.1, note 4 and paragraph 13.3.7)

12.1 In applying the second sentence of note 4 of table 18.1, a hardware system such as an electric or mechanical interlocking device should be provided to prevent inadvertent operation of cargo pumps and inadvertent opening of manifold ESD valves.

13 Oxygen deficiency monitoring equipment in a nitrogen generator room area (paragraph 13.6.4)

13.1 Two oxygen sensors should be positioned at appropriate locations in the space or spaces containing the inert gas system, in accordance with paragraph 15.2.2.4.5.4 of the FSS Code, for all gas carriers, irrespective of the carriage of cargo indicated by an "A" in column "f" in the table in chapter 19 of the Code.

14 Integrated systems (paragraph 13.9.3)

14.1 The expression "integrated system" means a combination of computer-based systems which are used for the control, monitoring/alarm and safety functions required for the carriage, handling and conditioning of cargo liquid and vapours and are interconnected in order to allow communication between computer-based systems and to allow centralized access to monitoring/alarm and safety information and/or command/control.

Referenced guidelines

MSC/Circ.891 – *Guidelines for the onboard use and application of computers*

2.1 Computer
A programmable electronic device for storing and processing data, making calculations, or any programmable electronic system (PES), including mainframe, mini-computer or micro-computer.

2.2 Computer-based system
A system of one or more computers, associated software, peripherals and interfaces.

2.3 Integrated system
A combination of computer-based systems which are interconnected in order to allow centralized access to sensor information and/or command/control.

15 Suitable pressure relief system for air inlet, scavenge spaces, exhaust system and crank case (paragraph 16.7.1.4)

15.1 Suitable pressure relief system for air inlet manifolds, scavenge spaces and exhaust system should be provided unless designed to accommodate the worst-case overpressure due to ignited gas leaks or justified by the safety concept of the engine. A detailed evaluation regarding the hazard potential of overpressure in air inlet manifolds, scavenge spaces and exhaust system should be carried out and reflected in the safety concept of the engine.

15.2 In the case of crankcases, the explosion relief valves, as required by SOLAS regulation II-1/27.4, should be considered suitable for the gas operation of the engine. For engines not covered by SOLAS regulation II-1/27.4, a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase should be carried out.

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MSC.1/Circ.1626
7 December 2020

UNIFIED INTERPRETATION OF THE IMDG CODE

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), with a view to providing more specific guidance for the application of the relevant requirements of the *International Maritime Dangerous Goods Code* (IMDG Code), approved the following unified interpretation of the IMDG Code prepared by the Sub-Committee on Carriage of Cargoes and Containers, at its sixth session:

"Life-saving appliances (paragraph 7.1.4.4.2)

The term "life-saving appliances" means the ship's main survival craft and rescue boat(s) as required by SOLAS regulations III/21 or III/31.1 and is not intended to mean other life-saving appliances, such as lifebuoys, additional liferafts as required by SOLAS regulation III/31.3.2 and III/31.1.4 and any lifejackets and immersion suits associated with such liferafts."

2 Member States are invited to use the above unified interpretation as guidance when applying the relevant provisions of the IMDG Code and to bring the unified interpretation to the attention of all parties concerned.

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MSC.1/Circ.1627
10 December 2020

INTERIM GUIDELINES ON THE SECOND GENERATION INTACT STABILITY CRITERIA

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), recognizing that performance-oriented criteria for dynamic stability phenomena in waves needed to be developed and implemented to ensure a uniform international level of safety, as specified in part A, section 1.2 of the International Code on Intact Stability, 2008 (resolution MSC.267(85), as amended), approved the *Interim guidelines on the second generation intact stability criteria* (Interim Guidelines), as set out in the annex.

2 The Committee agreed to keep the Interim Guidelines under review, taking into account experience in design and operation of ships gained during their application.

3 Member States are invited to use the annexed Interim Guidelines as complementary measures when applying the requirements of the mandatory criteria of part A of the Code and to bring them to the attention of all parties concerned, in particular shipbuilders, shipmasters, shipowners, ship operators and shipping companies, and recount their experience gained through the trial use of these Interim Guidelines to the Organization.

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ANNEX

INTERIM GUIDELINES ON THE SECOND GENERATION INTACT STABILITY CRITERIA

Preamble

1 In view of a wide variety of ship types, sizes, operational profiles and environmental conditions, the problems related to dynamic stability failures have generally not yet been solved. Administrations should be aware of the fact that some ships are more at risk of encountering critical stability in waves. The Administration may, for a particular ship or group of ships, apply dynamic stability criteria which demonstrate that the safety level of a ship in waves is sufficient.

2 For this purpose, performance-based criteria for assessing five dynamic stability failure modes in waves are provided in these guidelines, namely, dead ship condition, excessive acceleration, pure loss of stability, parametric rolling and surf-riding/broaching.

3 The physics and evaluation methods for these five stability failure modes had not been well understood or developed when the mandatory intact stability criteria were established. As such, the herewith presented dynamic stability criteria utilize the recent progress using best practices and the most advanced scientific tools available, for practical regulatory-oriented application. Accordingly, the background of the dynamic stability criteria is principally based on first principles and latest technology, as opposed to predominant use of casualty records which form the basis of the mandatory intact stability criteria. For this reason, the presented dynamic stability criteria may be considered as the second generation intact stability criteria.

4 The methodologies contained in these Interim Guidelines are based on general first-principle approaches derived from the analysis of ship dynamics. However, in the development process, it was also necessary to simplify some of the assessment methodologies and to perform some semi-empirical tuning.

5 In developing the framework of these Interim Guidelines, it was recognized that an integrated perspective, combining design methods and operational measures, is the most effective way for properly addressing and continuously improving safety against accidents related to stability for ships in a seaway.

6 Therefore, the second generation intact stability criteria should be used for helping to ensure a uniform international level of safety of ships with respect to dynamic stability failure modes in waves.

CONTENTS

1 GENERAL

1.1 Introduction

1.1.1 *Purpose*

1.1.1.1 The purpose of these Guidelines is to enable the use of the second generation intact stability criteria for the assessment of dynamic stability failure modes in waves, as requested in section 1.2 of part A of the 2008 Intact Stability (IS) Code. These dynamic stability failure modes are as follows: dead ship condition, excessive acceleration, pure loss of stability, parametric rolling and surf-riding/broaching. In this sense, the overarching aim is to use the latest technology and knowledge on ship dynamics to provide guidance for ship designers on dynamic stability failure modes and to provide operational guidance for ship masters. This is undertaken to further improve the safety level of a ship beyond the mandatory intact stability criteria.

1.1.1.2 The main purpose of these criteria is to enable the use of the latest numerical simulation techniques for evaluating the safety level of a ship from an intact stability viewpoint. By using such tools for simulating the dynamic ship behaviours in a random seaway, the safety level of a ship can be estimated with a probabilistic measure. This approach is hereby called direct stability assessment. However, applying such tools to all new ships that are subject to the 2008 IS Code is not practical due to the limitation of human resources and facilities that are required for experimentally validating the numerical tools. Thus, the vulnerability of a ship can be assessed using simpler vulnerability criteria or more comprehensive direct stability assessment. The guidance for vulnerability criteria and the guidance for direct stability assessment are provided in chapters 2 and 3 of the Interim Guidelines, respectively.

1.1.1.3 It is noted that compliance with the criteria contained within part A of the 2008 IS Code, good seamanship, appropriate ship-handling and appropriate operation may avoid the potential danger of excessive roll, excessive lateral accelerations or capsizing due to a dynamic stability failure mode. Mindful of this fact, operational measures for a ship may be provided as an alternative to the vulnerability criteria or direct stability assessment. For this purpose, the guidelines for operational measures are provided in chapter 4 of the Interim Guidelines. Whereas the natural order of application is from the vulnerability criteria to direct stability assessment and operational measures, all these alternatives are equivalent in the regulatory sense and any of them can be used independently of others, in the way that is most suitable for the particular design.

1.1.2 *Framework*

1.1.2.1 For the purpose of this framework, the following definitions apply:

.1 *criterion* is a procedure, an algorithm or a formula used for the assessment on the likelihood of a stability failure;

.2 *standard* is a boundary separating acceptable and unacceptable likelihood of a stability failure; and

.3 *rule* (or *regulation*) is a specification of a relationship between a standard and a value produced by a criterion.

1.1.2.2 The second generation intact stability criteria are tools to judge the likelihood of intact stability failures. Intact stability failure is an event that includes the occurrence of very large roll (heel, list) angles or excessive rigid body accelerations, which may result in capsizing or impairs normal operation of the ship and could be dangerous to crew, passengers, cargo or ship equipment. Three subtypes of intact stability failure are included:

.1 heel/list exceeding a prescribed limit;

.2 roll angles exceeding a prescribed limit; and

.3 lateral accelerations exceeding prescribed limit.

1.1.3 *Application logic*

1.1.3.1 The application logic is summarized in figure 1.1.3. Although the user may be guided by a sequential logic of the Interim Guidelines (see 1.1.3.2), it is also acceptable that the users apply any alternative design assessment or operational measure option (see 1.1.1.3). For example, a user may wish to immediately commence with the application of direct stability assessment procedures without passing through Levels 1 and 2 of the vulnerability criteria or develop operational measures without performing design assessment.

1.1.3.2 A sequential application logic can be summarized, as follows:

As the simplest options, the vulnerability criteria are presented in two levels: Level 1 and Level 2. The assessment of the five stability failure modes should begin with the use of these levels. Level 1 is an initial check and then, if the ship in a particular loading condition is assessed as not vulnerable for the tested failure mode, the assessment for that failure mode may conclude; otherwise, the design would progress to Level 2. If the ship in a particular loading condition is assessed as not vulnerable for the tested failure mode in Level 2, then the assessment would conclude; otherwise, the design would progress to the application of direct stability assessment, application of operational limitations, revising the design of the ship or discarding the loading condition. If the ship in a particular loading condition is not found acceptable with respect to direct stability assessment procedures, then the logic is that the design would then progress to the application of operational measures or operational guidance, revising the design or discarding the loading condition.

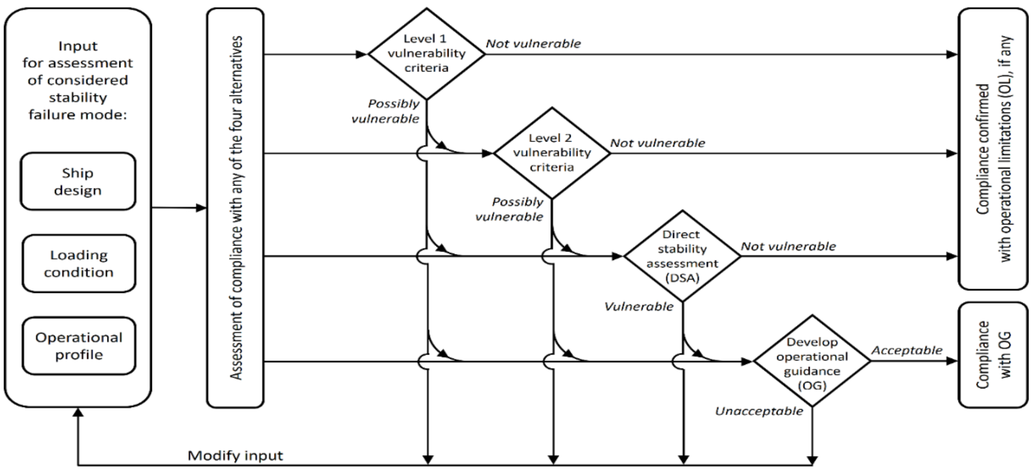

Figure 1.1.3 – Simplified scheme of the application structure of the second generation intact stability criteria. For actual application details, reference is to be made to the text of these Interim Guidelines.

1.1.4 *Testing*

1.1.4.1 The second generation intact stability criteria have been developed envisioning a future incorporation into the 2008 IS Code. However, they require testing before using them as mandatory criteria. This is because the robustness of the new criteria is not the same for the different stability failure modes.

Specifically, results obtained in the development process, indicate that:

.1 Level 1 and Level 2 vulnerability criteria for dead ship stability failure mode sometimes provide non-consistent results, i.e. Level 2 may be more conservative than Level 1 for some ships;

.2 vulnerability criteria for excessive acceleration may require further refinements;

.3 Level 2 vulnerability criterion for the pure loss of stability failure mode provides very conservative results for ships with low freeboard; therefore, results of testing for such ships should be treated with care; and

.4 parametric rolling and surf-riding/broaching Level 1 and Level 2 vulnerability criteria have sufficient scientific background and feasible methods for regulatory use.

1.1.4.2 Therefore, these criteria should be used on a trial basis at this stage. Such criteria usage and subsequent reporting are necessary to gain experience and consequently enable the introduction of this approach to the analysis of intact stability. It is also highly recommended to apply the criteria to ships already in service and to compare the results with operational experience.

1.1.5 *Feedback*

1.1.5.1 The second generation intact stability criteria methodology has been developed using the latest technology and scientific knowledge for assessing ship dynamics in waves. The methodology has been tested on a number of sample ships and, to this end, these draft Interim Guidelines are intended to generate data and feedback for a large number of ships.

1.1.5.2 These guidelines have been issued as "Interim Guidelines" in order to gain experience in their use. They should be reviewed in order to facilitate future amendments based on the experience gained.

1.1.5.3 Member States and international organizations are invited to submit information, observations, suggestions, comments and recommendations based on the practical experience gained through the application of these Interim Guidelines. To support the objective of obtaining robust criteria for regulatory use, suggestions for alternatives to and/or refinements of the criteria elements contained in the Interim Guidelines are encouraged. The suggestions should compare the outcomes with the criteria elements included in the Interim Guidelines.

1.1.5.4 With such feedback not only on the technical results but also their usability and clarity, the Organization will be able to subsequently refine the second generation intact stability criteria, if necessary.

1.1.6 *Relationship with mandatory criteria*

1.1.6.1 These Interim Guidelines are not intended to be used in lieu of the mandatory intact stability criteria contained in the 2008 IS Code. They are intended for use as a guide for ship designers to assess the aspects of ship stability not adequately covered by the mandatory criteria and to provide operational guidance for ship masters. Therefore, they should be used as a supplementary set of stability assessment methods.

1.1.7 *Notes for application*

1.1.7.1 These Interim Guidelines are intended to be applied to ships that are also subject to the 2008 IS Code.

1.1.7.2 These Interim Guidelines have not been specifically developed for multihulls. Moreover, for ships with an extended low weather deck, additional application provisions are provided in the relevant chapters.

1.2 Definitions

1.2.1 *Loading condition*, in the context of these Interim Guidelines, is defined by the mean draught d, trim angle θ, metacentric height GM and mass moments of inertia I_{xx} (or natural roll period T_r), I_{yy} and I_{zz}.

1.2.2 *Fully loaded departure condition* means the loading condition, as defined in section 3.4.1 of part B of the 2008 IS Code.

1.2.3 *Sea state* is the stationary condition of the free water surface and wind at a certain location and time, described in these Interim Guidelines by the significant wave height H_S, mean zero-crossing wave period T_Z, mean wave direction μ, wave elevation energy spectrum S_{zz}, and mean wind speed, gustiness characteristics and direction. For combined wind sea and swell, significant wave height, mean zero-crossing wave period and mean wave direction may be defined separately for each of the two wave systems.

1.2.4 *Sailing condition* is a short notation for the combination of the ship forward speed V_s and heading relative to mean wave direction μ.

1.2.5 *Assumed situation* is a condition of the ship that refers to the sailing condition combined with sea state. Thus, a situation is defined by the ship forward speed v_0, mean wave direction μ, significant wave height H_S and mean zero-crossing wave period T_Z, direction and gustiness characteristics of wind.

1.2.6 *Design situation* is an assumed situation representative for a particular stability failure mode.

1.2.7 *Wave scatter table* is a table containing the probabilities of each range of sea states encountered in the considered operational area or operational route. In these Interim Guidelines, the probabilities contained in a wave scatter table are defined to sum to unity.

1.2.8 *Limited wave scatter table* is a table obtained from the full wave scatter table by removing all sea state ranges with the significant wave height above a certain limit.

1.2.9 O*perational area* and *operational route* are the geographical areas specified for the ship operation. In the context of these Interim Guidelines, operational area or operational route are specified by the long-term wave statistics (wave scatter table) and wind statistics.

1.2.10 *Nominal ship forward speed* means the ship speed in calm water under action of the ship's propulsion at a given setting.

1.2.11 *Maximum service speed* means maximum ahead service speed, as defined in SOLAS regulation II-1/3.14.

1.2.12 *Design assessment* corresponds to the application of vulnerability criteria according to chapter 2 or direct stability assessment according to chapter 3 of these Interim Guidelines or a combination of the two.

1.2.13 *Operational measures* mean operational limitations or operational guidance.

1.2.14 *Guidelines for vulnerability assessment* means the content of chapter 2 of these Interim Guidelines.

1.2.15 *Guidelines for direct stability assessment* means the content of chapter 3 of these Interim Guidelines.

1.2.16 *Guidelines for operational measures* means the content of chapter 4 of these Interim Guidelines.

1.2.17 *2008 IS Code* means the International Code on Intact Stability, 2008, as amended.

1.2.18 *Mean 3-hour maximum amplitude* means the average value of several maximum amplitudes, each of which is determined for an exposure time of 3 hours.

1.3 Nomenclature

1.3.1 The general nomenclature used in these Interim Guidelines is set forth in 1.3.2, 1.3.3, 1.3.4 and 1.3.5. Nomenclature that is specific to a particular section is defined in that location and prevails over the general nomenclature reported here. If not otherwise stated, reference should be made to the nomenclature used in the 2008 IS Code.

1.3.2 General ship characteristics:

L	=	length of the ship, as defined in paragraph 2.12 of the introduction part of the 2008 IS Code (m)
B	=	moulded breadth of the ship (m)
B_{wl}	=	moulded breadth at waterline (m)
D	=	moulded depth, as defined in the 2008 IS Code (m)
V_s	=	service speed (m/s)
v_0	=	forward speed (m/s)
Fn	=	Froude number = $V_s / \sqrt{L\,g}$
A_k	=	total overall area of the bilge keels (no other appendages) (m^2)
∇_D	=	volume of displacement at waterline equal to D at zero trim (m^3)
D_p	=	propeller diameter (m);
x_i	=	longitudinal distance from the aft perpendicular to a station i (m), positive forward

1.3.3 Constants:

g = acceleration due to gravity, taken as 9.81 (m/s^2)

ρ = density of salt water, taken as 1025 (kg/m^3)

ρ_{air} = density of air, taken as 1.222 (kg/m^3)

1.3.4 Loading condition characteristics:

d_{full} = draft corresponding to the fully loaded departure condition in calm water (m)

$C_{B,full}$ = block coefficient of the fully loaded departure condition in calm water

$C_{m,full}$ = midship section coefficient of the fully loaded departure condition in calm water

d = mean draught, i.e. draft amidships corresponding to the loading condition under consideration in calm water (m)

L_{WL} = length of the ship on the waterline corresponding to the loading condition under consideration (m)

KB = height of the centre of buoyancy above baseline corresponding to the loading condition under consideration (m)

KG = height of the centre of gravity above baseline corresponding to the loading condition under consideration (m)

∇ = volume of displacement corresponding to the loading condition under consideration (m^3)

C_B = block coefficient corresponding to the loading condition under consideration (-)

Δ = displacement (t)

A_W = waterplane area at the draft equal to d (m^2)

I_T = transverse moment of inertia of water-plane area (m^4)

I_{xx} = dry roll moment of inertia (t m^2)

I_{yy} = dry pitch moment of inertia (t m^2)

I_{zz} = dry yaw moment of inertia (t m^2)

m = mass of the ship (t)

k_{xx} = dry roll radius of gyration around axis $x = \sqrt{I_{xx}/m}$ (m)

k_{yy} = dry pitch radius of gyration around axis $y = \sqrt{I_{yy}/m}$ (m)

k_{zz} = dry yaw radius of gyration around axis $z = \sqrt{I_{zz}/m}$ (m)

GM = metacentric height of the loading condition in calm water (m), with or without correction for free surface effect, as required

A_L = projected lateral area of the portion of the ship and deck cargo above the waterline (m^2)

Z = vertical distance from the centre of A_L to the centre of the underwater lateral area or approximately to a point at one-half the mean draft, d (m)

T_r = linear natural roll period in calm water (s)

ω_r = natural roll frequency = $2\,\pi\,/\,T_r$ (rad/s)

φ = angle of roll, heel, or list (rad or deg)

θ = angle of pitch or trim (rad or deg)

ψ = angle of yaw, heading or course (rad or deg)

φ_S = stable heel angle under the action of steady heeling moment calculated as the first intersection between the righting lever curve (GZ curve) and the heeling lever curve, (rad or deg)

φ_V = angle of vanishing stability. In presence of a heeling moment, it should be calculated as the second intersection between the righting lever curve (GZ curve) and the applied heeling lever curve (rad or deg)

1.3.5 Environmental condition characteristics:

λ = wavelength (m)

H = wave height (m)

H_S = significant wave height for the short-term environmental condition under consideration (m)

s = wave steepness = H/λ

T_Z = mean zero-crossing period for the short-term environmental condition under consideration (s)

T_p = wave period corresponding to peak of spectrum for the short-term environmental condition under consideration (s)

μ = mean wave direction with respect to ship centre plane (deg)

S_{zz} = wave elevation energy spectrum (m^2/(rad/s))

ω = circular frequency (rad/s)

k = wave number = $2\pi/\lambda$ (rad/m)

1.3.6 Other parameters

N_s = number of simulations

f_s = joint probability density of sea state (probability of sea states per unit range of significant wave heights and mean zero-crossing periods) (1/m·s)

2 Guidelines on vulnerability criteria

2.1 Preface

As described in section 1.2 of part A of the 2008 IS Code, the Administration may for a particular ship or group of ships apply criteria demonstrating that the safety of the ship in waves is sufficient. For this purpose, the criteria for the dynamic stability failure modes in waves have been developed, which address the dead ship condition, excessive acceleration, pure loss of stability, parametric rolling, and surf-riding/broaching failure modes. These criteria should be used for ensuring a uniform international level of safety of ships with respect to these failure modes.

2.2 Assessment of ship vulnerability to the dead ship condition failure mode

2.2.1 Application

2.2.1.1 The provisions given hereunder apply to all ships, except for ships with an extended low weather deck.[1]

2.2.1.2 For each loading condition, a ship that:

.1 meets the standard contained in the criteria contained in 2.2.2 is considered not to be vulnerable to the dead ship condition failure mode; or

.2 does not meet the standard contained in the criteria contained in 2.2.2 should be subject to more detailed assessment of vulnerability to the dead ship condition failure mode by applying the criteria contained in 2.2.3.

2.2.1.3 Alternatively to the criteria contained in 2.2.2 or 2.2.3, for each loading condition a ship may be subject to either:

.1 direct stability assessment for the dead ship condition failure mode that is performed according to the Guidelines for direct stability assessment in chapter 3; or

.2 operational limitations related to operational area or route and season developed in accordance with the Guidelines for operational measures in chapter 4.

2.2.1.4 A detailed assessment of Level 2 vulnerability according to the criteria contained in 2.2.3 may be performed without the requirement to conduct a more simplified assessment in 2.2.2. Similarly, a detailed direct stability assessment as provided in 2.2.1.3.1 may be performed without the requirement to conduct a more simplified assessment in 2.2.2 or 2.2.3.

2.2.1.5 Stability limit information for determining the safe zones as functions of GM, draught and trim is to be provided based on matrix calculations according to the criteria contained in 2.2.2 or 2.2.3, and, if appropriate, direct stability assessment according to the Guidelines for direct stability assessment in chapter 3. If relevant, the stability limit information for determining safe zones should take into account operational limitations related to specific operational areas or routes and specific season according to the Guidelines for operational measures in chapter 4.

2.2.1.6 Reference environmental conditions to be used in the assessment may be modified when introducing operational limitations permitting operation in specific operational areas or routes and, if appropriate, specific season, according to the Guidelines for operational measures in chapter 4.

2.2.1.7 Free surface effects should be accounted for as recommended in chapter 3 of part B of the 2008 IS Code.

[1] The criteria for this failure mode may not be applicable to a ship with an extended low weather deck due to increased likelihood of water on deck or deck-in-water.

2.2.2 Level 1 vulnerability criterion for the dead ship condition

2.2.2.1 A ship is considered not to be vulnerable to the dead ship condition failure mode, if its ability to withstand the combined effects of beam wind and rolling is demonstrated, with reference to figure 2.2.2.1, as follows:

.1 the ship is subjected to a steady wind pressure acting perpendicular to the ship's centreline which results in a steady wind heeling lever, l_{w1};

.2 from the resultant angle of equilibrium, φ_0, the ship is assumed to roll owing to wave action to an angle of roll, φ_1, to windward; and the angle of heel under action of steady wind, φ_0, should not exceed 16° or 80% of the angle of deck edge immersion, whichever is less;

.3 the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever, l_{w2}; and

.4 under these circumstances, area b should be equal to or greater than area a, as indicated in figure 2.2.2.1,

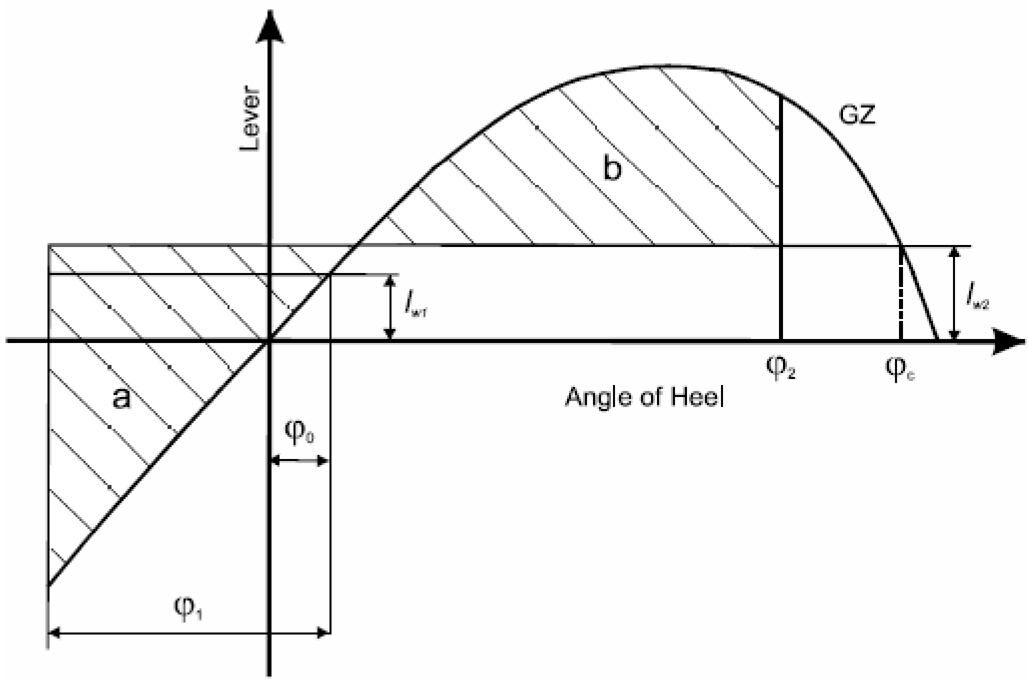

Figure 2.2.2.1 – Definition of area *a* and area *b*

where the angles in figure 2.2.2.1 are defined as follows:

φ_0 = angle of heel under action of steady wind (deg)

φ_1 = angle of roll to windward due to wave action (deg)(see 2.2.2.1.2 and 2.2.2.4)[2]

φ_2 = angle of downflooding, φ_f, or 50° or φ_c, whichever is least,

2 Refer to the *Explanatory Notes to the 2008 IS Code* (MSC.1/Circ.1281).

where:

φ_f = angle of heel at which openings in the hull, superstructures or deck houses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

φ_c = angle of second intercept between wind heeling lever l_{w2} and GZ curves.

2.2.2.2 The wind heeling levers l_{w1} and l_{w2} referred to in 2.2.2.1.1 and 2.2.2.1.3 are constant values at all angles of inclination and should be calculated as follows:

$$l_{w1} = \frac{P \cdot A_L \cdot Z}{1000 \cdot g \cdot \Delta} (\mathrm{m}) \text{ and}$$

$$l_{w2} = 1.5 \cdot l_{w1} (\mathrm{m})$$

where:

P = wind pressure of 504 (Pa). The value of P used for ships with operational limitations according to 2.2.1.6 may be reduced.

2.2.2.3 Alternative means for determining the wind heeling lever, l_{w1}, may be used as an equivalent to the calculation in 2.2.2.2. When such alternative tests are carried out, reference should be made to the Guidelines developed by the Organization.[3] The wind velocity used in the tests should be 26 m/s in full scale with uniform velocity profile. The value of wind velocity used for ships with operational limitations according to 2.2.1.6 may be reduced.

2.2.2.4 The angle of roll, φ_1, referred to in 2.2.2.1 should be calculated as follows:

$$\varphi_1 = 109 \cdot k \cdot X_1 \cdot X_2 \cdot \sqrt{r \cdot s} \text{ (deg)}$$

where:

X_1 = factor as shown in table 2.2.2.4-1

X_2 = factor as shown in table 2.2.2.4-2

k = factor as follows:

- k = 1.0 for a round-bilged ship having no bilge or bar keels
- k = 0.7 for a ship having sharp bilges
- k = as shown in table 2.2.2.4-3 for a ship having bilge keels, a bar keel, or both

r = 0.73 + 0.6 OG / d, where: $OG = KG - d$

s = wave steepness shown in table 2.2.2.4-4

A_k = total overall area of bilge keels or area of the lateral projection of the bar keel or sum of these areas (m^2)

3 Refer to the *Interim guidelines for alternative assessment of the weather criterion* (MSC.1/Circ.1200).

The angle of roll, φ_1, for ships with anti-rolling devices should be determined without taking into account the operation of these devices unless the Administration is satisfied with the proof that the devices are effective even with sudden shutdown of their supplied power.

Table 2.2.2.4-1 – Values of factor X_1

B/d	X_1
≤ 2.4	1.0
2.5	0.98
2.6	0.96
2.7	0.95
2.8	0.93
2.9	0.91
3.0	0.90
3.1	0.88
3.2	0.86
3.4	0.82
≥ 3.5	0.80

Table 2.2.2.4-2 – Values of factor X_2

C_B	X_2
≤ 0.45	0.75
0.50	0.82
0.55	0.89
0.60	0.95
0.65	0.97
≥ 0.70	1.00

Table 2.2.2.4-3 – Values of factor k

$\frac{A_k \cdot 100}{L_{WL} \cdot B}$	k
0	1.0
1.0	0.98
1.5	0.95
2.0	0.88
2.5	0.79
3.0	0.74
3.5	0.72
≥ 4.0	0.70

Table 2.2.2.4-4 – Values of wave steepness, s

Natural roll period, T_r (s)	Wave steepness factor, s
≤ 6	0.100
7	0.098
8	0.093
12	0.065
14	0.053
16	0.044
18	0.038
20	0.032
22	0.028
24	0.025
26	0.023
28	0.021
≥ 30	0.020

Note: Intermediate values in these tables should be obtained by linear interpolation.

2.2.2.5 For ships subject to operational limitations according to 2.2.1.6, the wave steepness, s, in table 2.2.2.4-4 may be modified.

2.2.2.6 For any ship, the angle of roll, φ_1, may also be determined by alternative means on the basis of the Guidelines developed by the Organization.[4]

2.2.3 Level 2 vulnerability criterion for the dead ship condition

2.2.3.1 A ship is considered not to be vulnerable to the dead ship condition failure mode if:

$$C \le R_{DS0}$$

where:

R_{DS0} = 0.06;

C = long-term probability index that measures the vulnerability of the ship to a stability failure in the dead ship condition based on the probability of occurrence of short-term environmental conditions, as specified according to 2.2.3.2.

2.2.3.2 The value of C is calculated as a weighted average from a set of short-term environmental conditions, as follows:

$$\mathrm{C} = \sum_{i=1}^{N} W_i C_{s,i}$$

where:

W_i = weighting factor for the short-term environmental condition, as specified in 2.7.2;

$C_{S,i}$ = short-term dead ship stability failure index for the short-term environmental condition under consideration, calculated as specified in 2.2.3.2.1;

N = total number of short-term environmental conditions, according to 2.7.2.

2.2.3.2.1 The short-term dead ship stability failure index, $C_{s,i}$, for the short-term environmental condition under consideration, is a measure of the probability that the ship will exceed specified heel angles at least once in the exposure time considered, taking into account an effective relative angle between the ship and the waves. Each index, $C_{s,i}$, is calculated according to the following formula:

$C_{S,i}$ = 1, if either:

.1 the mean wind heeling lever $\bar{l}_{wind,tot}$ (according to 2.2.3.2.2) exceeds the righting lever, GZ, at each angle of heel to leeward, or

[4] Refer to the procedure described in the *Interim guidelines for alternative assessment of the weather criterion* (MSC.1/Circ.1200).

.2 the stable heel angle under the action of steady wind, $\varphi_{S,}$, is greater than the angle of failure to leeward, $\varphi_{fail,+,}$; and

= 1 – $\exp(-r_{EA}\ T_{exp})$, otherwise;

where:

Heel angles are to be taken as positive to leeward and negative to windward;

T_{exp} = exposure time, to be taken as equal to $3600\ s$;

r_{EA} = $\frac{1}{T_{z,C_S}} \cdot \left[\exp\left(-\frac{1}{2 \cdot RI_{EA+}^2} \right) + \exp\left(-\frac{1}{2 \cdot RI_{EA-}^2} \right) \right]$ (1/s);

RI_{EA+} = $\frac{\sigma_{C_S}}{\delta\phi_{res,EA+}}$;

RI_{EA-} = $\frac{\sigma_{C_S}}{\delta\phi_{res,EA-}}$;

T_{z,C_S} = reference average zero-crossing period of the effective relative roll motion under the action of wind and waves determined according to 2.2.3.2.3 (s);

σ_{C_S} = standard deviation of the effective relative roll motion under the action of wind and waves determined according to 2.2.3.2.3 (rad);

$\delta\varphi_{res,EA+}$ = range of residual stability to the leeward equivalent area limit angle, to be calculated as

$\varphi_{EA+} - \varphi_S$ (rad);

$\delta\varphi_{res,EA-}$ = range of residual stability to the windward equivalent area limit angle, to be calculated as

$\varphi_S - \varphi_{EA-}$ (rad);

φ_{EA+} = equivalent area virtual limit angle to leeward, to be calculated as

$$\varphi_{EA+} = \varphi_S + \left(\frac{2 \cdot A_{res,+}}{GM_{res}} \right)^{1/2} \text{ (rad);}$$

φ_{EA-} = equivalent area virtual limit angle to windward, to be calculated as

$$\phi_{EA-} = \phi_S - \left(\frac{2 \cdot A_{res,-}}{GM_{res}} \right)^{1/2} \text{ (rad);}$$

φ_S	=	stable heel angle due to the mean wind heeling lever, $\bar{l}_{wind,tot}$, determined according to 2.2.3.2.2 (rad);
$A_{res,+}$	=	area under the residual righting lever curve (i.e., $GZ - \bar{l}_{wind,tot}$) from φ_S to $\varphi_{fail,+}$ (m rad);
$A_{res,-}$	=	area under the residual righting lever curve (i.e., $GZ - \bar{l}_{wind,tot}$) from $\varphi_{fail,-}$ to φ_S (m rad) ;
GM_{res}	=	residual metacentric height, to be taken as the slope of the residual righting lever curve (i.e., $GZ - \bar{l}_{wind,tot}$) at φ_S (m);
$\varphi_{fail,+}$	=	angle of failure to leeward, to be taken as $\min\{\varphi_{VW,+}, \varphi_{crit,+}\}$ (rad);
$\varphi_{fail,-}$	=	angle of failure to windward, to be taken as $\max\{\varphi_{VW,-}, \varphi_{crit,-}\}$ (rad);
$\varphi_{VW,+}$	=	angle of second intercept to leeward between the mean wind heeling lever $\bar{l}_{wind,tot}$ and the GZ curve;
$\varphi_{VW,-}$	=	angle of second intercept to windward between the mean wind heeling lever $\bar{l}_{wind,tot}$ and the GZ curve;
$\varphi_{crit,+}$	=	critical angle to leeward, to be taken as $\min\{\varphi_{f,+}, 50\deg\}$ (rad);
$\varphi_{crit,-}$	=	critical angle to windward, to be taken as $\max\{\varphi_{f,-}, -50\deg\}$ (rad);
$\varphi_{f,+}$, $\varphi_{f,-}$	=	angles of downflooding to leeward and windward, respectively, in accordance with the definition of "angle of downflooding" in the 2008 IS Code, Part A, 2.3.1 (rad);

2.2.3.2.2 The mean wind heeling lever $\bar{l}_{wind,tot}$ is a constant value at all angles of heel and is calculated according to the following formula:

$$\bar{l}_{wind,tot} = \frac{\overline{M}_{wind,tot}}{\rho \cdot g \cdot \nabla} \text{ (m)}$$

where:

$\overline{M}_{wind,tot}$ = mean wind heeling moment, to be calculated as:

$$\frac{1}{2}\rho_{air} \cdot U_w^2 \cdot C_{whm} \cdot A_L \cdot Z \qquad \text{(N m);}$$

U_w = mean wind speed, to be calculated as:

$$\left(\frac{H_S}{0.06717}\right)^{2/3} \qquad \text{(m/s)}$$

Different expressions can be used when considering alternative environmental conditions, in accordance with 2.2.1.6;

C_{whm} = wind heeling moment coefficient, to be taken as equal to 1.22 or as determined by other methods;

H_S = significant wave height for the short-term environmental condition under consideration, according to 2.7.2.

2.2.3.2.3 For the short-term environmental condition under consideration, the reference average zero-crossing period of the effective relative roll motion, T_{Z,C_S}, and the corresponding standard deviation, σ_{C_S}, to be used in the calculation of the short-term dead ship stability failure index, $C_{S,i}$, are determined using the spectrum of the effective relative roll motion under to the action of wind and waves, in accordance with the following formulae:

$$\sigma_{C_S} = (m_0)^{1/2} \quad \text{(rad)}$$

$$T_{z,C_S} = 2\pi \cdot (m_0 / m_2)^{1/2} \quad \text{(s)}$$

where:

m_o = area under the spectrum $S(\omega)$ (rad²);

m_2 = area under the function of $\omega^2 \cdot S(\omega)$ (rad⁴/s²);

$S(\omega)$ = spectrum of the effective relative roll angle, to be calculated as follows:

$$H_{rel}^2(\omega) \cdot S_{\alpha\alpha,c}(\omega) + H^2(\omega) \cdot \frac{S_{\delta M_{wind,tot}}(\omega)}{(\rho \cdot g \cdot \nabla \cdot GM)^2} \quad \text{(rad}^2\text{/(rad/s))}$$

$$H_{rel}^2(\omega) = \frac{\omega^4 + (2 \cdot \mu_e \cdot \omega)^2}{(\omega_{0,e}^2 - \omega^2)^2 + (2 \cdot \mu_e \cdot \omega)^2}$$

$$H^2(\omega) = \frac{\omega_0^4}{(\omega_{0,e}^2 - \omega^2)^2 + (2 \cdot \mu_e \cdot \omega)^2}$$

$S_{\alpha\alpha,c}(\omega)$ = spectrum of the effective wave slope, to be calculated as

$$r^2(\omega) \cdot S_{\alpha\alpha}(\omega) \quad \text{(rad}^2\text{/(rad/s))}$$

$S_{\alpha\alpha}(\omega)$ = spectrum of the wave slope, to be calculated as

$$\frac{\omega^4}{g^2} \cdot S_{zz}(\omega) \quad \text{(rad}^2\text{/(rad/s))}$$

$S_{zz}(\omega)$ = sea wave elevation energy spectrum (m²/(rad/s)). The standard expression for $S_{zz}(\omega)$ is defined in 2.7.2.1.1.

Different expressions can be used when considering alternative environmental conditions, in accordance with 2.2.1.6;

$S_{\delta M_{wind,tot}}(\omega)$ = spectrum of moment due to the action of the gust, to be calculated as

$$\left[\rho_{air} \cdot U_w \cdot C_{whm} \cdot A_L \cdot Z\right]^2 \cdot \chi^2(\omega) \cdot S_v(\omega) \quad ((\mathrm{N\ m})^2/(\mathrm{rad/s}))$$

$\chi(\omega)$ = standard aerodynamic admittance function, to be taken as a constant equal to 1.0;

$S_v(\omega)$ = gustiness spectrum. The standard expression for $S_v(\omega)$ is as follows:

$$4 \cdot K \cdot \frac{U_w^2}{\omega} \cdot \frac{X_D^2}{\left(1+X_D^2\right)^{\frac{4}{3}}} \quad ((\mathrm{m/s})^2/(\mathrm{rad/s}))$$

with $K = 0.003$ and $X_D = 600 \cdot \omega/(\pi \cdot U_w)$. Different expressions can be used when considering alternative environmental conditions in accordance with 2.2.1.6;

μ_e = equivalent linear roll damping coefficient (1/s), calculated according to the stochastic linearization method. This coefficient depends on linear and nonlinear roll damping coefficients and on the specific roll velocity standard deviation in the considered short-term environmental conditions;

$\omega_{0,e}(\varphi_S)$ = modified roll natural frequency close to the heel angle, φ_S, to be calculated as:

$$\omega_0 \cdot \left(\frac{GM_{res}}{GM}\right)^{1/2} \quad (\mathrm{rad/s});$$

ω_0 = upright natural roll frequency = $2\pi/T_r$ (rad/s);

$r(\omega)$ = effective wave slope function determined according to 2.2.3.2.4;

and other variables as defined in 2.2.3.2.1 and 2.2.3.2.2.

2.2.3.2.4 The effective wave slope function, $r(\omega)$, should be specified using a reliable method, based on computations or derived from experimental data,[5] and accepted by the Administration.

2.2.3.2.5 In the absence of sufficient information, the recommended methodology for the estimation of the effective wave slope function should be used, which is based on the following assumptions and approximations:

.1 The underwater part of each transverse section of the ship is substituted by an "equivalent underwater section" having, in general, the same breadth at waterline and the same underwater sectional area of the original section;

5 Refer to the procedure described in *the Interim guidelines for alternative assessment of the weather criterion* (MSC.1/Circ.1200) for guidance.

However:

.1 sections having zero breadth at waterline, such as those in the region of the bulbous bow, are neglected; and

.2 the draught of the "equivalent underwater section" is limited to the ship sectional draught.

.2 The effective wave slope coefficient for each wave frequency is determined by using the "equivalent underwater sections" considering only the undisturbed linear wave pressure; and

.3 For each section a formula is applied which is exact for rectangles.

2.2.3.2.6 The recommended methodology is applied considering the actual trim of the ship. The recommended methodology for the estimation of the effective wave slope is applicable only to monohull ships. For a ship that does not fall in this category, alternative prediction methods should be applied.

2.3 Assessment of ship vulnerability to the excessive acceleration failure mode

2.3.1 Application

2.3.1.1 The provisions given hereunder apply to each ship in each loading condition provided that:

.1 the distance from the waterline to the highest location along the length of the ship where passengers or crew may be present exceeds 70% of the breadth of the ship; and

.2 the metacentric height exceeds 8% of the breadth of the ship.

2.3.1.2 For each loading condition and location along the length of the ship where passengers or crew may be present, a ship that:

.1 meets the standard contained in the criteria contained in 2.3.2 is considered not to be vulnerable to the excessive acceleration failure mode; and

.2 does not meet the standard contained in the criteria contained in 2.3.2 should be subject to more detailed assessment of vulnerability to the excessive acceleration failure mode by applying the criteria contained in 2.3.3.

2.3.1.3 Alternatively to the criteria contained in 2.3.2 or 2.3.3, for each loading condition a ship may be subject to either:

.1 direct stability assessment for the excessive acceleration failure mode that is performed in accordance with chapter 3; or

.2 operational measures developed in accordance with chapter 4.

2.3.1.4 A detailed assessment of Level 2 vulnerability according to the criteria contained in 2.3.3 may be performed without the requirement to perform a more simplified assessment in 2.3.2. Similarly, a detailed direct stability assessment as provided in 2.3.1.3.1 may be performed without the requirement to perform a more simplified assessment in 2.3.2 or 2.3.3.

2.3.1.5 Stability limit information for determining the safe zones as functions of GM, draught and trim is to be provided based on matrix calculations according to the criteria contained in sections 2.3.2 or 2.3.3 and, if appropriate, direct stability assessment according to the provisions in chapter 3 on direct stability assessment. If relevant, the stability limit information for determining safe zones should take into account operational measures or operational guidance according to the provisions in chapter 4 on operational measures.

2.3.1.6 Reference environmental conditions to be used in the assessment may be modified, according to the Guidelines for operational measures in chapter 4.

2.3.1.7 Free surface corrections should not be applied.

2.3.2 Level 1 vulnerability criterion for the excessive acceleration failure mode

2.3.2.1 A ship is considered not to be vulnerable to the excessive acceleration stability failure mode if, for each loading condition and location along the length of the ship where passengers or crew may be present,

$$\varphi \cdot k_L \cdot \left(g + 4\pi^2 h_r / T_r^2 \right) \le R_{EA1}$$

where:

R_{EA1} = 4.64 (m/s^2)

φ = characteristic roll amplitude (rad) = 4.43 $r\,s / \delta_\varphi^{0.5}$;

k_L = factor taking into account simultaneous action of roll, yaw and pitch motions,

= 1.125 – 0.625 x/L, if $x < 0.2\,L$,

= 1.0, if $0.2\,L \le x \le 0.65\,L$,

= 0.527 + 0.727 x/L, if $x > 0.65\,L$;

x = longitudinal distance (m) of the location where passengers or crew may be present from the aft end of L;

h_r = height above the assumed roll axis of the location where passengers or crew may be present (m), for which definition, the roll axis may be assumed to be located at the midpoint between the waterline and the vertical centre of gravity;

r = effective wave slope coefficient = $\dfrac{K_1 + K_2 + (OG)(F)}{\dfrac{B^2}{12 C_B d} - \dfrac{C_B d}{2} - OG}$;

K_1 = $g\,\beta\,T_r^2\,(\tau + \tau\,\tilde{T} - 1/\tilde{T}) / (4\,\pi^2)$;

K_2 = $g\,\tau\,T_r^2\,(\beta - \cos\tilde{B}) / (4\,\pi^2)$;

OG = $KG - d$;

F = $\beta\,(\tau - 1/\tilde{T})$;

β = $\sin(\tilde{B}) / \tilde{B}$;

τ = $\exp(-\tilde{T}) / \tilde{T}$;

$\tilde{B}$ = $2 \pi^2 B / (g T_r^2)$;

$\tilde{T}$ = $4 \pi^2 C_B d / (g T_r^2)$;

s = wave steepness as a function of the natural roll period T_r (see 2.7.1), as determined from table 2.3.2.1; and

δ_φ = non-dimensional logarithmic decrement of roll decay.

Table 2.3.2.1 – Values of wave steepness, s
(Intermediate values in the table should be obtained by linear interpolation)

Natural roll period, T_r (s)	Wave steepness, s
≤ 6	0.100
7	0.098
8	0.093
12	0.065
14	0.053
16	0.044
18	0.038
20	0.032
22	0.028
24	0.025
26	0.023
28	0.021
≥ 30	0.020

2.3.3 Level 2 vulnerability criterion for the excessive acceleration failure mode

2.3.3.1 A ship in a loading condition is considered not to be vulnerable to the excessive acceleration stability failure mode if, for each location along the length of the ship where passengers or crew may be present:

$$C \leq R_{EA2}$$

where:

R_{EA2} = 0.00039;
C = long-term probability index that measures the vulnerability of the ship to a stability failure due to excessive acceleration for the loading condition and location under consideration based on the probability of occurrence of short-term environmental conditions, as specified according to 2.3.3.2.

2.3.3.2 The value of C is calculated as a weighted average from a set of short-term environmental conditions, as follows:

$$C = \sum_{i=1}^{N} W_i C_{S,i}$$

where:

W_i = weighting factor for the short-term environmental condition, as specified in 2.7.2;

$C_{S,i}$ = short-term excessive acceleration failure index for the short-term environmental condition under consideration, calculated as specified in 2.3.3.2.1; and

N = total number of short-term environmental conditions, according to 2.7.2.

2.3.3.2.1 The short-term excessive acceleration failure index, $C_{S,i}$, for the loading condition, location and for the short-term environmental condition under consideration is a measure of the probability that the ship will exceed a specified lateral acceleration, calculated according to the following formula:

$C_{S,i}$ = $\exp(-R_2^2 / (2\ \sigma_{LAi}^2))$;

where:

R_2 = 9.81 (m/s²);

σ_{LAi} = standard deviation of the lateral acceleration at zero speed and in a beam seaway determined according to 2.3.3.2.2 (m/s²).

2.3.3.2.2 The standard deviation of the lateral acceleration at zero speed and in a beam seaway, σ_{LAi}, is determined using the spectrum of roll motion due to the action of waves. The square of this standard deviation is calculated according to the following formula:

$$\sigma_{LAi}^2 = \frac{3}{4}\sum_{j=1}^{N}\left(a_y(\omega_j)\right)^2 S_{zz}(\omega_j)\Delta\omega$$

where:

$\Delta\omega$ = interval of wave frequency (rad/s) = $(\omega_2 - \omega_1) / N$ (rad/s);

ω_2 = upper frequency limit of the wave spectrum in the evaluation range = $\min((25 / T_r),2.0)$ (rad/s);

ω_1 = lower frequency limit of the wave spectrum in the evaluation range = $\max((0.5 / T_r),0.2)$ (rad/s);

N = number of intervals of wave frequency in the evaluation range, not to be taken less than 100;

ω_j = wave frequency at the mid-point of the considered frequency interval = $\omega_1 + ((2j - 1) / 2)\ \Delta\omega$ (rad/s);

$S_{zz}(\omega_j)$ = sea wave elevation spectrum (m²/(rad/s)). The standard expression for $S_{zz}(\omega)$ is defined in 2.7.2.1.1;

$a_y(\omega_j)$ = lateral acceleration = $k_L(g + h_r \cdot \omega_j^2) \cdot \varphi_a(\omega_j)$ per unit wave amplitude ((m/s²)/m);

k_L, h_r = as defined in 2.3.2.1;

$\varphi_a(\omega_j)$ = roll amplitude in regular beam waves of unit amplitude and circular frequency ω_j at zero speed, = $(\varphi_r(\omega_j)^2 + \varphi_i(\omega_j)^2)^{0.5}$ (rad/m);

$\varphi_r(\omega_j)$ = $\dfrac{a\left(\dfrac{\rho g \nabla GM}{1000} - J_{T,roll}\omega_j^2\right) + bB_e\omega_j}{\left(\dfrac{\rho g \nabla GM}{1000} - J_{T,roll}\omega_j^2\right)^2 + (B_e\omega_j)^2}$ (rad/m);

$\varphi_i(\omega_j)$ = $\dfrac{b\left(\dfrac{\rho g \nabla GM}{1000} - J_{T,roll}\omega_j^2\right) - aB_e\omega_j}{\left(\dfrac{\rho g \nabla GM}{1000} - J_{T,roll}\omega_j^2\right)^2 + (B_e\omega_j)^2}$ (rad/m);

a, b = cosine and sine components, respectively, of the Froude-Krylov roll moment in regular beam waves of unit amplitude (kN·m/m), calculated directly or using an appropriate approximation;

B_e = equivalent linear roll damping factor (kN m s), with $B_e = 2J_{T,roll}\mu_e$ where μ_e (1/s) is the equivalent linear roll damping coefficient;

$J_{T,roll}$ = roll moment of inertia comprising added inertia = $\dfrac{1}{1000}\dfrac{\rho\, g\, \nabla\, GM\, T_r^2}{4\pi^2}$ (t·m²).

Other suitable formulations for the numerical integration in the range from ω_1 to ω_2 can be used as an alternative.

2.4 Assessment of ship vulnerability to the pure loss of stability failure mode

2.4.1 Application

2.4.1.1 The provisions given hereunder apply to all ships, except for ships with an extended low weather deck,[6] for which the Froude number, Fn, corresponding to the service speed exceeds 0.24.

2.4.1.2 For each loading condition, a ship that:

.1 meets the standard contained in the criteria contained in 2.4.2 is considered not to be vulnerable to the pure loss of stability failure mode; and

.2 does not meet the standard contained in the criteria contained in 2.4.2 should be subject to more detailed assessment of vulnerability to the pure loss of stability failure mode by applying the criteria contained in 2.4.3.

2.4.1.3 Alternatively to the criteria contained in 2.4.2 or 2.4.3, for each loading condition a ship may be subject to either:

.1 direct stability assessment for the pure loss of stability failure mode that is performed according to the Guidelines for direct stability assessment in chapter 3; or

.2 operational measures according to the Guidelines for operational measures in chapter 4.

6 The criteria for this failure mode may not be applicable to a ship with an extended low weather deck due to increased likelihood of water on deck or deck-in-water.

2.4.1.4 A detailed assessment of Level 2 vulnerability according to the criteria contained in 2.4.3 may be performed without the requirement to perform a more simplified assessment in 2.4.2. Similarly, a detailed direct stability assessment, as provided in 2.4.1.3.1, may be performed without the requirement to perform a more simplified assessment in 2.4.2 or 2.4.3.

2.4.1.5 Stability limit information for determining the safe zones as functions of *GM*, draught and trim is to be provided based on matrix calculations according to the criteria contained in sections 2.4.2 or 2.4.3 and, if appropriate, direct stability assessment according to the provisions in chapter 3 on direct stability assessment. If relevant, the stability limit information for determining safe zones should take into account operational measures according to the provisions in chapter 4.

2.4.1.6 Reference environmental conditions to be used in the assessment may be modified, according to the Guidelines for operational measures in chapter 4.

2.4.1.7 Free surface effect should be accounted for as recommended in chapter 3 of part B of the 2008 IS Code.

2.4.2 Level 1 vulnerability criterion for the pure loss of stability failure mode

2.4.2.1 A ship is considered not to be vulnerable to the pure loss of stability failure mode, if:

$$GM_{\min} \geq R_{PLA} \text{ and } \frac{\nabla_D - \nabla}{A_W (D - d)} \geq 1.0$$

where:

R_{PLA} = 0.05 (m); and

$GM_{\min}$ = minimum value of the metacentric height (m) calculated as provided in 2.4.2.2.

2.4.2.2 As provided by 2.4.2.1, $GM_{\min}$ should be determined according to:

$$GM_{\min} = KB + \frac{I_{TL}}{\nabla} - KG$$

where:

I_{TL} = transverse moment of inertia of the waterplane at the draft d_L (m^4);

d_L = $d - \delta d_L$ (m);

δd_L = $\min(d - 0.25 d_{full}, \frac{L \cdot s_W}{2})$ (m);

and $d - 0.25 d_{full}$ should not be taken less than zero; and

s_W = 0.0334.

2.4.2.3 The use of the simplified conservative estimation of $GM_{\min}$ described in 2.4.2.2 without initial trim effect can be applied for ships having non-even keel condition.

2.4.3 Level 2 vulnerability criteria for the pure loss of stability failure mode

2.4.3.1 A ship is considered not to be vulnerable to the pure loss of stability failure mode if, when underway at the service speed, V_S,

$$\max\left(CR_1, CR_2\right) \le R_{PL0}$$

where:

R_{PL0} = 0.06; and

CR_1, CR_2 = criteria calculated according to 2.4.3.2.

2.4.3.2 Each of the two criteria, CR_1 and CR_2 in 2.4.3.1, represents a weighted average of certain stability parameters for a ship considered to be statically positioned in waves of defined height, H_i, and length, λ_i, obtained according to 2.4.3.2.2. CR_1 and CR_2 are calculated as follows:

$$CR_1 = \sum_{i=1}^{N} W_i C1_i$$

$$CR_2 = \sum_{i=1}^{N} W_i C2_i$$

where:

CR_1 = weighted criterion 1, computed using Criterion 1, $C1_i$, as evaluated according to 2.4.3.3;

CR_2 = weighted criterion 2, computed using Criterion 2, $C2_i$, as evaluated according to 2.4.3.4;

W_i = weighting factor for the short-term environmental condition, as specified in 2.4.3.2.2;

N = total number of wave cases for which $C1_i$ and $C2_i$ are evaluated, according to 2.4.3.2.2.

2.4.3.2.1 For calculating the restoring moment in waves, the following wavelength and wave heights should be used:

Length $\lambda = L$; and

Height $h = 0.01 \cdot iL \quad i = 0,1,...,10$.

The index for the two criteria, based on φ_v and φ_s, should be calculated according to the formulations given in 2.4.3.3 and 2.4.3.4, respectively. This is undertaken for the loading condition under consideration and the ship assumed to be balanced in sinkage and trim in a series of waves with the characteristics as described above.

In these waves to be studied, the wave crest is to be centred amidships, and at *0.1L*, *0.2L*, *0.3L*, *0.4L* and *0.5L* forward and *0.1L*, *0.2L*, *0.3L* and *0.4L* aft thereof.

2.4.3.2.2 For each combination of H_s and T_z specified in 2.7.2, W_i is obtained as the value in table 2.7.2.1.2 divided by the amount of observations given in this table, which is associated with a H_i as calculated in 2.4.3.2.3 below and λ_i is taken as equal to L. The indices for each H_i should be linearly interpolated from the relationship between h used in 2.4.3.2.1 and the indices obtained in 2.4.3.2.1 above.

2.4.3.2.3 The 3% largest effective wave height, H_i, for use in the evaluation of the requirements is calculated by filtering waves within the ship length. For this purpose, an appropriate wave spectrum shape should be assumed.

2.4.3.3 *Criterion 1*

Criterion 1, $C1_i$, is a criterion based on the calculation of the angle of vanishing stability, φ_V, as provided in the following formula:

$$C1_i = \begin{cases} 1 & \varphi_V < K_{PL1} \\ 0 & otherwise \end{cases}$$

where:

K_{PL1} = 30 (deg)

The angle of vanishing stability, φ_V, should be determined as the minimum value calculated, as provided in 2.4.3.2.1, 2.4.3.2.2 and 2.4.3.2.3 for the ship without consideration of the angle of downflooding.

2.4.3.4 *Criterion 2*

Criterion 2, $C2_i$, is a criterion based on the calculation of the angle of heel, φ_{sw}, under action of heeling lever specified by l_{PL2} as provided in the following formula:

$$C2_i = \begin{cases} 1 & \varphi_{sw} > K_{PL2} \\ 0 & \text{otherwise} \end{cases}$$

where:

K_{PL2} = 15 degrees for passenger ships; and

= 25 degrees for all other ship types

l_{PL2} = $8(H_i/\lambda)\, dFn^2$ (m);

H_i = as provided in 2.4.3.2.2 and 2.4.3.2.3;

λ = as provided in 2.4.3.2.2;

The angle of heel, φ_{sw}, should be determined as the maximum value calculated as provided in 2.4.3.2.1, 2.4.3.2.2 and 2.4.3.2.3, for the ship without consideration of the angle of downflooding.

2.5 Assessment of ship vulnerability to the parametric rolling failure mode

2.5.1 Application

2.5.1.1 For each loading condition, a ship that:

.1 meets the standard contained in the criteria contained in 2.5.2 is considered not to be vulnerable to the parametric rolling failure mode;

.2 does not meet the standard contained in the criteria contained in 2.5.2 should be subject to more detailed assessment of vulnerability to the parametric rolling failure mode by applying the criteria contained in 2.5.3.

2.5.1.2 Alternatively to the criteria contained in 2.5.2 or 2.5.3, for each loading condition a ship may be subject to either:

.1 a direct stability assessment for the parametric rolling failure mode that is performed according to the Guidelines for direct stability assessment in chapter 3; or

.2 operational measures for the parametric rolling failure mode according to the Guidelines for operational measures in chapter 4.

2.5.1.3 A detailed assessment of Level 2 vulnerability according to the criteria contained in 2.5.3 may be performed without the requirement to perform a more simplified assessment in 2.5.2. Similarly, a detailed direct stability assessment as provided in 2.5.1.3.1 may be performed without the requirement to perform a more simplified assessment in 2.5.2 or 2.5.3.

2.5.1.4 Stability limit information for determining the safe zones as functions of GM, draught and trim is to be provided based on matrix calculations according to the criteria contained in 2.5.2 or 2.5.3 and, if appropriate, direct stability assessment according to the provisions in chapter 3 on direct stability assessment. If relevant, the stability limit information for determining safe zones should take into account operational measures according to the provisions in chapter 4.

2.5.1.5 Reference environmental conditions to be used in the assessment may be modified, according to the Guidelines for operational measures in chapter 4.

2.5.1.6 Free surface effects should be accounted for as recommended in chapter 3 of part B of 2008 IS Code.

2.5.2 Level 1 vulnerability criterion for the parametric rolling failure mode

2.5.2.1 A ship is considered not to be vulnerable to the parametric rolling failure mode if

$$\frac{\delta GM_1}{GM} \leq R_{PR} \quad \text{and} \quad \frac{\nabla_D - \nabla}{A_W(D-d)} \geq 1.0$$

where:

R_{PR} = 1.87, if the ship has a sharp bilge; and, otherwise,

$$= 0.17 + 0.425\left(\frac{100A_k}{LB}\right), \text{ if } C_{m,full} > 0.96;$$

$$= 0.17 + \left(10.625 \times C_{m,full} - 9.775\right)\left(\frac{100A_k}{LB}\right), \text{ if } 0.94 \leq C_{m,full} \leq 0.96;$$

$$= 0.17 + 0.2125\left(\frac{100A_k}{LB}\right), \text{ if } C_{m,full} < 0.94; \text{ and}$$

for each formula, $\left(\frac{100A_k}{LB}\right)$ should not exceed 4;

δGM_1 = amplitude of the variation of the metacentric height (m) calculated as provided in 2.5.2.2.

2.5.2.2 As provided by 2.5.2.1, δGM_1 should be determined according to:

$$\delta GM_1 = \frac{I_{TH} - I_{TL}}{2\nabla}$$

where:

δd_H = $\min(D-d, \frac{L \cdot S_W}{2})$ (m);

δd_L = $\min(d-0.25d_{full}, \frac{L \cdot S_W}{2})$ (m);

and $d-0.25d_{full}$ should not be taken less than zero;

d_H = $d+\delta d_H$ (m);

d_L = $d-\delta d_L$ (m);

S_W = 0.0167;

I_{TH} = transverse moment of inertia of the waterplane at the draft d_H (m^4); and

I_{TL} = transverse moment of inertia of the waterplane at the draft d_L (m^4).

2.5.2.3 The use of the simplified conservative estimation of δGM_1 described in 2.5.2.2, without initial trim effect, can be applied for ships having a non-even keel condition.

2.5.3 Level 2 vulnerability criteria for the parametric rolling failure mode

2.5.3.1 A ship is considered not to be vulnerable to the parametric rolling failure mode, if

.1 $C1 \leq R_{PR1}$; or

.2 $C2 \leq R_{PR2}$;

where:

R_{PR1} = 0.06;

R_{PR2} = 0.025;

$C1$ = criterion calculated according to 2.5.3.2; and

$C2$ = criterion calculated according to 2.5.3.3.

2.5.3.2 The value for $C1$ is calculated as a weighted average from a set of waves specified in 2.5.3.2.3, as:

$$C1 = \sum_{i=1}^{N} W_i C_i$$

where:

W_i = weighting factor for the respective wave specified in 2.5.3.2.3;

C_i = 0, if the requirements of either the variation of GM in waves contained in 2.5.3.2.1 or the ship speed in waves contained in 2.5.3.2.2 is satisfied;

= 1, if not;

N = the number of wave cases evaluated, as specified in 2.5.3.2.3.

2.5.3.2.1 For each wave specified in 2.5.3.2.3, the requirement for the variation of GM in waves is satisfied if:

$$GM(H_i, \lambda_i) > 0 \quad and \quad \frac{\delta GM(H_i, \lambda_i)}{GM(H_i, \lambda_i)} < R_{PR}$$

where:

R_{PR} = as defined in 2.5.2.1;

$\delta GM(H_i, \lambda_i)$ = one-half the difference between the maximum and minimum values of the metacentric height calculated for the ship (m), corresponding to the loading condition under consideration, considering the ship to be balanced in sinkage and trim on a series of waves characterized by a wave height H_i, and a wavelength λ_i;

$GM(H_i, \lambda_i)$ = the average value of the metacentric height calculated for the ship (m), corresponding to the loading condition under consideration, considering the ship to be balanced in sinkage and trim on a series of waves characterized by a wave height H_i, and a wavelength λ_i;

H_i = wave height specified in 2.5.3.2.3 (m); and

λ_i = wavelength specified in 2.5.3.2.3 (m).

2.5.3.2.2 For each wave specified in 2.5.3.2.3, the requirement for the ship speed in waves is satisfied if:

$$V_{PR\,i} > V_s$$

where:

V_{PRi} = the reference ship speed (m/s) corresponding to parametric resonance conditions, when $GM(H_i, \lambda_i)$>0:

$$= \left| \frac{2\lambda_i}{T_r} \cdot \sqrt{\frac{GM(H_i, \lambda_i)}{GM}} - \sqrt{g\frac{\lambda_i}{2\pi}} \right|$$

$GM(H_i, \lambda_i)$ = as defined in 2.5.3.2.1 (m);

λ_i = wavelength specified in 2.5.3.2.3 (m);

$|\ |$ = the absolute value operation.

2.5.3.2.3 The specified wave cases for evaluation of the requirements contained in 2.5.3.2.1 and 2.5.3.2.2 are presented in table 2.5.3.2.3. In table 2.5.3.2.3, W_i, H_i, λ_i are as defined in 2.5.3.2.

Table 2.5.3.2.3
Wave cases for parametric rolling evaluation

Wave case number	Weight factor W_i	Wavelength λ_i (m)	Wave height H_i (m)
1	0.000013	22.574	0.350
2	0.001654	37.316	0.495
3	0.020912	55.743	0.857
4	0.092799	77.857	1.295
5	0.199218	103.655	1.732
6	0.248788	133.139	2.205
7	0.208699	166.309	2.697
8	0.128984	203.164	3.176
9	0.062446	243.705	3.625
10	0.024790	287.931	4.040
11	0.008367	335.843	4.421
12	0.002473	387.440	4.769
13	0.000658	442.723	5.097
14	0.000158	501.691	5.370
15	0.000034	564.345	5.621
16	0.000007	630.684	5.950

2.5.3.2.4 In the calculation of $\delta GM(H_i, \lambda_i)$ and $GM(H_i, \lambda_i)$ in 2.5.3.2.1, the wave crest should be located amidships, and at 0.1 λ_i, 0.2 λ_i, 0.3 λ_i, 0.4 λ_i, and 0.5 λ_i forward and 0.1 λ_i, 0.2 λ_i, 0.3 λ_i, and 0.4 λ_i aft thereof.

2.5.3.3 The value of $C2$ is calculated as an average of values of $C2(Fn_i,\beta_i)$, each of which is a weighted average from the set of waves specified in 2.5.3.4.2, for each set of Froude numbers and wave directions specified:

$$C2 = \left[\sum_{i=1}^{12} C2\left(Fn_i,\beta_h\right) + \frac{1}{2}\left\{C2(0,\beta_h) + C2\left(0,\beta_f\right)\right\} + \sum_{i=1}^{12} C2\left(Fn_i,\beta_f\right)\right] / 25$$

where:

$C2(Fn_i,\beta_h)$ = $C2(Fn,\beta)$ calculated as specified in 2.5.3.3.1 with the ship proceeding in head waves with a speed equal to V_i;

$C2(Fn_i,\beta_f)$ = $C2(Fn,\beta)$ calculated as specified in 2.5.3.3.1 with the ship proceeding in following waves with a speed equal to V_i;

Fn_i = $V_i / \sqrt{L\,g}$, Froude number corresponding to ship speed V_i;

V_i = $V_s \cdot K_i$, ship speed (m/s); and

K_i = as obtained from table 2.5.3.3.

Table 2.5.3.3
Speed factor, K_i

i	K_i
1	1.0
2	0.991
3	0.966
4	0.924
5	0.866
6	0.793
7	0.707
8	0.609
9	0.500
10	0.383
11	0.259
12	0.131

2.5.3.3.1 The weighted criteria $C2(Fn_i, \beta)$ are calculated as a weighted average of the short-term parametric rolling failure index considering the set of waves specified in 2.5.3.4.2, for a given Froude number and wave direction, as follows:

$$C2(Fn_i, \beta) = \sum_{i=1}^{N} W_i C_{S,i}$$

where:

W_i = weighting factor for the respective wave cases specified in 2.5.3.4.2;

$C_{S,i}$ = 1, if the maximum roll angle evaluated according to 2.5.3.4 exceeds 25 degrees, and
= 0, otherwise;

N = total number of wave cases for which the maximum roll angle is evaluated for a combination of speed and heading.

2.5.3.4 The maximum roll angle in head and following waves is evaluated as recommended in 2.5.3.4.1 for each speed, V_i, defined in 2.5.3.3. For each evaluation, the calculation of stability in waves should assume the ship to be balanced in sinkage and trim on a series of waves with the following characteristics:

wavelength, $\lambda = L$;
wave height, $h_j = 0.01 \cdot jL, \quad \text{where } j = 0,1,...,10$.

For each wave height, h_j, the maximum roll angle is evaluated.

2.5.3.4.1 The evaluation of roll angle should be carried out using the time domain simulation method with GZ calculated in waves.

2.5.3.4.2 W_i is obtained as the value in table 2.7.2.1.2 divided by the number of observations given in the table. Each cell of the table corresponds to an average zero-crossing wave period, T_z, and a significant wave height, H_s. With these two values, a representative wave height, Hr_i, should be calculated by filtering waves within the ship length. The maximum roll angle, corresponding to the representative wave height, Hr_i, is obtained by linear interpolation of the maximum roll angles for different wave heights, h_j, obtained in 2.5.3.4. This maximum roll angle should be used for the evaluation of $C_{S,i}$ in 2.5.3.3.1.

2.6 Assessment of ship vulnerability to the surf-riding/broaching failure mode

2.6.1 Application

2.6.1.1 For each loading condition, a ship that:

.1 meets the standard contained in the criteria contained in 2.6.2 is considered not to be vulnerable to the surf-riding/broaching failure mode;

.2 does not meet the standard contained in the criteria in 2.6.2 should be subject to either:

  .1 the procedures of ship handling on how to avoid dangerous conditions for surf-riding/broaching, as recommended in section 4.2.1 of the *Revised guidance to the master for avoiding dangerous situations in adverse weather and sea conditions* (MSC.1/Circ.1228), subject to the approval of the Administration; or

  .2 more detailed assessment of vulnerability to the surf-riding/broaching failure mode by applying the criteria contained in 2.6.3.

2.6.1.2 Alternatively to the criteria contained in 2.6.2 or 2.6.3, for each loading condition a ship may be subject to either:

.1 direct stability assessment for the surf-riding/broaching failure mode that is performed according to the Guidelines for direct stability assessment in chapter 3; or

.2 operational measures based on the Guidelines for operational measures in chapter 4.

2.6.1.3 A detailed assessment of Level 2 vulnerability according to the criteria contained in 2.6.3 may be performed without the requirement to perform a more simplified assessment in 2.6.2. Similarly, a detailed direct stability assessment as provided in 2.6.1.3.1 may be performed without the requirement to conduct a more simplified assessment in 2.6.2 or 2.6.3.

2.6.1.4 For ships that do not meet the standard contained in 2.6.2 and which are not applying MSC.1/Circ.1228 according to 2.6.1.1 above, relevant consistent safety information should be provided according to the criteria contained in either 2.6.3 of these Guidelines, Guidelines for direct stability assessment in chapter 3 or Guidelines for operational measures in chapter 4, as appropriate.

2.6.1.5 Reference environmental conditions to be used in the assessment may be modified according to the Guidelines for operational measures in chapter 4.

2.6.2 Level 1 vulnerability criteria for the surf-riding/broaching failure mode

2.6.2.1 A ship is considered not to be vulnerable to the surf-riding/broaching failure mode if:

.1 $L \geq 200$ m; or

.2 $Fn \leq 0.3$.

2.6.3 Level 2 vulnerability criterion for the surf-riding/broaching failure mode

2.6.3.1 A ship is considered not to be vulnerable to the surf-riding/broaching failure mode if

$$C \leq R_{SR}$$

where:

R_{SR} = 0.005;

C = criterion calculated according to 2.6.3.2.

2.6.3.2 The value of C is calculated as

$$C = \sum_{H_S}\sum_{T_Z}\left(W2(H_S,T_Z)\sum_{i=0}^{N_\lambda}\sum_{j=0}^{N_a} w_{ij} C2_{ij}\right)$$

where:

$W2(H_s, T_z)$ = weighting factor of short-term sea state specified in 2.7.2.1 as a function of the significant wave height, H_S, and the zero-crossing wave period, T_Z, in which $W2(H_s, T_z)$ is equal to the number of occurrences of the combination divided by the total number of occurrences in the table, and it corresponds to the factor W_i specified in 2.7.2;

w_{ij} = statistical weight of a wave specified in 2.6.3.3 with steepness $(H/\lambda)_j$ and wavelength to ship length ratio $(\lambda /L)_i$ calculated with the joint distribution of local wave steepness and lengths, which is, with specified discretization N_λ = 80 and N_a = 100; and

$C2_{ij}$ = coefficient specified in 2.6.3.4.

2.6.3.3 The value of w_{ij} should be calculated using the following formula:

$$w_{ij} = 4\frac{\sqrt{g}}{\pi\nu}\frac{L^{5/2}T_{01}}{(H_s)^3}s_j^2 r_i^{3/2}\left(\frac{\sqrt{1+\nu^2}}{1+\sqrt{1+\nu^2}}\right)\Delta r\Delta s\cdot exp\left[-2\left(\frac{L\cdot r_i\cdot s_j}{H_s}\right)^2\left\{1+\frac{1}{\nu^2}\left(1-\sqrt{\frac{gT_{01}^2}{2\pi r_i L}}\right)^2\right\}\right]$$

where:

ν = 0.425;

T_{01} = 1.086 T_z;

s_j = $(H/\lambda)_j$ = wave steepness varying from 0.03 to 0.15 with increment Δs = 0.0012; and

r_i = $(\lambda/L)_i$ = wavelength to ship length ratio varying from 1.0 to 3.0 with increment Δr = 0.025.

2.6.3.4 The value of $C2_{ij}$ is calculated for each wave, as follows:

$$C2_{ij} = \begin{cases} 1 & if \quad Fn > Fn_{cr}(r_j, s_i) \\ 0 & if \quad Fn \le Fn_{cr}(r_j, s_i) \end{cases}$$

where:

Fn_{cr} = critical Froude number corresponding to the threshold of surf-riding (surf-riding occurring under any initial condition) which should be calculated in accordance with 2.6.3.4.1 for the regular wave with steepness s_j and wavelength to ship length ratio r_i.

2.6.3.4.1 The critical Froude number, Fn_{cr}, is calculated as

$$Fn_{cr} = u_{cr} / \sqrt{L\,g}$$

where the critical nominal ship speed, u_{cr} (m/s), is determined according to 2.6.3.4.2.

2.6.3.4.2 The critical nominal ship speed, u_{cr}, is determined by solving the following equation with the critical propulsor revolutions, n_{cr}:

$$T_e(u_{cr}; n_{cr}) - R(u_{cr}) = 0$$

where:

$R(u_{cr})$ = calm water resistance (N) of the ship at the ship speed of u_{cr}, see 2.6.3.4.3;

$T_e(u_{cr}; n_{cr})$ = thrust (N) delivered by the ship's propulsor(s) in calm water determined in accordance with 2.6.3.4.4; and

n_{cr} = commanded number of revolutions of propulsor(s) (1/s) corresponding to the threshold of surf-riding (surf-riding occurs under any initial conditions), see 2.6.3.4.6.

2.6.3.4.3 The calm water resistance, $R(u)$, is approximated based on available data with a polynomial fit suitable to represent the characteristics of the resistance for the ship in question. The fit should be appropriate to ensure the resistance is continuously increasing as a function of speed in the appropriate range.

2.6.3.4.4 For a ship using one propeller as the main propulsor, the propulsor thrust, $T_e(u;n)$, in calm water may be approximated using a second degree polynomial:

$$T_e(u;n) = (1 - t_p)\rho n^2 D_p{}^4 \{\kappa_0 + \kappa_1 J + \kappa_2 J^2\} \text{ (N)}$$

where:

u = speed of the ship (m/s) in calm water;

n = commanded number of revolutions of propulsor (1/s);

t_p = approximate thrust deduction factor;

w_p = approximate wake fraction;

$\kappa_0, \kappa_1, \kappa_2$	=	approximation coefficients for the approximated propeller thrust coefficient in calm water;
J	=	$\frac{u(1-w_p)}{nD_P}$ = advance ratio.

In case of a ship having multiple propellers, the overall thrust can be calculated by summing the effect of the individual propellers calculated as indicated above.

For a ship using a propulsor(s) other than a propeller(s), the propulsor thrust should be evaluated by a method appropriate to the type of propulsor used.

2.6.3.4.5 The amplitude of wave surging force for each wave is calculated as:

$$f_{ij} = \rho g k_i \frac{H_{ij}}{2} \sqrt{Fc_i^2 + Fs_i^2} \text{ (N)}$$

where:

k_i	=	wave number = $\frac{2\pi}{r_i L}$ (1/m);
H_{ij}	=	wave height = $s_j r_i L$ (m);
s_j ,r_i	=	as defined in 2.6.3.3;

$$F_{c_i} = \sum_{m=1}^{N} \delta x_m \, S(x_m) \sin(k_i \, x_m) \exp(-0.5 k_i \cdot d(x_m))$$

$$F_{s_i} = \sum_{m=1}^{N} \delta x_m \, S(x_m) \cos(k_i \, x_m) \exp(-0.5 k_i \cdot d(x_m))$$

F_{Ci} and F_{Si} are parts of the Froude-Krylov component of the wave surging force (m)

x_m	=	longitudinal distance from the midship to a station (m), positive for a bow section;
δx_m	=	length of the ship strip associated with station m (m);
$d(x_m)$	=	draft at station m in calm water (m);
$S(x_m)$	=	area of submerged portion of the ship at station m in calm water (m^2);
N	=	number of stations; and
m	=	index of a station.

2.6.3.4.6 The critical number of revolutions of the propulsor corresponding to the surf-riding threshold, n_{cr} (r_j, s_i), can be determined by solving the following quadratic equation:

$$2\pi \frac{T_e(c_i, n_{cr}) - R(c_i)}{f_{ij}} + 8a_0 n_{cr} + 8a_1 - 4\pi a_2 + \frac{64}{3} a_3 - 12\pi a_4 + \frac{1024}{15} a_5 = 0$$

where:

$$a_0 = -\frac{\tau_1}{\sqrt{f_{ij} \cdot k_i \cdot (M + M_x)}};$$

$$a_1 = \frac{r_1 + 2r_2 c_i + 3r_3 c_i^2 + 4r_4 c_i^3 + 5r_5 c_i^4 - 2\tau_2 c_i}{\sqrt{f_{ij} \cdot k_i \cdot (M + M_x)}};$$

$$a_2 = \frac{r_2 + 3r_3c_i + 6r_4c_i^2 + 10r_5c_i^3 - \tau_2}{k_i \cdot (M + M_x)};$$

$$a_3 = \frac{r_3 + 4r_4c_i + 10r_5c_i^2}{\sqrt{k_i^3 (M + M_x)^3}} \cdot \sqrt{f_{ij}};$$

$$a_4 = \frac{r_4 + 5r_5c_i}{k_i^2 (M + M_x)^2} f_{ij};$$

$$a_5 = \frac{r_5}{\sqrt{k_i^5 (M + M_x)^5}} \sqrt{f_{ij}^3};$$

r_1, r_2, r_3, r_4, r_5= regression coefficients for the calm water resistance under a fifth degree polynomial approximation $R(u) \approx r_1u + r_2u^2 + r_3u^3 + r_4u^4 + r_5u^5$.

M = mass of the ship (kg);

M_x = added mass of the ship in surge (kg). In absence of ship specific data, M_x may be assumed to be 0.1 M;

c_i = $\sqrt{\frac{g}{k_i}}$ = wave celerity (m/s).

$$\tau_1 = \kappa_1(1 - t_p)(1 - w_p)\rho D_p^3$$

$$\tau_2 = \kappa_2(1 - t_p)(1 - w_p)^2 \rho D_p^2$$

2.7 Parameters common to stability failure mode assessments

2.7.1 Inertial properties of a ship and natural period of roll motion

2.7.1.1 In the absence of direct calculations, the roll moment of inertia of the ship comprising the effect of added inertia, $J_{T,roll}$, may be estimated as follows:

$$J_{T,roll} = \frac{1}{1000} \frac{\rho\, g\, \nabla\, GM\, T_r^2}{4\pi^2} \text{ (t·m}^2\text{)}$$

2.7.1.2 The natural roll period, T_r, in a given loading condition, in the absence of sufficient information, direct calculation or measurement, may be approximated using the formulae given in part A, 2.3 of the 2008 IS Code, which is repeated below,

$$T_r = \frac{2 \cdot C \cdot B}{\sqrt{GM}}, \text{ where } C = 0.373 + 0.023(B/d) - 0.043(L_{WL}/100),$$

or its alternatives.

2.7.2 Environmental data

2.7.2.1 A set of standard environmental conditions are assumed. The characterization of the standard environmental conditions refers to both the short-term and the long-term. The short-term characterization is given in terms of the spectrum of sea elevation, known as the spectral density of the sea wave elevation. The long-term characterization is given in terms of a wave scatter table. The standard short-term and long-term characterizations are given in 2.7.2.1.1 and 2.7.2.1.2, respectively.

2.7.2.1.1 The spectral density of sea wave elevation, $S_{zz}(\omega)$, is provided by the Bretschneider wave energy spectrum as a function of the wave frequency, ω, as follows:

$$S_{zz}(\omega) = \frac{H_S^2}{4\pi} \cdot \left(\frac{2\pi}{T_Z}\right)^4 \omega^{-5} \exp\left(-\frac{1}{\pi}\left(\frac{2\pi}{T_Z}\right)^4 \omega^{-4}\right)$$

2.7.2.1.2 The long-term characterization of the standard environmental conditions (used in unrestricted service) is given by means of a wave scatter table. The wave scatter table contains the number of occurrences W_i within each range of significant wave height H_s and zero crossing wave period T_z in 100,000 observations. The wave scatter table, given in table 2.7.2.1.2, specifies factors W_i as functions of H_s and T_z values which represent the mean values of corresponding ranges.[7]

Table 2.7.2.1.2 Wave scatter table

Number of occurrences: 100 000 / T_z (s) = average zero-crossing wave period / H_s (m) = significant wave height																
Tz (s) ►	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5
Hs (m) ▼																
0.5	1.3	133.7	865.6	1186.0	634.2	186.3	36.9	5.6	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1.5	0.0	29.3	986.0	4976.0	7738.0	5569.7	2375.7	703.5	160.7	30.5	5.1	0.8	0.1	0.0	0.0	0.0
2.5	0.0	2.2	197.5	2158.8	6230.0	7449.5	4860.4	2066.0	644.5	160.2	33.7	6.3	1.1	0.2	0.0	0.0
3.5	0.0	0.2	34.9	695.5	3226.5	5675.0	5099.1	2838.0	1114.1	337.7	84.3	18.2	3.5	0.6	0.1	0.0
4.5	0.0	0.0	6.0	196.1	1354.3	3288.5	3857.5	2685.5	1275.2	455.1	130.9	31.9	6.9	1.3	0.2	0.0
5.5	0.0	0.0	1.0	51.0	498.4	1602.9	2372.7	2008.3	1126.0	463.6	150.9	41.0	9.7	2.1	0.4	0.1
6.5	0.0	0.0	0.2	12.6	167.0	690.3	1257.9	1268.6	825.9	386.8	140.8	42.2	10.9	2.5	0.5	0.1
7.5	0.0	0.0	0.0	3.0	52.1	270.1	594.4	703.2	524.9	276.7	111.7	36.7	10.2	2.5	0.6	0.1
8.5	0.0	0.0	0.0	0.7	15.4	97.9	255.9	350.6	296.9	174.6	77.6	27.7	8.4	2.2	0.5	0.1
9.5	0.0	0.0	0.0	0.2	4.3	33.2	101.9	159.9	152.2	99.2	48.3	18.7	6.1	1.7	0.4	0.1
10.5	0.0	0.0	0.0	0.0	1.2	10.7	37.9	67.5	71.7	51.5	27.3	11.4	4.0	1.2	0.3	0.1
11.5	0.0	0.0	0.0	0.0	0.3	3.3	13.3	26.6	31.4	24.7	14.2	6.4	2.4	0.7	0.2	0.1
12.5	0.0	0.0	0.0	0.0	0.1	1.0	4.4	9.9	12.8	11.0	6.8	3.3	1.3	0.4	0.1	0.0
13.5	0.0	0.0	0.0	0.0	0.0	0.3	1.4	3.5	5.0	4.6	3.1	1.6	0.7	0.2	0.1	0.0
14.5	0.0	0.0	0.0	0.0	0.0	0.1	0.4	1.2	1.8	1.8	1.3	0.7	0.3	0.1	0.0	0.0
15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.6	0.7	0.5	0.3	0.1	0.1	0.0	0.0
16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0

[7] Refer to International Association of Classification Societies (IACS) Recommendation No.34 (Corr. Nov.2001).

2.7.2.2 Alternative environmental conditions can be used for ships subject to operational measures according to chapter 4 and should be accepted by the Administration.

2.7.2.2.1 Such alternative environmental conditions should specify the short-term characteristics of wind and sea state, together with the probability of occurrence of each short-term environmental condition.

2.7.2.2.2 The short-term sea state characteristics should be given in terms of a sea elevation spectrum. The short-term wind state should be given in terms of a mean wind speed and a gustiness spectrum.

2.7.2.2.3 The long-term characterization of the environmental condition should be given in terms of probability of occurrence of each short-term condition. The probability of occurrence of each short-term environmental condition corresponds to the weighting factor, W_i. The set of short-term environmental conditions and corresponding weighting factors should be such that the sum of the weighting factors, i.e. the probabilities of occurrence, is unity.

2.7.3 Other common parameters

2.7.3.1 Active means of motion reduction, such as active anti-roll fins and anti-roll tanks, can significantly reduce roll motions in seaway. However, the safety of the ship should be ensured in cases of failure of such devices, therefore, the vulnerability assessment according to these Interim Guidelines should be conducted with such devices inactive or retracted, if they are retractable.

3 Guidelines for direct stability failure assessment

3.1 Objective

3.1.1 These Guidelines provide specifications for direct stability assessment procedures for the following stability failure modes:

.1 dead ship condition;
.2 excessive acceleration;
.3 pure loss of stability;
.4 parametric rolling; and
.5 surf-riding/broaching.

3.1.2 The criteria, procedures and standards recommended in these guidelines ensure a safety level corresponding to the average stability failure rate not exceeding $2.6 \cdot 10^{-3}$ per ship per year.

3.1.3 Direct stability assessment procedures are intended to employ latest technology while being sufficiently practical to be uniformly accepted and applied using currently available infrastructure.

3.1.4 The provisions given hereunder apply to all ships and all failure modes. However, the provisions for both the dead ship condition and pure loss of stability failure modes should not apply to ships with an extended low weather deck.

3.2 Requirements

3.2.1 The failure event is defined as:

.1 *exceedance of roll angle*, defined as: 40 degrees, angle of vanishing stability in calm water or angle of submergence of unprotected openings in calm water, whichever is less; or

.2 *exceedance of lateral acceleration* of 9.81 m/s^2, at the highest location along the length of the ship where passengers or crew may be present.

The Administrations may define stricter requirements, if deemed necessary.

3.2.2 Active means of motion reduction, such as active anti-roll fins and anti-roll tanks, can significantly reduce roll motions in seaway. However, the safety of the ship should be ensured in cases of failure of such devices, therefore, the vulnerability assessment according to these Interim Guidelines should be conducted with such devices inactive or retracted, if they are retractable.

3.2.3 The procedure for direct stability assessment consists of two major components:

.1 a method that adequately replicates ship motions in waves (see 3.3); and

.2 a prescribed procedure that identifies the process by which input values are obtained for the assessment, how the output values are processed, and how the results are evaluated (see 3.5).

3.3 Requirements for a method that adequately predicts ship motions

3.3.1 General considerations

3.3.1.1 The motion of ships in waves can be predicted by means of numerical simulations or model tests.

3.3.1.2 The choice between numerical simulations, model tests or their combination should be agreed with the Administration on a case-by-case basis taking into account these Interim Guidelines.

3.3.1.3 The procedures, calibrations and proper application of technology involved in the conduct of model tests should follow "Recommended Procedures, Model Tests on Intact Stability, 7.5-02-07-04.1" issued by the International Towing Tank Conference (ITTC) in 2008. Users may follow recent amended versions of the Recommended Procedures at the time of execution of tests, if deemed necessary.

3.3.1.4 Numerical simulation of ship motions may be defined as the numerical solution of the motion equations of a ship sailing in waves including or excluding the effect of wind (see 3.3.2).

3.3.2 General requirements

3.3.2.1 Modelling of waves

3.3.2.1.1 The mathematical model of waves should be consistent and appropriate for the calculation of the forces.

3.3.2.1.2 Modelling of irregular waves should be statistically and hydrodynamically valid. Caution should be exercised to avoid a self-repetition effect.

3.*3.2.2 Modelling of roll damping: avoiding duplication*

3.3.2.2.1 Roll damping forces should include wave, lift, vortex (i.e. eddy-making) and skin friction components.

3.3.2.2.2 The data to be used for the calibration of roll damping may be defined from:

.1 roll decay or forced roll test;

.2 CFD computations, if sufficient agreement with experimental results in terms of roll damping is demonstrated;

.3 existing databases of measurements or CFD computations for similar ships, if suitable range is available; or

.4 empirical formulae, applied within their applicability limits.

3.3.2.2.3 If the wave component of roll damping is already included in the calculation of radiation forces, measures should be taken to avoid including these effects more than once.

3.3.2.2.4 Similarly, if any components of roll damping (e.g. cross-flow drag) are directly computed whereas others are taken from the calibration data, similar measures should be taken to exclude these directly computed elements from the calibration data used.

3.3.2.2.5 Consideration of the essential roll damping elements more than once can be avoided through use of an iterative calibration procedure in which the roll decay or forced roll tests are replicated in numerical simulations. The results should be determined to be reasonably close to the original calibration model test data set.

3.*3.2.3 Mathematical modelling of forces and moments*

3.3.2.3.1 The Froude-Krylov forces should be calculated using body-exact formulations at least for the dead ship condition, pure loss of stability and parametric rolling failure modes, for instance using panel or strip-theory approaches.

3.3.2.3.2 Radiation and diffraction forces should be represented in one of three ways: one is to use approximate coefficients and the other two involve either a body linear formulation or a body-exact solution of the appropriate boundary-value problem.

3.3.2.3.3 Resistance forces should include wave, vortex and skin friction components. The preferred source for these data is a model test. The added resistance in waves can be approximated, if this element is not already included in the calculation of diffraction and radiation forces. If the radiation and diffraction forces are calculated as a solution of the hull boundary-value problem, measures must be taken to avoid including these effects more than once.

3.3.2.3.4 Hydrodynamic reaction sway forces, roll moment and yaw moments could be approximated, based on:

.1 Coefficients derived from model tests in calm water with planar motion mechanism (PMM) or in stationary circular tests, by means of a rotating arm or an *x-y* carriage.[8]

.2 CFD computations, provided that sufficient agreement is demonstrated with a model experiment in terms of values of sway force and yaw moment. If the radiation and diffraction forces are calculated as a solution of the hull boundary-value problem, measures must be taken to avoid including these effects more than once.

.3 Empirical database or empirical formulae, used within their applicability range.

3.3.2.3.5 Thrust may be obtained by use of a coefficient-based model with approximate coefficients to account for propulsor-hull interactions.

3.3.3 *Requirements for particular stability failure modes*

3.3.3.1 For the dead ship condition failure mode:

.1 Ship motion simulations should include at least the following four degrees of freedom: sway, heave, roll and pitch.

.2 Three-component aerodynamic forces and moments generated on topside surfaces may be evaluated using model test results. CFD results may be admitted upon demonstration of sufficient agreement with a model experiment in terms of values of aerodynamic force and moments. Empirical data or formulae could be applied within their applicability range.

3.3.3.2 For the excessive acceleration failure mode, the ship motion simulations should include at least the following three degrees of freedom: heave, pitch and roll. If sway motion is not modelled, consideration should be given to accurate reproduction of lateral acceleration.

3.3.3.3 For the pure loss of stability failure mode, ship motion simulations should include at least the following four degrees of freedom: surge, sway, roll and yaw. For those degrees of freedom not included in the dynamic modelling, static equilibrium should be assumed.

3.3.3.4 For the parametric rolling failure mode, ship motion simulations should include at least the following three degrees of freedom: heave, roll and pitch.

3.3.3.5 For the surf-riding/broaching failure mode:

.1 Ship motion simulations should include at least the following four degrees of freedom: surge, sway, roll and yaw. For those degrees of freedom not included in the dynamic modelling, static equilibrium should be assumed.

[8] The captive model test procedure should be based on the ITTC recommended procedure 7.5-02-06-02, issued in 2014, as amended. The stationary circular test by means of an *x-y* carriage can reproduce a circular model motion with any specified drift angle by combining the motion of an *x-y* carriage and a turn table.

.2 Hydrodynamic forces due to vortex shedding from a hull should be properly modelled. This should include hydrodynamic lift forces and moments due to the coexistence of wave particle velocity and ship forward velocity, other than manoeuvring forces and moments in calm water.

3.3.3.6 For the pure loss of stability and surf-riding/broaching failure modes, an appropriate autopilot should be used.

3.3.3.7 For the pure loss of stability and surf-riding/broaching failure modes, the initial condition should be set with a sufficiently small forward speed in order to avoid artificial surf-riding, which cannot occur for a self-propelled ship.

3.4 Requirements for validation of software for numerical simulation of ship motions

3.4.1 Validation

3.4.1.1 Validation is the process of determining the degree to which a numerical simulation is an accurate representation of the real physical world from the perspective of each intended use of the model or simulation.

3.4.1.2 Different physical phenomena are responsible for different modes of stability failure. Therefore, the validation of software for the numerical simulation of ship motions is failure-mode specific.

3.4.1.3 The validation data should be compatible with the general characteristics of the ship for which the direct stability assessment is intended to be carried out.

3.4.1.4 The process of validation should be performed in two phases: one qualitative and the other quantitative. In the qualitative phase, the objective is to demonstrate that the software is capable of reproducing the relevant physics of the failure mode considered. The objective of the quantitative phase is to determine the degree to which the software is capable of predicting the specific failure mode considered.

3.4.2 Qualitative validation requirements

Table 3.4.2 – Requirements and acceptance criteria for qualitative validation

Item	Required for	Objective	Acceptance criteria
Periodic properties of roll oscillator	Software where hydrostatic and Froude-Krylov forces are calculated with body exact formulation	Demonstrate consistency between calculated roll backbone curve (dependence of roll frequency in calm water on roll amplitude) and GZ curve in calm water	Based on the shape of calculated backbone curve. The backbone curve must follow a trend which is consistent with the righting lever
Response curve of roll oscillator	Software where hydrostatic and Froude-Krylov forces are calculated with body exact formulation	Demonstrate consistency between the calculated roll backbone curve and the calculated roll response curve (dependence of amplitude of excited roll motion on the frequency of excitation)	Based on the shape of the roll response curve. The roll response curve must "fold around" the backbone curve and may show hysteresis when the magnitude of excitation is increased

Change of stability in waves	Software where hydrostatic and Froude-Krylov forces are calculated with body exact formulation. Additional capability to track the instantaneous GZ curve in waves may be required	Demonstrate capability to reproduce wave pass effect	Typically in head and following waves, the stability decreases when the wave crest is located near the midship section (within the quarter of length) and the stability increases when the wave trough is located near the midship section (within the quarter of length)
Principal parametric resonance	Software where hydrostatic and Froude-Krylov forces are calculated with a body exact formulation	Demonstrate capability to reproduce principal parametric resonance	Usually, observing an increase and stabilization of amplitude of roll oscillation in exact following or head seas when encounter frequency is about twice of natural roll frequency

Table 3.4.2 (continued) – Requirements and acceptance criteria for qualitative validation

Item	Required for	Objective	Acceptance criteria
Surf-riding equilibrium	Software for numerical simulation of surf-riding/ broaching	Demonstrate capability to reproduce surf-riding, while yaw is fixed.	Observing sailing with the speed equal to wave celerity when the propeller RPM is set for the speed in calm water which is less than the wave celerity. The horizontal position of centre of gravity is expected to be located near a wave trough
Heel during turn	Software for numerical simulation of surf-riding/ broaching	Demonstrate capability to reproduce heel caused by turn	Observing development of heel angle during the turn
Turn in calm water	Software for numerical simulation of surf-riding/ broaching	Demonstrate correct modelling of manoeuvring forces	Observing correct direction of turn with large rudder angles
Straight captive run in stern quartering waves	Software for numerical simulation of surf-riding/ broaching	Demonstrate correct modelling of wave forces including effect of wave particle velocity	Observing correct tendency of phase difference of wave force to incident waves
Heel caused by drift and wind	Software for numerical simulation of ship motions in dead ship condition	Demonstrate capability to reproduce heel caused by a moment created by aerodynamic load and drag caused by drift	Observing slowly developed heel angle after applying aerodynamic load

3.4.3 *Quantitative validation requirements*

3.4.3.1 There are two objectives of quantitative validation of numerical simulation. The first is to find the degree to which the results of numerical simulation differ from the model test results. The results of a model test carried out in accordance with 3.3.1.3 should be recognized as reference values. The second objective is to judge if the observed difference between simulations and model tests is sufficiently small or conservative for direct stability assessment to be performed for the considered failure modes.

Table 3.4.3 – Indicative requirements and acceptance criteria for quantitative validation

Item	Required for	Objective	Acceptance criteria
Response curve for parametric rolling in regular waves	Parametric rolling	Demonstrate agreement between numerical simulation and model tests regarding amplitude of the roll response	Maximum (over encounter frequency) roll amplitude should not be underpredicted by more than 10%, if the amplitude is below the angle of maximum GZ or 20% otherwise. Underprediction less than 2 degrees may be disregarded.
Response curve for synchronous roll in regular waves	All modes	Demonstrate agreement between numerical simulation and model tests regarding amplitude of the roll response	Maximum (over encounter frequency) roll amplitude should not be underpredicted for more than 10%, if the amplitude is below the angle of maximum GZ or 20% otherwise. Under-prediction less than 2 degrees may be disregarded.
Variance test for synchronous roll	Software for numerical simulation of dead ship condition and excessive acceleration	Demonstrate correct (in terms of statistics) modelling of roll response in irregular waves	Reproduction of experimental results either within 95% confidence interval or conservative
Variance test for parametric rolling	Software for numerical simulation of parametric rolling	Demonstrate correct (in terms of statistics) modelling of roll response in irregular waves	Reproduction of experimental results either within 95% confidence interval or conservative
Wave conditions for surf-riding and broaching	Software for numerical simulation of surf-riding/ broaching	Demonstrate correct modelling of surf-riding/ broaching dynamics in regular waves	Wave steepness causing surf-riding and broaching at the wavelength 0.75 – 1.5 of ship length is within 15% of difference between model tests and numerical simulations. Speed settings are also within 15% difference between model tests and numerical simulations.

3.5 Procedures for direct stability assessment

3.5.1 General description

3.5.1.1 The procedures for direct stability assessment contain a description of the necessary calculations of ship motions including the choice of input data, pre- and post-processing.

3.5.1.2 The direct stability assessment procedure is aimed at the estimation of a likelihood of a stability failure in an irregular wave environment and because the stability failures may be rare, the direct stability assessment procedure may require a solution of the problem of rarity. This arises when the mean time to stability failure is very long in comparison with the natural roll period that serves as a main timescale for the roll motion process. The solution of the problem of rarity essentially requires a statistical extrapolation; for this reason, the validation must be performed for all elements of the direct stability assessment procedure.

3.5.1.3 These Guidelines provide two general approaches to circumvent the problem of rarity, namely assessment in design situations and assessment using deterministic criteria. Mathematical techniques are provided that reduce the required number of simulations or simulation time and can be used to accelerate assessment for both, the full assessment and the assessment performed in design situations.

3.5.2 Verification of failure modes

3.5.2.1 Once a failure is identified in a numerical simulation, it is necessary to examine whether it can be regarded as a failure mode for which the numerical method is validated and direct assessment is intended. The suggested judging criteria for this purpose are provided below.

3.5.2.2 If the local period of the obtained roll motion in following waves or in stern quartering waves is nearly equal to the local wave encounter period and the maximum roll angle occurs nearly at the relative wave position in which the metacentric height becomes the smallest, it can be regarded as pure loss of stability failure.

3.5.2.3 If the local period of the obtained roll motion is nearly equal to twice the local wave encounter period and is nearly equal to the ship natural roll period, it can be regarded as the parametric rolling stability failure considered in the vulnerability criteria, which is sometimes called as "principal parametric rolling". Other types of parametric rolling may occur with much smaller probability, which are not addressed by the second generation intact stability criteria.

3.5.2.4 The condition when the ship cannot keep a straight course despite the application of maximum steering efforts is known as broaching. The second generation intact stability criteria address broaching associated with surf-riding. Other types of broaching may occur at slower speed but are not considered here because the centrifugal force, due to such slow-speed broaching which could induce heel, is much smaller. The broaching associated with surf-riding can be identified if both the yaw angle and yaw angular velocity increase over time under the application of the maximum opposite rudder deflection.

3.5.2.5 If the local period of the obtained roll motion in beam waves is nearly equal to the local wave encounter period, it can be regarded as harmonic rolling, which is relevant to the dead ship condition failure mode, as well as the excessive acceleration failure mode.

3.5.3 *Environmental and sailing conditions*

3.*5.3.1* *General approaches for selection of environmental and sailing conditions*

3.5.3.1.1 The sea states chosen for the direct stability assessment must be representative for the intended service of the ship.

3.5.3.1.2 Sea states are defined by the type of wave spectrum and statistical data of its integral characteristics, such as the significant wave height and the mean zero-crossing wave period. For ships of unrestricted service, the environment should be described by the wave scatter table shown in table 2.7.2.1.2. For ships of restricted service, the wave scatter table accepted by the Administration should be used.

3.5.3.1.3 It is recommended to use the Bretschneider wave energy spectrum (see 2.7.2.1.1) and cosine-squared wave energy spreading with respect to the mean wave direction. If short-crested waves are considered impracticable in model tests or numerical simulations, long-crested waves can be used.

3.5.3.1.4 For a given set of environmental conditions, the assessment can be performed using any of the following equivalent alternatives:

.1 full probabilistic assessment according to 3.5.3.2;

.2 assessment in design situations using probabilistic criteria according to 3.5.3.3; or

.3 assessment in design situations using deterministic criteria according to 3.5.3.4.

3.*5.3.2* *Full probabilistic assessment*

3.5.3.2.1 In this approach, the criterion used is the estimate of the mean long-term rate of stability failures, which is calculated as a weighted average over all relevant sea states, wave directions with respect to the ship heading and ship forward speeds, for each addressed loading condition.

3.5.3.2.2 To satisfy the requirements of this assessment, this criterion should not exceed the standard of $2.6 \cdot 10^{-8}$ (1/s).

3.5.3.2.3 The probabilities of the sea states are defined according to the wave scatter table (see 3.5.3.1). For the excessive accelerations, pure loss of stability, parametric rolling and surf-riding/broaching failure modes, the mean wave directions with respect to the ship heading are assumed uniformly distributed and the ship forward speed should be regarded as uniformly distributed from zero to the maximum service speed. For the dead ship condition failure mode, beam waves and wind should be assumed and the ship forward speed should be taken as zero.

3.*5.3.3* *Assessment in design situations using probabilistic criteria*

3.5.3.3.1 Compared to the full probabilistic assessment, this approach significantly reduces the required simulation time and number of simulations since the assessment is conducted in fewer design situations. These design situations are specified for each stability failure mode as combinations of the ship forward speed, mean wave direction with respect to the ship heading, significant wave height and mean zero-crossing wave period for each addressed loading condition.

3.5.3.3.2 In this approach, the criterion is the maximum (over the design situations corresponding to a particular stability failure mode) stability failure rate, defined in each design situation as the upper boundary of its 95%-confidence interval.

3.5.3.3.3 To satisfy the requirements of this assessment, this criterion should not exceed the threshold corresponding to one stability failure every 2 hours in full scale in design sea states with probability density 10^{-5} $(m{\cdot}s)^{-1}$.

3.5.3.3.4 Table 3.5.3.3.4 shows the design situations for particular stability failure modes, including mean wave direction with respect to the ship heading, ship forward speed and range of wave periods; and the step of the zero-crossing wave period in the specified ranges should not exceed 1.0 s.

Table 3.5.3.3.4 – Design situations for each stability failure mode

Stability failure mode	Wave directions	Forward speeds	Wave period
Dead ship condition	Beam wind and waves	Zero	T_z/T_r from 0.7 to 1.3
Excessive acceleration	Beam	Zero	Tz/Tr from 0.7 to 1.3
Pure loss of stability	Following	Maximum nominal service speed	Tp corresponding to wavelengths comparable to ship length
Parametric rolling	Head and following	Zero	All wave periods in the wave scatter table
Surf-riding/broaching	Following	Maximum nominal service speed	Tp corresponding to wavelengths in the range from 1.0*L* to 1.5*L*

3.5.3.3.5 For each mean zero-crossing wave period, the significant wave height is selected according to the probability density of the sea state, as specified in 3.5.3.3.3. For unrestricted service, the significant wave heights are shown in table 3.5.3.3.5 depending on the mean zero-crossing wave period.

Table 3.5.3.3.5 – Significant wave heights for design sea states with probability density 10^{-5} $(m{\cdot}s)^{-1}$ for unrestricted service

T_z (s)	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5
H_s (m)	2.8	5.5	8.2	10.6	12.5	13.8	14.6	15.1	15.1	14.8	14.1	12.9	10.9

3.5.3.4 Assessment in design situations using deterministic criteria

3.5.3.4.1 A probabilistic assessment may require a long simulation time even when using design situations and this can make it difficult to use model tests rather than numerical simulations. Applying deterministic criteria, such as the mean 3-hour maximum roll amplitude, may reduce the required simulation time and this may make it easier to use model tests with, or instead of, numerical simulations. However, the inaccuracy of this approach needs to be balanced by additional conservativeness.

3.5.3.4.2 In this approach, the criteria are the greatest (with respect to all design situations for a particular stability failure mode) mean 3-hour maximum roll amplitude and lateral acceleration for each addressed loading condition.

3.5.3.4.3 To satisfy the requirements of this assessment, these criteria should not exceed half of the values in the definition of stability failure in 3.2.1.

3.5.3.4.4 The simulations or model tests for each design situation should comprise at least 15 hours in full scale. This duration can be divided into several parts. The results should be post-processed to provide at least five values of the 3-hour maximum amplitude of roll angle or lateral acceleration, which are averaged to define the mean 3-hour maximum amplitudes.

3.5.3.4.5 This approach uses design situations with the same mean wave directions with respect to the ship heading, the same ship forward speeds and the same ranges of the mean zero-crossing wave periods as the assessment in design situations using probabilistic criteria (see 3.5.3.3).

3.5.3.4.6 For each mean zero-crossing wave period, the significant wave height is selected according to the probability density of the sea state equal to $7{\cdot}10^{-5}$ $(m{\cdot}s)^{-1}$. Table 3.5.3.4.6 shows these significant wave heights for unrestricted service depending on the mean zero-crossing wave period.

Table 3.5.3.4.6 Significant wave heights, in metres, for design sea states with probability density $7{\cdot}10^{-5}$ $(m{\cdot}s)^{-1}$ for assessment using deterministic criteria for unrestricted service

T_z (s)	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5
H_s (m)	2.0	4.4	6.9	9.1	10.9	12.1	12.8	13.1	13.0	12.5	11.3	9.0

3.5.4 *Direct counting procedure*

3.5.4.1 The direct counting procedure uses ship motions resulting from multiple independent realisations of an irregular seaway to estimate the rate of stability failure, *r*.

3.5.4.2 The procedure used for direct counting should provide the upper boundary of the 95% confidence interval of the estimated rate of stability failure. This upper boundary is the one which is used in direct stability assessment and operational measures.

3.5.4.3 The counting procedure should ensure independence of the counted stability failure events.

3.5.4.4 The failure rate *r* and associated confidence interval can be estimated:

.1 by carrying out a simulation for each realisation of an irregular seaway only until the first stability failure; or

.2 on the basis of a set of independent simulations with fixed specified exposure time t_{exp} (s), under the assumption that the relation between the probability *p* of failure within t_{exp} and the failure rate *r* is $p = 1 - \exp(-r{\cdot}t_{exp})$.

3.5.4.5 Alternatively to direct counting, extrapolation procedures can be used as specified in section 3.5.5.

3.5.5 Extrapolation procedures

3.5.5.1 The extrapolation procedures to be used with these Guidelines should only include those procedures that have been successfully validated and applied and which should also include a detailed description of their application.

3.5.5.2 *Cautions*

3.5.5.2.1 The extrapolation method may be applied as an alternative to the direct counting procedure.

3.5.5.2.2 Caution should be exercised because uncertainty increases, as the extrapolation is associated with additional assumptions used for describing ship motions in waves.

3.5.5.2.3 The statistical uncertainty of the extrapolated values should be provided in a form of boundaries of the confidence interval evaluated with a confidence level of 95%.

3.5.5.2.4 To control the uncertainty caused by nonlinearity, the principle of separation may be used. Extrapolation methods based on the principle of separation consist of at least two numerical procedures addressing different aspects of the problem: "non-rare" and "rare".

3.5.5.2.5 The "non-rare" procedure focuses on the estimation of ship motions or waves of small-to-moderate level for which the stability failure events can be characterized statistically with acceptable uncertainty.

3.5.5.2.6 The "rare" procedure focuses on ship motions of moderate-to-severe level for which numerical simulation are rarely required. Large motions may be separated from the rest of the time domain data to obtain practical estimates of these motions.

3.5.5.2.7 Different extrapolation methods based on the separation principle may use different assumptions on how the separation is introduced.

3.5.5.3 *Extrapolation over wave height*

3.5.5.3.1 Extrapolation of the mean time to stability failure or mean rate of stability failures over significant wave height is a technique allowing the reduction of the required simulation time by performing numerical simulations or model tests at greater significant wave heights than those required in the assessment and extrapolating the results to lower significant wave heights.

3.5.5.3.2 The extrapolation is based on the approximation $\ln T = A + B/H_s^2$, where T (s) is the mean time to stability failure; H_s (m) is the significant wave height; and A, B are coefficients which do not depend on the significant wave height but depend on the other parameters specifying the situation (wave period, wave direction and ship forward speed).

3.5.5.3.3 The extrapolation can be performed when at least three values of the stability failure rate are available. These values should be obtained by direct counting for a range of significant wave heights of at least 2 m. Each of the values used in the extrapolation should correspond to the upper boundary of the 95%-confidence interval of stability failure rate and not exceed 5% of the reciprocal natural roll period of the ship. The results should be checked for the presence of outliers and non-conservative extrapolation and corrected, when necessary, by adding or removing points used for extrapolation.

3.5.5.4 Other extrapolation procedures

3.5.5.4.1 Other extrapolation procedures may be used, taking into account 3.5.5.1 and 3.5.5.2. Such procedures may include those listed below and others:

.1 envelope peak-over-threshold (EPOT);

.2 split-time/motion perturbation method (MPM); and

.3 critical wave method.

3.5.6. Validation of extrapolation procedures

3.5.6.1 Extrapolation procedures used for direct stability assessment should be validated.

3.5.6.2 Validation of an extrapolation procedure is a demonstration that the extrapolated value is in reasonable statistical agreement with the result of the direct counting, if such volume of data would be available.

3.5.6.3 The data for validation of the extrapolation procedure may be produced by a mathematical model of reduced complexity (e.g. a set of ordinary differential equations instead of a numerical solution of a boundary value problem) or by running the full mathematical model on significantly more severe environmental and/or more onerous loading conditions. The objective is to decrease the computational cost by which a large data set can be obtained (the validation data set). Physical experiments can be used for the same purpose.

3.5.6.4 The direct counting procedure applied to the validation data set should produce the "true value". The extrapolation procedure applied to a minimally required fraction of the validation data set should re-produce the "true value" within 95% confidence.

3.5.6.5 Validation of the extrapolation procedure should be performed for 50 statistically independent data sets and evaluated for a number of ship speeds, relative wave headings and sea states.

3.5.6.6 A comparison should be made between the extrapolation and the "true value" for each data set. The comparison should be considered successful if the extrapolation confidence interval and the confidence interval of the "true value" overlap.

3.5.6.7 The validation should be considered successful if at least 88% of individual data set comparisons are successful.

4 Guidelines for operational measures

4.1 General principles

4.1.1 A combined consideration of design and operational aspects can effectively be used to achieve a sufficient safety level. In application, this principle requires guidance to be provided for the preparation of operational measures, consistent with the design assessment requirements.

4.1.2 Whereas the principles used in these Guidelines can be applied to consider any operational problems related to ship behaviour in a seaway, detailed procedures in these Guidelines cover the following stability failure modes:

.1 dead ship condition;

.2 excessive acceleration;

.3 pure loss of stability;

.4 parametric rolling; and

.5 surf-riding/broaching.

4.1.3 These Guidelines consider the operational limitations and operational guidance, which are defined in 4.3.1. Either operational limitations or operational guidance can be used for the following four stability failure modes: excessive acceleration, pure loss of stability, parametric rolling and surf-riding/broaching. For the dead ship condition failure mode, only operational limitations related to areas or routes and season (4.3.1.1 and 4.5.1) can be applied. This means that neither operational limitations related to maximum significant wave height nor operational guidance are applicable because the ship's main propulsion plant and auxiliaries are inoperable. This means that the ship is neither able to avoid heavy weather nor control speed and course.

4.1.4 Operational limitations and operational guidance should provide at least the same level of safety as that provided by the procedures and standards given by the Guidelines for vulnerability criteria in chapter 2 or the direct stability assessment in chapter 3. In particular, the safety level of those loading conditions that fail design assessment requirements in chapter 2 or chapter 3 should become sufficient if all combinations of the sailing condition and sea state that are not recommended by these operational measures are removed from the design assessment.

4.1.5 Whereas the principle in 4.1.4 can be directly used to prepare operational measures ensuring a required safety level, more detailed procedures were developed as described in these Guidelines for convenience of ship designers and Administrations. Using the procedures and standards described herein corresponds to setting a safety level in accordance with the Guidelines for direct stability assessment in chapter 3.

4.1.6 Although the application of operational measures can reduce the likelihood of stability failure to a desired low level, a loading condition for which too many situations should be avoided to achieve the required safety level should not be considered as acceptable. Therefore, from practical and regulatory perspectives, operational measures should not be considered as always sufficient for any loading condition.

4.1.7 In case operational measures are provided for particular failure mode(s) based on these Guidelines, they may be applied instead of the relevant provisions in the guidance provided in MSC.1/Circ.1228.

4.2 Stability failures

4.2.1 The definition of stability failure should be consistent with those used in either the Guidelines for vulnerability criteria in chapter 2 or the Guidelines for direct stability assessment in chapter 3.

4.2.2 The provisions given hereunder apply to all ships, except for ships with an extended low weather deck when considering the dead ship condition failure mode or the pure loss of stability failure mode.

4.3 Operational measures

4.3.1 These Guidelines consider the following ship specific operational measures:

.1 *Operational limitations* which define the limits on a ship's operation in a considered loading condition, are as follows:

.1 *Operational limitations related to areas or routes and season* permit operation in specific operational areas (either geographical areas or specific types of operational areas like sheltered waters) or routes and, if appropriate, the specific season. For the operational area, route and season, the environmental conditions are specified by the wave scatter table and corresponding wind statistics; and

.2 *Operational limitations related to maximum significant wave height* permit operation in conditions up to a maximum significant wave height. The environmental conditions are specified by the combination of the wave scatter table related to operational area or route and season, and corresponding wind statistics. The wave scatter table limited to a specific significant wave height is referred to as a *limited wave scatter table; and*

.2 *Operational guidance* which defines the combinations of ship speed and heading relative to mean wave direction that are not recommended and that should be avoided in each relevant sea state.

4.3.2 The operational measures specified in 4.3.1 require different amount of information and planning in their application, as follows:

.1 operational limitations related to areas or routes and season do not require weather data during the operation of the ship and thus do not need any specific information and planning;

.2 operational limitations related to maximum significant wave height need a forecast for the significant wave height and the availability of appropriate routing in a sufficient time before encountering possible storm conditions; and

.3 operational guidance requires detailed forecast information about wave energy spectrum and wind characteristics, together with means for indicating combinations of ship speed and heading relative to mean wave direction that should be avoided, which should be available for safe routeing in a sufficient time before encountering possible storm conditions.

4.3.3 The operational measures specified in 4.3.1 can be combined, e.g. operational limitations can be applied up to a certain significant wave height and operational guidance for greater significant wave heights. When operational limitations are combined with operational guidance, the requirements for operational guidance apply.

4.4 Acceptance of operational measures

4.4.1 Operational limitations and operational guidance should be accepted by the Administration according to these Guidelines.

4.4.2 Acceptance of a loading condition for unrestricted operation, limited operation or operation using onboard operational guidance should be performed following these Guidelines in combination with the design assessment requirements according to chapter 2 or chapter 3. A loading condition is considered as:

.1 *acceptable for unrestricted operation*, if it satisfies the design assessment requirements for all five stability failure modes specified in 4.1.2;

.2 *acceptable for limited operation*, if it is provided with operational limitations for one or more stability failure modes specified in 4.1.2 for unrestricted operation and satisfies the design assessment requirements for the remaining stability failure modes;

.3 *acceptable for operation using onboard operational guidance*, if it is provided with operational guidance for one or more stability failure modes specified in 4.1.2 for unrestricted operation and is either provided with operational limitations for unrestricted operation or satisfies the design assessment requirements for the remaining stability failure modes;

.4 *acceptable for operation in a specified area or on a specified route during a specified season*, if it is provided with operational limitations for one or more stability failure modes specified in 4.1.2 for this area or route and season, and satisfies the design assessment requirements for the remaining stability failure modes;

.5 *acceptable for limited operation in a specified area or on a specified route during a specified season*, if it is provided with operational limitations for one or more stability failure modes specified in 4.1.2 for a given significant wave height limit for this area or route and season, and either has operational limitations without specification of maximum operational significant wave height for this area or route and season, or satisfies the design assessment requirements for the remaining stability failure modes; and

.6 *acceptable for operation using onboard operational guidance in a specified area or on a specified route during a specified season*, if it is provided with operational guidance for one or more stability failure modes specified in 4.1.2 for this area or route and season and is either provided with operational limitations for this area or route and season or satisfies the design assessment requirements for the remaining stability failure modes.

4.4.3 Application of the operational limitations related to maximum significant wave height or operational guidance can reduce the stability failure rate to any low level. However, if too many sailing conditions in too many sea states should be avoided for a certain loading condition, such loading condition cannot be considered as acceptable in practical operation. Therefore:

.1 a loading condition cannot be considered as acceptable if the ratio of the total duration of all situations which should be avoided to the total operational time, is greater than 0.2. In the calculation of this ratio, the situations that should be avoided include those defined by:

.1 operational limitations related to maximum significant wave height; or

.2 operational guidance; and

.2 in the calculation of the ratio in 4.4.3.1, the probabilities of the sea states are taken according to the full wave scatter table. Wave headings are assumed uniformly distributed and the ship forward speed is assumed uniformly distributed between zero and the maximum service speed.

4.4.4 Active means of motion reduction, such as active anti-roll fins and anti-roll tanks, can significantly reduce roll motions in seaway. Therefore, if such devices are not considered in the development and application of the operational measures, the advice to the ship master may be suboptimal or misleading. On the other hand, the safety of the ship with specific reference to aspects addressed by the present Guidelines should be ensured also in cases of failure of such devices. Therefore, it is recommended that the development, application and acceptance of the operational measures is done both with operating and inactive (or retracted, if retractable) anti-roll devices.

4.4.5 Operational guidance can indicate some sailing conditions as safe with respect to roll motion but they may be unattainable due to limits of the propulsion and steering systems of the ship or undesirable due to other problems, such as excessive vertical motions or accelerations and slamming. For example, for parametric rolling in bow waves, roll motions may reduce with increasing forward speed, but high speeds in bow waves could be either unattainable or could lead to excessive vertical motions or loads. Neglecting this contradiction can lead to misleading operational guidance or even put the ship in danger if in some sea state all sailing conditions, acceptable from the point of view of roll motions, are unattainable or dangerous because of other reasons.

4.5 Preparation procedures

4.5.1 Operational limitations related to areas or routes and season

4.5.1.1 Operational limitations are prepared following the design assessment procedures in chapter 2 or chapter 3 with modified environmental conditions assumed in operation. The modification of the reference environmental conditions is based on the wave scatter table for a specified area or a specified route during a specified season and corresponding wind statistics, acceptable to the Administration.

4.5.1.2 The environmental conditions applied in the preparation of the operational limitations related to specified areas or specified routes during a specified season should be consistent with the corresponding vulnerability criteria if the preparation is based on the Guidelines for vulnerability assessment in chapter 2. If the preparation is based on direct stability assessment these environmental conditions should be consistent with the Guidelines for direct stability assessment in chapter 3. Other environmental conditions may be applied, as appropriate.

4.5.1.3 For some Level 1 and Level 2 vulnerability assessment procedures, regular wave cases should be defined, based on the wave statistics.

4.5.2 Operational limitations related to maximum significant wave height

4.5.2.1 Operational limitations related to maximum significant wave height are developed using design assessment procedures in chapter 2 or chapter 3 for a specific environment, which is defined by cutting the wave scatter table for a specified area or a specified route during a specified season at a specified significant wave height and by corresponding modification of wind statistics.

4.5.2.2 The environmental conditions applied in the preparation of the operational limitations related to maximum significant wave height should be consistent with the corresponding vulnerability criteria, if the preparation is based on the Guidelines for vulnerability assessment in chapter 2. If the preparation is based on the direct stability assessment, these conditions should be consistent with the Guidelines for direct stability assessment in chapter 3. Other environmental conditions may be applied, as appropriate.

4.5.2.3 For certain Level 1 and Level 2 vulnerability assessment procedures, definition of the corresponding regular wave cases is required; this is done in the same way as for operational limitations without specification of maximum operational significant wave height.

4.5.3 General principles of preparation of operational guidance

4.5.3.1 Operational guidance should indicate all sailing conditions that should be avoided for each range of sea states in the relevant wave scatter table.

4.5.3.2 Operational guidance should ensure that the considered loading condition satisfies the design assessment requirements in chapter 2 or chapter 3 after removing from the design assessment all sailing conditions that should be avoided. To simplify the preparation and acceptance of operational guidance, three equivalent approaches, recommended for the preparation of operational guidance, are considered below in detail. These approaches are based on:

.1 probabilistic motion criteria and standards (referred to as probabilistic operational guidance);

.2 deterministic motion criteria and standards (referred to as deterministic operational guidance); and

.3 simplified motion criteria and standards (referred to as simplified operational guidance).

4.5.3.3 Operational guidance should clearly indicate acceptable and unacceptable sailing conditions for each relevant sea state and may be presented in the form of a polar diagram.

4.5.3.4 Other forms different from polar diagrams could be used for displaying operational guidance, provided that equivalent information is included.

4.5.4 Probabilistic operational guidance

4.5.4.1 This type of operational guidance uses probabilistic criteria, such as the probability of stability failure during a specified time or the rate of stability failures, and corresponding probabilistic thresholds to distinguish sailing conditions which should be avoided.

4.5.4.2 Sailing conditions that should be avoided are those for which:

$r > 10^{-6}\ s^{-1}$;

where r (s^{-1}) is the upper boundary of the 95% confidence interval of the stability failure rate.

4.5.4.3 Procedures and numerical methods applied for the determination of the failure rate as referred to in 4.5.4.2 should satisfy the recommendations of the Guidelines for direct stability assessment in chapter 3.

4.5.4.4 If a certain assumed situation should be avoided, assessment for higher significant wave heights, with other parameters unchanged, is not required. Conversely, if a certain assumed situation does not have to be avoided, assessment for lower significant wave heights, with other parameters unchanged, is not required.

4.5.5 Deterministic operational guidance

4.5.5.1 Using deterministic criteria, such as maximum roll amplitude in a given exposure time, represent a simpler but less accurate approach than using probabilistic criteria. Therefore, in order to provide an equivalent safety level, the thresholds for deterministic criteria are conservatively selected.

4.5.5.2 Deterministic operational guidance can be prepared using only model tests, only numerical simulations or their combination. Numerical methods applied in such simulations should satisfy the recommendations of the Guidelines for direct stability assessment in chapter 3.

4.5.5.3 Sailing conditions that should be avoided are those for which:

$$\alpha \cdot x_{3h} > x_{lim},$$

where $\alpha = 2$ is the scaling factor, x_{3h} is the mean 3-hour maximum roll or lateral acceleration amplitude and x_{lim} is the corresponding stability failure threshold, as defined in the Guidelines for direct stability assessment in 3.2.1.

4.5.5.4 To define the mean 3-hour maximum amplitude, the total recommended duration of a test or simulation is 15 hours at full scale for each considered situation.

4.5.5.5 If a certain assumed situation should be avoided, an assessment for higher significant wave heights, with other parameters unchanged, is not required. Conversely, if a certain assumed situation does not have to be avoided, an assessment for lower significant wave heights, with other parameters unchanged, is not required.

4.5.6 Simplified operational guidance

4.5.6.1 Whereas probabilistic and deterministic operational guidance provides accurate and detailed recommendations for the ship forward speed and course in each sea state, it requires model tests or numerical methods of high accuracy. Therefore, simpler conservative approaches may be used to develop operational guidance for acceptable forward speed and course when it is deemed practicable.

4.5.6.2 In principle, any simple conservative estimations for the sailing conditions that should be avoided in each relevant sea state, can be used if they are shown to provide a superior safety level compared to the design assessment requirements. In particular, Level 1 or Level 2 vulnerability criteria of the Guidelines for vulnerability assessment in chapter 2 can be used. Some examples of recommended approaches based on Level 1 and Level 2 vulnerability criteria are included below:

.1 For the excessive acceleration stability failure mode, all forward speeds should be avoided in all sea states where $C_{S,i} > 10^{-6}$, where $C_{S,i}$ is defined according to 2.3.3.2.1 of the Guidelines for vulnerability assessment. The transfer function $a_y(\omega)$ defined in 2.3.3.2.2 is multiplied by the absolute value of the sine of the wave heading angle μ and calculated by replacing the wave frequency ω_j with wave encounter frequency ω_{ej}.

.2 For the pure loss of stability failure mode, nominal ship forward speed of the ship of $0.752 \cdot L^{1/2}$ m/s or greater, should be avoided in following to beam wave directions in sea states for which $\max(C1_i, C2_i) = 1$, where $C1_i$ and $C2_i$ are defined in 2.4.3.3 and 2.4.3.4, respectively, of the Guidelines for vulnerability assessment.

.3 For the parametric rolling stability failure mode, forward speed, for which $C_{S,i}(v_s, H_s, T_z)$, defined according to 2.5.3.3.1 of the Guidelines for vulnerability assessment, is equal to 1, should be avoided in all wave directions and all sea states.

.4 For the surf-riding/broaching failure mode, either:

.1 nominal ship speed of $0.94 \cdot L^{1/2}$ (m/s), or greater, should be avoided when the wavelength, based on mean wave period, is greater than 80% of the ship length, the significant wave height is greater than 4% of the ship length L (m) and the heading angle μ (deg) from the wave direction is less than 45 degrees; or

.2 alternatively, the critical nominal ship speed provided by the Level 2 vulnerability criteria (see 2.6.3.4.2) or above should be avoided in following to beam wave directions in sea states for which c_{HT} > 0.005, where c_{HT} is calculated as:

$$c_{HT}\left(H_s, T_z\right) = \sum_{i=1}^{N_\lambda} \sum_{j=1}^{N_a} w_{ij}\left(H_s, T_z\right) C2_{ij}$$

where $w_{ij}\left(H_s, T_z\right)$ and $C2_{ij}$ should be calculated based on the level 2 vulnerability criteria in 2.6.3.2, but with the diffraction component of the wave force taken into account.

4.6 Application

4.6.1 Operational guidance should be provided as easily accessible and understandable information in graphical form which clearly indicates unacceptable sailing conditions for a given sea state, as well as the relevant stability failure modes. Automatic alert systems can be used for the cases when sailing conditions are close to or within the areas of unacceptable sailing conditions.

4.6.2 Unacceptable sailing conditions are derived from the pre-defined databases of probabilistic, deterministic or simplified safety criteria, stored as functions of the ship forward speed and ship heading with respect to the mean wave direction for relevant sea states. These sea states are specified by using as input the actual significant wave height, mean zero-crossing wave period, mean wave direction and ship course.

4.6.3 The effect of non-parallel wave systems (cross sea) can be reproduced using these pre-defined databases by combining separate responses to the wind sea and swell which correspond to the significant wave height, mean zero-crossing wave period and mean wave direction of each of these wave systems by:

.1 summing the rate of stability failures for each of these wave systems when using probabilistic operational guidance;

.2 summing the maximum responses to each of these wave systems when using deterministic operational guidance; and

.3 overlaying the unacceptable sailing conditions for each of these wave systems when using simplified operational guidance.

The procedure described above is meant to be a practical approximation tool for addressing cross sea conditions starting from pre-calculations based on simpler standard sea states. However, such a procedure is an approximate one and sea states encountered in the ship's operation can be characterized by complex spectra combining multiple wind sea and swell systems. Therefore, particular caution is recommended to be exercised during operation when making use of operational guidance developed according to the described procedure, if the sea state is characterized by complex combinations of wind sea and swell systems.

4.6.4 The master should ensure that the ship, at any time during the voyage and considering the available weather forecasts, satisfies the operational limitations related to maximum significant wave height or operational guidance.

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4 December 2020

UNIFIED INTERPRETATIONS OF SOLAS CHAPTER II-2

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), with a view to providing more specific guidance regarding SOLAS regulation II-2/9, approved a unified interpretation of SOLAS regulation II-2/9 regarding isolated pantries containing no cooking appliances in accommodation spaces, prepared by the Sub-Committee on Ship Systems and Equipment, at its seventh session (2 to 6 March 2020), as set out in the annex.

2 Member States are invited to use the annexed unified interpretation as guidance when applying SOLAS regulation II-2/9 on ships contracted for construction on or after 1 January 2021, and to bring the unified interpretation to the attention of all parties concerned.

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ANNEX

UNIFIED INTERPRETATIONS OF SOLAS CHAPTER II-2

Regulation II-2/9.2.2.3.2.2(9) – Containment of fire, thermal and structural boundaries

"Isolated pantries containing no cooking appliances in accommodation spaces" are pantries enclosed in an accommodation space and are only accessible from accommodation spaces and/or open deck. For the purpose of this categorization, "accommodation space" is as defined in SOLAS regulation II-2/3.1. These pantries, shown in figure 1 below, should not have communicating openings to spaces other than accommodation spaces, such as a category 12 "main galley". These pantries do not contain cooking appliances, except as allowed in accordance with *Amendments to the unified interpretations of SOLAS chapter II-2, the FSS Code, the FTP Code and related fire test procedures (MSC/Circ.1120)* (MSC.1/Circ.1436).

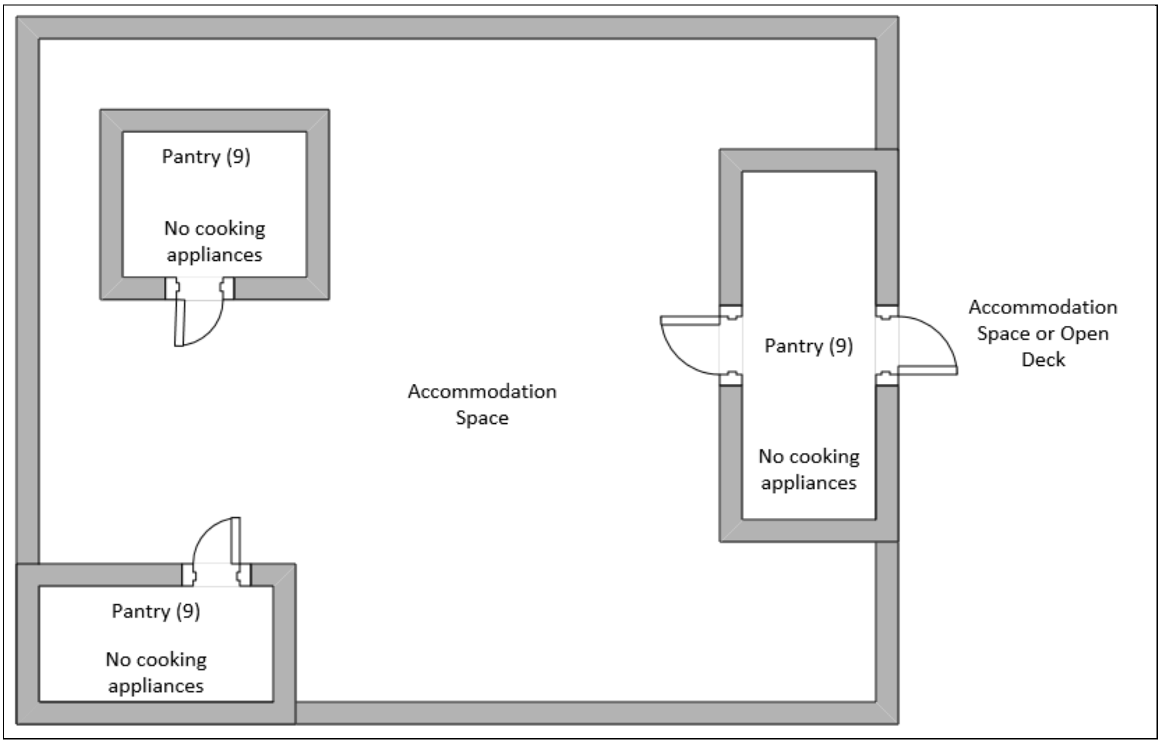

Figure 1: Examples of category 9 "Isolated pantry containing no cooking appliances in an accommodation space"

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MSC.1/Circ.1175/Rev.1
9 December 2020

REVISED GUIDANCE ON SHIPBOARD TOWING AND MOORING EQUIPMENT

1 The Maritime Safety Committee, at its eightieth session (11 to 20 May 2005), approved guidance concerning shipboard equipment, fittings and supporting hull structures associated with towing and mooring for the uniform implementation of SOLAS regulation II-1/3-8, adopted by resolution MSC.194(80), which became effective on 1 January 2007.

2 The Committee, at its 102nd session (4 to 11 November 2020), having considered a proposal by the Sub-Committee on Ship Design and Construction, at its sixth session, with a view to ensuring a uniform approach towards the application of the provisions of SOLAS regulation II-1/3-8, as amended by resolution MSC.473(102), which is expected to become effective on 1 January 2024, approved the *Revised guidance on shipboard towing and mooring equipment*, as set out in the annex.

3 This revised guidance is applicable to ships constructed on or after 1 January 2024 and does not supersede the *Guidance on shipboard towing and mooring equipment* (MSC.1/Circ.1175) which remains applicable to ships constructed on or after 1 January 2007 but before 1 January 2024.

4 Member Governments are invited to use the annexed guidance when applying the revised SOLAS regulation II-1/3-8, and to bring it to the attention of all parties concerned.

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ANNEX

SHIPBOARD EQUIPMENT, FITTINGS AND SUPPORTING HULL STRUCTURES ASSOCIATED WITH TOWING AND MOORING

1 Application

1.1 Under regulation II-1/3-8 of the 1974 SOLAS Convention, as adopted by resolution MSC.473(102), new displacement type ships, except high-speed craft and offshore units, shall be provided with arrangements, equipment and fittings of sufficient safe working load to enable the safe conduct of all towing and mooring operations associated with the normal operations of the ship. The arrangements, equipment and fittings shall meet the appropriate requirements of the Administration or an organization recognized by the Administration.

1.2 The *Revised guidance on shipboard towing and mooring equipment* (MSC.1/Circ.1175/Rev.1) should apply to ships constructed on or after 1 January 2024. To ships constructed on or after 1 January 2007 and before 1 January 2024, the *Guidance on shipboard towing and mooring equipment* (MSC.1/Circ.1175) should apply.

1.3 This circular provides standards for the design and construction of shipboard fittings and supporting hull structures associated with normal towing and mooring operations in harbours or sheltered waters, which Administrations are recommended to implement. This circular also contains design guidance for fittings of ships that are further intended to be towed by another ship or tug, e.g. in an emergency. This circular does not require tow lines nor mandate standards for mooring lines on board the ship. Furthermore, this guidance is not applicable to the design and construction of shipboard fittings and supporting hull structures used for special towing services defined as:

.1 *Escort towing*: Towing service required in some estuaries to control the ship in case of failures of the propulsion or steering system. It should be referred to local escort requirements;

.2 *Canal transit towing*: Towing service for ships transiting canals, e.g. the Panama Canal. It should be referred to local canal transit requirements; and

.3 *Emergency towing for tankers*: Towing service to assist tankers in case of emergency. It should be referred to paragraph 1 of SOLAS regulation II-1/3-4.

1.4 Equipment that is used for both towing and mooring should be in accordance with sections 3 and 4.

2 Definitions

For the purpose of this guidance:

2.1 *Normal towing* means towing operations necessary for manoeuvring in ports and sheltered waters associated with the normal operations of the ship.

2.2 *Other towing* means towing by another ship or a tug, such as to assist the ship in case of emergency.

2.3 *Shipboard fittings* mean bollards and bitts, fairleads, pedestal rollers and chocks used for mooring of the ship and similar components used for normal or other towing of the ship. Any weld, bolt or other fastening connecting the shipboard fitting to the supporting hull structure is part of the shipboard fitting and subject to any industry standard applicable to such fitting.

2.4 *Supporting hull structure* means that part of the ship structure on/in which the shipboard fitting is placed and which is directly submitted to the forces exerted on the shipboard fitting. The hull structure supporting capstans, winches, etc. used for normal or other towing and mooring operations mentioned above should also be subject to this guidance.

2.5 *Industry standard* means international or national standards which are recognized in the country where the ship is built, subject to the approval of the Administration.

2.6 *Safe working load (SWL)* means the safe load limit of shipboard fittings used for mooring operations in harbours or similar sheltered waters.

2.7 *Safe towing load (TOW)* means the safe load limit of shipboard fittings used for normal and other towing.

2.8 *Ship Design Minimum Breaking Load* (MBL_{SD}) means the minimum breaking load of new, dry mooring lines for which shipboard fittings and supporting hull structures are designed in order to meet mooring restraint requirements.

3 Towing

3.1 Strength

The strength of shipboard fittings used for normal towing operations and their supporting hull structures should comply with the provisions of 3.2 to 3.6. Where a ship is equipped with shipboard fittings intended to be used for other towing services, the strength of these fittings and their supporting hull structures should also comply with these provisions. The strength of shipboard fittings intended to be used for both towing and mooring and of their supporting hull structures should also comply with the provisions of section 4.

3.2 Arrangements

Shipboard fittings for towing should be located on stiffeners and/or girders which are part of the deck construction so as to facilitate efficient distribution of the towing load. Other equivalent arrangements may be accepted (for chocks in bulwarks, etc.), provided the strength is confirmed as adequate for the intended service.

3.3 Load considerations

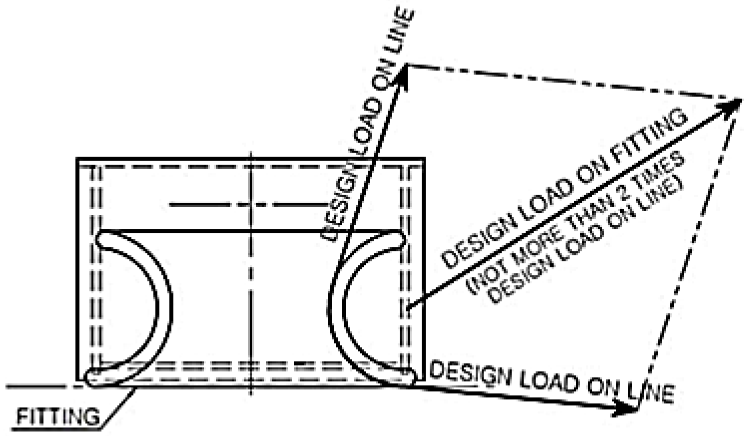
3.3.1 The minimum design load applied to supporting hull structures for shipboard fittings should be:

.1 for normal towing operations, 1.25 times the intended maximum towing load (e.g. static bollard pull), as indicated on the towing and mooring arrangements plan;

.2 for other towing services, the ship design minimum breaking load of the tow line defined in appendix A; and

.3 for fittings intended to be used for both normal and other towing operations, the greater of the design loads according to .1 and .2.

3.3.2 The design load should be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the towing line takes a turn at a fitting, the total design load applied to the fitting is equal to the resultant of the design loads acting on the line. However, in no case does the design load applied to the fitting need to be more than twice the design load on the line as specified in 3.3.1 (see figure below).



3.4 Shipboard fittings

3.4.1 Shipboard fittings may be selected from an industry standard accepted by the Administration and at least based on the following loads:

.1 for normal towing operations, the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangements plan;

.2 for other towing services, the ship design minimum breaking load of the tow line according to appendix A; and

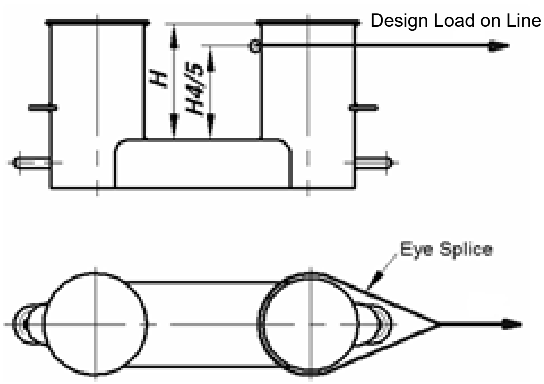
.3 for fittings intended to be used for both normal and other towing operations, the greater of the loads according to .1 and .2.

3.4.2 When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting and of its attachment to the supporting hull structure should be in accordance with 3.3 and 3.5.

3.5 Supporting hull structure

3.5.1 The reinforcing members beneath shipboard fittings should be effectively arranged for any variation of direction (horizontally and vertically) of the towing forces acting upon the shipboard fittings. Proper alignment of fitting and supporting hull structures should be ensured.

3.5.2 The acting point of the towing force on shipboard fittings should be taken at the attachment point of a towing line or at a change in its direction. For bollards and bitts the attachment point of the towing line should be taken not less than 4/5 of the tube height above the base (see figure below).



3.5.3 Under the design load conditions as specified in 3.3 the allowable normal stress should be taken as 100% and the allowable shearing stress as 60% of the specified yield point for the material used. Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress. No stress concentration factors being taken into account.

3.6 Safe towing load (TOW)

3.6.1 TOW used for normal towing operations should not exceed 80% of the design load as given in 3.3.1.1 and TOW used for other towing operations should not exceed 80% of the design load as given in 3.3.1.2. For fittings used for both, normal and other towing operations, the greater of the safe towing loads should be used.

3.6.2 TOW, in tonnes, of each shipboard fitting should be marked (by weld bead or equivalent) on the fittings intended for towing. For fittings intended to be used for both, towing and mooring, SWL, in tonnes, according to 4.6, should be marked in addition to TOW.

3.6.3 The above provisions on TOW apply for the use of no more than one towing line.

3.6.4 The towing and mooring arrangements plan described in section 5 should define the method of use of towing lines.

4 Mooring

4.1 Strength

The strength of shipboard fittings used for mooring operations and of their supporting hull structures, as well as the strength of supporting hull structures of winches and capstans, should comply with the provisions of 4.2 to 4.6. The strength of shipboard fittings, intended to be used for both, mooring and towing, and of their supporting hull structures, should also comply with the provisions of section 3.

4.2 Arrangements

Shipboard fittings, winches and capstans for mooring should be located on stiffeners and/or girders, which are part of the deck construction, so as to facilitate efficient distribution of the mooring load. Other equivalent arrangements may be accepted (for chocks in bulwarks, etc.) provided the strength is confirmed adequate for the service.

4.3 Load considerations

4.3.1 The minimum design load applied to supporting hull structures:

.1 of shipboard fittings should be 1.15 times the ship design minimum breaking load of the mooring line provided in accordance with appendix A;

.2 of winches should be 1.25 times the intended maximum brake holding load, where the maximum brake holding load should be assumed not less than 80% of the ship design minimum breaking load of the mooring line according to appendix A; and

.3 of capstans 1.25 times the maximum hauling-in force.

4.3.2 The design load should be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the mooring line takes a turn at a fitting, the total design load applied to the fitting is equal to the resultant of the design loads acting on the line. However, in no case does the design load need to be more than twice the design load on the line as specified in 4.3.1 (see figure in 3.3).

4.4 Shipboard fittings

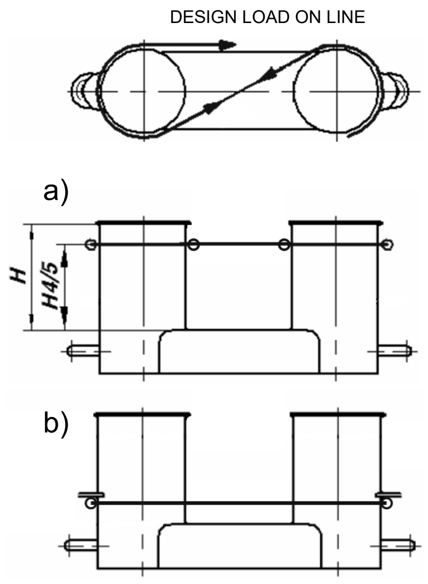
4.4.1 Shipboard fittings may be selected from industry standards accepted by the Administration at least based on the ship design minimum breaking load of the mooring line according to appendix A.

4.4.2 When the shipboard fitting is not selected from an accepted industry standard, the strength of the fittings and of its attachment to the supporting hull structure should be in accordance with 4.3 and 4.5.

4.5 Supporting hull structure

4.5.1 Arrangement of reinforcing members beneath shipboard fittings, winches and capstans should consider any variation of direction (horizontally and vertically) of the mooring forces acting upon the shipboard fittings. Proper alignment of fitting and supporting hull structures should be ensured.

4.5.2 The acting point of the mooring force on shipboard fittings should be taken at the attachment point of a mooring line or at a change in its direction. For bollards and bitts the attachment point of the mooring line should be taken not less than 4/5 of the tube height above the base (see figure a) below). However, if fins are fitted to the bollard tubes to keep the mooring line as low as possible, the attachment point of the mooring line may be taken at the location of the fins (see figure b) below).



4.5.3 Under the design load conditions, as specified in 4.3, the allowable normal stress should be taken as 100% and the allowable shearing stress as 60% of the specified yield point for the material used. Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress, no stress concentration factors being taken into account.

4.6 Safe working load (SWL)

4.6.1 The SWL, for the purpose of marking, should be equal to the ship design minimum breaking load of the mooring line according to appendix A.

4.6.2 The SWL, in tonnes, of each shipboard fitting should be marked (by weld bead or equivalent) on the fittings intended for mooring. For fittings intended to be used for both mooring and towing, TOW, in tonnes, according to 3.6, should be marked in addition to SWL.

4.6.3 The above provisions on SWL apply for the use of no more than one mooring line.

4.6.4 The towing and mooring arrangements plan described in section 5 should define the method of use of mooring lines.

5 Towing and mooring arrangements plan

5.1 The SWL and TOW for the intended use for each shipboard fitting should be noted in the towing and mooring arrangements plan available on board for the guidance of the master. It should be noted that TOW is the load limit for towing purposes and SWL is the load limit for mooring purposes.

5.2 Information provided in the plan should include, in respect of each shipboard fitting:

.1 location on the ship;

.2 fitting type;

.3 SWL/TOW;

.4 purpose (mooring, normal towing or other towing); and

.5 method of applying load of towing or mooring line including limiting fleet angle, i.e. angle of change in direction of a line at the fitting.

5.3 Furthermore, information provided on the plan is to include:

.1 the arrangement of mooring lines showing number of lines (N);

.2 the ship design minimum breaking load of each mooring line (MBL_{SD});

.3 the length of each mooring line;

.4 restrictions or limitations on the type (including material and construction), stiffness and diameter of mooring lines which are compatible with the mooring equipment and fittings; and

.5 the acceptable environmental conditions as given in appendix A, section 3 for the recommended ship design minimum breaking load of mooring lines for ships with Equipment Number EN > 2000:

.1 30 second mean wind speed from any direction (v_W or v_W* according to 3.1.3 or 3.2.2, respectively); and

.2 maximum current speed acting on bow or stern (±10°).

Note: When the applied design environmental criteria exceed the above given criteria, information provided in the plan should include the design environmental criteria, similar to the parameters in appendix A:

.1 wind speed and direction; and

.2 current speed and direction.

APPENDIX A

MOORING AND TOW LINES

1 General

1.1 The mooring lines for ships with Equipment Number (EN) of less than or equal to 2,000 are given in section 2. For other ships the mooring lines are given in section 3.

1.2 The applicable provisions for tow lines are given in section 2.

1.3 The EN should be calculated in compliance with appendix B. Deck cargo as given by the loading manual should be included for the determination of side-projected area A.

1.4 Sections 2 and 3 specify the minimum recommended number and minimum strength of mooring lines (MBL_{SD}). The designer should consider verifying the adequacy of mooring lines based on assessments carried out for the individual mooring arrangement, expected shore-side mooring facilities and expected prevalent environmental conditions.

2 Mooring lines for ships with EN ≤ 2000 and tow lines

2.1 The minimum recommended mooring lines for ships having an EN of less than or equal to 2,000 are given in table 1.

2.2 For ships having the ratio A/EN > 0.9 the following number of lines should be added to the number of mooring lines as given in table 1:

one line where $0.9 < \frac{A}{EN} \leq 1.1$,

two lines where $1.1 < \frac{A}{EN} \leq 1.2$,

three lines where $1.2 < \frac{A}{EN}$.

2.3 The tow lines are given in table 1 and are intended as own tow line of a ship to be towed by a tug or another ship.

Table 1: Mooring and tow lines for ships with EN ≤ 2000

EQUIPMENT NUMBER		MOORING LINES		TOW LINE*
Exceeding	Not exceeding	No. of mooring lines	Ship design minimum breaking load (kN)	Ship design minimum breaking load (kN)
1	*2*	*3*	*4*	*5*
50	70	3	37	98
70	90	3	40	98
90	110	3	42	98
110	130	3	48	98
130	150	3	53	98
150	175	3	59	98
175	205	3	64	112
205	240	4	69	129
240	280	4	75	150
280	320	4	80	174
320	360	4	85	207
360	400	4	96	224
400	450	4	107	250
450	500	4	117	277
500	550	4	134	306
550	600	4	143	338
600	660	4	160	370
660	720	4	171	406
720	780	4	187	441
780	840	4	202	479
840	910	4	218	518
910	980	4	235	559
980	1,060	4	250	603
1,060	1,140	4	272	647
1,140	1,220	4	293	691
1,220	1,300	4	309	738
1,300	1,390	4	336	786
1,390	1,480	4	352	836
1,480	1,570	5	352	888
1,570	1,670	5	362	941
1,670	1,790	5	384	1,024
1,790	1,930	5	411	1,109
1,930	2,080	5**	437**	1,168
2,080	2,230	**	**	1,259
2,230	2,380	**	**	1,356
2,380	2,530	**	**	1,453
2,530	-	**	**	1,471

* Information is provided in relation to 3.3.1.2 and 3.4.1.2 of the annex to Revised guidance and provision on board of such a line is not necessary under this guidance.

** For ships with EN > 2,000 see section 3 of appendix A.

3 Mooring lines for ships with EN > 2,000

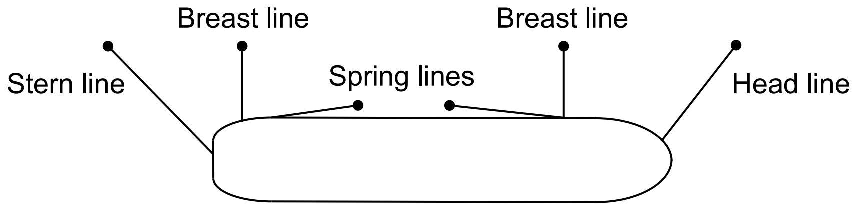
3.1 General

3.1.1 The following is defined with respect to the purpose of mooring lines (see also figure below):

.1 *Breast line*: A mooring line that is deployed perpendicular to the ship, restraining the ship in the off-berth direction;

.2 *Spring line*: A mooring line that is deployed almost parallel to the ship, restraining the ship in fore or aft direction; and

.3 *Head/Stern line*: A mooring line that is oriented between longitudinal and transverse direction, restraining the ship in the off-berth and in fore or aft direction. The amount of restraint in fore or aft and off-berth direction depends on the line angle relative to these directions.



.4 Breast lines provide the maximum transverse restraint and spring lines the maximum longitudinal restraint against vessel movement in athwart and in fore-aft direction, respectively. Head and stern lines are much less effective for these purposes. The applied mooring layout should follow these principles as far as possible with respect to the port facilities and as far as reasonable with respect to the vertical line angles.

3.1.2 The strength of mooring lines and the number of head, stern and breast lines for ships with an EN > 2,000 are based on the side-projected area A_1. Side projected area A_1 should be calculated similar to the side-projected area A according to appendix B but considering the following conditions:

.1 For oil tankers, chemical tankers, bulk carriers and ore carriers the lightest ballast draft should be considered for the calculation of the side-projected area A_1. For other ships the lightest draft of usual loading conditions should be considered if the ratio of the freeboard in the lightest draft and the full load condition is equal to or above two. Usual loading conditions mean loading conditions as given by the trim and stability booklet that are to be expected to regularly occur during operations, excluding light weight conditions, propeller inspection conditions, etc.

.2 Wind shielding of the pier can be considered for the calculation of the side-projected area A_1 unless the ship is intended to be regularly moored to jetty-type piers. A height of the pier surface of 3 m above the waterline may be assumed, i.e. the lower part of the side-projected area with a height of 3 m above the waterline for the considered loading condition may be disregarded for the calculation of the side-projected area A_1.

.3 Deck cargoes as given by the loading manual should be included for the determination of side-projected area A_1. Deck cargo may not need to be considered if a usual light draft condition without cargo on deck generates a larger side-projected area A_1 than the full load condition with cargo on deck. The larger of both side-projected areas should be chosen as side-projected area A_1.

3.1.3 The mooring lines as given hereunder are based on a maximum current speed of 1.0 m/s and the following maximum wind speed v_w, in m/s:

v_w = 25.0 - 0.002 (A_1 – 2,000) for passenger ships, ferries and car carriers with 2,000 m^2 < A_1 ≤ 4,000 m^2

= 21.0 for passenger ships, ferries and car carriers with A_1 > 4,000 m^2

= 25.0 for other ships

3.1.4 The wind speed is considered representative of a 30 second mean speed from any direction and at a height of 10 m above the ground. The current speed is considered representative of the maximum current speed acting on bow or stern (±10°) and at a depth of one-half of the mean draft. Furthermore, it is considered that ships are moored to solid piers that provide shielding against cross current.

3.1.5 Additional loads caused by, for example, higher wind or current speeds, cross currents, additional wave loads or reduced shielding from non-solid piers may need to be particularly considered. Furthermore, it should be observed that unbeneficial mooring layouts can considerably increase the loads on single mooring lines.

3.2 Ship design minimum breaking load

3.2.1 The ship design minimum breaking load, in kN, of the mooring lines should be taken as:

$$MBL_{SD} = 0.1 \cdot A_1 + 350$$

3.2.2 The ship design minimum breaking load may be limited to 1,275 kN (130 t). However, in this case the moorings are to be considered as not sufficient for environmental conditions given by A.3.1.3. For these ships, the acceptable wind speed v_w,* in m/s, can be estimated as follows:

$$v_w^* = v_w \cdot \sqrt{\frac{MBL_{SD}^*}{MBL_{SD}}}$$

where v_w is the wind speed as per 3.1.3 above, MBL_{SD}* the breaking strength of the mooring lines intended to be supplied and MBL_{SD} the breaking strength as recommended according to the above formula. However, the ship design minimum breaking load should not be taken less than corresponding to an acceptable wind speed of 21 m/s:

$$MBL_{SD}^* \geq \left(\frac{21}{v_w}\right)^2 \cdot MBL_{SD}$$

3.2.3 If lines are intended to be supplied for an acceptable wind speed v_w* higher than v_w as per 3.1.3, the ship design minimum breaking load should be taken as:

$$MBL_{SD}^* = \left(\frac{v_w^*}{v_w}\right)^2 \cdot MBL_{SD}$$

3.3 Number of mooring lines

3.3.1 The total number of head, stern and breast lines should be taken as:

$$n = 8.3 \cdot 10^{-4} \cdot A_1 + 6$$

3.3.2 For oil tankers, chemical tankers, bulk carriers and ore carriers, the total number of head, stern and breast lines should be taken as:

$$n = 8.3 \cdot 10^{-4} \cdot A_1 + 4$$

3.3.3 The total number of head, stern and breast lines should be rounded to the nearest whole number.

3.3.4 The number of head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the strength of the lines. The adjusted strength, MBL_{SD},** should be taken as:

$MBL_{SD}^{**} = 1.2 \cdot MBL_{SD} \cdot n/n^{**} \leq MBL_{SD}$ for increased number of lines,

$MBL_{SD}^{**} = MBL_{SD} \cdot n/n^{**}$ for reduced number of lines,

where MBL_{SD} is MBL_{SD} or MBL_{SD}^* specified in 3.2, as appropriate; n** is the increased or decreased total number of head, stern and breast lines and n the number of lines for the considered ship type as calculated according to 3.3.1 or 3.3.2 without rounding.

3.3.5 Vice versa, the strength of head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the number of lines.

3.3.6 The total number of spring lines should be taken not less than:

two lines where EN < 5,000; and

four lines where EN ≥ 5,000.

3.3.7 The strength of spring lines should be the same as that of the head, stern and breast lines. If the number of head, stern and breast lines is increased in conjunction with an adjustment to the strength of the lines, the number of spring lines should be taken as follows, but rounded up to the nearest even number:

$$n_S^* = MBL_{SD} / MBL_{SD}^{**} \cdot n_S$$

where MBL_{SD} is MBL_{SD} or MBL_{SD}^* specified in 3.2, as appropriate, MBL_{SD}^{**} the adjusted strength of lines as specified in 3.3.4, n_S the number of spring lines as given in 3.3.6 and n_S^* the increased number of spring lines.

APPENDIX B

EQUIPMENT NUMBER

The equipment number (EN) should be calculated as follows:

$$EN = \Delta^{2/3} + 2.0hB + \frac{A}{10}$$

where:

Δ= Moulded displacement, in tonnes, to the Summer Load Waterline.

B = Moulded breadth, in metres.

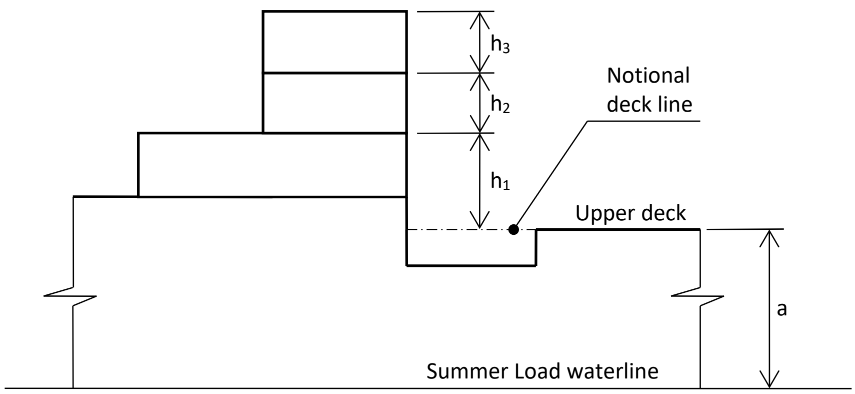
h = Effective height, in metres, from the Summer Load Waterline to the top of the uppermost house; for the lowest tier 'h' should be measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck (see figure below for an example).

$h = a + \Sigma h_i$

a = Distance, in metres, from the Summer Load Waterline amidships to the upper deck.

hi = Height, in metres, on the centreline of each tier of houses having a breadth greater than B/4.

A = Side-projected area, in square metres, of the hull, superstructures and houses above the Summer Load Waterline which are within the equipment length of the ship and also have a breadth greater than B/4.

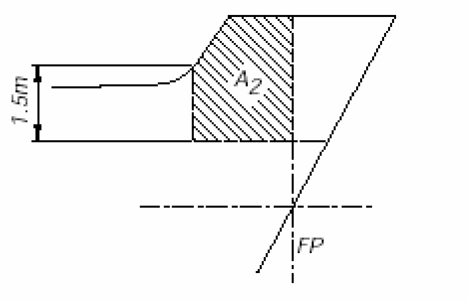


NOTES:

1 When calculating h, sheer and trim should be ignored, i.e. h is the sum of freeboard amidships plus the height (at centreline) of each tier of houses having a breadth greater than B/4.

2 If a house having a breadth greater than B/4 is above a house with a breadth of B/4 or less, then the wide house should be included but the narrow house ignored.

3 Screens or bulwarks 1.5 metres or more in height should be regarded as parts of houses when determining h and A. The height of the hatch coamings and that of any deck cargo, such as containers, may be disregarded when determining h and A. With regard to determining A, when a bulwark is more than 1.5 metres high, the area shown below as A2 should be included in A.



4 The equipment length of the ships is the length between perpendiculars but should not be less than 96% nor greater than 97% of the extreme length on the Summer Waterline (measured from the forward end of the waterline).

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MSC.1/Circ.1353/Rev.2
7 December 2020

REVISED GUIDELINES FOR THE PREPARATION OF THE CARGO SECURING MANUAL

1 In accordance with regulations VI/5 and VII/5 of the 1974 SOLAS Convention, cargo units and cargo transport units shall be loaded, stowed and secured throughout a voyage in accordance with the Cargo Securing Manual approved by the Administration, which shall be drawn up to a standard at least equivalent to the guidelines developed by the Organization.

2 The Maritime Safety Committee, at its eighty-seventh session (12 to 21 May 2010), considered a proposal by the Sub-Committee on Dangerous Goods, Solid Cargoes and Containers (DSC), at its fourteenth session (21 to 25 September 2009), and approved MSC.1/Circ.1353/Rev.1 on *Revised guidelines for the preparation of the Cargo Securing Manual*.

3 These Revised Guidelines were based on the provisions contained in the annex to MSC/Circ.745 but have been expanded to include safe access for lashing of containers, taking into account the provisions of the *Code of Safe Practice for Cargo Stowage and Securing* (CSS Code). They are of a general nature and intended to provide guidance on the preparation of Cargo Securing Manuals required on all types of ships engaged in the carriage of cargoes other than solid and liquid bulk cargoes.

4 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), agreed to amend the Revised Guidelines, in conjunction with the approval of amendments to the CSS Code (MSC.1/Circ.1623) and approved *Revised guidelines for the preparation of the Cargo Securing Manual*, as set out in the annex.

5 Member Governments are invited to bring these Guidelines to the attention of all parties concerned, with the aim of having Cargo Securing Manuals carried on board ships prepared appropriately and in a consistent manner, and to:

.1 apply the Revised Guidelines in their entirety to containerships* the keels of which were laid or which were at a similar stage of construction on or after 1 January 2015; and

* As approved by the Maritime Safety Committee at its ninety-fourth session (17 to 21 November 2014), reference to containerships means dedicated containerships and those parts of other ships for which arrangements are specifically designed and fitted for the purpose of carrying containers on deck.

.2 apply chapters 1 to 4 of the Revised Guidelines to existing containerships* the keels of which were laid or which were at a similar stage of construction before 1 January 2015.

6 This circular supersedes MSC.1/Circ.1353/Rev.1.

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ANNEX

REVISED GUIDELINES FOR THE PREPARATION OF THE CARGO SECURING MANUAL

PREAMBLE

1 In accordance with the *International Convention for the Safety of Life at Sea, 1974* (SOLAS) chapters VI, VII and the *Code of Safe Practice for Cargo Stowage and Securing* (CSS Code), cargo units, including containers, shall be stowed and secured throughout the voyage in accordance with a Cargo Securing Manual approved by the Administration.

2 The Cargo Securing Manual is required on all types of ships engaged in the carriage of all cargoes other than solid and liquid bulk cargoes.

3 The purpose of these Guidelines is to ensure that Cargo Securing Manuals cover all relevant aspects of cargo stowage and securing and to provide a uniform approach to the preparation of Cargo Securing Manuals, their layout and content. Administrations may continue accepting Cargo Securing Manuals drafted in accordance with *Containers and cargoes (BC) – Cargo Securing Manual* (MSC/Circ.385) provided that they satisfy the requirements of these Guidelines.

4 If necessary, those manuals should be revised explicitly when the ship is intended to carry containers in a standardized system.

5 It is important that securing devices meet acceptable functional and strength criteria applicable to the ship and its cargo. It is also important that the officers on board are aware of the magnitude and direction of the forces involved and the correct application and limitations of the cargo securing devices. The crew and other persons employed for the securing of cargoes should be instructed in the correct application and use of the cargo securing devices on board the ship.

CHAPTER 1

GENERAL

1.1 Definitions

1.1.1 *Cargo securing devices* are all fixed and portable devices used to secure and support cargo units.

1.1.2 *Maximum securing load (MSL)* is a term used to define the allowable load capacity for a device used to secure cargo to a ship. *Safe working load (SWL)* may be substituted for MSL for securing purposes, provided this is equal to or exceeds the strength defined by MSL.

1.1.3 *Standardized cargo* means cargo for which the ship is provided with an approved securing system based upon cargo units of specific types.

1.1.4 *Semi-standardized cargo* means cargo for which the ship is provided with a securing system capable of accommodating a limited variety of cargo units, such as vehicles and trailers.

1.1.5 *Non-standardized cargo* means cargo which requires individual stowage and securing arrangements.

1.2 Preparation of the manual

The Cargo Securing Manual should be developed, taking into account the recommendations given in these Guidelines, and should be written in the working language or languages of the ship. If the language or languages used is not English, French or Spanish, a translation into one of these languages should be included.

1.3 General information

This chapter should contain the following general statements:

.1 "The guidance given herein should by no means rule out the principles of good seamanship, neither can it replace experience in stowage and securing practice.";

.2 "The information and requirements set forth in this manual are consistent with the requirements of the vessel's trim and stability booklet, International Load Line Certificate (1966), the hull strength loading manual (if provided) and with the requirements of the *International Maritime Dangerous Goods* (IMDG) *Code* (if applicable).";

.3 "This Cargo Securing Manual specifies arrangements and cargo securing devices provided on board the ship for the correct application to and the securing of cargo units, containers, vehicles and other entities, based on transverse, longitudinal and vertical forces which may arise during adverse weather and sea conditions.";

.4 "It is imperative to the safety of the ship and the protection of the cargo and personnel that the securing of the cargo is carried out properly and that only appropriate securing points or fittings should be used for cargo securing.";

.5 "The cargo securing devices mentioned in this manual should be applied so as to be suitable and adapted to the quantity, type of packaging and physical properties of the cargo to be carried. When new or alternative types of cargo securing devices are introduced, the Cargo Securing Manual should be revised accordingly. Alternative cargo securing devices introduced should not have less strength than the devices being replaced.";

.6 "There should be a sufficient quantity of reserve cargo securing devices on board the ship.";

.7 "Information on the strength and instructions for the use and maintenance of each specific type of cargo securing device, where applicable, is provided in this manual. The cargo securing devices should be maintained in a satisfactory condition. Items worn or damaged to such an extent that their quality is impaired should be replaced."; and

.8 The Cargo Safe Access Plan (CSAP) is intended to provide detailed information for persons engaged in work connected with cargo stowage and securing. Safe access should be provided and maintained in accordance with this plan.

CHAPTER 2

SECURING DEVICES AND ARRANGEMENTS

2.1 Specification for fixed cargo securing devices

This section should indicate and where necessary illustrate the number, locations, type and MSL of the fixed devices used to secure cargo and should as a minimum contain the following information:

.1 a list and/or plan of the fixed cargo securing devices, which should be supplemented with appropriate documentation for each type of device as far as practicable. The appropriate documentation should include information as applicable regarding:

  .1 name of manufacturer;

  .2 type designation of item with simple sketch for ease of identification;

  .3 material(s);

  .4 identification marking;

  .5 strength test result or ultimate tensile strength test result;

  .6 result of non-destructive testing; and

  .7 maximum securing load (MSL);

.2 fixed securing devices on bulkheads, web frames, stanchions, etc. and their types (e.g. pad eyes, eyebolts), where provided, including their MSL;

.3 fixed securing devices on decks and their types (e.g. elephant feet fittings, container fittings, apertures) where provided, including their MSL;

.4 fixed securing devices on deckheads, where provided, listing their types and MSL; and

.5 for existing ships with non-standardized fixed securing devices, the information on MSL and location of securing points is deemed sufficient.

2.2 Specification for portable cargo securing devices

This section should describe the number of and the functional and design characteristics of the portable cargo securing devices carried on board the ship, and should be supplemented by suitable drawings or sketches if deemed necessary. It should contain the following information as applicable:

.1 a list for the portable securing devices, which should be supplemented with appropriate documentation for each type of device, as far as practicable; the appropriate documentation should include information as applicable regarding:

  .1 name of manufacturer;

.2 type designation of item with simple sketch for ease of identification;

.3 material(s), including minimum safe operational temperature;

.4 identification marking;

.5 strength test result or ultimate tensile strength test result;

.6 result of non-destructive testing; and

.7 maximum securing load (MSL);

.2 container stacking fittings, container deck securing fittings, fittings for interlocking of containers, bridge-fittings, etc. their MSL and use;

.3 chains, wire lashings, rods, etc. their MSL and use;

.4 tensioners (e.g. turnbuckles, chain tensioners), their MSL and use;

.5 securing gear for cars, if appropriate, and other vehicles, their MSL and use;

.6 trestles and jacks, etc. for vehicles (trailers) where provided, including their MSL and use; and

.7 anti-skid material (e.g. soft boards) for use with cargo units having low frictional characteristics.

2.3 Inspection and maintenance schemes

This section should describe inspection and maintenance schemes of the cargo securing devices on board the ship.

2.3.1 Regular inspections and maintenance should be carried out under the responsibility of the master. Cargo securing devices inspections as a minimum should include:

.1 routine visual examinations of components being utilized; and

.2 periodic examinations/re-testing as required by the Administration; when required, the cargo securing devices concerned should be subjected to inspections by the Administration.

2.3.2 This section should document actions to inspect and maintain the ship's cargo securing devices. Entries should be made in a record book, which should be kept with the Cargo Securing Manual. This record book should contain the following information:

.1 procedures for accepting, maintaining and repairing or rejecting cargo securing devices; and

.2 record of inspections.

2.3.3 This section should contain information for the master regarding inspections and adjustment of securing arrangements during the voyage.

2.3.4 Computerized maintenance procedures may be referred to in this section.

CHAPTER 3

STOWAGE AND SECURING OF NON-STANDARDIZED AND SEMI-STANDARDIZED CARGO

3.1 Handling and safety instructions

This section should contain:

.1 instructions on the proper handling of the securing devices; and

.2 safety instructions related to handling of securing devices and to securing and unsecuring of units by ship or shore personnel.

3.2 Evaluation of forces acting on cargo units

This section should contain the following information:

.1 tables or diagrams giving a broad outline of the accelerations which can be expected in various positions on board the ship in adverse sea conditions and with a range of applicable metacentric height (GM) values;

.2 examples of the forces acting on typical cargo units when subjected to the accelerations referred to in paragraph 3.2.1 and angles of roll and metacentric height (GM) values above which the forces acting on the cargo units exceed the permissible limit for the specified securing arrangements as far as practicable;

.3 examples of how to calculate number and strength of portable securing devices required to counteract the forces referred to in 3.2.2 as well as safety factors to be used for different types of portable cargo securing devices; calculations may be carried out according to annex 13 to the CSS Code or methods accepted by the Administration;

.4 it is recommended that the designer of a Cargo Securing Manual convert the calculation method used into a form suiting the particular ship, its securing devices and the cargo carried; this form may consist of applicable diagrams, tables or calculated examples; and

.5 other operational arrangements such as electronic data processing (EDP) or use of a loading computer may be accepted as alternatives to the requirements of paragraphs 3.2.1 to 3.2.4 above, providing that this system contains the same information.

3.3 Application of portable securing devices on various cargo units, vehicles and stowage blocks

3.3.1 This section should draw the master's attention to the correct application of portable securing devices, taking into account the following factors, as reflected in annex 13 of the CSS Code:

.1 duration of the voyage;

.2 geographical area of the voyage with particular regard to the minimum safe operational temperature of the portable securing devices;

.3 sea conditions which may be expected;

.4 dimensions, design and characteristics of the ship;

.5 expected static and dynamic forces during the voyage;

.6 type and packaging of cargo units including vehicles;

.7 intended stowage pattern of the cargo units including vehicles; and

.8 mass and dimensions of the cargo units and vehicles.

3.3.2 This section should describe the application of portable cargo securing devices as to number of lashings and allowable lashing angles. Where necessary, the text should be supplemented by suitable drawings or sketches to facilitate the correct understanding and proper application of the securing devices to various types of cargo and cargo units. It should be pointed out that for certain cargo units and other entities with low friction resistance, it is advisable to place soft boards or other anti-skid material under the cargo to increase friction between the deck and the cargo.

3.3.3 This section should contain guidance as to the recommended location and method of stowing and securing of containers, trailers and other cargo carrying vehicles, palletized cargoes, unit loads and single cargo items (e.g. woodpulp, paper rolls), heavy weight cargoes, cars and other vehicles.

3.3.4 When weather-dependent lashing is applied, operational procedures should be developed in accordance with annex 13 of the CSS Code.

3.4 Supplementary requirements for ro-ro ships

3.4.1 The manual should contain sketches showing the layout of the fixed securing devices with identification of strength (MSL) as well as longitudinal and transverse distances between securing points. In preparing this section further guidance should be utilized from IMO Assembly resolutions A.533(13) and A.581(14), as appropriate.

3.4.2 In designing securing arrangements for cargo units, including vehicles and containers, on ro-ro passenger ships and specifying minimum strength requirements for securing devices used, forces due to the motion of the ship, angle of heel after damage or flooding and other considerations relevant to the effectiveness of the cargo securing arrangement should be taken into account.

3.5 Bulk carriers

If bulk carriers carry cargo units falling within the scope of chapter VI/5 or chapter VII/5 of the SOLAS Convention, this cargo shall be stowed and secured in accordance with a Cargo Securing Manual, approved by the Administration.

CHAPTER 4

STOWAGE AND SECURING OF CONTAINERS AND OTHER STANDARDIZED CARGO

4.1 Handling and safety instructions

This section should contain:

.1 instructions on the proper handling of the securing devices; and

.2 safety instructions related to handling of securing devices and to securing and unsecuring of containers or other standardized cargo by ship or shore personnel.

4.2 Stowage and securing instructions

This section is applicable to any stowage and securing system (i.e. stowage within or without cellguides) for containers and other standardized cargo. On existing ships the relevant documents regarding safe stowage and securing may be integrated into the material used for the preparation of this chapter.

4.2.1 Stowage and securing plan

This section should consist of a comprehensive and understandable plan or set of plans providing the necessary overview on:

.1 longitudinal and athwartship views of under deck and on deck stowage locations of containers as appropriate;

.2 alternative stowage patterns for containers of different dimensions;

.3 maximum stack masses;

.4 permissible vertical sequences of masses in stacks;

.5 maximum stack heights with respect to approved sight lines; and

.6 application of securing devices using suitable symbols with due regard to stowage position, stack mass, sequence of masses in stack and stack height; the symbols used should be consistent throughout the Cargo Securing Manual.

4.2.2 Stowage and securing principle on deck and under deck

This section should support the interpretation of the stowage and securing plan with regard to container stowage, highlighting:

.1 the use of the specified devices; and

.2 any guiding or limiting parameters such as dimension of containers, maximum stack masses, sequence of masses in stacks, stacks affected by wind load, height of stacks.

It should contain specific warnings of possible consequences from misuse of securing devices or misinterpretation of instructions given.

4.3 Other allowable stowage patterns

4.3.1 This section should provide the necessary information for the master to deal with cargo stowage situations deviating from the general instructions addressed under section 4.2, including appropriate warnings of possible consequences from misuse of securing devices or misinterpretation of instructions given.

4.3.2 Information should be provided with regard to, inter alia:

.1 alternative vertical sequences of masses in stacks;

.2 stacks affected by wind load in the absence of outer stacks;

.3 alternative stowage of containers with various dimensions; and

.4 permissible reduction of securing effort with regard to lower stacks masses, lesser stack heights or other reasons.

4.4 Forces acting on cargo units

4.4.1 This section should present the distribution of accelerations on which the stowage and securing system is based, and specify the underlying condition of stability. Information on forces induced by wind and sea on deck cargo should be provided.

4.4.2 It should further contain information on the nominal increase of forces or accelerations with an increase of initial stability. Recommendations should be given for reducing the risk of cargo losses from deck stowage by restrictions to stack masses or stack heights, where high initial stability cannot be avoided.

CHAPTER 5

CARGO SAFE ACCESS PLAN (CSAP)

5.1 Ships which are specifically designed and fitted for the purpose of carrying containers should be provided with a Cargo Safe Access Plan (CSAP) in order to demonstrate that personnel will have safe access for container securing operations. This plan should detail arrangements necessary for conducting cargo stowage and securing in a safe manner. It should include the following for all areas to be worked by personnel:

.1 handrails;

.2 platforms;

.3 walkways;

.4 ladders;

.5 access covers;

.6 location of equipment storage facilities;

.7 lighting fixtures;

.8 container alignment on hatch covers/pedestals;

.9 fittings for specialized containers, such as reefer plugs/receptacles;

.10 first aid stations and emergency access/egress;

.11 gangways; and

.12 any other arrangements necessary for the provision of safe access.

5.2 Guidelines for specific requirements are contained in annex 14 to the CSS Code.

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MSC.1/Circ.1572/Rev.1
8 December 2020

UNIFIED INTERPRETATIONS OF SOLAS CHAPTERS II-1 AND XII, OF THE TECHNICAL PROVISIONS FOR MEANS OF ACCESS FOR INSPECTIONS (RESOLUTION MSC.158(78)) AND OF THE PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS (RESOLUTION MSC.188(79))

1 The Maritime Safety Committee, at its ninety-second session (12 to 21 June 2013), approved unified interpretations of the provisions of SOLAS chapters II-1 and XII, of the *Technical provisions for means of access for inspections* (resolution MSC.158(78)) and of the *Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers* (resolution MSC.188(79)), as set out in the annex to MSC.1/Circ.1464/Rev.1 and in Corr.1, following the recommendations made by the Sub-Committee on Ship Design and Equipment at its fifty-seventh session, with a view to ensuring a uniform approach towards the application of the provisions of SOLAS chapters II-1 and XII.

2 The Maritime Safety Committee, at its ninety-fifth session (3 to 12 June 2015), with a view to providing more specific guidance on the application of SOLAS regulation II-1/3-6.3.1, as amended, and the revised *Technical provisions for means of access for inspections* (resolution MSC.158(78)), approved amendments to the *Unified interpretations of the provisions of SOLAS chapters II-1 and XII, of the Technical provisions for means of access for inspections (resolution MSC.158(78)) and of the Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers (resolution MSC.188(79))* (MSC.1/Circ.1464/Rev.1), as prepared by the Sub-Committee on Ship Design and Construction, at its second session (16 to 20 February 2015), as set out in the annex to MSC.1/Circ.1507.

3 The Maritime Safety Committee, at its ninety-sixth session (11 to 20 May 2016), approved the unified interpretations relating to the application of SOLAS regulation II-1/3-6, as amended, and the *Revised technical provisions for means of access for inspections* (resolution MSC.158(78)), prepared by the Sub-Committee on Ship Design and Construction, at its third session (18 to 22 January 2016), as set out in the annex to MSC.1/Circ.1545, with a view to ensuring a uniform approach towards the application of the provisions of SOLAS regulation II-1/3-6. Having approved MSC.1/Circ.1545 and considered the need to consequentially amend MSC.1/Circ.1464/Rev.1 and its Corr.1, as amended by MSC.1/Circ.1507, the Committee requested the Secretariat to prepare a consolidated MSC circular containing the provisions of MSC.1/Circ.1464/Rev.1 and Corr.1, as amended by MSC.1/Circ.1507, and MSC.1/Circ.1545.

4 The Maritime Safety Committee, at its ninety-eighth session (7 to 16 June 2017), approved the unified interpretations of the provisions of SOLAS chapters II-1 and XII, of the *Revised technical provisions for means of access for inspections* (resolution MSC.158(78)) and of the *Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers* (resolution MSC.188(79)), containing the provisions of MSC.1/Circ.1464/Rev.1 and Corr.1, as amended by MSC.1/Circ.1507, and MSC.1/Circ.1545.

5 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), approved amendments to section 3, prepared by the Sub-Committee on Ship Design and Construction, at its seventh session (3 to 7 February 2020). The revised unified interpretations are set out in the annex.

6 Member States are invited to use the annexed interpretations when applying relevant provisions of SOLAS chapters II-1 and XII to ships constructed on or after 9 June 2017, and to bring them to the attention of all parties concerned.

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ANNEX

UNIFIED INTERPRETATIONS OF SOLAS CHAPTERS II-1 AND XII, OF THE TECHNICAL PROVISIONS FOR MEANS OF ACCESS FOR INSPECTIONS (RESOLUTION MSC.158(78)) AND OF THE PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS (RESOLUTION MSC.188(79))

TABLE OF CONTENTS

1 SOLAS REGULATION II-1/3-6 – ACCESS TO AND WITHIN SPACES IN, AND FORWARD OF, THE CARGO AREA OF OIL TANKERS AND BULK CARRIERS

1.1 SOLAS REGULATION II-1/3-6, SECTION 1

Interpretation

Oil tankers

This regulation is only applicable to oil tankers having integral tanks for carriage of oil in bulk, which is contained in the definition of oil in Annex I of MARPOL. Independent oil tanks can be excluded. Regulation II-1/3-6 should not normally be applied to FPSO or FSU unless the Administration decides otherwise.

Technical background

Means of access specified in the Technical provisions contained in resolution MSC.158(78) are not specific with respect to the application to integral cargo oil tanks or also to independent cargo oil tanks. Enhanced survey programme (ESP) requirements of oil tankers have been established assuming the target cargo oil tanks are integral tanks. The means of access regulated under regulation II-1/3-6 is for overall and close-up inspections as defined in regulation IX/1. Therefore it is assumed that the target cargo oil tanks are those of ESP, i.e. integral cargo tanks. Regulation II-1/3-6 is applicable to new, purpose-built FPSO or FSU if they are subject to the scope of the 2011 ESP Code (resolution A.1049(27), as amended). Considering that the principles of the *Technical provisions for means of access for inspections* (resolution MSC.158(78)) recognize that permanent means of access should be considered and provided for at the design stage so that, to the maximum extent possible, they can be made an integral part of the designed structural arrangement, regulation II-1/3-6 is not considered applicable to an FPSO/FSU that is converted from an existing tanker.

Reference

SOLAS regulation IX/1 and the 2011 ESP Code, as amended.

1.2 SOLAS REGULATION II-1/3-6, PARAGRAPH 2.1

Interpretation

Each space for which close-up inspection is not required such as fuel oil tanks and void spaces forward of cargo area, may be provided with a means of access necessary for overall survey intended to report on the overall conditions of the hull structure.

1.3 SOLAS REGULATION II-1/3-6, PARAGRAPH 2.2

Interpretation

Some possible alternative means of access are listed under paragraph 3.9 of the Technical provisions for means of access for inspections. Always subject to acceptance as equivalent by the Administration, alternative means such as an unmanned robot arm, ROVs and dirigibles with necessary equipment of the permanent means of access for overall and close-up inspections and thickness measurements of the deck head structure such as deck transverses and deck longitudinals of cargo oil tanks and ballast tanks, should be capable of:

.1 safe operation in ullage space in gas-free environment; and
.2 introduction into the place directly from a deck access.

Technical background

Innovative approaches, in particular the development of robots in place of elevated passageways, are encouraged and it is considered worthwhile to provide the functional requirement for the innovative approach.

1.4 SOLAS REGULATION II-1/3-6, PARAGRAPH 2.3

Interpretation

Inspection

The means of access arrangements, including portable equipment and attachments, should be periodically inspected by the crew or competent inspectors as and when it is going to be used to confirm that the means of access remain in serviceable condition.

Procedures

1 Any Company authorized person using the means of access should assume the role of inspector and check for obvious damage prior to using the access arrangements. Whilst using the means of access, the inspector should verify the condition of the sections used by close-up examination of those sections and note any deterioration in the provisions. Should any damage or deterioration be found, the effect of such deterioration should be assessed as to whether the damage or deterioration affects the safety for continued use of the access. Deterioration found that is considered to affect safe use should be determined as "substantial damage" and measures should be put in place to ensure that the affected section(s) are not to be further used prior to effective repair.

2 Statutory survey of any space that contains means of access should include verification of the continued effectiveness of the means of access in that space. Survey of the means of access should not be expected to exceed the scope and extent of the survey being undertaken. If the means of access is found deficient the scope of survey should be extended if this is considered appropriate.

3 Records of all inspections should be established based on the requirements detailed in the ship's Safety Management System. The records should be readily available to persons using the means of access and a copy attached to the Ship Structure Access Manual. The latest record for the portion of the means of access inspected should include as a minimum the date of the inspection, the name and title of the inspector, a confirmation signature, the sections of means of access inspected, verification of continued serviceable condition or details of any deterioration or substantial damage found. A file of permits issued should be maintained for verification.

Technical background

It is recognized that means of access may be subject to deterioration in the long term due to corrosive environment and external forces from ship motions and sloshing of liquid contained in the tank. Means of access therefore should be inspected at every opportunity of tank/space entry. The above interpretation should be contained in a section of the Ship Structure Access Manual.

1.5 SOLAS REGULATION II-1/3-6, PARAGRAPH 3.1

Interpretation

1 Access to a double-side skin space of bulk carriers may be either from a topside tank or double-bottom tank or from both.

2 The wording "not intended for the carriage of oil or hazardous cargoes" applies only to "similar compartments", i.e. safe access can be through a pump-room, deep cofferdam, pipe tunnel, cargo hold or double-hull space.

Technical background

Unless used for other purposes, the double-side skin space should be designed as a part of a large U-shaped ballast tank and such space should be accessed through the adjacent part of the tank, i.e. topside tank or double-bottom/bilge hopper tank. Access to the double-side skin space from the adjacent part rather than direct from the open deck is justified. Any such arrangement should provide a directly routed, logical and safe access that facilitates easy evacuation of the space.

1.6 SOLAS REGULATION II-1/3-6, PARAGRAPH 3.2

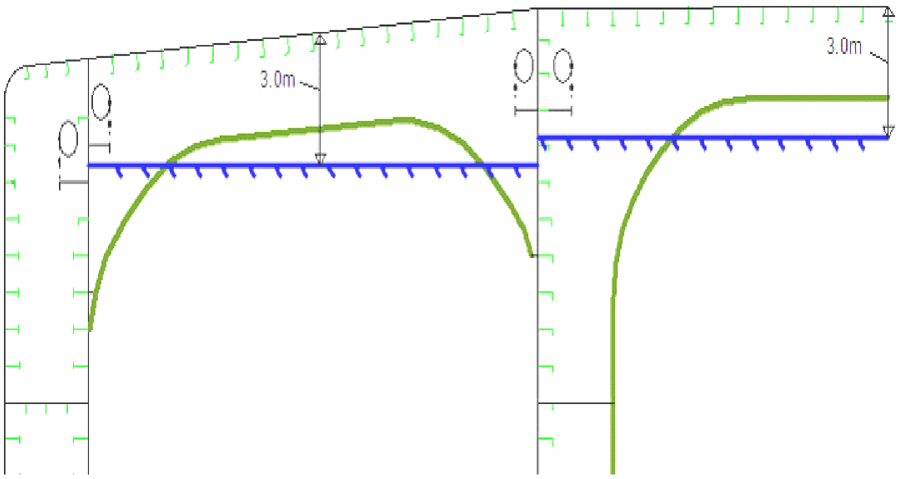
Interpretation

1 A cargo oil tank of less than 35 m length without a swash bulkhead requires only one access hatch.

2 Where rafting is indicated in the ship structures access manual as the means to gain ready access to the under-deck structure, the term "*similar obstructions*" referred to in the regulation includes internal structures (e.g. webs > 1.5 m deep) which restrict the ability to raft (at the maximum water level needed for rafting of under-deck structure) directly to the nearest access ladder and hatchway to deck. When rafts or boats alone, as an alternative means of access, are allowed under the conditions specified in the 2011 ESP Code, permanent means of access are to be provided to allow safe entry and exit. This means:

.1 access direct from the deck via a vertical ladder and small platform fitted approximately 2 m below the deck in each bay; or

.2 access to the deck from a longitudinal permanent platform having ladders to the deck in each end of the tank. The platform should, for the full length of the tank, be arranged in level with, or above, the maximum water level needed for rafting of the under-deck structure. For this purpose, the ullage corresponding to the maximum water level should not be assumed more than 3 m from the deck plate measured at the midspan of deck transverses and in the middle length of the tank (see figure below). A permanent means of access from the longitudinal permanent platform to the water level indicated above should be fitted in each bay (e.g. permanent rungs on one of the deck webs inboard of the longitudinal permanent platform).



1.7 SOLAS REGULATION II-1/3-6, PARAGRAPH 4.1

Interpretation

1 The access manual should address spaces listed in paragraph 3 of regulation II-1/3-6. As a minimum the English version should be provided. The ship structure access manual should contain at least the following two parts:

Part 1: Plans, instructions and inventory required by paragraphs 4.1.1 to 4.1.7 of regulation II-1/3-6. This part should be approved by the Administration or the organization recognized by the Administration.

Part 2: Form of record of inspections and maintenance, and change of inventory of portable equipment due to additions or replacement after construction. This part should be approved for its form only at new building.

2 The following matters should be addressed in the ship structure access manual:

.1 the access manual should clearly cover scope as specified in the regulations for use by crews, surveyors and port State control officers;

.2 approval/re-approval procedure for the manual, i.e. any changes of the permanent, portable, movable or alternative means of access within the scope of the regulation and the Technical provisions are subject to review and approval by the Administration or by the organization recognized by the Administration;

.3 verification of means of access should be part of the safety construction survey for continued effectiveness of the means of access in that space which is subject to the statutory survey;

.4 inspection of means of access by the crew and/or a competent inspector of the company as a part of regular inspection and maintenance (see interpretation of paragraph 2.3 of regulation II-1/3-6);

.5 actions to be taken if means of access is found unsafe to use; and

.6 in case of use of portable equipment plans showing the means of access within each space indicating from where and how each area in the space can be inspected.

1.8 SOLAS REGULATION II-1/3-6, PARAGRAPH 4.2

Interpretation

1 Critical structural areas should be identified by advanced calculation techniques for structural strength and fatigue performance, if available, and feedback from the service history and design development of similar or sister ships.

2 Reference should be made to the following publications for critical structural areas, where applicable:

.1 oil tankers: Guidance Manual for Tanker Structures by TSCF;

.2 bulk carriers: Bulk Carriers Guidelines for Surveys, Assessment and Repair of Hull Structure by IACS; and

.3 oil tankers and bulk carriers: the 2011 ESP Code (resolution A.1049(27), as amended).

Technical background

These documents contain the relevant information for the present ship types. However, identification of critical areas for new double-hull tankers and double-side skin bulk carriers of improved structural design should be made by structural analysis at the design stage, this information should be taken into account to ensure appropriate access to all identified critical areas.

1.9 SOLAS REGULATION II-1/3-6, PARAGRAPH 5.1

Interpretation

The minimum clear opening of 600 mm x 600 mm may have corner radii up to 100 mm maximum. The clear opening is specified in MSC/Circ.686/Rev.1 to keep the opening fit for passage of personnel wearing a breathing apparatus. In such a case where, as a consequence of structural analysis of a given design the stress should be reduced around the opening, it is considered appropriate to take measures to reduce the stress such as making the opening larger with increased radii, e.g. 600 x 800 with 300 mm radii, in which a clear opening of 600 x 600 mm with corner radii up to 100 mm maximum fits.

Technical background

The interpretation is based upon the established Guidelines in MSC/Circ.686/Rev.1.

Reference

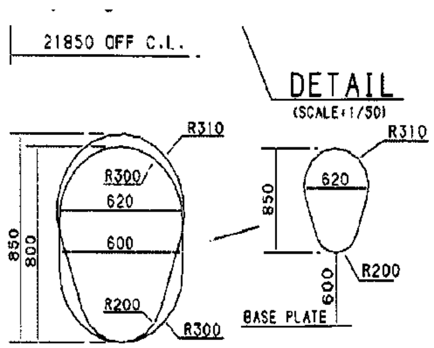
Paragraph 9 of the annex to MSC/Circ.686/Rev.1.

1.10 SOLAS REGULATION II-1/3-6, PARAGRAPH 5.2

Interpretation

1 The minimum clear opening of not less than 600 mm x 800 mm may also include an opening with corner radii of 300 mm. An opening of 600 mm in height x 800 mm in width may be accepted as access openings in vertical structures where it is not desirable to make large openings in the structural strength aspects, i.e. girders and floors in double-bottom tanks.

2 Subject to verification of easy evacuation of an injured person on a stretcher the vertical opening 850 mm x 620 mm with wider upper half than 600 mm, while the lower half may be less than 600 mm with the overall height not less than 850 mm is considered an acceptable alternative to the traditional opening of 600 mm x 800 mm with corner radii of 300 mm.



3 If a vertical opening is at a height of more than 600 mm steps then handgrips should be provided. In such arrangements it should be demonstrated that an injured person can be easily evacuated.

Technical background

The interpretation is based upon the established Guidelines in MSC/Circ.686/Rev.1 and an innovative design is considered for easy access by humans through the opening.

Reference

Paragraph 11 of the annex to MSC/Circ.686/Rev.1.

2 TECHNICAL PROVISIONS FOR MEANS OF ACCESS FOR INSPECTIONS (RESOLUTION MSC.158(78))

2.1 PARAGRAPH 1.3

Interpretation

A "combined chemical/oil tanker complying with the provisions of the IBC Code" is a tanker that holds both a valid IOPP certificate as a tanker and a valid certificate of fitness for the carriage of dangerous chemicals in bulk, i.e. a tanker that is certified to carry both oil cargoes under MARPOL Annex I and Chemical cargoes in chapter 17 of the IBC Code either as full or part cargoes. The Technical provisions should be applied to ballast tanks of combined chemical/oil tankers complying with the provisions of the IBC Code.

2.2 PARAGRAPH 1.4

Interpretation

1 In the context of the above requirement, the deviation should be applied only to distances between integrated permanent means of access that are the subject of paragraph 2.1.2 of table 1.

2 Deviations should not be applied to the distances governing the installation of under-deck longitudinal walkways and dimensions that determine whether permanent access is required or not, such as height of the spaces and height to elements of the structure (e.g. cross-ties).

2.3 PARAGRAPH 3.1

Interpretation

The permanent means of access to a space can be credited for the permanent means of access for inspection.

Technical background

The Technical provisions specify means of access to a space and to hull structure for carrying out overall and close-up surveys and inspections. Requirements of means of access to hull structure may not always be suitable for access to a space. However, if the means of access to a space can also be used for the intended surveys and inspections such means of access can be credited for the means of access for use for surveys and inspections.

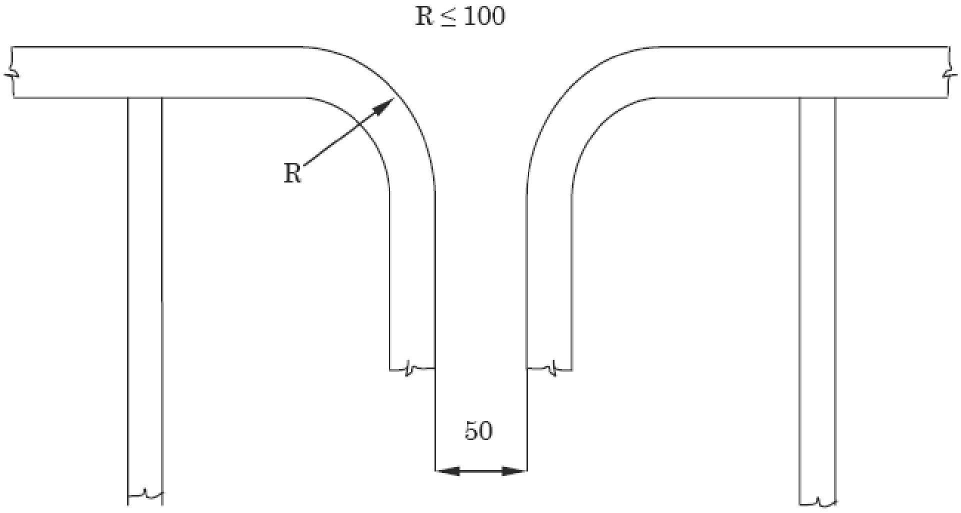
2.4 PARAGRAPH 3.3

Interpretation

1 Sloping structures are structures that are sloped by 5 or more degrees from horizontal plane when a ship is in an upright position at even-keel.

2 Guard rails should be fitted on the open side and should be at least 1,000 mm in height. For stand-alone passageways guard rails should be fitted on both sides of these structures. Guardrail stanchions are to be attached to the permanent means of access. The distance between the passageway and the intermediate bar and the distance between the intermediate bar and the top rail should not be more than 500 mm.

3 Discontinuous top handrails are allowed, provided the gap does not exceed 50 mm. The same maximum gap is to be considered between the top handrail and other structural members (i.e. bulkhead, web frame, etc.). The maximum distance between the adjacent stanchions across the handrail gaps is to be 350 mm where the top and mid handrails are not connected together and 550 mm when they are connected together. The maximum distance between the stanchion and other structural members is not to exceed 200 mm where the top and mid handrails are not connected together and 300 mm when they are connected together. When the top and mid handrails are connected by a bent rail, the outside radius of the bent part is not to exceed 100 mm (see figure below).



4 Non-skid construction is such that the surface on which personnel walks provides sufficient friction to the sole of boots even if the surface is wet and covered with thin sediment.

5 "Substantial construction" is taken to refer to the as-designed strength as well as the residual strength during the service life of the vessel. Durability of passageways together with guard rails should be ensured by the initial corrosion protection and inspection and maintenance during services.

6 For guard rails, use of alternative materials such as GRP should be subject to compatibility with the liquid carried in the tank. Non-fire resistant materials should not be used for means of access to a space with a view to securing an escape route at a high temperature.

7 Requirements for resting platforms placed between ladders should be equivalent to those applicable to elevated passageways.

Reference

Paragraph 10 of the annex to MSC/Circ.686/Rev.1.

2.5 PARAGRAPH 3.4

Interpretation

Where the vertical manhole is at a height of more than 600 mm above the walking level, it should be demonstrated that an injured person can be easily evacuated.

2.6 PARAGRAPH 3.5

Interpretation

Means of access to ballast tanks, cargo tanks and spaces other than fore peak tanks:

For oil tankers:

1 Tanks and subdivisions of tanks having a length of 35 m or more with two access hatchways:

First access hatchway: Inclined ladder or ladders should be used.

Second access hatchway:

.1 A vertical ladder may be used. In such a case where the vertical distance is more than 6 m, vertical ladders should comprise one or more ladder-linking platforms spaced not more than 6 m apart vertically and displaced to one side of the ladder.

The uppermost section of the vertical ladder, measured clear of the overhead obstructions in the way of the tank entrance, should not be less than 2.5 m but not exceed 3.0 m and should comprise a ladder-linking platform which should be displaced to one side of a vertical ladder. However, the vertical distance of the uppermost section of the vertical ladder may be reduced to 1.6 m, measured clear of the overhead obstructions in the way of the tank entrance, if the ladder lands on a longitudinal or athwartship permanent means of access fitted within that range. Adjacent sections of the ladder should be laterally offset from each other by at least the width of the ladder (see paragraph 20 of MSC/Circ.686/Rev.1 and refer to the interpretation of paragraphs 3.13.2 and 3.13.6 of the Technical provisions (resolution MSC.158(78))); or

.2 Where an inclined ladder or combination of ladders is used for access to the space, the uppermost section of the ladder, measured clear of the overhead obstructions in the way of the tank entrance, should be vertical for not less than 2.5 m but not exceed 3.0 m and should comprise a landing platform continuing with an inclined ladder. However, the vertical distance of the uppermost section of the vertical ladder may be reduced to 1.6 m, measured clear of the overhead obstructions in the way of the tank entrance, if the ladder lands on a longitudinal or athwartship permanent means of access fitted within that range. The flights of the inclined ladders are normally to be not more than 6 m in vertical height. The lowermost section of the ladders may be vertical for the vertical distance not exceeding 2.5 m.

2 Tanks less than 35 m in length and served by one access hatchway: an inclined ladder or combination of ladders should be used to the space as specified in 1.2 above.

3 In spaces of less than 2.5 m in width the access to the space may be by means of vertical ladders that comprise one or more ladder-linking platforms spaced not more than 6 m apart vertically and displaced to one side of the ladder. The uppermost section of the vertical ladder, measured clear of the overhead obstructions in the way of the tank entrance, should not be less than 2.5 m but not exceed 3.0 m and should comprise a ladder-linking platform which should be displaced to one side of a vertical ladder. However, the vertical distance of the uppermost section of the vertical ladder may be reduced to 1.6 m, measured clear of the overhead obstructions in the way of the tank entrance, if the ladder lands on a longitudinal or athwartship permanent means of access fitted within that range. Adjacent sections of the ladder should be laterally offset from each other by at least the width of the ladder (see paragraph 20 of MSC/Circ.686/Rev.1 and refer to the interpretation of paragraphs 3.13.2 and 3.13.6 of the Technical provisions (resolution MSC.158(78))).

4 Access from the deck to a double-bottom space may be by means of vertical ladders through a trunk. The vertical distance from deck to a resting platform, between resting platforms, or a resting platform and the tank bottom should not be more than 6 m, unless otherwise approved by the Administration.

Means of access for inspection of the vertical structure of oil tankers:

Vertical ladders provided for means of access to the space may be used for access for inspection of the vertical structure.

Unless stated otherwise in table 1 of the Technical provisions, vertical ladders that are fitted on vertical structures for inspection should comprise one or more ladder-linking platforms spaced not more than 6 m apart vertically and displaced to one side of the ladder. Adjacent sections of ladder should be laterally offset from each other by at least the width of the ladder (see paragraph 20 of MSC/Circ.686/Rev.1 and refer to the interpretation of paragraphs 3.13.2 and 3.13.6 of the Technical provisions (resolution MSC.158(78))).

Obstruction distances

The minimum distance between the inclined ladder face and obstructions, i.e. 750 mm and, in the way of openings, 600 mm specified in paragraph 3.5 of the Technical provisions, should be measured perpendicular to the face of the ladder.

Technical background

It is common practice to use a vertical ladder from the deck to the first landing to clear overhead obstructions before continuing to an inclined ladder or a vertical ladder displaced to one side of the first vertical ladder.

Reference

For vertical ladders: paragraph 20 of the annex to MSC/Circ.686/Rev.1.

2.7 PARAGRAPH 3.6

Interpretation

1 The vertical height of handrails should not be less than 890 mm from the centre of the step and two course handrails need only be provided where the gap between the stringer and the top handrail is greater than 500 mm.

2 The requirement of two square bars for treads specified in paragraph 3.6 of the Technical provisions is based upon the specification of the construction of ladders in paragraph 3(e) of annex 1 to resolution A.272(VIII), which addresses inclined ladders. Paragraph 3.4 of the Technical Provisions allows for single rungs fitted to vertical surfaces, which is considered a safe grip. For vertical ladders, when steel is used, the rungs should be formed of single square bars of not less than 22 mm by 22 mm for the sake of safe grip.

3 The width of inclined ladders for access to a cargo hold should be at least 450 mm to comply with the Australian AMSA Marine Orders part 32, appendix 17.

4 The width of inclined ladders other than an access to a cargo hold should be not less than 400 mm.

5 The minimum width of vertical ladders should be 350 mm and the vertical distance between the rungs should be equal and should be between 250 mm and 350 mm.

6 A minimum climbing clearance in width should be 600 mm other than the ladders placed between the hold frames.

7 The vertical ladders should be secured at intervals not exceeding 2.5 m apart to prevent vibration.

Technical background

1 Paragraph 3.6 of the Technical provisions is a continuation of paragraph 3.5 of the Technical Provisions, which addresses inclined ladders. Interpretations for vertical ladders are needed based upon the current standards of IMO, AMSA or the industry.

2 Interpretations 2 and 5 address vertical ladders based upon the current standards.

3 Double square bars for treads become too large for a grip for vertical ladders and single rungs facilitate a safe grip.

4 Interpretation 7 is introduced consistently with the requirement and the interpretation of paragraph 3.4 of the Technical provisions.

Reference

1 Annex 1 to resolution A.272(VIII).

2 Australian AMSA Marine Orders part 32, appendix 17.

3 ILO Code of Practice *Safety and health in dock work* – section 3.6, Access to ship's hold.

2.8 PARAGRAPH 3.9.6

Interpretation

A mechanical device such as hooks for securing at the upper end of a ladder should be considered as an appropriate securing device if a movement fore/aft and sideways can be prevented at the upper end of the ladder.

Technical background

Innovative design should be accepted if it fits the functional requirement with due consideration for safe use.

2.9 PARAGRAPHS 3.10 AND 3.11

Interpretation

See interpretation for paragraphs 5.1 and 5.2 of SOLAS regulation II-1/3-6.

2.10 PARAGRAPH 3.13.1

Interpretation

1 Either a vertical or an inclined ladder or a combination of them may be used for access to a cargo hold where the vertical distance is 6 m or less from the deck to the bottom of the cargo hold.

2 Deck is defined as "weather deck".

2.11 PARAGRAPHS 3.13.2 AND 3.13.6

Adjacent sections of vertical ladder should be installed so that the following provisions are complied with:

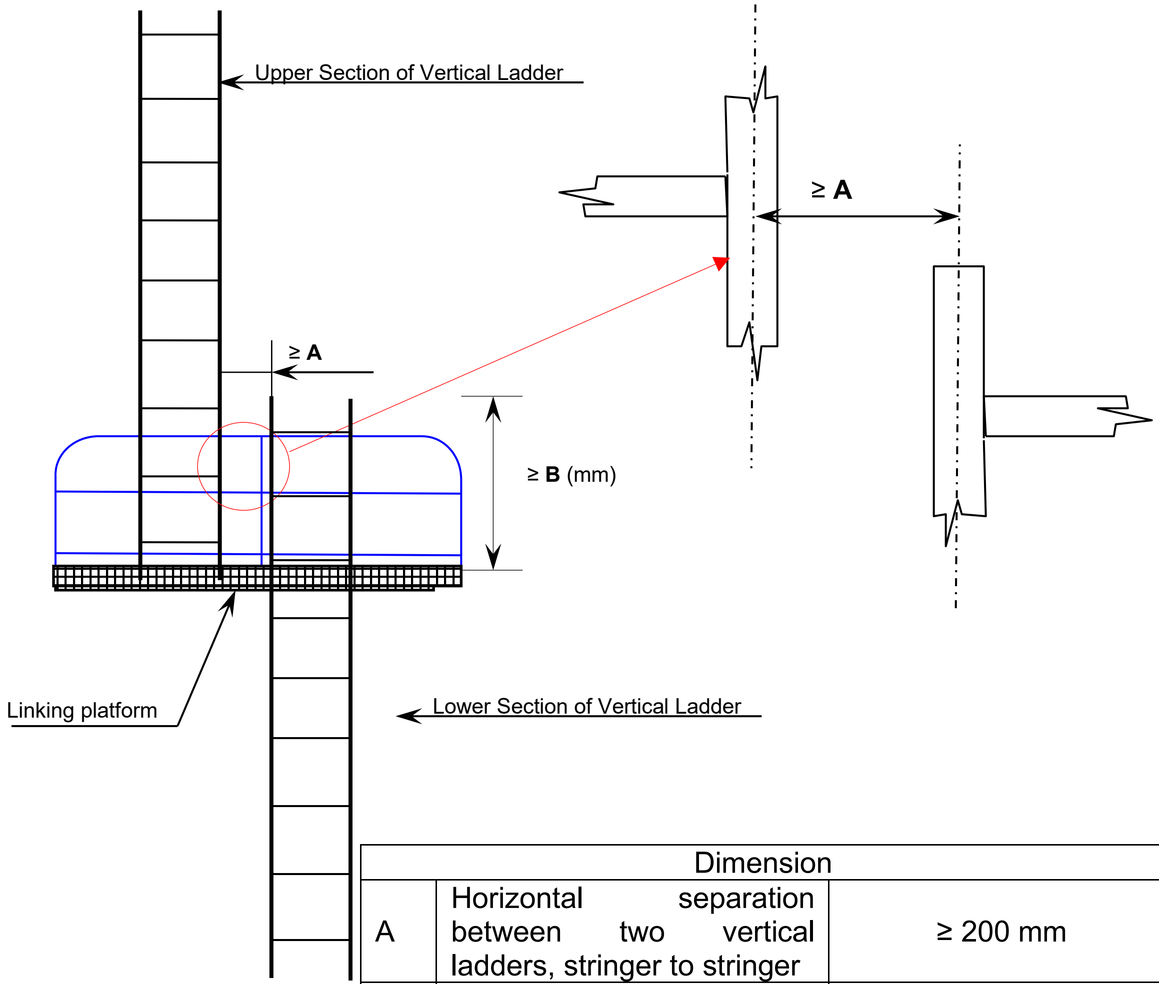
- the minimum "lateral offset" between two adjacent sections of vertical ladder, is the distance between the sections, upper and lower, so that the adjacent stringers are spaced of at least 200 mm, measured from half thickness of each stringer;

- adjacent sections of vertical ladder should be installed so that the upper end of the lower section is vertically overlapped, in respect to the lower end of the upper section, to a height of 1,500 mm in order to permit a safe transfer between ladders; and

- no section of the access ladder should be terminated directly or partly above an access opening.

Figure "A"

Vertical Ladder – Ladder through the linking platform



Dimension		
A	Horizontal separation between two vertical ladders, stringer to stringer	≥ 200 mm
B	Stringer height above landing or intermediate platform	≥ 1,500* mm
C	Horizontal separation between ladder and platform	100 mm ≤ C < 300 mm
*	The minimum height of the handrail of resting platform is 1,000 mm (paragraph 3.3 of the Technical provisions (resolution MSC.158(78)))	

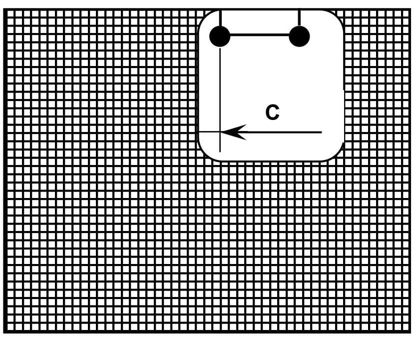
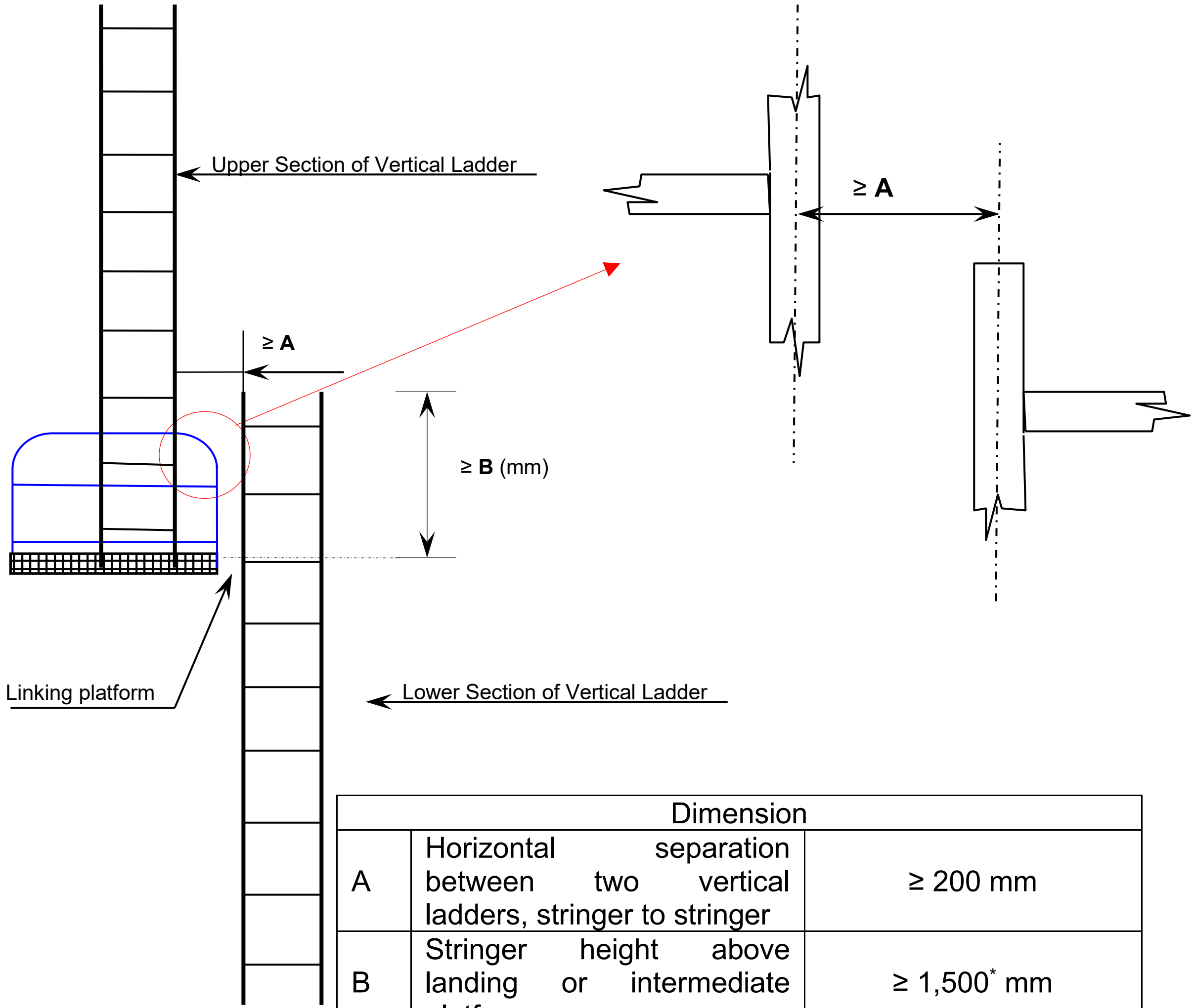
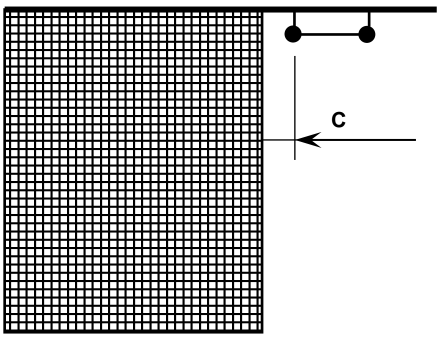


Figure "B"

Vertical Ladder – Side mount



Dimension		
A	Horizontal separation between two vertical ladders, stringer to stringer	≥ 200 mm
B	Stringer height above landing or intermediate platform	≥ 1,500* mm
C	Horizontal separation between ladder and platform	100 mm ≤ C < 300 mm
*	The minimum height of the handrail of resting platform is 1,000 mm (paragraph 3.3 of the Technical provisions, (resolution MSC.158(78)))	



2.12 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 1.1

Interpretation

1 Sub-paragraphs .1 to .3 define access to under-deck structures, access to the uppermost sections of transverse webs and connection between these structures.

2 Sub-paragraphs .4 to .6 define access to vertical structures only and are linked to the presence of transverse webs on longitudinal bulkheads.

3 If there are no under-deck structures (deck longitudinals and deck transverses) but there are vertical structures in the cargo tank supporting transverse and longitudinal bulkheads, access in accordance with sub-paragraphs .1 to .6 should be provided for inspection of the upper parts of vertical structure on transverse and longitudinal bulkheads.

4 If there is no structure in the cargo tank, section 1.1 of table 1 should not be applied.

5 Section 1 of table 1 should also be applied to void spaces in the cargo area, comparable in volume to spaces covered by SOLAS regulation II-1/3-6, except those spaces covered by section 2.

6 The vertical distance below the overhead structure should be measured from the underside of the main deck plating to the top of the platform of the means of access at a given location.

7 The height of the tank should be measured at each tank. For a tank the height of which varies at different bays, item 1.1 should be applied to such bays of a tank that have a height of 6 m and over.

Technical background

Interpretation 7, if the height of the tank is increasing along the length of a ship, the permanent means of access should be provided locally where the height is above 6 m.

Reference

Paragraph 10 of the annex to MSC/Circ.686/Rev.1.

2.13 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 1.1.2

Interpretation

There is a need to provide a continuous longitudinal permanent means of access when the deck longitudinals and deck transverses are fitted on deck but supporting brackets are fitted under the deck.

2.14 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 1.1.3

Interpretation

Means of access to tanks may be used for access to the permanent means of access for inspection.

Technical background

As a matter of principle, in such a case where the means of access can be utilized for the purpose of accessing structural members for inspection there is no need of duplicated installation of the means of access.

2.15 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 1.1.4

Interpretation

The permanent fittings required to serve alternative means of access such as wire lift platform, that should be used by crew and surveyors for inspection should provide at least an equal level of safety as the permanent means of access stated by the same paragraph. These means of access should be carried on board the ship and be readily available for use without filling of water in the tank. Therefore, rafting should not be acceptable under this provision. Alternative means of access should be part of the Ship Structure Access Manual which should be approved on behalf of the flag State. For water ballast tanks of 5 m or more in width, such as on an ore carrier, side shell plating should be considered in the same way as "longitudinal bulkhead".

2.16 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 2.1

Interpretation

Section 2 of table 1 should also be applied to wing tanks designed as void spaces. Paragraph 2.1.1 represents requirements for access to under-deck structures, while paragraph 2.1.2 is a requirement for access for survey and inspection of vertical structures on longitudinal bulkheads (transverse webs).

Technical background

SOLAS regulation II-1/3-6.2.1 requires each space to be provided with means of access. Though void spaces are not addressed in the technical provisions contained in resolution MSC.158(78), it is arguable whether means of access are not required in void spaces. Means of access or portable means of access are necessary arrangements to facilitate inspection of the structural condition of the space and the boundary structure. Therefore, the requirements of section 2 of table 1 should be applied to double-hull spaces even when designed as void spaces.

2.17 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 2.1.1

Interpretation

1 For a tank, the vertical distance between horizontal upper stringer and deck head of which varies at different sections, paragraph 2.1.1 should be applied to such sections that fall under the criteria.

2 The continuous permanent means of access may be a wide longitudinal, which provides access to critical details on the opposite side by means of platforms as necessary on web frames. In case the vertical opening of the web frame is located in the way of the open

part between the wide longitudinal and the longitudinal on the opposite side, platforms should be provided on both sides of the web frames to allow safe passage through the web frame.

3 Where two access hatches are required by SOLAS regulation II-1/3-6.3.2, access ladders at each end of the tank should lead to the deck.

Technical background

Interpretation 1: The interpretation of varied tank height in column 1 of table 1 is applied to the vertical distance between horizontal upper stringer and deck head for consistency.

2.18 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 2.1.2

Interpretation

The continuous permanent means of access may be a wide longitudinal, which provides access to critical details on the opposite side by means of platforms as necessary on web frames. In case the vertical opening of the web is located in the way of the open part between the wide longitudinal and the longitudinal on the opposite side, platforms should be provided on both sides of the web to allow safe passage through the web. A "reasonable deviation", as noted in paragraph 1.4 of the Technical provisions, of not more than 10% may be applied where the permanent means of access is integral with the structure itself.

2.19 TABLE 1 – MEANS OF ACCESS FOR BALLAST AND CARGO TANKS OF OIL TANKERS, PARAGRAPH 2.2

Interpretation

1 Permanent means of access between the longitudinal continuous permanent means of access and the bottom of the space should be provided.

2 The height of a bilge hopper tank located outside of the parallel part of the ship should be taken as the maximum of the clear vertical distance measured from the bottom plating to the hopper plating of the tank.

3 The foremost and aftmost bilge hopper ballast tanks with raised bottom, of which the height is 6 m and over, a combination of transverse and vertical means of access to the upper knuckle point for each transverse web, should be accepted in place of the longitudinal permanent means of access.

Technical background

Interpretation 2: The bilge hopper tanks at fore and aft of cargo area narrow due to raised bottom plating and the actual vertical distance from the bottom of the tank to hopper plating of the tank is more appropriate to judge if a portable means of access could be utilized for the purpose.

Interpretation 3: In the foremost or aftmost bilge hopper tanks where the vertical distance is 6 m or over but installation of longitudinal permanent means of access is not practicable, permanent means of access of combination of transverse and vertical ladders provides an alternative means of access to the upper knuckle point.

2.20 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 1.1

Interpretation

1 Means of access should be provided to the cross-deck structures of the foremost and aftermost part of each cargo hold.

2 Interconnected means of access under the cross deck for access to three locations at both sides and in the vicinity of the centreline should be acceptable as the three means of access.

3 Permanent means of access fitted at three separate locations accessible independently, one at each side and one in the vicinity of the centreline, should be acceptable.

4 Special attention should be paid to the structural strength where any access opening is provided in the main deck or cross deck.

5 The requirements for a bulk carrier cross-deck structure should also be considered applicable to ore carriers.

Technical background

Pragmatic arrangements of the means of access are provided.

2.21 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 1.3

Interpretation

Particular attention should be paid to preserve the structural strength in way of access opening provided in the main deck or cross deck.

2.22 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 1.4

Interpretation

"Full upper stools" are understood to be stools with a full extension between topside tanks and between hatch end beams.

2.23 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 1.5

Interpretation

1 The movable means of access to the under-deck structure of cross deck need not necessarily be carried on board the ship. It should be sufficient if it is made available when needed.

2 The requirements for a bulk carrier cross-deck structure should also be considered applicable to ore carriers.

2.24 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 1.6

Interpretation

The maximum vertical distance of the rungs of vertical ladders for access to hold frames should be 350 mm. If a safety harness is to be used, means should be provided for connecting the safety harness in suitable places in a practical way.

Technical background

The maximum vertical distance of the rungs of 350 mm is applied with a view to reducing trapping cargoes.

2.25 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 1.7

Interpretation

Portable, movable or alternative means of access should also be applied to corrugated bulkheads.

2.26 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 1.8

Interpretation

Readily available means able to be transported to location in cargo hold and safely erected by ships' crew.

2.27 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 2.3

Interpretation

If the longitudinal structures on the sloping plate are fitted outside of the tank, a means of access should be provided.

2.28 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 2.5

Interpretation

1 The height of a bilge hopper tank located outside of the parallel part of the vessel should be taken as the maximum of the clear vertical height measured from the bottom plating to the hopper plating of the tank.

2 It should be demonstrated that portable means for inspection can be deployed and made readily available in the areas where needed.

2.29 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 2.5.2

Interpretation

A wide longitudinal frame of at least 600 mm clear width may be used for the purpose of the longitudinal continuous permanent means of access. The foremost and aftermost bilge hopper ballast tanks with raised bottom, of which the height is 6 m and over, a combination of transverse and vertical means of access to the sloping plate of hopper tank connection with side shell plating for each transverse web can be accepted in place of the longitudinal permanent means of access.

2.30 TABLE 2 – MEANS OF ACCESS FOR BULK CARRIERS, PARAGRAPH 2.6

Interpretation

The height of web frame rings should be measured in way of side shell and tank base.

Technical background

In the bilge hopper tank the sloping plating is above the opening, while the movement of the surveyor is along the bottom of the tank. Therefore, the measurement of 1 m should be taken from the bottom of the tank.

3 SOLAS CHAPTER II-1, PARTS B-2 – SUBDIVISION, WATERTIGHT AND WEATHERTIGHT INTEGRITY AND B-4 – STABILITY MANAGEMENT

DOORS IN WATERTIGHT BULKHEADS OF PASSENGER SHIPS AND CARGO SHIPS

Interpretation

This interpretation pertains to doors[1] located in way of the internal watertight subdivision boundaries and the external watertight boundaries necessary to ensure compliance with the relevant subdivision and damage stability regulations.

This interpretation does not apply to doors located in external boundaries above equilibrium or intermediate waterplanes.

The design and testing requirements for watertight doors vary according to their location relative to the 1) equilibrium waterplane or intermediate waterplane at any stage of assumed flooding, and/or 2) bulkhead deck or freeboard deck.

1 DEFINITIONS

For the purpose of this interpretation the following definitions apply:

1.1 Watertight: Capable of preventing the passage of water in any direction under a design head. The design head for any part of a structure should be determined by reference to its location relative to the bulkhead deck or freeboard deck, as applicable, or to the most unfavourable equilibrium/intermediate waterplane, in accordance with the applicable subdivision and damage stability regulations, whichever is the greater. A watertight door is thus one that will maintain the watertight integrity of the subdivision bulkhead in which it is located.

1.2 Equilibrium waterplane: The waterplane in still water when, taking account of flooding due to an assumed damage, the weight and buoyancy forces acting on a ship are in balance. This relates to the final condition when no further flooding takes place or after cross flooding is completed.

1.3 Intermediate waterplane: The waterplane in still water, which represents the instantaneous floating position of a ship at some intermediate stage between commencement and completion of flooding when, taking account of the assumed instantaneous state of flooding, the weight and buoyancy forces acting on a ship are in balance.

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1 Doors in watertight bulkheads of small cargo ships, not subject to any statutory subdivision and damage stability requirements, may be hinged quick-acting doors arranged to open out of the major space protected. They should be constructed in accordance with the requirements of the Administration and have notices affixed to each side stating: "To be kept closed at sea".

1.4 ***Sliding door or rolling door***: A door having a horizontal or vertical motion generally parallel to the plane of the door.

1.5 ***Hinged door***: A door having a pivoting motion about one vertical or horizontal edge.

2 STRUCTURAL DESIGN

Doors and their frames should be of approved design and substantial construction in accordance with the requirements of the Administration and should preserve the strength of the subdivision bulkheads in which they are fitted.

3 OPERATION MODE, LOCATION AND OUTFITTING

Doors should be fitted in accordance with all requirements regarding their operation mode, location and outfitting, i.e. provision of controls, means of indication, etc., as shown in table 1 below. This table should be read in conjunction with paragraphs 3.1 to 5.4 below.

3.1 Frequency of use while at sea

3.1.1 Normally closed: Kept closed at sea but may be used if authorized. To be closed again after use.

3.1.2 Permanently closed: The time of opening such doors in port and of closing them before the ship leaves port should be entered in the logbook. Should such doors be accessible during the voyage, they should be fitted with a device to prevent unauthorized opening.

3.1.3 Used: Kept closed but may be opened during navigation when authorized by the Administration to permit the passage of passengers or crew, or when work in the immediate vicinity of the door necessitates it being opened. The door should be immediately closed after use.

3.2 Type

Power operated, sliding or rolling[2]	POS
Power operated, hinged	POH
Sliding or rolling	S
Hinged	H

3.3 Control

3.3.1 Local

3.3.1.1 All doors, except those which should be permanently closed at sea, should be capable of being opened and closed by hand (and by power, where applicable) locally[3] from both sides of the doors, with the ship listed to either side.

3.3.1.2 For passenger ships, the angle of list at which operation by hand should be possible is 15 degrees.

2 Rolling doors are technically identical to sliding doors.

3 Arrangements should be in accordance with regulations II-I/13.7.1.4 and II-1/13.7.1.5 for passenger ships and regulation II-I/13-1.2 for cargo ships.

3.3.1.3 For cargo ships, the angle of list at which operation by hand should be possible is 30 degrees.

3.3.2 Remote

Where indicated in table 1, doors should be capable of being remotely closed by power from the bridge[4] for all ships, and also by hand from a position above the bulkhead deck for passenger ships, as required by regulation II-1/13.7.1.4. Where it is necessary to start the power unit for operation of the watertight door, means to start the power unit should also be provided at remote control stations. The operation of such remote control should be in accordance with regulations II-1/13.8.1 to II-1/13.8.3. For tankers, where there is a permanent access from a pipe tunnel to the main pump room, in accordance with regulation II-2/4.5.2.4 the watertight door should be capable of being manually closed from outside the main pump-room entrance in addition to the requirements above.

3.4 Indication[5]

3.4.1 Where shown in table 1, position indicators should be provided at all remote operating positions for all ships and provided locally on both sides of the internal doors for cargo ships, to show whether the doors are open or closed and, if applicable, with all dogs/cleats fully and properly engaged.

3.4.2 The door position indicating system should be of self-monitoring type and the means for testing of the indicating system should be provided at the position where the indicators are fitted.

3.4.3 A diagram showing the location of the door and an indication to show its position should be provided at the central operating console located at the navigation bridge. A red light should indicate the door is in the open position and a green light should indicate the door is in the closed position. When the door is closed from this remote position, the red light should flash when the door is in an intermediate position. This applies to passenger ships and cargo ships.

3.4.4 Special care should be taken in order to avoid potential danger when passing through the door. Signboard/instructions should be placed in way of the door advising how to act when the door is in "doors closed" mode.

3.5 Alarms[6]

3.5.1 For passenger ships, failure of the normal power supply of the required alarms should be indicated by an audible and visual alarm at the central operating console at the navigation bridge. For cargo ships, failure of the normal power supply of the required alarms should be indicated by an audible and visual alarm at the navigation bridge.

3.5.2 All door types, including power-operated sliding watertight doors, which are capable of being remotely closed should be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever such a door is remotely closed. For passenger

[4] Arrangements should be in accordance with regulation II-1/13.7.1.5 for passenger ships and II 1/13-1.2 for cargo ships.

[5] Refer to regulations II-I/13, 13-1, 15 1 and 17-1, IEC 60092-504, and the Code on Alerts and Indicators, 2009 (resolution A.1021(26)).

[6] Refer to regulations II-I/13, 13-1, 15 1 and 17-1, IEC 60092-504, and the Code on Alerts and Indicators, 2009 (resolution A.1021(26)).

ships the alarm should sound for at least 5 seconds but not more than 10 seconds before the door begins to move and should continue sounding until the door is completely closed. In the case of remote closure by hand operation, an alarm should sound only while the door is actually moving.

3.5.3 In passenger areas and areas of high ambient noise, the audible alarms should be supplemented by visual signals at both sides of the doors.

3.5.4 All watertight doors, including sliding doors, operated by hydraulic door actuators, either a central hydraulic unit or an independent hydraulic unit for each door should be provided with a low fluid level alarm or low gas pressure alarm, as applicable, or some other means of monitoring loss of stored energy in the hydraulic accumulators. For passenger ships, this alarm should be both audible and visible and should be located at the central operating console at the navigation bridge. For cargo ships, this alarm should be both audible and visible and should be located at the navigation bridge.

3.6 Notices

As shown in table 1, doors which are normally closed at sea, but are not provided with means of remote closure, should have notices fixed to both sides of the doors stating: "To be kept closed at sea". Doors which should be permanently closed at sea should have notices fixed to both sides stating: "Not to be opened at sea".

3.7 Location

For passenger ships the watertight doors and their controls should be located in compliance with regulations II-1/13.5.3 and II-1/13.7.1.2.2.

4 FIRE DOORS

4.1 Watertight doors may also serve as fire doors but need not be fire-tested if fitted on cargo ships or if fitted below the bulkhead deck on passenger ships. However, such doors fitted above the bulkhead deck on passenger ships should be tested to the Fire Test Procedures (FTP) Code in accordance with the fire rating of the division they are fitted in. These doors should also comply with the means of escape provisions of regulation II-2/13. If it is not practicable to ensure self-closing, means of indication on the bridge showing whether these doors are open or closed and a notice stating "To be kept closed at sea" can be an alternative to self-closing.

4.2 Where a watertight door is located adjacent to a fire door, both doors should be capable of independent operation, remotely if required by regulations II-1/13.8.1 to II-1/13.8.3 and from both sides of each door.

5 TESTING

5.1 Doors which become immersed by an equilibrium or intermediate waterplane or are below the freeboard or bulkhead deck should be subjected to a hydrostatic pressure test.

5.2 For large doors intended for use in the watertight subdivision boundaries of cargo spaces, structural analysis may be accepted in lieu of pressure testing. Where such doors utilize gasket seals, a prototype pressure test to confirm that the compression of the gasket material is capable of accommodating any deflection, revealed by the structural analysis, should be carried out.

5.3 Doors above freeboard or bulkhead deck, which are not immersed by an equilibrium or intermediate waterplane but become intermittently immersed at angles of heel in the required range of positive stability beyond the equilibrium position, should be hose tested.

5.4 Pressure testing

5.4.1 The head of water used for the pressure test should correspond at least to the head measured from the lower edge of the door opening, at the location in which the door should be fitted in the ship, to the bulkhead deck or freeboard deck, as applicable, or to the most unfavourable damage waterplane, if that be greater. Testing may be carried out at the factory or other shore-based testing facility prior to installation in the ship.

5.4.2 Leakage criteria

5.4.2.1 The following acceptable leakage criteria should apply:

Doors with gaskets	No leakage
Doors with metallic sealing	Maximum leakage 1 litre/min

5.4.2.2 Limited leakage may be accepted for pressure tests on large doors located in cargo spaces employing gasket seals or guillotine doors located in conveyor tunnels, in accordance with the following:[7]

$$\text{Leakage rate (litre/min)} = \frac{(P+4.572)\, h^3}{6568}$$

where P = perimeter of door opening (metres)
h = test head of water (metres)

5.4.2.3 However, in the case of doors where the water head taken for the determination of the scantling does not exceed 6.1 m, the leakage rate may be taken equal to 0.375 *litre*/min if this value is greater than that calculated by the above-mentioned formula.

5.4.3 For doors of passenger ships which are used at sea and which become submerged by the equilibrium or intermediate waterplane, a prototype test should be conducted, on each side of the door, to check the satisfactory closing of the door against a force equivalent to a water height of at least 1 m above the sill on the centre line of the door.[8]

5.5 Hose testing after installation

All watertight doors should be subject to a hose test[9] after installation in a ship. Hose testing should be carried out from each side of a door unless, for a specific application, exposure to floodwater is anticipated only from one side. Where a hose test is not practicable because of possible damage to machinery, electrical equipment insulation, or outfitting items, it may be replaced by means such as an ultrasonic leak test or an equivalent test.

7 Published in the ASTM F 1196, Standard Specification for Sliding Watertight Door Assemblies and referenced in the Title 46 US Code of Federal Regulations 170.270 Door design, operation installation and testing.

8 Arrangements for passenger ships should be in accordance with regulation II-1/13.5.2.

9 Refer to IACS URS 14.2.3 IACS Reg. 1996/Rev.2, 2001.

Table 1 – Doors in internal watertight bulkheads and external watertight boundaries in passenger ships and cargo ships

A. Doors in internal watertight bulkheads

Position relative to bulkhead or freeboard deck	1 SOLAS Regulation	2 Frequency of use while at sea	3 Type	4 Remote closure	5 Remote indication	6 Audible or visual alarm	7 Notice	8 Comments
I. Passenger ships								
A. Below	II-1/10, 13.4, 13.5.1, 13.5.2, 13.6, 13.7.1, 13.8.1, 13.8.2, 16.2, 22.1, 22.3 and 22.4	Used	POS	Yes	Yes	Yes (local)	No	For doors that are used, see II-1/22.3 and MSC.1/Circ.1564
	II-1/10, 13.9.1, 13.9.2, 14.2, 16.2, 22.2 and 22.5	Permanently Closed	S, H	No	No	No	Yes	See Notes 2 + 3 + 4
B. At or above	II-1/10, 16.2, 17.1 and 22.3	Used	POS, POH	Yes	Yes	Yes (local)	No	See Note 5
			S, H	No	Yes	No	Yes	See Note 1
	II-1/17-1.1.1, 17-1.1.2, 17-1.1.3, 23.6 and 23.8		S, H	No	Yes	Yes (remote)	Yes	Doors giving access to below the ro-ro deck
	II-1/17-1.1.1, 17-1.1.2, 17-1.1.3, 22.7 and 23.3 to 23.5	Permanently Closed	S, H	No	Yes	Yes (remote)	Yes	See Notes 1 + 2 + 3
II. Cargo ships								
A. Below	II-1/10, 13-1.2, 16.2 and 22.3	Used	POS	Yes	Yes	Yes (local)	No	
	II-1/10, 13-1.3, 16.2, 22.3 and 24.4	Normally closed	S, H	No	Yes	No	Yes	See Note 1
	II-1/10, 13-1.4, 16.2, 24.3, and 24.4	Permanently closed	S, H	No	No	No	Yes	See Notes 2 + 3
	II-1/10, 13-1.4, 13-1.5, 16.2, 22.2, 24.3 and 24.4							
B. At or above	II-1/10, 13-1.2, 16.2 and 22.3	Used	POS	Yes	Yes	Yes (local)	No	
	II-1/10, 13-1.3, 16.2, 22.3 and 24.4	Normally closed	S, H	No	Yes	No	Yes	See Note 1
	II-1/10, 13-1.4, 13-1.5, 16.2, 24.3 and 24.4	Permanently closed	S, H	No	No	No	Yes	See Notes 2 + 3

Notes:

1 If hinged, this door should be of quick acting or single action type.

2 The time of opening such doors in port and closing them before a voyage commences should be entered in the logbook, in case of doors in watertight bulkheads subdividing cargo spaces.

3 Doors should be fitted with a device which prevents unauthorized opening.

4 Passenger ships which have to comply with regulation II-1/14.2 require an indicator on the navigation bridge to show automatically when each door is closed and all door fastenings are secured.

5 Refer to the explanatory note to regulation II-1/17.1 regarding sliding watertight doors with a reduced pressure head and sliding semi-watertight doors.

B. Doors in external watertight boundaries below equilibrium or intermediate waterplane

Position relative to bulkhead or freeboard deck	1 SOLAS Regulation	2 Frequency of use while at sea	3 Type	4 Remote closure	5 Remote indication	6 Audible or visual alarm	7 Notice	8 Comments
I. Passenger ships								
A. Below	II-1/15.9, 22.6 and 22.12	Permanently closed	S, H	No	No	No	Yes	See Notes 2 + 3
B. At or above	II-1/17.1 and 22.3 MSC.Circ.541	Normally closed	S, H	No	Yes	No	Yes	See Note 1
	II-1/17-1.1.1, 17-1.1.2, 17-1.3, 23.6 and 23.8		S, H	No	Yes	Yes (Remote)	Yes	Doors giving access to below ro-ro deck
	II-1/17-1.1.1, 17-1.2, 17-1.3, 23.3 and 23.5	Permanently closed	S, H	No	Yes	Yes (Remote)	Yes	See Notes 2 + 3
II. Cargo ships								
A. Below	II-1/15.9, 15-1.2, 15-1.3, 15-1.4, 22.6, 22.12 and 24.1	Permanently closed	S, H	No	Yes	No	Yes	See Notes 2 + 3
B. At or above	II-1/15-1.2	Normally closed	S, H	No	Yes	No	Yes	See Note 1
	II-1/15-1.2 and 15-1.4	Permanently closed	S, H	No	Yes	No	Yes	See Notes 2 + 3

Notes:

1 If hinged, this door should be of quick acting or single action type.

2 The time of opening such doors in port and closing them before a voyage commences should be entered in the logbook.

3 Doors should be fitted with a device which prevents unauthorized opening.

4 SOLAS REGULATION II-1/26 – GENERAL

4.1 PARAGRAPH 4

Interpretation

1 Dead ship condition for the purpose of regulation II-1/26.4 should be understood to mean a condition under which the main propulsion plant, boilers and auxiliaries are not in operation and in restoring the propulsion, no stored energy for starting and operating the propulsion plant, the main source of electrical power and other essential auxiliaries is assumed to be available.

2 Where the emergency source of power is an emergency generator which complies with regulation II-1/44, IACS SC185 and IACS SC124, this generator may be used for restoring operation of the main propulsion plant, boilers and auxiliaries where any power supplies necessary for engine operation are also protected to a similar level as the starting arrangements.

3 Where there is no emergency generator installed or an emergency generator does not comply with regulation II-1/44, the arrangements for bringing main and auxiliary machinery into operation should be such that the initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed on board ships without external aid. If for this purpose an emergency air compressor or an electric generator is required, these units should be powered by a hand-starting oil engine or a hand-operated compressor. The arrangements for bringing main and auxiliary machinery into operation should have capacity such that the starting energy and any power supplies for engine operation are available within 30 min of a dead ship condition.

4.2 PARAGRAPH 11

Interpretation

1 Arrangements complying with this regulation and acceptable "equivalent arrangements", for the most commonly utilized fuel systems, are shown below.

2 A service tank is a fuel oil tank which contains only fuel of a quality ready for use, i.e. fuel of a grade and quality that meets the specification required by the equipment manufacturer. A service tank should be declared as such and not be used for any other purpose.

3 Use of a setting tank with or without purifiers, or purifiers alone, and one service tank is not acceptable as an "equivalent arrangement" to two service tanks.

Examples of application for the most common systems

1 Example 1

1.1 Requirement according to SOLAS – Main and auxiliary engines and boiler(s) operating with heavy fuel oil (HFO) (one fuel ship)

HFO Serv. TK Capacity for at least 8 h Main Eng. + Aux. Eng. + Aux. Boiler	HFO Serv. TK Capacity for at least 8 h Main Eng. + Aux. Eng. + Aux. Boiler	MDO TK For initial cold starting or repair work Engines/Boiler

1.2 Equivalent arrangement

HFO Serv. TK Capacity for at least 8 h Main Eng. + Aux. Eng. + Aux. Boiler	MDO Serv. TK Capacity for at least 8 h Main Eng. + Aux. Eng. + Aux. Boiler

This interpretation only applies where main and auxiliary engines can operate with heavy fuel oil under all load conditions and, in the case of main engines, during manoeuvring.

For pilot burners of auxiliary boilers if provided, an additional MDO tank for 8 hours may be necessary.

2 Example 2

2.1 Requirement according to SOLAS – Main engine(s) and auxiliary boiler(s) operating with HFO and auxiliary engine operating with marine diesel oil (MDO)

HFO Serv. TK Capacity for at least 8 h Main Eng. + Aux. Boiler	HFO Serv. TK Capacity for at least 8 h Main Eng. + Aux. Boiler	MDO Serv. TK Capacity for at least 8 h Aux. Eng.	MDO Serv. TK Capacity for at least 8 h Aux. Eng.

2.2 Equivalent arrangement

HFO Serv. TK Capacity for at least 8 h Main Eng. + Aux. Boiler	MDO Serv. TK Capacity for at least the highest of: • 4 h Main Eng. + Aux. Eng + Aux. Boiler or • 8 h Aux. Eng. + Aux Boiler	MDO Serv. TK Capacity for at least the highest of: • 4 h Main Eng. + Aux. Eng + Aux. Boiler or • 8 h Aux. Eng. + Aux Boiler

The arrangements in paragraphs 1.2 and 2.2 apply, provided the propulsion and vital systems which use two types of fuel support rapid fuel changeover and are capable of operating in all normal operating conditions at sea with both types of fuel (MDO and HFO).

5 SOLAS REGULATIONS II-1/40 – GENERAL – AND II-1/41 – MAIN SOURCE OF ELECTRICAL POWER AND LIGHTING SYSTEMS

Interpretation

Essential services and arrangements of sources of power, supply, control and monitoring to the different categories of essential services

1 Classification of essential services

1.1 Essential services are those services essential for propulsion and steering, and safety of the ship, which are made up of "Primary Essential Services" and "Secondary Essential Services". Definitions and examples of such services are given in 2 and 3 below.

1.2 Services to ensure minimum comfortable conditions of habitability are those services defined in 4 below.

2 Primary Essential Services

Primary Essential Services are those services which need to be in continuous operation to maintain propulsion and steering. Examples of equipment for "Primary Essential Services" are as follows:

- steering gears;
- pumps for controllable pitch propellers;
- scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for propulsion;
- forced draught fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for steam plants on steam turbine ships, and also for auxiliary boilers on ships where steam is used for equipment supplying primary essential services;
- oil burning installations for steam plants on steam turbine ships and for auxiliary boilers where steam is used for equipment supplying primary essential services;
- azimuth thrusters, which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps;
- electrical equipment for electric propulsion plant with lubricating oil pumps and cooling water pumps;
- electric generators and associated power sources supplying the above equipment;
- hydraulic pumps supplying the above equipment;
- viscosity control equipment for heavy fuel oil;
- control, monitoring, and safety devices/systems for equipment to primary essential services;
- fire pumps and other fire extinguishing medium pumps;
- navigation lights, aids and signals;
- internal safety communication equipment; and
- lighting system.

3 Secondary Essential Services

Secondary Essential Services are those services which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the vessel's safety. Examples of equipment for secondary essential services are as follows:

- windlass;
- fuel oil transfer pumps and fuel oil treatment equipment;
- lubrication oil transfer pumps and lubrication oil treatment equipment;
- pre-heaters for heavy fuel oil;
- starting air and control air compressors;
- bilge, ballast and heeling pumps;
- ventilating fans for engine and boiler rooms;
- services considered necessary to maintain dangerous spaces in a safe condition;
- fire detection and alarm system;
- electrical equipment for watertight closing appliances;
- electric generators and associated power sources supplying the above equipment;
- hydraulic pumps supplying the above equipment;
- control, monitoring, and safety systems for cargo containment systems; and
- control, monitoring, and safety devices/systems for equipment to secondary essential services.

4 Services for habitability

Services for habitability are those services which need to be in operation for maintaining the ship's minimum comfort conditions for the crew and passengers. Examples of equipment for maintaining conditions of habitability are as follows:

- cooking;
- heating;
- domestic refrigeration;
- mechanical ventilation;
- sanitary and fresh water; and
- electrical generators and associated power sources supplying the above equipment.

5 Regulations II-1/40.1.1 and II-1/41.1.1 – For the purposes of these regulations, the services as included in paragraphs 2 to 4 should be considered.

6 Regulation II-1/40.1.2 – For the purposes of this regulation, the services as included in paragraphs 2 and 3 and the services in regulations II-1/42 or II-1/43, as applicable, should be considered.

7 Regulation II-1/41.1.2 – For the purposes of this regulation, the services as included in paragraphs 2 to 4, except for those also listed in the interpretation set out in section 6.1 below, should be considered.

8 Regulation II-1/41.1.5 – For the purposes of this regulation, the services as included in paragraphs 2, 3 and 4 should be considered.[10]

[10] See also IACS UI SC83.

9 Regulation II-1/41.5.1.2 – For the purposes of this regulation, the following interpretations are applicable:

.1 services in paragraph 2 should not be included in any automatic load shedding or other equivalent arrangements;

.2 services in paragraph 3 may be included in the automatic load shedding or other equivalent arrangement provided disconnection will not prevent services required for safety being immediately available when the power supply is restored to normal operating conditions; and

.3 services for habitability in paragraph 4 may be included in the load shedding or other equivalent arrangement.

6 SOLAS REGULATION II-1/41 – MAIN SOURCE OF ELECTRICAL POWER AND LIGHTING SYSTEMS

6.1 PARAGRAPH 1.2

Interpretation

Those services necessary to provide normal operational conditions of propulsion and safety do not include services such as:

.1 thrusters not forming part of the main propulsion;

.2 moorings;

.3 cargo handling gear;

.4 cargo pumps; and

.5 refrigerators for air conditioning (those which are not necessary to establish a minimum condition of habitability).

6.2 PARAGRAPH 1.3

Interpretation

Generators and generator systems, having the ship's main propulsion machinery as their prime mover, may be accepted as part of the ship's main source of electrical power, provided that:

.1 they are capable of operating under all weather conditions during sailing and during manoeuvring, also when the ship is stopped, within the specified limits for the voltage variation in IEC 60092-301 and the frequency variation in IACS UR E5;

.2 their rated capacity is safeguarded during all operations given under 1, and is such that in the event of any other one of the generators failing, the services given under regulation II-1/41.1.2 (see section 6.1 above) can be maintained;

.3 the short circuit current of the generator/generator system is sufficient to trip the generator/generator system circuit-breaker taking into account the selectivity of the protective devices for the distribution system. Protection should be arranged in order to safeguard the generator/generator system in case of a short circuit in the main busbar. The generator/generator system should be suitable for further use after fault clearance; and

.4 standby sets are started in compliance with paragraph 2 of the interpretation of regulation II-1/41.5.1.1 (see section 6.3 below).

6.3 PARAGRAPH 5

Interpretation of paragraph 5.1.1

1 Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection of sufficient non-essential services and, if necessary, secondary essential services as defined in the unified interpretation of SOLAS regulations II-1/40 and II-1/41 (see chapter 5 above) and those provided for habitability, should be made to ensure that, in case of loss of any of these generating sets, the remaining ones are kept in operation to permit propulsion and steering and to ensure safety.

2 Where Administrations permit electrical power to be normally supplied by one generator, provision should be made, upon loss of power, for automatic starting and connecting to the main switchboard of stand-by generator(s) of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of one generator should be as rapid as possible, preferably within 30 seconds after loss of power. Where prime movers with longer starting time are used, this starting and connection time may be exceeded upon approval from the Administration.

Interpretation of paragraph 5.1.2

3 The load shedding should be automatic.

4 The non-essential services, service for habitable conditions, may be shed and, where necessary, additionally the Secondary Essential Services, sufficient to ensure the connected generator set(s) is/are not overloaded.

Interpretation of paragraph 5.1.3

1 Other approved means can be achieved by:

.1 circuit breaker without tripping mechanism; or

.2 disconnecting link or switch by which busbars can be split easily and safely.

2 Bolted links, for example bolted busbar sections, should not be accepted.

7 SOLAS REGULATIONS II-1/42 AND II-1/43 – EMERGENCY SOURCE OF ELECTRICAL POWER IN PASSENGER AND CARGO SHIPS

Interpretation

1 "Blackout" as used in regulations II-1/42.3.4 and II-1/43.3.4 should be understood to mean a "dead ship" condition-initiating event.

2 "Dead ship" condition, for the purpose of regulations II-1/42.3.4 and II-1/43.3.4, should be understood to mean a condition under which the main propulsion plant, boilers and auxiliaries are not in operation and in restoring the propulsion, no stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliaries should be assumed available. It is assumed that means are available to start the emergency generator at all times.

3 Emergency generator stored starting energy is not to be directly used for starting the propulsion plant, the main source of electrical power and/or other essential auxiliaries (emergency generator excluded).

4 For steam ships, the 30-min time limit given in SOLAS can be interpreted as time from blackout defined above to light-off of the first boiler.

5 Exceptionally is understood to mean conditions such as:

.1 blackout situation;

.2 dead ship situation;

.3 routine use for testing;

.4 short-term parallel operation with the main source of electrical power for the purpose of load transfer; and

.5 use of the emergency generator during lay time in port for the supply of the ship's main switchboard, provided the requirements of 6 (Suitable measures for the exceptional use of the emergency generator for power-supply of non-emergency circuits in port) are achieved and unless instructed otherwise by the Administration.

6 Suitable measures for the exceptional use of the emergency generator for power-supply of non-emergency circuits in port:

.1 To prevent the generator or its prime mover from becoming overloaded when used in port, arrangements should be provided to shed sufficient non-emergency loads to ensure its continued safe operation.

.2 The prime mover should be arranged with fuel oil filters and lubrication oil filters, monitoring equipment and protection devices as required for the prime mover for main power generation and for unattended operation.

.3 The fuel oil supply tank to the prime mover should be provided with a low-level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services for the period of time as required by SOLAS.

.4 The prime mover should be designed and built for continuous operation and should be subjected to a planned maintenance scheme ensuring that it is always available and capable of fulfilling its role in the event of an emergency at sea.

.5 Fire detectors should be installed in the location where the emergency generator set and emergency switchboard are installed.

.6 Means should be provided to readily change over to emergency operation.

.7 Control, monitoring and supply circuits, for the purpose of the use of emergency generator in port should be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services.

.8 When necessary for safe operation, the emergency switchboard should be fitted with switches to isolate the circuits.

.9 Instructions should be provided on board to ensure that when the ship is under way all control devices (e.g. valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard.

8 SOLAS REGULATION II-1/44 – STARTING ARRANGEMENTS FOR EMERGENCY GENERATING SETS

8.1 PARAGRAPH 1

Interpretation (from MSC/Circ.736)

Emergency generating sets should be capable of being readily started in their cold condition at a temperature of 0ºC. If this is impracticable, or if lower temperatures are likely to be encountered, heating should be provided to ensure ready starting of the generating sets.

8.2 PARAGRAPH 2

Interpretation (from MSC/Circ.736)

Each emergency generating set arranged to be automatically started should be equipped with starting devices with a stored energy capability of at least three consecutive starts. A second source of energy should be provided for an additional three starts within 30 min unless manual starting can be demonstrated to be effective.

9 SOLAS REGULATION XII/12 – HOLD, BALLAST AND DRY SPACE WATER INGRESS ALARMS

When water level detectors are installed on bulk carriers in compliance with regulation XII/12, the *Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers*, annexed to resolution MSC.188(79) adopted on 3 December 2004, should be applied, taking into account the following interpretations to the paragraphs of the Performance standards.

9.1 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, PARAGRAPH 3.2.3

Interpretation

Detection equipment includes the sensor and any filter and protection arrangements for the detector installed in cargo holds and other spaces as required by regulation XII/12.1.

9.2 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, PARAGRAPH 3.2.5

Interpretation

1 In general, the construction and type testing should be in accordance with publication IEC 60079: Electrical Equipment for Explosive Gas Atmospheres to a minimum requirement of EX(ia). Where a ship is designed only for the carriage of cargoes that cannot create a combustible or explosive atmosphere then the requirement for intrinsically safe circuitry should not be insisted upon, provided the operational instructions included in the Manual required by 4.1 of the appendix to the annex specifically exclude the carriage of cargoes that could produce a potential explosive atmosphere. Any exclusion of cargoes identified in the annex should be consistent with the ship's Cargo Book and any Certification relating to the carriage of specifically identified cargoes.

2 The maximum surface temperature of equipment installed within cargo spaces should be appropriate for the combustible dusts and/or explosive gases likely to be encountered. Where the characteristics of the dust and gases are unknown, the maximum surface temperature of equipment should not exceed 85ºC.

3 Where intrinsically safe equipment is installed, it should be of a certified safe type.

4 Where detector systems include intrinsically safe circuits, plans of the arrangements should be appraised/approved by individual classification societies.

9.3 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, PARAGRAPH 3.3.2

Interpretation

The pre-alarm, as a primary alarm, should indicate a condition that requires prompt attention to prevent an emergency condition and the main alarm, as an emergency alarm should indicate that immediate actions must be taken to prevent danger to human life or to the ship.

9.4 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, PARAGRAPH 3.3.7

Interpretation

Fault monitoring should address faults associated with the system that include open circuit, short circuit, as well as arrangement details that would include loss of power supplies and CPU failure for computer-based alarm/monitoring system, etc.

9.5 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, PARAGRAPH 3.3.8

Interpretation

1 The electrical power supply should be from two separate sources, one should be the main source of electrical power and the other should be the emergency source, unless a continuously charged dedicated accumulator battery is fitted, having arrangement, location and endurance equivalent to that of the emergency source (18 hours). The battery supply may be an internal battery in the water level detector system.

2 The changeover arrangement of supply from one electrical source to another need not be integrated into the water level detector system.

3 Where batteries are used for the secondary power supply, failure alarms for both power supplies should be provided.

9.6 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, FOOTNOTE TO PARAGRAPH 3.4.1

Interpretation

1 IACS UR E10 may be used as an equivalent test standard to IEC 60092-504.

2 The range of tests should include the following:

For alarm/monitoring panel:

.1 functional tests in accordance with resolution MSC.188(79) on the *Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers*;

.2 electrical power supply failure test;

.3 power supply variation test;

.4 dry heat tests;

.5 damp heat tests;

.6 vibration test;

.7 EMC tests;

.8 insulation resistance test;

.9 high-voltage test; and

.10 static and dynamic inclinations tests, if moving parts are contained.

For IS barrier unit, if located in the wheelhouse: in addition to the certificate issued by a competent independent testing laboratory, EMC tests should also be carried out.

For water ingress detectors:

.1 functional tests in accordance with resolution MSC.188(79) on the *Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers*;

.2 electrical power supply failure test;

.3 power supply variation test;

.4 dry-heat test;

.5 damp-heat test;

.6 vibration test;

.7 enclosure class in accordance with resolution MSC.188(79) on the *Performance standards for water level detectors on bulk carriers and single hold cargo ships other than bulk carriers*;

.8 insulation resistance test;

.9 high-voltage test; and

.10 static and dynamic inclinations tests (if the detectors contain moving parts).

9.7 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, APPENDIX, PARAGRAPH 2.1.1

Interpretation

The test procedure should satisfy the following criteria:

.1 the type tests should be witnessed by a classification society surveyor if the tests are not carried out by a competent independent test facility;

.2 type tests should be carried out on a prototype or randomly selected item(s) which are representative of the manufactured item that is being type tested; and

.3 type tests should be documented (type test reports) by the manufacturer and submitted for review by classification societies.

9.8 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, APPENDIX, PARAGRAPH 2.1.1.1

Interpretation

1 The submerged test period for electrical components intended to be installed in ballast tanks and cargo tanks used as ballast tanks should be not less than 20 days.

2 The submerged test period for electrical components intended to be installed in dry spaces and cargo holds not intended to be used as ballast tanks should be not less than 24 hours.

3 Where a detector and/or cable connecting device (e.g. junction box, etc.) is installed in a space adjacent to a cargo hold (e.g. lower stool, etc.) and the space is considered to be flooded under damage stability calculations, the detectors and equipment should satisfy the requirements of IP68 for a water head equal to the hold depth for a period of 20 days or 24 hours on the basis of whether or not the cargo hold is intended to be used as a ballast tank as described in the previous paragraphs.

9.9 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, APPENDIX, PARAGRAPH 2.1.1.2

Interpretation

1 The type test required for the sensor should be in accordance with the following:

.1 The test container for the cargo/water mixture should be dimensioned so that its height and volume are such that the sensor and any filtration fitted can be totally submerged for the repeated functionality tests required by paragraph 2.1.1.2 and the static and dynamic inclination tests identified in the previous interpretation.

.2 The sensor and any filtration fitted that should be submerged and should be arranged in the container as they would be installed in accordance with the installation instructions required by paragraph 4.4.

.3 The pressure in the container for testing the complete detector should be not more than 0.2 bar at the sensor and any filter arrangement. The pressure may be realized by pressurization or by using a container of sufficient height.

.4 The cargo/water mixture should be pumped into the test container and suitable agitation of the mixture provided to keep the solids in suspension. The effect of pumping the cargo/water mixture into the container should not affect the operation of the sensor and filter arrangements.

.5 The cargo/water mixture should be pumped into the test container to a predetermined level that submerges the detector and the operation of the alarm observed.

.6 The test container should then be drained and the deactivation of the alarm condition observed.

.7 The test container and sensor with any filter arrangement should be allowed to dry without physical intervention.

.8 The test procedure should be repeated consecutively ten times without cleaning any filter arrangement that may be fitted in accordance with the manufacturer's installation instructions (see also 2.1.1.2).

.9 Satisfactory alarm activation and deactivation at each of the 10 consecutive tests will demonstrate satisfactory type testing.

2 The cargo/water mixture used for type testing should be representative of the range of cargoes within the following groups and should include the cargo with the smallest particles expected to be found from a typical representative sample:

.1 iron ore particles and seawater;

.2 coal particles and seawater;

.3 grain particles and seawater; and

.4 aggregate (sand) particles and seawater.

The smallest and largest particle size together with the density of the dry mixture should be ascertained and recorded. The particles should be evenly distributed throughout the mixture. Type testing with representative particles will in general qualify all types of cargoes within the four groupings shown above.

The following provides guidance on the selection of particles for testing purposes:

.1 Iron ore particles should mainly consist of small loose screenings of iron ore and not lumps of ore (dust with particle size < 0.1 mm).

.2 Coal particles should mainly consist of small loose screenings of coal and not lumps of coal (dust with particle size < 0.1 mm).

.3 Grain particles should mainly consist of small loose grains of free-flowing grain (grain having a size > 3 mm, such as wheat).

.4 Aggregate particles should mainly consist of small loose grains of free-flowing sand and without lumps (dust with particle size < 0.1 mm).

9.10 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, APPENDIX, PARAGRAPH 3.1.1

Interpretation

The test procedure should satisfy the following criteria:

.1 type tests should be witnessed by a classification society surveyor if the tests are not carried out by a competent independent test facility;

.2 type tests should be carried out on a prototype or randomly selected item(s) which are representative of the manufactured item that is being type tested; and

.3 type tests should be documented (type test reports) by the manufacturer and submitted for review by classification societies.

9.11 PERFORMANCE STANDARDS FOR WATER LEVEL DETECTORS ON BULK CARRIERS AND SINGLE HOLD CARGO SHIPS OTHER THAN BULK CARRIERS, APPENDIX, SECTION 4 – MANUALS

Interpretation

For each ship, a copy of the manual should be made available to the surveyor at least 24 hours prior to survey of the water-level detection installation. Each classification society should ensure that any plans required for classification purposes have been appraised/approved as appropriate.

10 SOLAS REGULATION XII/13 – AVAILABILITY OF PUMPING SYSTEMS

SOLAS REGULATION XII/13.1 AND MSC/CIRC.1069

Dewatering of forward spaces of bulk carriers

Interpretation

1 Where the piping arrangements for dewatering closed dry spaces are connected to the piping arrangements for the drainage of water ballast tanks, two non-return valves should be provided to prevent the ingress of water into dry spaces from those intended for the carriage of water ballast. One of these non-return valves should be fitted with a shut-off isolation arrangement. The non-return valves should be located in readily accessible positions. The shut-off isolation arrangement should be capable of being controlled from the navigation bridge, the propulsion machinery control position or enclosed space which is readily accessible from the navigation bridge or the propulsion machinery control position without travelling exposed freeboard or superstructure decks. In this context, a position which is accessible via an under-deck passage, a pipe trunk or other similar means of access should not be taken as being in the "readily accessible enclosed space".

2 Under regulation XII/13.1:

.1 the valve specified under SOLAS regulation II-1/12.6.1 should be capable of being controlled from the navigation bridge, the propulsion machinery control position or enclosed space which is readily accessible from the navigation bridge or the propulsion machinery control position without travelling exposed freeboard or superstructure decks. In this context, a position which is accessible via an under-deck passage, a pipe trunk or other similar means of access should not be taken as being in the "readily accessible enclosed space";

.2 the valve should not move from the demanded position in the case of failure of the control system power or actuator power;

.3 positive indication should be provided at the remote control station to show that the valve is fully open or closed; and

.4 local hand-powered valve operation from above the freeboard deck, as permitted under SOLAS regulation II-1/12.6.1, is required. An acceptable alternative to such arrangement may be remotely operated actuators as specified in regulation XII/13.1, on the condition that all of the provisions of regulation XII/13.1 are met.

3 The dewatering arrangements should be such that any accumulated water can be drained directly by a pump or eductor.

4 The dewatering arrangements should be such that when they are in operation, other systems essential for the safety of the ship, including firefighting and bilge systems, remain available and ready for immediate use. The systems for normal operation of electric power supplies, propulsion and steering should not be affected by the operation of the dewatering systems. It should also be possible to immediately start fire pumps and have a readily available supply of firefighting water, and to be able to configure and use the bilge system for any compartment when the dewatering system is in operation.

5 Bilge wells should be provided with gratings or strainers that will prevent blockage of the dewatering system with debris.

6 The enclosures of electrical equipment for the dewatering system installed in any of the forward dry spaces should provide protection to IPX8 standard as defined in publication IEC 60529 for a water head equal to the height of the space in which the electrical equipment is installed for a time duration of at least 24 hours.

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MSC.8/Circ.1
10 December 2020

VOLUNTARY EARLY IMPLEMENTATION OF THE AMENDMENTS TO SOLAS REGULATION II-1/12 ADOPTED BY RESOLUTION MSC.474(102)

1 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), adopted amendments to SOLAS regulation II-1/12 by resolution MSC.474(102).

2 The entry-into-force date of the aforementioned amendments is 1 January 2024.

3 In adopting the above-mentioned amendments to SOLAS regulation II-1/12, the Committee, having considered the need for their voluntary early implementation, in accordance with the *Guidelines on the voluntary early implementation of amendments to the 1974 SOLAS Convention and related mandatory instruments* (MSC.1/Circ.1565), agreed to invite the Contracting Governments to the International Convention for the Safety of Life at Sea, 1974, as amended, to implement them prior to the entry-into-force date.

4 Voluntary early implementation should be communicated by a Contracting Government to the Organization for dissemination through GISIS.

5 In addition to the aforementioned communication, a Contracting Government may also consider the use of the existing provisions for equivalent arrangements under SOLAS regulation I/5 to cover the interim period between the date of the voluntary early implementation and the entry-into-force date of the amendments.

6 A Contracting Government, in line with paragraph 1.2.3 of the *Procedures for port State control, 2019* (resolution A.1138(31)), as may be amended, when acting as a port State, should refrain from enforcing its decision to voluntarily early implement the amendments to SOLAS regulation II-1/12 to ships entitled to fly the flag of other Contracting Governments, calling at its ports.

7 The Contracting Governments, when undertaking port State control activities, should take into account the present invitation and any subsequent notifications communicated by other Contracting Governments through GISIS.

8 Contracting Governments are invited to be guided accordingly and to bring the contents of this circular to the attention of all concerned, especially port State control authorities and recognized organizations.

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