RULES

PUBLICATION 94/P

SUBDIVISION AND AND DAMAGE STABILITY OF NEW OIL TANKERS, CHEMICAL TANKERS AND GAS CARRIERS

January
2022

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków
complete or extend the Rules and are mandatory where applicable.

GDAŃSK

*Publication 94/P – Subdivision and Damage Stability of New Oil Tankers, Chemical Tankers and Gas Carriers –
January 2022* is an extension of the requirements contained in *Part IV – Stability and Subdivision of the Rules
for the Classification and Construction of Sea-Going Ships.*

This Publication was approved by PRS Board on 14 December 2021 and enters into force on 1 January 2022.

This Publication also applies to other PRS regulations if it is mentioned there.

CONTENTS

1   APPLICATION

Publication No. 94/P – Subdivision and Damage Stability of New Oil Tankers, Chemical Tankers and Gas Carriers is a guidance aimed to facilitate carrying out subdivision and damage stability verification regarding the following types of ships:

− oil tankers, excluding combination carriers,
− chemical tankers,
− gas carriers.

For ships constructed on or after 14 June 2016, guidance facilitating the proper performance of stability and subdivision analysis is contained in IMO document MSC.1/Circ. 1461 of 8 July 2013

2   RELATED IMO DOCUMENTS

2.1   General Documents

− *SOLAS,* Chapter II-1, Regulations 4.1,4.2, 5-1 and 19;
− Resolution MSC.143(77) *Adoption of Amendments to the Protocol of 1988 Relating to the International Convention on Load Lines, 1966* (Regulation 27, paragraphs (2), (3), (11), (12) and (13));
− Part B, *chapter* 4 of the *International Code on Intact Stability*, 2008 (2008 IS Code), adopted by resolution MSC.267(85), as amended;
− MSC.1/Circ.1229 *Guidelines for the Approval of Stability Instruments* (paragraph 4);
− MSC.1/Circ.1245 *Guidelines for Damage Control Plans and Information to the Master*.
− Res. MSC.429(98) "Explanatory Notes to the SOLAS Chapter II-1 Subdivision and Damage Stability Regulations" – special attention should be paid to Guidelines for the Preparation of Subdivision and Damage Stability Calculations specified in the Appendix;
− Res. MSC.429(98)/Rev.1 "Explanatory Notes to the SOLAS Chapter II-1 Subdivision and Damage Stability Regulations" – special attention should be paid to Guidelines for the Preparation of Subdivision and Damage Stability Calculations specified in the Appendix;
− Res. MSC.362(92)"Revised Recommendation on a Standard Method for Evaluating Cross-Flooding Arrangements";

2.2   Documents Applicable to Oil Tankers

− *MARPOL*, Annex 1, Regulation 28 and
− ICLL 66/88 Annex I, Reg.27 for type "A" ships with a length of more than 150m and assigned freeboard less than type "B". An overview is shown in Annex I of this document.

2.3   Documents Applicable to Chemical Tankers

− *International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)*, (Chapter 2, paragraphs 2.1, 2.4, 2.5, 2.6.2, 2.7, 2.8 and 2.9);
− MSC/Circ.406/Rev.1 *Guidelines on Interpretation of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC) and Guidelines for the Uniform Application of the Survival Requirements of the IBC and IGC Codes.*
− ICLL 66/88 Annex I, Reg.27 for type "A" ships with a length of more than 150m and assigned freeboard less than type "B". An overview is shown in Annex I of this document.

2.4   Documents Applicable to Gas Carriers

− *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)* (Chapter 2, paragraphs 2.1, 2.4, 2.5, 2.6.2, 2.6.3, 2.7, 2.8 and 2.9);

– MSC/Circ.406/Rev.1 *Guidelines on Interpretation of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC) and Guidelines for the Uniform Application of the Survival Requirements of the IBC and IGC Codes.*
– ICLL 66/88 Annex I, Reg.27 for type "A" ships with a length of more than 150m and assigned freeboard less than type "B". An overview is shown in Annex I of this document.

2.5   Damage Stability Requirements

Ships complying with the requirements of the international conventions and codes, listed in the below Table, are not subject to damage stability requirements of *SOLAS*, Chapter II-1, Part B.

Ship type	Assigned freeboard	Ship length	Compliance with requirements
Oil tanker	Type „A" ship with assigned freeboard less than type „B"	$L \leq 150$ m	*MARPOL*, ANNEX I
		$L > 150$ m	*MARPOL*, ANNEX I + ICLL, Reg. 27
	Not less than type "B"	Regardless of length	*MARPOL*, ANNEX I
Gas carrier	Type „A" ship with assigned freeboard less than type „B"	$L \leq 150$ m	IGC
		$L > 150$ m	IGC + ICLL, Reg. 27
	Not less than type "B"	Regardless of length	IGC
Chemical tanker	Type „A" ship with assigned freeboard less than type „B"	$L \leq 150$ m	IBC
		$L > 150$ m	IBC + ICLL, Reg. 27
	Not less than type "B"	Regardless of length	IBC

3   SCOPE OF STABILITY VERIFICATION AND ASSUMPTIONS FOR CALCULATIONS

3.1   Scope of Stability Verification

The scope of the stability verification should be such as to demonstrate compliance with relevant stability criteria in all anticipated loading conditions. The aim of the verification is to provide the ship's master with a sufficient number of approved loading conditions to be used for the loading of the ship.

In general for non-approved loading conditions, the ship's master should be provided with instruments allowing to verify compliance with stability criteria. The instruments are:

– KG_{max}/GM_{min} limiting curve(s), approved by PRS,
– loading instrument approved by PRS.

Such instruments should allow to verify compliance with stability requirements (intact and after flooding a compartment) for the draught range to be covered.

3.2   A review of submitted calculations and supporting documentation with independent check calculations is required for damage stability verification and approval to comply with relevant stability criteria.

For the loading instrument software installed on board (for assessing intact and damage stability) examination and approval of shall also be carried out. A loading instrument means hardware and software. The accuracy of the computation results and actual ship data used by the software shall be verified as well.

3.3   Calculation Methodology

– For loading calculations, the initial metacentric height *GM* and the righting lever curve should be corrected for the effect of free surfaces of liquids in tanks;
– Superstructures and deckhouses not regarded as enclosed can be taken into account in stability calculations up to the angle at which their openings are flooded; full compliance with residual stability criteria must be achieved before any such point becomes immersed;
– When calculating the ship's stability after flooding, lost buoyancy method (constant displacement) should be used;
– Submitted conditions of loading and instructions used with applicable KG/GM limit curve(s) and variety of loading patterns and cargoes are taken as representative operating features of the ship.

4   REQUIRED DOCUMENTS

4.1   Design Documentation

4.1.1   Prior to the commencement of the ship's construction, the following documentation should be submitted to PRS:

– body lines;
– hydrostatic curves (drawing or table);
– cross curves of stability (drawing or table);
– plan of watertight compartments with moulded volumes, centres of gravity and permeability, as well as calculation guidelines;
– watertight integrity plan with particulars on openings, their closing devices, watertight bulkheads penetrations, as well as the location of watertight door position indicators and controls;
– preliminary stability booklet containing loading conditions required by Rules;
– preliminary subdivision and damage stability verification, including definitions of damage cases, information on Rule damage extent, as well as the results of calculations for loading conditions in accordance with stability booklet and all anticipated damage scenarios. The calculations should take into account the real distribution of cargo, density of cargo and consumables, as well as the effect of free surfaces of liquids on stability.

4.1.2   Where necessary, irrespective of calculations demonstrating compliance with damage stability criteria, calculations of possible cross/down flooding effects should be submitted. The calculations should be made in accordance with Annex to MSC.281(85).

4.1.3   If any stability criteria during intermediate flooding stages (before equalization or during replacement of cargo by ballast water) show more severe values than in the final stage of flooding, calculations of these intermediate flooding stages should be submitted to PRS for consideration.

4.1.4   If design documentation contains KG_{max}/GM_{min} limiting curve, this curve should be developed in accordance with 5.3.

4.2   Delivery Documentation

Upon completion of the ship's construction, the following documentation should be submitted to PRS for approval:

  .1   updated design documentation (according to 4.1), based on light ship parameters obtained from inclining test,
  .2   *Damage control plan* prepared in accordance with MSC.1/Circ.1245,

.3   *Damage* control *booklet* – a useful supplement to *Damage control plan*; guidelines for the preparation of such booklet are given in MSC.1/Circ.1245.

5   OPERATING LIMITS

Operating limits resulting from subdivision verification should be clearly presented in stability booklet. Operating limits should include the following:

– specification of types of liquid cargoes allowed to be carried;
– restrictions on different liquid cargoes to be carried simultaneously;
– range of permissible densities of liquid cargoes to be carried;
– restrictions regarding tank filling levels;
– restrictions regarding loading/reloading sequence, as well as asymmetrical loading conditions;
– restrictions regarding the use of ballast water.

5.1   Loading Conditions

The following are regarded as permissible loading conditions:

– loading conditions identical to the approved loading conditions of stability booklet; or
– loading conditions complying with the approved intact and damage stability KG_{max}/GM_{min} limiting curve, where provided (according to 5.3); or
– loading conditions which have been checked with an onboard stability software, approved by PRS (according to 5.4).

Loading conditions not complying with the above-listed requirements are prohibited or should be specially approved by PRS in each particular case.

5.2   Matrix of Permissible Loading Conditions

In the absence of stability software and KG_{max}/GM_{min} limiting curve, in lieu of Rule loading conditions, a matrix clearly listing the allowable range of loading parameters (draught, trim, KG, cargo loading pattern and cargo density) can be developed for stability booklet and so applied as to show compliance with the applicable intact and damage stability criteria when a greater degree of flexibility than that afforded by the Rule loading conditions is needed.

5.3   KG$_{max}$/GM$_{min}$ Limiting Curves

KG_{max}/GM_{min} limiting curves are one of the instruments allowing to check correctness of the planned loading condition. The preparation of these curves is particularly arduous in the case of ships intended for the carriage of liquid cargoes. It requires carrying out a comprehensive calculation taking into account the following items:

– the intended loading patterns resulting from segregation of cargo and the permission to leave certain cargo tanks empty (in accordance with the relevant mark affixed to the symbol of class),
– range of permissible densities of liquid loads to be carried,
– permissible trim range of the ship,
– draught range of the ship, when verifying the damage stability, according to MSC/Circ.406/Rev.1 and MSC.1/Circ 1537 the tropical freeboard needs to be considered, however, the fresh water allowance and tropical fresh water allowance need not be taken into account under MARPOL, IBC and IGC;
– permissible range of cargo tanks partial filling.

The calculation should be performed at the design stage and should take into account stability criteria of the ship, both intact and damaged. The calculation should be made without free surface correction.

Stability booklet should contain a family of limiting curves corresponding to elements which may be considered separately. It is recommended, however, that an envelope curve taking into account the most unfavourable condition should be developed.

5.4   Direct Calculation on Board

Where approved stability software for stability calculations is installed on board, it should cover all stability requirements (intact and damage) applicable to the ship. The following types of stability software may be used:

– simplified software allowing to check the ship's stability by comparing the actual metacentric height or the vertical centre of gravity for the planned loading condition with the developed and approved KG_{max}/GM_{min} curve,
– full software allowing to calculate intact and damage stability for each loading condition, including calculation of intermediate stages of flooding. Stability software shall be based on a hull form model, that is, directly calculated from a full three-dimensional geometric model.

The stability software, installed on board, should not be regarded as a substitute for the approved stability documentation.

6   HULL AND COMPARTMENT MODELLING TOLERANCES

6.1   Acceptable tolerances for particular parameters are given in the table, below:

Hull form dependent	
Displacement	+/– 2%
Longitudinal center of buoyancy from AP	+/– 1% / 50 cm
Vertical center of buoyancy	+/– 1% / 5 cm
Transverse center of buoyancy	+/– 0,5% B / 5 cm
Longitudinal center of flotation from AP	+/– 1% / 50 cm
Moment to trim 1 cm	+/– 2%
Transverse metacentric height	+/– 1% / 5 cm
Longitudinal metacentric height	+/– 1% / 50 cm
Cross curves of stability	+/– 5 cm
Compartment dependent	
Volume of deadweight	+/– 2%
Longitudinal center of gravity from AP	+/– 1% / 50 cm
Vertical center of gravity	+/– 1% / 5 cm
Transverse center of gravity	+/– 0,5 B / 5 cm
Free surface moment	+/– 2%
Shifting moment	+/– 5%
Level of contents	+/– 2%
Trim and stabilty	
Draughts (forward, aft, mean)	+/– 1%, 5 cm
GMt (both solid and corrected for free surfaces)	+/– 1%, max 5 cm
GZ values	+/– 5%, max 5 cm

Downflooding angle	+/− 2°
Equilibrium angles	+/− 1°
Distance from WL to unprotected and weathertight openings or other relevant point, if applicable	+/− 5%, max 5 cm
Areas under righting arm curve	+/− 5% lub 0,0012 mrad

Deviation in % = [(base value-calculated value)/base value] × 100, where the „base value" means the value taken from the approved stability booklet or the computer model, approved by PRS.

Where differences in calculation methodology exist between the programs used in the comparison, this may be a basis for accepting deviations greater than that specified in Table 1 provided a software examination is carried out in sufficient detail to clearly document that such differences are technically justifiable.

Deviation from these tolerances shall not be accepted unless the Society considers that there is a satisfactory explanation for the difference and that it is clearly evident from the Society's stability calculations that the deviation does not impact compliance with the required stability criteria for the ship under consideration.

7 SUBDIVISION VERIFICATION

7.1 Calculation Methodology

For subdivision and damage stability calculations, constant displacement/lost buoyancy method shall be used. The compartment once damaged is not considered as contributing to the buoyancy of the ship. Consequently, a new condition of equilibrium occurs. In order to define the new equilibrium condition and to assess the stability of the ship after damage, the lost buoyancy/ constant displacement method is used. The lost buoyancy of the damaged compartment has to be compensated by sinkage, heel and/or trim of the remaining intact ship. For the new condition of equilibrium, the metacentric height GM and the righting lever curve GZ are calculated.

For the intermediate stages of flooding, the added weight method is used.

7.2 Arguments Used in Calculations

7.2.1 Trim – free trimming of the ship.

7.2.2 The righting lever curve GZ should be calculated over a range of heeling angles 0 – 60º It is recommended to use an increment not exceeding 5º.

7.2.3 For the calculation of the metacentric height GM and the righting lever curve GZ, the effect of the free surfaces of liquids should be taken into account, in accordance with 7.5.

7.2.4 The positive range of righting levers is calculated from the angle of equilibrium to the angle of immersion of the unprotected opening leading to intact spaces, see paragraph 7.6

7.2.5 To comply with stability requirements, weathertight openings should be located above the final equilibrium damage waterline, see paragraph 7.6.

7.2.6 Progressive flooding of undamaged compartments through internal pipes should be considered, unless suitable arrangements – check valves or valves with remote means of control – are fitted.

7.2.7   When defining the spaces which can be flooded, permeabilities specified in *Part IV – Stability and Subdivision* should be applied.

7.3   Cargo Outflow

7.3.1   If the damage involves the cargo tank, it is assumed that cargo is flowing out and that sea water starts to ingress. During the intermediate stages of flooding it is considered that both cargo and sea water are in the damaged tank. In the final stage it is assumed that the cargo has completely flown out and the tank is filled with sea water up to the level of damage waterline.

7.3.2   The impact on the ship's stability, due to the inflow and outflow of liquid cargo is dependent on the following parameters:

–   the density of the cargo in the damaged tank: liquid cargo with density greater than 0.95 t/m^3 should be considered as heavy liquid cargo. In the case of lesser vertical extent of damage (damage above the tank top), the release of heavy liquid cargo might lead to large angle of heel on the intact side of the ship. Depending on the initial draught and cargo tank filling level, the outflow of cargo of lesser density may also cause heel to opposite side;
–   the permeability of the cargo space, taking into account that permeabilities smaller than those specified in the Rules can be applied if justified.

7.4   Permeability (permeability factors)

7.4.1   According to the definition given in *Part IV – Stability and Subdivision*, permeability of a space (permeability factor) is a ratio of the volume within the space, which should be assumed to be occupied by water, to the total volume of the space. The total volume of the space should be calculated based on moulded lines without taking into account any structural members. Account of structural members is taken in Rule permeabilities.

7.4.2   Depending on the applicable requirements, the permeabilities assumed for the ship's spaces should be as shown in the Table below.

Spaces	Permeabilities according to:			
	MARPOL	ICLL[1]	IBC	IGC
Appropriated to stores	0.60	0.95	0.60	0.60
Occupied by accommodation	0.95	0.95	0.95	0.95
Occupied by machinery	0.85	0.85	0.85	0.85
Void spaces	0.95	0.95	0.95	0.95
Intended for consumable liquids	0÷0.95*	0÷0.95*	0÷0.95*	0÷0.95*
Intended for other liquids	0÷0.95*	0÷0.95*	0÷0.95*	0÷0.95*

*   The permeability of partially filled tanks should be consistent with the amount of liquid carried in the tanks.
[1] In accordance with the requirements of ICLL – see 2.5.

7.4.3   Permeabilities other than those indicated in the above Table should be considered only in cases where it is evident that there is a significant discrepancy between the values shown in the Rules and the actual values (due to specific tank structure or insulating material).

7.4.4   The application of permeabilities other than those prescribed by the Rules shall be substantiated with calculations, the details of which should be included in stability booklet.

7.4.5   The applied permeabilities should reflect the general conditions of the ship throughout its service life, rather than specific loading conditions.

7.5   Free Surface Correction

7.5.1   The effect of free surfaces of liquids may lead to:

− the increase of the centre of gravity, *KG*,
− the reduction of the metacentric height *GM*, by correction for free surfaces,
− the reduction of the righting lever curve, *GZ*.

Depending on the filling level, free surfaces can exist in tanks with consumable liquids, sea water ballast and liquid cargo.

7.5.2   For consumable liquids, free surface corrections should be taken into account whenever the filling level is equal to or less than 98%.

7.5.3   When calculating the free surface effects in tanks containing consumable liquids, it should be assumed that for each type of liquid, a single centreline tank or combination of tanks taken into account should be those where the effect of free surfaces is the greatest. The greatest free surfaces effect should correspond to the maximum value attainable between the filling levels envisaged.

7.5.4   During ballasting between departure and arrival condition, the correction for the free surfaces should correspond to the maximum value attainable between the filling levels. This applies also for the situation where in the departure condition the filling level of a ballast tank is 0% and in the arrival condition – 100% (or the opposite).

7.5.5   With respect to consumable liquids tanks, as an alternative, intermediate loading conditions may be considered, covering the stage where the free surfaces are the greatest. They may be calculated as the actual liquid transfer moments, taking into account the actual heel and trim, depending on the interval angles of the *GZ* curve. This is a more accurate method.

7.5.6   For liquid cargo tankers, the effect of free surface should be taken into account for filling level equal to or smaller than 98%. If the filling level is fixed, the actual fee surfaces can be applied. The following methods can be applied for the calculation of the *GZ* curve:

− calculation with constant effect of free surfaces, without taking into account the change in heel and trim,
− calculation with varying free surface moments, taking into account the actual heel and trim.

7.5.7   For the damaged liquid cargo tanks, account should be taken of the following:

− the impact on stability of the ship due to the outflow of cargo and ingress of sea water can be verified with the calculation of the intermediate stages of flooding,
− at the final equilibrium stage, the free surface correction should exclude the free surface moment of the cargo.

7.5.8   Where free surface effect has not been calculated using free surface moment, it should be calculated at an angle of heel of 5 degrees for each individual cargo tank.

7.5.9   The correction for the free surfaces for the compartments assumed to be damaged in the final stage of flooding is not needed; the correction for the free surfaces for the compartments assumed to be damaged in intermediate stages of flooding should be considered when added weight method is used.

7.6   Downflooding Openings

Downflooding point is the lower edge of any opening through which progressive flooding of the ship's spaces/compartments may take place. Such openings should include air-pipes, ventilators and those 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 flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, watertight doors including hinged type, which comply with SOLAS, ICLL, MARPOL Annex I, IGC Code and IBC Code requirements, as applicable and sidescuttles of the non-opening type.

All openings through which progressive flooding may take place should be defined: both weathertight and unprotected. As an alternative it might be accepted to consider only the most critical openings, which are considered to be the openings with the lowest vertical position and close to the side shell. Concerning the longitudinal position it depends on the aft or fore trim of the initial condition and the trim after damage at equilibrium. Unprotected openings should not be immersed within the minimum range of righting-lever curve required for the ship. Within this range, the immersion of any of openings capable of being closed weathertight may be permitted, except openings required to be fitted with weathertight closing devices under the SOLAS, ICLL, MARPOL Annex I, IGC Code and IBC Code requirements, as applicable, that, for operational reasons, are required to be kept open and should be considered as downflooding points in stability calculation (refer to MSC.1/Circ.1535/Rev.1, MSC.1/Circ.1539/Rev.1, MEPC.1/Circ.867, MSC.1/Circ.1543 and MSC-MEPC.5/Circ.11).

The longitudinal position of openings through which progressive flooding may take place is also important. Such openings, located fore and aft, may have significant impact on the ship's damage stability. For such case, the trim range should be in taken into account in calculations.

Openings closed by watertight closing devices, fixed or provided with an arrangement for remote control and signaling should be disregarded in subdivision verification.

Minor progressive flooding through the pipes, situated within the assumed extent of damage, having small diameter and not fitted (due to their purpose) with cutting off valves (e.g. CO_2 system) may be permitted by PRS. The total cross-sectional area of such pipes between the considered watertight compartments should not exceed 710 mm^2.

7.7   Cross-flooding Time

Cross-flooding time should be calculated in accordance with recommendation on a standard method for evaluating cross-flooding arrangements, specified in *Resolution* MSC.362(92).

The following conditions connected with cross-flooding time apply:

  .1   if complete fluid equalization occurs in 60 seconds or less, the considered tanks may be assumed to be flooded instantaneously and no further calculations need to be carried out,

  .2   for instantaneous flooding, only passive open cross-flooding arrangements without valves should be considered,

  .3   where cross-flooding devices are fitted, the safety of the ship should be demonstrated in all stages of flooding. The cross-flooding devices should have the capacity to ensure that the equalization will take place within 10 min,

  .4   tanks/compartments taking part in such equalization should be fitted with air pipes or equivalent means of sufficient cross-section to ensure that the flow of water into the tanks/compartments is not delayed.

7.8   Extent of Damage

The below Table shows the maximum extent of damage according to IMO Conventions/Codes.

Item	Side damage	*MARPOL / IBC / IGC*	*ILLC* (Type A ships)
1	2	3	4
.1.1	Longitudinal extent	$1/3L^{2/3}$ or 14.5 m, whichever is the lesser	Single compartment between adjacent transverse bulkheads, as specified in *ILLC*, Regulation 12(d)
.1.2	Transverse extent	$B/5$ or 11.5 m, whichever is the lesser (measured inboard from the ship's side perpendicularly to the centre plane at the level of the summer load line)	$B/5$ or 11.5 m, whichever is the lesser (measured inboard from the ship's side perpendicularly to the centre plane at the level of the summer load line)
.1.3	Vertical extent	From base plane upwards without limit	From base plane upwards without limit
.2	Bottom damage [1]	*MARPOL / IBC / IGC*	
		For 0.3*L* from the forward perpendicular of the ship	Any other part of the ship
.2.1	Longitudinal extent	$1/3L^{2/3}$ or 14.5 m, whichever is the lesser	MARPOL/IBC $1/3L^{2/3}$ or 5 m, whichever is the lesser IGC: $1/3L^{2/3}$ or 14.5 m whichever is less
.2.2	Transverse extent	B/6 or 10 m, whichever is the lesser	B/6 or 5 m, whichever is the lesser
.2.3	Vertical extent	*MARPOL / IBC*: B/15 or 6 m, whichever is the lesser (measured from the moulded line of the bottom shell plating at centre plane) *IGC*: B/15 or 2 m, whichever is the lesser (measured from the moulded line of the bottom shell plating at centre plane)	*MARPOL / IBC*: B/15 or 6 m, whichever is the lesser (measured from the moulded line of the bottom shell plating at centre plane) *IGC*: B/15 or 2 m, whichever is the lesser (measured from the moulded line of the bottom shell plating at centre plane)
.3	Bottom raking damage [2]	*MARPOL*	
.3.1	Longitudinal extent	In tankers of 75.000 tonnes deadweight and above: 0.6*L* (m) measured from the forward perpendicular of the ship	
		In tankers of less than 75.000 tonnes deadweight: 0.4*L* (m) measured from the forward perpendicular of the ship	
.3.2	Transverse extent	$B/3$ anywhere in the bottom	
.3.3	Vertical extent	Breach of the outer hull	

[1] Bottom damage is not required in the *ICLL*.
[2] Bottom raking damage is required only for oil tankers of 20.000 tonnes deadweight and above.

7.9   Damage of Lesser Extent than the Maximum Damage

If a damage of a lesser extent than the maximum damage (specified in the above Table) would result in a more severe condition as regards equilibrium or damage stability, such damage should be considered.

For a given loading condition, the following examples of damages of lesser extent may result in a more severe situation than that caused by a maximum Rule extent of damage:

.1 damage of lesser transverse extent, e.g. of a tank – without the loss of tightness of the watertight structure preventing the transverse flow of sea water across the hull. It may lead to the asymmetry of flooding, resulting in significant angles of heel,

  .2   damage of lesser vertical extent, e.g. flooding only the spaces above double bottom. This may result in a more onerous residual stability;

  .3   In the case of gas carrier, local damage anywhere in the cargo area extending inboard distance "*d*" as defined in 2.4.1 of IGC Code (Res. MSC.370(93)), measured normal to the hull moulded line of the outer shell shall be considered and transverse bulkheads should be assumed damaged when also required by the applicable sub-paragraphs of 2.8.1 of the IGC Code. Bulkheads shall be assumed damaged when the relevant subparagraphs of 2.6.1 of IGC Code (Res. MSC.370(93)) apply. If a damage of a lesser extent than "*d*" would result in a more severe condition, such damage shall be assumed.

8   THE EFFECT OF CARGO LOADING PATTERN ON DAMAGE STABILITY

For subdivision and damage stability calculations of tankers, the following effects due to loading patterns, specified in 8.1 to 8.3, should be taken into account when determining the scope of verification.

8.1   Homogeneous Loading Condition

For homogenous loading condition, damage of cargo tanks may have a major effect on the ship's stability and ability to regain its upright position if the ship's longitudinal watertight division leads to the outflow of significant amount of cargo and causes heel to opposite side of the damage. In the case of structures which exclude the asymmetry of flooding, damage of cargo tanks leads only to the changes of displacement resulting from the outflow of cargo and ingress of water.

8.2   Alternate Loading Condition

Alternate loading condition characterized by fully loaded cargo tanks, empty cargo tanks and/or partial tanks leads to different effects, depending on whether the damage involves a fully loaded tank or an empty tank. Damage to a fully loaded tank gives the same effect as the homogeneous loading condition (possible heel to the opposite side), whereas damage to an empty tank might cause the opposite effect. For the damage to two adjacent tanks, one fully loaded and one empty, the total effect might be less severe due to two (partly) neutralizing effects.

8.3   Symmetrical Loading Pattern

Subdivision and damage stability calculations for symmetrical loading (alternate, homogeneous, full/empty/partial tanks) may be performed for one side only if the ship and all its openings are also symmetrical. Otherwise, damage stability calculations should be performed for both sides.

9   INTERMEDIATE STAGES OF FLOODING

Intermediate stages of flooding cover the flooding process from the commencement of flooding up to but excluding the final equilibrium damage condition.

9.1   Check Calculations

Intermediate stages of flooding should be checked at the design appraisal stage to verify if the required stability criteria are satisfied. If stability criteria during intermediate stages of flooding do not show more severe values than in the final stage of flooding, the check calculations results need not be submitted for approval.

9.2   Number of Intermediate Stages

A sufficient number of intermediate stages should be examined for all damage cases to verify compliance with stability criteria. It is generally recommended to check 5 intermediate stages of flooding.

If the ship is equipped with non-instantaneous (greater than 60 seconds) passive equalization arrangements or non-passive equalization arrangements, the following procedures should be applied:

   .1   compliance with the relevant criteria should be demonstrated without using equalization arrangements for intermediate and final stages,
   .2   for subsequent equalization, additional 2 intermediate stages and final stages should be checked to demonstrate compliance with the relevant criteria.

9.3   Cargo Outflow and Sea Water Inflow

During intermediate flooding stages, a practical method of calculating the floating position and residual righting moments is the added mass method. The intact condition is corrected for the weights of outflowing cargo and inflowing sea water.

The following method of determining the assumed amount of added sea water and/or cargo outflow is recommended:

   .1   for fully loaded tanks, an equal loss of liquid cargo mass and equal inflow of sea water mass at each intermediate stage resulting in a total loss of liquid cargo and the total inflow of sea water to the final damage equilibrium waterline;
   .2   for empty tanks, an equal inflow of sea water mass at each stage resulting in the total inflow of sea water to the final damage equilibrium waterline;

The following alternative method may be also used:

   .3   for fully loaded tanks, the loss of liquid cargo mass and inflow of sea water is based on a linear change of the total tank content density over each intermediate stage from pure cargo at the intact condition to pure sea water at the final damage equilibrium waterline;
   .4   for empty tanks, an increasing depth of sea water at each intermediate stage is based on the difference between the depth of water in the tank and the depth to the waterline in way of the tank, divided by the number of remaining intermediate stages.

9.4   Free Surface Correction

To take account of free surface effect, it is generally recommended to apply the actual liquid transfer moments for all tank filling levels in each of the considered intermediate stage of flooding.

Noting that there will be combinations of empty and loaded tanks within the damaged extent, free surfaces should be considered individually for each flooded compartment. All compartments should be considered open to the sea in the final equilibrium damage condition.

10   FINAL STAGES OF FLOODING

Equilibrium and stability in the final stages of flooding should be calculated by constant displacement/lost buoyancy method. For subdivision and damage stability verification, the ship's watertight and weathertight integrity is of vital importance. The watertight and weathertight integrity of the ship is ensured through suitable closing devices of openings. The principles regarding consideration of particular types of closing devices of openings in damage stability calculations are given in 7.6.

For closing devices of openings, the interpretation given in 10.1 to 10.4, applies.

10.1 Sliding Watertight Doors

In general, remotely operated sliding watertight doors are permitted to be flooded up to the maximum height at which the effect of the exerted water pressure does not exceed the strength of the doors. The strength of the doors should correspond to the strength of the bulkhead in which they are fitted.

10.2 Hinged Watertight Doors

Hinged watertight doors are permitted to be installed in the following locations:

.1 between the engine room and the steering gear room if the doors are fitted with a quick acting closing device and a permanent notice stating: *To be kept closed at sea*. The sill of the doors should be above the summer load waterline,

.2 in passageways, which are used at sea only occasionally – subject to special consideration in each particular case,

.3 to allow access to a forecastle space, provided that the extent of potential flooding is predictable and the final stage of flooding, if the flooding takes place, will meet the required stability criteria. No further flooding of the forecastle is permitted.

10.3 Weathertight Openings

It is considered that weathertight openings do not provide sufficient protection against flooding and their effectiveness is limited by weather conditions. Weathertight openings include all doors and steel covers which are not watertight, as well as ventilating pipes and ducts, irrespective of type of closing device fitted. Weathertight openings are considered effective if they are above the final equilibrium damage waterline.

10.4 Unprotected Openings

Unprotected openings are openings which are not fitted with closing appliances and openings which, despite being fitted with closing appliances, shall or may remain open even in situations hazardous to the ship. Such openings include air intakes to machinery spaces of Category A, as well as doors leading from crew spaces to survival craft.

It is assumed that the positive range of righting levers should terminate at the angle at which the lower edge of an unprotected opening is immersed.

List of changes effective as of 1 January 2022

	Title/Subject	*Source*
1	Application	IACS REC. 110 Rev.2 p.1
2	Related IMO Documents	IACS REC. 110 Rev.2 p.2
3.2 3.1 (new); 3.3	Scope of Stability verification	ibidem 3.2
5.3, 5.4	Operating limits	Ibid 5.1, 5.2
6	New table of tolerances	Ibidem 6
7.5	Free Surface Correction	Ibid. 9.4
7.6	Downflooding openings	Ibidem 6.7
7.7	Cross flooding time	Ibid.6.8
7.8	Extent of Damage (2.1)	Ibid.7.1
7.9	Damage of lesser extent	Ibid. 7.2