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AUSTRALIAN NAVAL CLASSIFICATION AUTHORITY MANUAL (VOLUME 2)

DIVISION 3: SHIP RULES

CHAPTER 03: BUOYANCY AND STABILITY

PART 2: SOLUTIONS TO THE ANC RULES

This document is issued for use by Defence and Defence Industry personnel and is effective forthwith.

CN Dagg, CSC
Assistant Secretary
Australian Naval Classification Authority
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3 https://www.legislation.gov.au/Series/C2004A03712

4 http://drnet/AssociateSecretary/security/policy/Pages/dspf.aspx

AUSTRALIAN NAVAL CLASSIFICATION RULES

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Division 3: Ship Rules
Part 2: Solutions to the ANC Rules

Chapter 03: Buoyancy and Stability

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Solutions to the ANC Rules

Rule 0. Goal

0.1 The Goal of this chapter is contained in Part 1.

Rule 1. General

1.1 The Naval Vessel Operator (NVO) shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. All decisions that affect compliance with the requirements of this chapter shall be recorded at all stages from concept to disposal and these records shall be maintained throughout the life of the ship.

Solution

1.2 Solutions to the general performance requirements of this Rule shall be selected as an integral element of the Solutions to Rules 2 to 9 of this Chapter, which shall be assessed to ensure they meet the requirements of Part 1.

1.3 All Rules, Regulations, Codes and Standards used shall be the latest versions as amended at the time of drafting the ANC Basis unless a specific version date is specified in the text.

Rule 2. Watertight Integrity

2.1 The NVO shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. In the presentation and justification of a solution, the following must be considered.

Solution

Watertight & Weathertight Boundaries

2.2 The ship's watertight and weathertight boundaries, including any openings, closures, penetrations, drainage and arrangements shall be designed, constructed and maintained to the rules of the ship's Classification Society applicable to the area(s) of operation defined in the Operating and Support Intent (OSI), and shall be certified with the relevant character/construction symbols, or marks, assigned by that society.

Note: The following requirements in this Rule supplement the Classification Society requirements. The ANC Authority shall be contacted for clarification in case conflict is found between requirements when being applied to a vessel.

2.3 Openings in watertight bulkheads shall comply with IMO SOLAS Chapter II-1 Regulation 13 *Openings in watertight bulkheads below the bulkhead deck in passenger ships*, supplemented by the following:

2.3.1 Manually operated hinged watertight doors in compliance with paragraph 2.8 are permitted in place of power-operated sliding watertight doors, where justified to meet the ship's OSI;

2.3.2 Watertight doors shall, as far as practicable, be located across the centre line of the ship;

2.3.3 Watertight doors in fire boundaries shall meet the requirements of Part 2 Chapter 06 *Fire Safety* Rule 8 *Containment of Fire*;

2.3.4 The watertight door central operating console shall be at a permanently manned central control station, which need not be the navigating bridge.

2.3.5 An interconnecting passage to shaft tunnels on ships with multiple shaft lines is not required where the tunnels are required to be separated to meet the ship's separation and redundancy requirements, so long as the ship's damage stability criteria are met.

2.3.6 Where ships do not have an emergency switchboard, door indication and power operated watertight doors shall have equivalent redundancy of power supply in case of loss of the primary power supply.

2.3.7 Portable plates shall not be permitted in watertight bulkheads.

2.3.8 For Naval Vessels with a combat role or other increased survivability requirement:

2.3.8.1 Doors shall not penetrate transverse watertight bulkheads below the damage control deck.

2.3.8.2 Only one door shall be permitted to penetrate each watertight bulkhead below the waterline created by the 'V-Line' (see Rule 3 para.0) when the ship is heeled to port or starboard.

2.4 Each watertight subdivision boundary, shall be constructed having scantlings capable of preventing the passage of water in any direction under the head of water corresponding to the submergence limit.

2.5 Vital spaces within a main watertight compartment shall be provided with watertight boundaries.

Extents of Watertight and Weathertight Integrity

2.6 The extents of the external and internal watertight and weathertight integrity are defined by the intact and damage stability requirements. From these extents, the minimum design pressure heads for bulkheads and other boundaries shall be derived as well as the closing arrangement requirements for openings.

2.7 For the purpose of this Rule, two positions of hatchways, doorways and ventilators are defined as follows:

2.7.1 Position 1 - Upon any part of the damage control deck exposed to the weather, and upon exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular.

2.7.2 Position 2 - Upon exposed superstructure decks situated abaft a quarter of the ship's length from the forward perpendicular and located at least one standard height of superstructure above the damage control deck.

Manually operated watertight and weathertight doors and hatches

2.8 Manually operated hinged watertight doors shall:

2.8.1 Be predominately constructed of the same material to that of the structure on which they are placed;

2.8.2 Be fitted so that the whole structure is of equivalent strength to the un-pierced bulkhead and watertight when closed;

2.8.3 Be fitted with means for securing these doors watertight consisting of gaskets and clamping devices or other equivalent means which are permanently attached to the bulkhead or to the doors themselves, and so arranged that they can be operated from both sides of the bulkhead;

2.8.4 Be capable of being closed with the ship listed to at least the maximum damaged list angle permitted by the damage stability criteria applied in Rule 4;

2.8.5 Indicate their status at the central control station; and

2.8.6 Have procedures in place to ensure the doors are kept closed when there is a risk of damage.

Weathertight Doors

2.9 All access openings in bulkheads at ends of enclosed superstructures above the submergence limit shall be fitted with doors that are predominately constructed of the same material to that of the structure on which they are placed.

2.10 Weathertight doors shall be fitted so that the whole structure is of equivalent strength to the un-pierced bulkhead and weathertight when closed.

2.11 The means for securing these doors weathertight shall consist of gaskets and clamping devices or other equivalent means and shall be permanently attached to the bulkhead or to the doors themselves, and the doors shall be so arranged that they can be operated from both sides of the bulkhead.

Watertight Hatches

2.12 All hatchways below the submergence limit shall be fitted with hatch covers that are predominately constructed of the same material to that of the structure on which they are placed.

2.13 Closures shall be of equivalent strength to the un-pierced structure and watertight when closed.

2.14 The means for securing these hatches watertight shall consist of gaskets and clamping devices.

Weathertight Hatches

2.15 All hatchways above the submergence limit shall be fitted with hatch covers that are predominately constructed of the same material to that of the structure on which they are placed.

2.16 Closures shall be of equivalent strength to the un-pierced structure and weathertight when closed.

2.17 The means for securing these hatches weathertight shall consist of gaskets and clamping devices.

Arrangement details for watertight and weathertight doors

2.18 Doors opening onto open decks shall open outwards to provide additional security against the impact of the sea.

2.19 The sill height for watertight and weathertight doors in Position 1 shall be at least 600mm. Except as otherwise provided in this Rule, the height of the sills of access openings in bulkheads and the external envelope for all other watertight and weathertight doors shall be at least 380 mm above the deck, or a greater height where required by the damage stability criteria.

2.20 Portable sills shall be avoided. However, subject to ANC Authority approval, in order to facilitate the loading/unloading of heavy spare parts or similar, portable sills may be fitted to weathertight doors on the following conditions:

2.20.1 they shall be installed before the ship leaves port; and

2.20.2 they shall be gasketed and fastened by closely spaced through bolts.

2.21 Access openings which are positioned below the submergence limit, which provide access below shall be fitted with a sill height of not less than 600mm above the deck. Other openings positioned below the submergence limit which lead to spaces where access is not provided from above shall be fitted with a sill height of not less than 600 mm above the deck.

2.22 External watertight doors, including shell doors, which are positioned below the submergence limit shall be fitted with a watertight trunk leading above the submergence limit. Alternatively, and where deemed acceptable to the ANC Authority the watertight trunk need not lead upwards provided a second watertight door is fitted, a leakage detection device is provided in the compartment between the two doors and drainage of this compartment is provided, controlled by a readily accessible screw down valve. The outer door shall open outwards except where permitted by paragraph 2.23. In all such instances the doors fitted shall have a sill height of at least 600 mm.

2.23 Pilot doors shall not open outwards. Pilot doors or any other external doors which are permitted by the ANC Authority to open inwards, shall be provided with suitable means to give additional protection against the impact of the sea. Such means may include a strongback or an equivalent arrangement.

2.24 Aviation system hangar doors for access of aviation systems may be exempted from a sill above deck height provided they are:

2.24.1 Aft facing;

2.24.2 Compliant with Chapter 11 *Aviation Systems* Rule 7 *Aviation System Storage Area*;

2.24.3 Situated adjacent to a flight deck which is compliant with Chapter 11 *Aviation Systems* Rule 8 *Flight Deck*.

Arrangement details for watertight and weathertight hatches

2.25 Hatches on the weather deck shall be fitted with coamings of a height of not less than 600 mm measured above the upper surface of the deck. Hatches on decks other than the weatherdeck shall be fitted with coamings of a height of not less than 450 mm measured above the upper surface of the deck. The ANC Authority may permit the coamings to be reduced in height or omitted entirely, if the safety of the ship is not thereby impaired in any sea condition. Special attention shall be given in such cases to the scantlings of the covers, to their gasketing and securing arrangements and to the drainage of recesses in the deck.

2.26 In areas where the fitting of hatches of regular height may interfere with the normal operation of the ship, flush hatches may be admitted provided they are of a type approved as watertight and provided with a status indicator at the navigation bridge. The indicator system shall be of a fail-safe type.

2.27 Small hatches, including escape hatches, shall be situated clear of RADHAZ areas and RAS stores receiving areas and storing routes.

2.28 Escape hatches shall be capable of being opened and closed from either side unless specified otherwise. The ANC Authority may accept these being fitted without a coaming so long as they are demonstrated to be watertight or weathertight as applicable. In particular escape scuttles on the external boundary shall be tethered to allow the opening to be closed following passage through.

2.29 Where portable plates are required in decks for disembark machinery, or for other similar reasons, they may be accepted provided they are to be secured by gaskets and closely spaced bolts at a pitch not exceeding five diameters or equivalent naval standard in way to restore the same level of tightness of surrounding structures.

Construction details of manually operated doors and hatches

2.30 Manually operated doors shall be provided with a gasket seal, with two hinges and secured by means of clips which can be operated from either side of the bulkhead. Each hinge shall be provided with an oval eye hole, in order to allow the clips to compress the door seal uniformly against the door frame coaming.

2.31 Manually operated hatches shall be provided with a gasket seal, with hinges. The hinges shall not form part of the securing device. Each hinge shall be provided with an oval hole, in order to allow the closing devices to compress the hatch seal. Where no coaming is fitted attention shall be given to avoid protrusions, which may form trip hazards.

2.32 Weathertight doors shall be fitted with at least four corner clips positioned 350 mm from the upper and bottom edges of the door, at each side. Watertight doors shall have a least six clips, where the two additional clips shall be positioned in the middle of the door on the upper and bottom edges.

2.33 Seals shall be fitted to the door or hatch and be secured by a retaining bar. The seal shall be bonded to the door plate or hatch cover by an adhesive suitable for marine conditions.

2.34 In order to prevent damage to the door or hatch seal, the edges of the door frame or hatch coaming shall be rounded or chamfered.

2.35 The door clips shall engage downwards to prevent them being shaken free.

2.36 The door clips shall align with wedges, so that when the clips are closed the door seal is compressed. The direction of the slope of the wedge shall correspond to the required closing direction of the clips.

Note: A slope of 1:12 for the wedges is recommended.

2.37 Securing arrangements, such as a holdback device situated on the adjacent structure shall be provided to retain doors and hatches in the open position.

2.38 Where quick release doors are required, the engagement of the door clips shall be operated by a control hand wheel.

2.39 Manually operated doors and frames shall meet the quality of manufacture requirements of ISO 6042 *Ships and marine technology – Weathertight single-leaf steel doors*.

2.40 Hatch coamings and covers shall meet the quality of manufacture requirements of ISO 5778 *Ships and marine technology – Small weathertight steel hatches*.

Operation

2.41 Where manually operated doors and hatches are used, the personnel on-board shall be suitably familiar with their safe operation and the associated closure requirements. The closure requirements for individual doors and hatches shall align with the intact and damage stability requirements, and a suitable closure procedural system is to be implemented.

2.42 Doors and hatches situated in escape routes shall meet the requirements of Chapter 07 *Escape, Evacuation and Rescue* Rule 17.

2.43 Small hatches and their securing devices shall be easily operable by one person in the expected operating conditions; this is typically achieved if the maximum operating force does not exceed 150N. Where necessary, counterbalance weights, springs or other equivalent mechanisms shall be provided to assist the user in opening and closing the hatch. Any mechanism fitted is to be designed so as not to present a hazard to persons using the hatch. Failure of the mechanism is not to prevent the operation of the hatch.

Markings

2.44 All doors and hatches shall be provided with markings to uniquely identify them and the conditions under which they are to be closed.

Miscellaneous openings

2.45 Watertight ventilators and trunks shall be:

2.45.1 Carried above the submergence limit; and

2.45.2 Compliant with the applicable requirements of IMO International Convention on Load Lines 66/88 Annex I Regulation 17 *Machinery Space Openings* and Regulation 19 *Ventilators*.

2.46 Airpipes shall comply with IMO International Convention on Load Lines 66/88 Annex I Regulation 20 *Air pipes* incorporating IACS Unified Interpretation LL.49. Airpipe height shall be measured from the upper face of the deck, including sheathing or any other covering, up to the point where water may penetrate inboard.

Drainage

2.47 Naval Vessels shall comply with the requirements of IMO SOLAS Chapter II-1 Regulation 35-1 *Bilge pumping arrangements* and Regulation 48 *Protection against flooding*, supplemented by the following:

2.47.1 The requirements applicable to passenger ships shall apply to Ship Type A and Type B.

2.47.2 Regulation 48 *Protection against flooding* shall apply to all spaces located in the ship's bottom, except tanks or spaces intended to be flooded in normal operation.

2.48 Scuppers, sufficient in number and suitable in size, are to be provided to permit the drainage of water likely to accumulate in the spaces which are not located in the ship's bottom.

2.49 Scuppers, inlets and discharges shall comply with IMO International Convention on Load Lines 66/88 Annex I Regulation 22 *Scuppers, inlets and discharges*, supplemented by the following:

2.49.1 In Reg.22 paragraph (2) "enclosed superstructures used for the carriage of cargo" is amended to "enclosed vehicle spaces or ro-ro vehicle spaces or hangar(s)".

2.49.2 In Reg.22 paragraph (3), the control position shall be considered in line with the ship's damage control philosophy.

2.49.3 In Reg.22 paragraph (7), in any case the pipe thickness need not be thicker than the shell plating.

2.50 Where bulwarks and open superstructures on weather decks form wells, they shall be provided with freeing ports in accordance with IMO International Convention on Load Lines 66/88 Annex I Regulation 24 *Freeing ports*, supplemented by the following:

2.50.1 In Reg.24 paragraph (1) “freeboard deck” should be read as “weather decks” so there is no reduction in size for freeing ports in bulwarks on superstructure decks.

2.50.2 Standard sheer is that shown in IMO International Convention on Load Lines 66/88 Annex I Regulation 38 *Sheer*.

2.50.3 When the deck has little or no sheer, the freeing area shall be spread along the length of the well.

2.50.4 Standard superstructure height is that shown in IMO International Convention on Load Lines 66/88 Annex I Regulation 33 *Standard height of Superstructure.*

Rule 3. Reserve of Buoyancy

Note:

Solution 1 shall be used in conjunction with Rule 4 Solution 1 or;

Solution 2 shall be used in conjunction with Rule 4 Solution 2.

The Lightweight survey and inclining experiment, Freeboard, Draught marks and Tank gauging solutions are common for both Solution 1 and Solution 2.

3.1 The NVO shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. In the presentation and justification of a solution, the following must be considered.

Solution 1 & Solution 2

<u>Lightweight survey and inclining experiment</u>

3.2 The first ship constructed of a class shall be inclined to determine the displacement and centre of gravity. The experiment shall be conducted in accordance with the IMO International Code on Intact Stability. Subsequent ships constructed to the same design at the same yard shall be lightweight surveyed but are not required to be inclined unless the lightweight survey results deviate from the first-in-class lightship by the following criteria:

3.2.1 In displacement exceeding 1% for ships of 160 m or more in Length at Water Line (LWL) and 2% for ships of 50 m or less in LWL and as determined by linear interpolation for intermediate LWLs; or

3.2.2 In the Longitudinal Centre of Gravity exceeding 0.5% of LWL.

Note: In these Rules, Lightweight survey has the same meaning as a Lightship Displacement Check (LSDC)

3.3 A lightweight survey or inclining experiment shall be witnessed and approved by the ANC Authority at intervals through the life of the ship to establish if a degradation in stability and buoyancy has occurred.

3.3.1 If a ship is subject to an alteration, addition or unaccountable growth is suspected to affect displacement or the location of centre of gravity, a lightweight survey shall be conducted. Additionally, if the cumulative effect of alterations causes a rise of lightship vertical centre of gravity that exceeds 1% an inclining experiment shall be conducted.

3.3.2 Lightweight surveys are also to be conducted at 5 yearly intervals or at other intervals determined from the margins management plan and specified in the Trim and Stability Booklet.

3.3.3 Subject to ANC Authority agreement, the lightweight survey (displacement check) may be conducted as an alternative to an inclining test (experiment) however the ship is to be inclined whenever, in comparison with the approved lightship, a deviation is found or anticipated:

3.3.3.1 In displacement exceeding ±2%; or

3.3.3.2 In the Longitudinal Centre of Gravity exceeding ±1% of LWL.

3.3.4 When a lightweight survey result does not exceed the specified deviation limits, the lightship displacement and the longitudinal and transverse centres of gravity obtained from the lightweight survey shall be used in conjunction with the vertical centre of gravity derived from the most recent inclining in all subsequent Stability and Buoyancy Operational Information (see Rule 8) supplied to the Command.

3.4 The Stability & Buoyancy operational information (See Rule 8) shall be renewed and re-approved by the ANC Authority whenever, in comparison with the approved lightship, a deviation is found:

3.4.1 In displacement exceeding ±2%; or

3.4.2 Of the Longitudinal Centre of Gravity exceeding ±1% of LWL; or

3.4.3 Of the Vertical Centre of Gravity exceeding ±1%.

3.5 Where subsequent ships are constructed to the same design as the first of class they can be considered as “sister” ships and be issued with the same operational information so long as the lightweight survey meets the criteria given in paragraph 3.2.

3.6 Where ships are of the same design and through life have lightweight surveys and/or inclining experiments and have displacements and centres of gravity within the limits stated in paragraph 3.4 above they can be considered as “sister” ships and be issued with the same operational information.

Freeboard

3.7 The minimum freeboard and bow height shall:

3.7.1 Comply with Annex I Chapter III and Annex II of the IMO International Convention on Load Lines, as applicable to the ship's area of operation specified in the OSI; and

3.7.2 Satisfy the requirements to STANAG 4154 Common Procedures for Seakeeping in the Ship Design Process specified in Rule 6 *Safety of Embarked Persons and Seakeeping*.

Draught Marks

3.8 Calculative draught marks shall be provided on the port and starboard sides of vessels at the following locations:

3.8.1 Forward – abaft the forward perpendicular at a distance dependent on the geometry of the stem and forefoot and the position of the anchor stowage arrangement that allows reading down to a draught half the design draught or less.

3.8.2 Mid – as close to amidships as is practicable.

3.8.3 Aft – forward of the aft perpendicular at a distance dependent on the geometry of the stern that allows reading down to a draught half the design draught or less. Typically, this would be located at the aft cut-up.

3.8.4 Transom – A set of draught marks may be located on the transom in addition to the aft marks, provided the transom extends below the designed waterline and the rake of the transom is less than 15º.

3.9 Projection (or navigation) draught marks shall be provided on the port and starboard sides of vessels at the following locations:

3.9.1 Deepest part of the hull, such as the aft cut-up or skeg ending, if not already provided for by a calculative draught mark.

3.9.2 Where permanent projections such as a sonar dome or propeller project below the main line of the keel, the draught marks are to be in line with the lowest point or sweep of the projection.

3.10 Calculative and projection draught marks shall have the following characteristics:

3.10.1 The size, style and positioning of the draught marks must be such that they are clearly legible from typical reading distances, such as dockside, and that they provide an unambiguous indication of the draught.

3.10.2 Draught marks shall be affixed to the hull only.

3.10.3 Raised marks of cut plate shall be provided. Where noise may be a problem, such as below the waterline forward of sonar, painted marks may be used in lieu.

3.10.4 Numerals shall be half the spacing in height when measured on a vertical projection.

3.10.5 All marks shall be vertical.

3.10.6 The base of the numeral shall be at the indicated draught.

3.10.7 The zero of calculative draught marks shall be at the underside of keel or a suitable projection from the nearest cut-up from the keel, such as tangential or horizontal.

3.10.8 The range (lowest to highest) of calculative draught marks shall allow for grounding/docking and damage.

3.10.9 Metric marks using Arabic numerals, spaced at even decimetre heights, shall be provided.

3.10.10 A single digit shall be used for intermediate decimetre heights and a digit and the letter M at each metre height.

3.10.11 Wherever possible, forward and aft calculative draught marks should be equally spaced about amidships in order to facilitate calculation of the draught amidships.

3.10.12 All projection draught marks must be labelled with a symbol that indicates the type of projection of a word such as “PROJ”.

3.10.13 The zero of projection draught marks must be the lowest point or sweep of the feature.

3.10.14 The range of projection draught marks need only be sufficient to cover all possible floating draughts.

3.10.15 A permanent reference (datum) mark should be located port and starboard as near as possible to the weatherdeck directly above the calculative marks, for use as a reference mark for the following purposes:

3.10.15.1 To facilitate the measurement of the vessels draught when in the damaged condition; and

3.10.15.2 To locate the horizontal and vertical datum (reference line) for lining off the draught marks when repainting is necessary.

3.10.16 The offset from the zero to the hydrostatics baseline for all marks shall be noted on the draught marks diagram.

3.11 Limiting draught marks shall be provided as follows:

3.11.1 If required to define limiting draughts, such as defined from reserve buoyancy considerations.

3.11.2 The dimensions of the limiting draught mark are shown in Figure 1 and Figure 2, except for the lengths labelled D (given in Table 1). The units in the two figures below are in millimetres and degrees.

3.11.3 The limiting draught mark’s bar line is a welded bar at least 3mm thick, which is used to indicate a permanent reference point for the limiting draught mark. The dimensions shown are the acceptable minima.

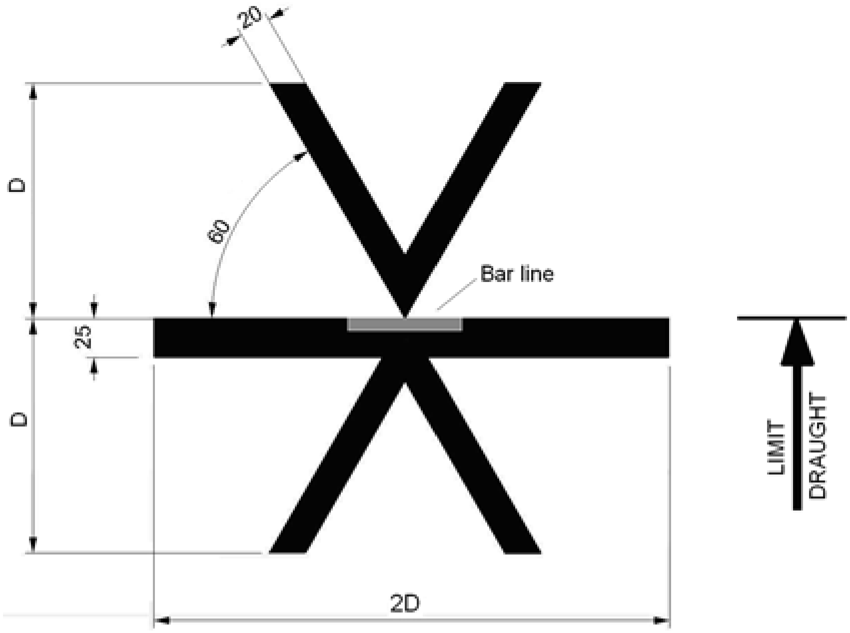


Figure 1: Limiting draught mark

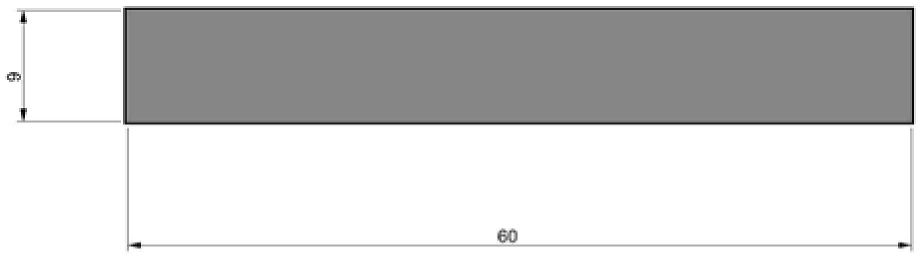


Figure 2: Limiting draught mark bar

Table 1: Limiting Draught Mark Dimensions

	Dimension "D" for ships with freeboard less than or equal to 5m	Dimension "D" for ships with freeboard greater than 5m
Limiting draught mark	150mm	200mm

3.11.4 The mid mark shall be located at the point on the hull corresponding to the transverse plane of the longitudinal centre of floatation at the limiting draught and design trim. This also applies to using a load line mark as the limiting draught mark.

3.11.5 If there are trim limitations, forward and aft marks located near the ends of the ship, shall also be installed.

3.11.6 Where the OSI requires that ships are assigned a load line, this should be an all seasons load line, no higher than the scantling draught, and marked in accordance with the *International Convention on Load Lines* Chapter I Regulation 5 as per the Load Line assignment letter from the assigning authority.

Tank Gauging

3.12 A system for determining the level of contents of all tanks through a gauging system shall be provided. This shall be provided by manual soundings. Ullage or sensors may also be provided to supplement the manual soundings. Tank sounding systems shall be in accordance with the rules of the ship's Classification Society and shall be certified with the relevant character/construction symbols, or marks, assigned by that society subject. The gauging system shall be adequately calibrated.

Solution 1

Submergence Limit

3.13 Solution 1 for determining the submergence limit & watertight/weathertight integrity requirements is the approach used by SOLAS.

Note: Refer to Part 3 for information on motions of a damaged ship in a seaway.

3.14 In any stage of flooding the waterline, taking into account sinkage, heel and trim, shall be below:

3.14.1 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 watertight sliding doors or manually operated hinged watertight doors, and sidescuttles of the non-opening type;

3.14.2 Any part of the bulkhead deck considered an evacuation route or route for damage control;

3.14.3 The exit of a vertical escape route;

3.14.4 Any controls intended for the operation of watertight doors, equalisation devices, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads;

3.14.5 Emergency source of electrical power.

3.15 A watertight closure is required for openings that may be submerged under a constant head of water at any stage of flooding. A weathertight closure is required for openings that are submerged with intermittent head of water such as transitional phase due to ship motion and green water.

Solution 2

Submergence Limit

3.16 Solution 2 for determining the submergence limit & watertight/weathertight integrity requirements is the V-line & Margin Line approach and is applicable when selecting Rule 4 Solution 2.

Note: Refer to Part 3 for information on motions of a damaged ship in a seaway

3.17 In a damaged condition the ship's Margin Line shall remain above the static damaged waterline (in still water without the influence of the environment).

V-Line

Note: The V-Line defines the limit of watertight integrity in the hull and watertight boundaries.

3.18 The V-Line shall be defined by the actual damage waterline, or not exceeding the maximum damaged list angle permitted by the damage stability criteria applied in Rule 4 for design purposes (Rule 4.38.3.1) with an allowance for ship motion and wave action as contained in Figure 3.

3.19 Non-watertight openings and penetrations shall not be fitted below the V Line.

3.20 Watertight boundaries shall be designed and maintained to withstand a head of water up to the V-Line.

3.21 All damaged waterlines on both sides of main watertight bulkheads shall be assessed to determine the most onerous V-line.

3.22 Roll angle θ_2 shall be calculated from the equation given in 3.26 and shall be used in determining damage waterlines depicted in Figure 3, the Red Line, below which is a zone that is at immediate risk of damage.

3.23 Closing devices in this region shall be marked for rapid closure in the event of flooding.

Note: The θ2 values simply represent reasonable roll amplitudes which ships of varying displacements intact or damaged are likely to exhibit in moderate seas where the wave height is 1.25m. The values of θ_2 and 1.25m wave height recognise the fact that the ship is not expected to withstand the same degree of sea and weather hazards as the undamaged ship.

3.24 The Damage Control Deck shall be located above the Red Line (see Figure 3) at the centreline of each watertight transverse bulkhead.

Note: If this is not practical, arrangements are to be proposed which rapidly control resulting progressive flooding and ensure compliance with the requirements of Rule 4.29.

3.25 No openings or penetrations shall be fitted in watertight bulkheads below the Damage Control Deck.

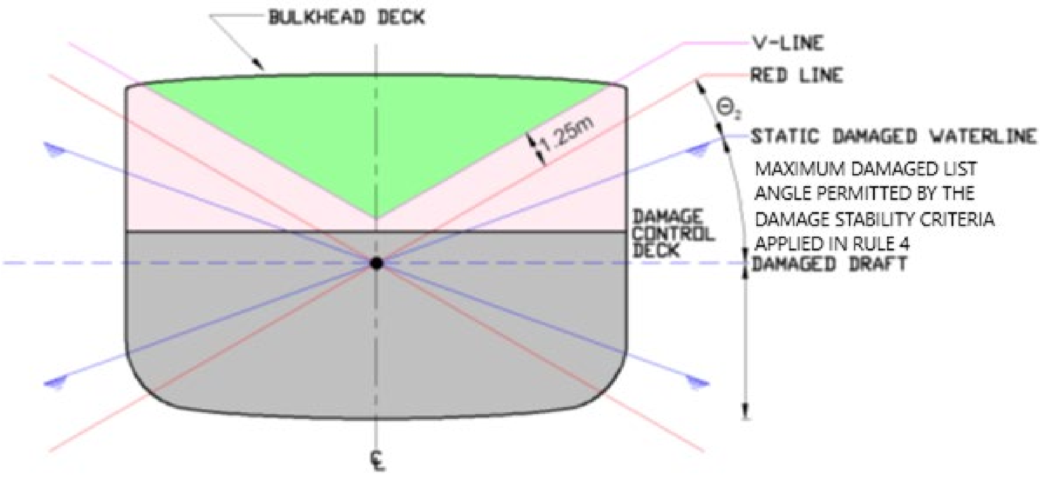


Figure 3: V-Line submergence limit

3.26 The damage roll back (Θ_2) empirical equation is presented below:

$$Damage\ Roll\ Back = 14\left(\frac{\Delta + 8000}{8000}\right)^{-0.5}$$

Rule 4. Reserve of Stability

Note: Solutions are to be wholly employed and not mixed i.e. Solution 1 Intact stability element combined with Solution 2 damage stability element.

• Solution 1 shall be used in conjunction with Rule 3 Solution 1; or

• Solution 2 shall be used in conjunction with Rule 3 Solution 2.

The Stability Model and Analysis solution is common for both Solution 1 and Solution 2.

4.1 The NVO shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. In the presentation and justification of a solution, the following must be considered.

Solution 1 & Solution 2

4.2 The requirements of this Rule shall be demonstrated by a stability analysis based on the results of the first inclining and prior to the ship proceeding to sea. This is separate to any operator guidance to be provided under Rule 8 Provision of Operational information.

4.3 Any standards, models (numerical or physical), calculations, tests, trials or procedures used to determine the centre of gravity and restoring energy of the ship and the magnitude of foreseeable disturbances shall be made available for approval by the ANC Authority.

4.4 Any operator guidance as defined in Rule 8 shall be made available for approval by the ANC Authority. This may include but not be limited to trim & stability handbook, damage control book (where relevant to reserve of stability), stability or loading computer, weather routing advice, operational restrictions, loading guidance, poster, simulator or electronic display required by the crew to safely operate the ship.

Stability Model & Analysis

4.5 Stability Model

4.5.1 Where stability software is used for calculations to demonstrate compliance with the stability standard it is to be agreed with the ANC Authority. The stability computer model is to be a suitably accurate representation of the constructed ship. Where a model originates from benchmark or construction data the following tolerances are appropriate.

4.5.2 Displacement

4.5.2.1 The variation in displacement between the benchmark data and the results from the new model should correspond to a difference in draught of approximately 2mm, since this is the best accuracy which can be expected at inclining experiments. However, for small ships it is more difficult to achieve close agreement. Therefore, the validation tolerances to be applied imply closer agreement in displacement should be expected as size increases, and the following values are recommended which will limit the variation in draught to approximately 0.2 - 1.5cm:

a. 1% for ships less than 5000 tonnes;

b. 0.5% for ships between 5000 and 15000 tonnes;

c. 0.25% for ships greater than 15000 tonnes.

4.5.3 LCB

4.5.3.1 The following validation tolerances are recommended, which requires a lower variation in absolute trim on smaller ships (approximately 2 cm), but a greater variation on the trim angle:

4.5.3.2 0.1% of LWL at design draught for ships less than 5000 tonnes;

4.5.3.3 0.075% of LWL at design draught for ships between 5000 and 15000 tonnes;

4.5.3.4 0.05% of LWL at design draught for ships greater than 15000 tonnes.

4.5.4 VCB and BMT

4.5.4.1 The validation tolerance for each of these parameters should be taken as 1%.

4.5.5 TCB

4.5.5.1 The validation tolerance is 0.05% of moulded beam.

4.5.6 MCT, TPC, LCF & KM

4.5.6.1 The validation tolerance for each of these parameters should be taken as 2%.

4.5.7 Cross curves

4.5.7.1 The validation tolerance for each of these parameters should be taken as 1% for all heel angles up to 90 degrees.

4.5.8 Internal subdivision

4.5.8.1 Internal compartments shall not overlap or contain voids and shall fill the space within the hull envelope.

4.5.8.2 The gross volume of tanks is to be compared. The permeability of tanks is permitted to vary to allow for structure using the following guide:

a. Up to 3% for tanks with extensive pipework inside;

b. 2% for small tanks or those having a high degree of internal structure e.g. fore/aft peaks and double bottom;

c. 1% for all other tanks.

4.5.8.3 When gross tank volumes are being compared, normal acceptance criteria is to allow a variation of ±2%. A tolerance of 1% is however to be applied to VCG since this parameter has a direct influence on stability. A tolerance of 1% should also be applied to LCG/LWL and TCG/B. The free surface moments of tanks have a variation allowance of ±1% to reflect the allowance specified for tank volume above.

4.6 Stability Analysis

4.6.1 Modelling Assumptions

4.6.1.1 Calculations should account for shell displacement due to shell thickness and any appendages, as well as lost volume such as sea chests. The method used shall be stated in the stability analysis report.

4.6.1.2 Where superstructure or deckhouses can be considered as watertight and robust such structure may be considered as effective for the purposes of stability analysis. It should be noted that superstructure on the first deck above the weather deck or above, are often not watertight. Where the effectiveness of the superstructure is not known, the cross curves and curves of statical stability shall be derived without the superstructure included in the model.

4.6.1.3 Submergence of openings that lead to consequential flooding must be taken into account during the assessment of stability. However, small openings through which only limited water may flow, and which may then be pumped out, need not be taken into account as long as they only submerge infrequently as a result of transient ship motion and wave action. All down flooding which may lead to the loss of the ship shall lead to termination of the GZ curve.

4.6.2 Free Surface Effects

4.6.2.1 Several modelling methods exist by which liquid free surface effects can be allowed for during a stability analysis e.g. Free Surface Correction and Tank Shift Moment. The stability analysis is to use the most appropriate method through agreement with the ANC Authority.

4.6.2.2 The effect of unpumpable fluid from tanks is to be specially considered.

4.6.3 Fluid Restrictions

4.6.3.1 It may be necessary for the fluid to be retained in tanks in order to comply with the stability criteria. This is to be brought to the attention of the ANC Authority with the associated draught and trim range that are applicable.

4.6.4 Definitions of Loading and Lightship conditions

4.6.4.1 Refer to selected stability Solution

4.6.5 Growth

4.6.5.1 The stability analysis is to include, where appropriate, an allowance for any future alterations, additions and unaccountable growth that will affect the displacement and location of centre of gravity. The ANC Authority approval of the stability performance will remain valid for the period of growth applied until the lightship and centres of gravity are re-evaluated, refer to Rule 3 paragraphs 3.2-3.6.

4.6.6 Stability Calculation

4.6.6.1 The ship shall initially be in an upright condition for the analysis to provide evidence of compliance with the intact and damage stability criteria. The lost buoyancy approach to damage stability calculations is to be used. Where asymmetry exists the stability analysis is to be conducted to both Port and Starboard. The following accuracy of stability calculations can be applied:

Table 2: Resolutions for Stability Analysis Results

	Absolute Resolution	Percentage Error (Maximum)
Areas under heeling arm and righting arm curves	0.001 m-rads	1.0%
Maximum GZ and minimum GM	0.005 metres	0.8%
Angles of heel or list (based on 30 degrees)	0.5 deg.	1.3%

Solution 1

Intact Stability

4.7 For ships with similar foreseeable operating conditions to, and a requirement to have similar survivability to, merchant ships the IMO International Code on Intact Stability (IS Code) shall be applied with the following provisions:

4.7.1 The criteria applicable to passenger ships shall apply to:

4.7.1.1 Ship Type A and Type B; or

4.7.1.2 Ships whose OSI includes Humanitarian and Disaster Relief evacuation.

4.7.2 Ships which may carry out towing or lifting operations shall meet the applicable criteria given in IMO Resolution MSC.415(97) *Amendments to Part B of the 2008 IS Code*.

4.7.3 Ships which may be expected to operate in areas where icing is possible shall apply an icing allowance in the stability calculations as given in the IS Code Part B Chapter 6 *Icing Considerations* for fishing vessels.

Damage Stability

4.8 For ships with similar foreseeable operating conditions to, and a requirement to have similar survivability to, merchant ships the IMO Safety of Life at Sea Convention (SOLAS) II-1 Part B shall be applied with the following provisions:

4.8.1 The Part B criteria applicable to passenger ships shall apply to Ship Type A and Type B.

4.8.2 Damage stability criteria for Ship Type C with Length Between Perpendiculars (LBP) <80m shall be selected, as appropriate to the OSI and agreed with the ANC Authority, from one of:

4.8.2.1 The National Standard for Commercial Vessels; or

4.8.2.2 The International Convention on Load Lines 1966/1988 Regulation 27 Types of ships; or

4.8.2.3 The International Code of Safety for High Speed Craft 2000 Chapter 2 Buoyancy, stability and subdivision.

4.8.3 For all ships, the damage stability analysis shall consider damage at each Main Watertight Bulkhead and include flooding of the two adjacent Main Watertight Compartments as a minimum.

4.9 The ship shall satisfy the Post Damage Capability stability, flooding and any consequential watertight subdivision requirements of Chapter 01 *General Requirements* Rule 2 *Post Damage Capability*.

Solution 2

Intact Stability

4.10 Ships whose OSI requires survivability traditionally expected of constabulary and combat naval ships shall comply with the following Solution 2 requirements.

4.11 Intact stability shall be assessed against stability criteria appropriate to the ship's operational requirement for the full range of ship loading conditions. Typical intact stability criteria are given in Table 3 below.

Table 3: GZ Curve Requirements

Parameter	Requirement
Area under GZ curve, 0°-30°	Not less than 3.15 m-deg
Area under GZ curve, 30°-40°	Not less than 1.72 m-deg
Area under GZ curve, 0°-40°	Not less than 5.16 m-deg
Maximum GZ	Not less than 0.3m (taken at the GZ curve first peak or 50 deg whichever is less)
Angle of maximum GZ	Not less than 30°
GM_{fluid}	Not less than 0.3m
Downflooding Angle	As determined, but taken as no greater than 70°

4.12 Table 4 describes the standard loading conditions requiring assessment for compliance, with a minimum of 0% for consumables and cargo (fluids and solids); however, the actual number and description of loading conditions to be assessed shall be determined from the ship's OSI.

Note: Guidance on the selection of loading conditions is provided in Part 3.

Table 4: Standard Loading Conditions Requiring Stability Assessment

Load Variable	Full Load	Inter-mediate Conditions	Light Arrival	Harbour	Comments
Lightship	Full	Full	Full	Full	See definition in Part 3
Crew and Effects	Full	Full	Full	Full	See definition of Embarked Persons
Provisions	Full	Proportion	Zero	Worst	
General Stores	Full	Proportion	Zero	Worst	

Load Variable	Full Load	Inter-mediate Conditions	Light Arrival	Harbour	Comments
Role based Stores - Permanent	Full	Full	Full	Full	
Role-based stores - Consumable	Full	Proportion	Zero	Worst	
Ship Ammunition	Full	Proportion	Worst	Worst	
Fresh Water	Full or Operating	Proportion	Zero or Operating	Zero or Operating	Operating if Fresh Water is produced on board
Ship's Fuel, Storage	Full	Proportion	Zero	Zero	
Ship's Fuel, Service	Full	Operating	Zero	Operating	
Fuel overflow	Zero	Zero	Zero	Zero	
Sea Water Ballast	Zero	Operating	Operating	Operating	As required to comply with stability, trim and heel requirements. For legacy ships with compensating or dirty ballast, see Part 3
Lubricating Oil/Hydraulic Oil Storage	Full	Proportion	Zero	Zero	
Settling/Renovating Tanks	Zero	Half or Operating	Half	Zero	
Drain/Sludge Tanks	Zero	Half	Half	Zero	
Waste Holding Tanks	Zero or Operating	Half or Operating	Half or Operating	Zero or Operating	Operating where waste treatment plant is provided
Stabiliser/Flume Tanks	Operating	Operating	Operating	Zero	
Miscellaneous Liquids	As applicable	As applicable	As applicable	As applicable	Includes fuel for ships boats, vehicles, etc
Aircraft	Full	Full	Full	Zero	
Aviation Spares and Stores	Full	Full	Full	Full	
Aviation Ammunition	Full	Proportion	Worst	Worst	
Aviation Fuel	Full	Proportion	Zero	Zero	
Non-crew and Effects	As applicable	As applicable	As applicable	As applicable	See definition of Embarked Persons
Cargo	As applicable	As applicable	As applicable	Zero	
Garbage Stores	Zero	Proportion	Full	Zero	

Notes to Table 4:

Definitions of Full and lesser amounts as follows:

Full. The full allowance of each load variable is generally the maximum amount than can be or is allowed to be carried. For example, the maximum capacity of ship's store rooms will usually apply. There will be cases where lesser amounts are appropriate. Full in the case of tanks is 100% of capacity for water, 95% of capacity for fuel and oil tanks, or rated capacity if one is specified. Fuel tanks filled till overflowing, either into the next tank in line or into an overflow tank are taken as Full at the point where overflow occurs, even if this is 100% of capacity.

Zero. Nothing usable left. For most load variables everything has been consumed. For tanks, this means to bottom of suction. During early design phases, a default value to bottom of suction, typically 2% of total volume, may be assumed, but actual value is explicitly determined for the tank tables presented in the buoyancy and stability information required by Rule 8.

Min. The minimum (Min) amounts for most load conditions are defined individually for each load variable. Consideration may be given to changing this amount on a case by case basis, subject to ANC Authority approval.

Proportion. Load variables are set to the same proportion consumed or increased between the Full and Min values matching the particular load condition (e.g. An intermediate load condition, one third between Full Load and Light Arrival, would have load variables changed by one third of the difference between Full Load and Light Arrival). Generally, the worst case disposition should be assumed.

Worst. The least favourable quantity and disposition is assumed down to the minimum (Min) amount. In the case of ammunition where the bulk is stored in low magazines, the total would be proportioned and distributed with ready use stowages full, missiles on launchers, and the balance is in magazines. Ammunition stored in high magazines is usually retained in full.

Operating. The average quantity and disposition that is usually carried in each tank in accordance with any liquid loading instructions. This usually applies to fresh water tanks where adequate make-up facilities are available or tanks that are periodically emptied. Where the working level of a tank cannot be ascertained, 2/3 of the tank capacity may be assumed.

4.13 Free surface effects should be considered whenever the filling level in a tank is less than 98% of full condition. Tanks which are taken into consideration when determining the free surface correction may be in one of two categories:

4.13.1 Tanks with filling levels fixed (e.g. liquid cargo, water ballast). The free surface correction should be defined for the actual filling level to be used in each tank; or

4.13.2 Tanks with variable filling levels (e.g., consumable liquids such as fuel oil, diesel oil and fresh water, and also liquid cargo and water ballast during liquid transfer operations). The free surface correction should be the maximum value attainable between the filling limits envisaged for each tank, consistent with any operating instructions.

4.14 In calculating the free surface effect in tanks containing consumable liquids, it is to be assumed that for each type of liquid at least one transverse pair or a single centreline tank has a free surface and the tank or combination of tanks taken into account are to be those where the effect of free surface is the greatest.

4.15 For ships engaged in liquid transfer operations, the free surface corrections at any stage of the liquid transfer operations may be determined in accordance with the filling level in each tank at that stage of the transfer operation.

4.16 Where the Solution to Chapter 06 *Fire Safety* requirements includes drenching or other applications of large quantities of water, the free surface effect from any undrained water shall be considered.

4.17 Any unusual threats to stability must be investigated separately, assuming the most unfavourable circumstances.

4.18 The intact ship shall be assessed against, and must satisfy criteria limits, including but not limited to the following scenarios, where applicable to the ship's OSI:

4.18.1 Beam winds combined with rolling due to wave action;

4.18.2 Beam winds combined with rolling due to wave action including topside icing effects;

4.18.3 Lifting of heavy weights;

4.18.4 High-speed turning;

4.18.5 Crowding of embarked persons;

4.18.6 Towline pull;

4.18.7 Docking;

4.18.8 Beaching; and

4.18.9 Payload movement where there is a risk to stability.

4.19 Stability assessment for ships subjected to beam winds and wave action.

4.19.1 The effects of beam winds and rolling are to be considered simultaneously. Wind heeling levers for intact stability are calculated using the procedures set out below. A rollback angle of 25° is to be applied to represent the additional energy imparted on the ship by the rolling motion.

4.19.2 The following wind velocities are to be used in the calculation of the wind heeling lever.

Table 5: Wind velocities

Service		Minimum wind velocity
Ocean Unlimited	Ships which may be expected to weather conditions encountered. This includes all ships which move with the operational fleet.	100 knots
Ocean Limited	Ships which may be expected to avoid extreme conditions.	80 knots

Service		Minimum wind velocity
Offshore	Ships which may be expected to weather conditions encountered.	60 knots
Restricted Offshore	Ships which may be expected to avoid gale force conditions.	50 knots

Note: Refer to Division 2 Chapter 01 *General Requirements* Rule 1 *General* for definition of Service Classification and Environmental Conditions.

4.19.3 Windage calculation.

4.19.3.1 Wind acting on the ship profile above water exerts a heeling moment which is characterised by a heeling lever:

$$Wind\ Heeling\ Lever = \frac{Wind\ Heeling\ Moment}{Displacement}$$

4.19.3.2 The following paragraphs provide a method for determining the wind heeling lever. The heeling moment is calculated for the upright intact case and is then assumed to reduce with angle of heel as a function of cosine^2. This is because both the profile area, and the lever to the centre of lateral resistance, are each deemed to reduce as a function of the cosine of the heel angle.

4.19.3.3 Integration of the wind pressure profile over the above water profile area should be conducted to find the total force and associated centre of effort applied by the wind. From this the heeling lever can be deduced. The centre of lateral resistance is to be established and can be estimated as half of the mean draught or alternatively derived from simulations or experiments.

Note: Broad shallow draught ships can significantly increase their windage area and shift their centre of lateral resistance and due allowance should be made for this and the approach approved by the ANC Authority.

4.19.3.4 The following equation should be used to calculate the wind heeling pressure to be assumed acting on structure at a given height above the mean waterline:

$$P = \frac{1}{2g}\rho_a v^2 C_D$$

Where:
P = Wind pressure (te/m^2)
g = Acceleration due to gravity (m/s^2)
ρ_a = Density of air (te/m^3)
v = wind velocity at the required height above waterline (m/s)
C_D = Assumed effective drag coefficient

4.19.3.5 The assumed wind velocity profile is described by:

$$v = V\left[\frac{Z}{10}\right]^{\frac{1}{7.5}}$$

Where:
v = velocity at height Z (m/s)
V = “nominal” wind velocity at 10 meters above the mean waterline (m/s)
Z = Height above the mean waterline (m)

4.19.3.6 A typical value of the assumed effective drag coefficient is 1.2 at a standard air density of 0.001225 te/m^3 (at 15°C, 1atm).

4.19.3.7 To develop the wind heeling moment with a wind speed profile, the vessel is divided into strips, the analysis applied to each strip, and the results summed:

$$Wind\ Heeling\ Moment = \sum_{1}^{n} \left(P_i\, A_{VPi}\, (h_{ai} + h_d)\right)$$

Where:

P_i = Wind pressure of the ith strip (or element) [te/m^2]
A_{Pi} = Cross-sectional projected area of the ith strip (or element) [m^2]
h_{ai} = Distance from the waterline of the ith strip (or element) [m]
v = Wind velocity at the required height above the waterline [m/s]
h_d = Distance from the waterline to the center of the underwater area [m]

This method is depicted in Figure 4:

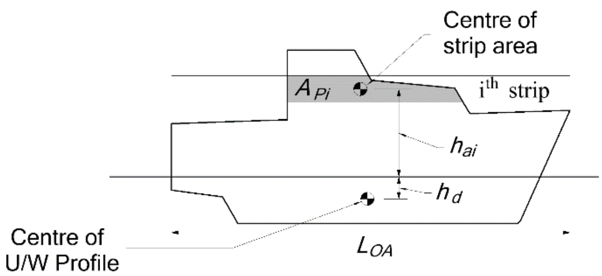
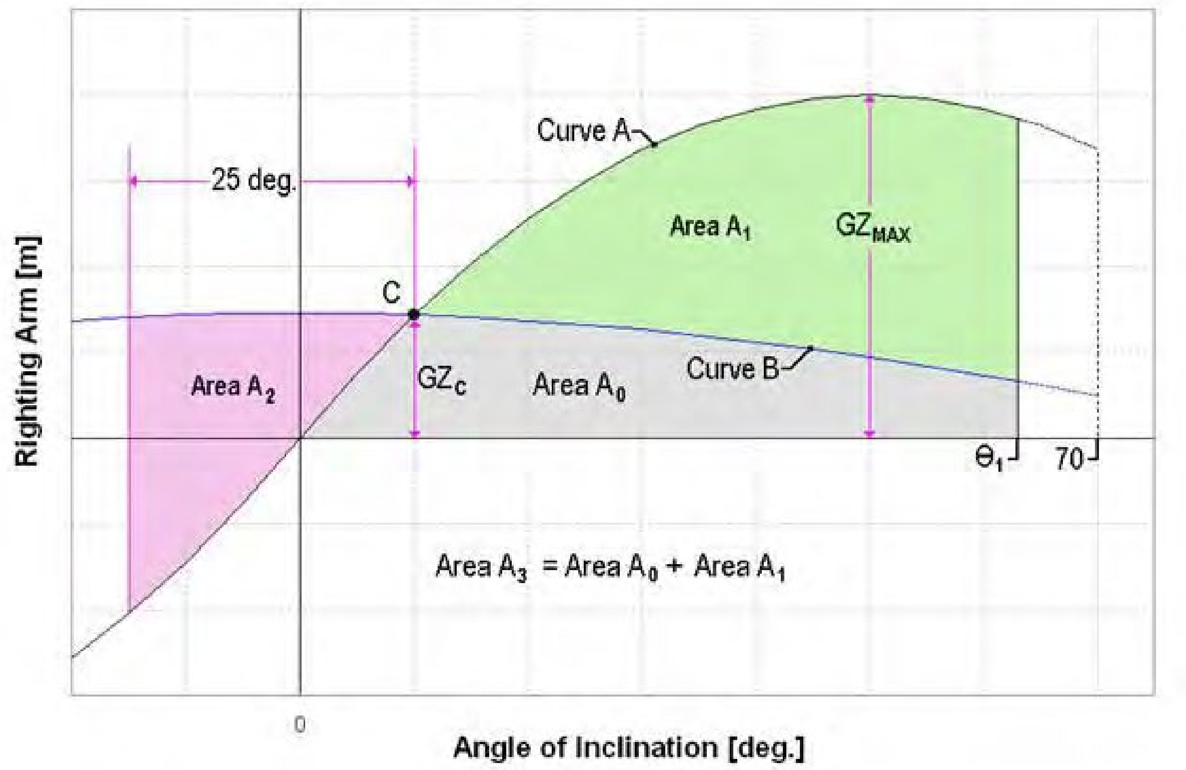


Figure 4: Definition of levers used in wind heeling moment analysis

4.19.4 Criteria for adequate stability.

4.19.4.1 The criteria for adequate stability under adverse wind and sea conditions are based on a comparison of the ship's righting lever and wind heeling lever, shown as Curve A and Curve B respectively in Figure 5 below.



Curve A =	Intact righting arm curve	Area A_0 =	Area to the right of zero degrees inclination that is below Curve A, below Curve B and bounded by a vertical line at Θ_1.
Curve B =	Heeling arm due to hazard (i.e. wind, turning, heavy lift or crowding)	Area A_1 =	Area to the right of point C that is below Curve A, above Curve B and bounded by a vertical line at Θ_1.
C =	Intact equilibrium point (Intersection point of Curve A = Curve B)	Area A_2 =	Area to the left of point C that is above Curve A, below Curve B and bounded by a vertical line 25 degrees to the left of point C.
GZ_C =	Righting arm at equilibrium point C	Area A_3 =	Area under the intact righting arm curve between zero Degrees inclination and a vertical line at Θ_1.
GZ_{MAX} =	Maximum righting arm	Area A_3 =	Area A_0 + Area A_1
Θ_1 =	the angle of unrestricted down-flooding or 70°, whichever is less		
Notes: [1] The angle of unrestricted down-flooding is the angle of heel at which water can freely enter the ship through non-watertight openings in upper decks.			

Figure 5: Righting and heeling levers

4.19.4.2 Apply the heeling lever as Curve B to the intact righting curve as shown in Figure 5.

4.19.4.3 Adequate stability is achieved when the following criteria are met:

a. Intact righting lever $GZ_C \leq 60\%\ GZ_{MAX}$

b. Area $A_1 \geq 140\%\ A_2$

4.20 Stability assessment for ships subjected to beam winds and wave action including topside icing effects.

4.20.1 For ships which may be expected to operate in areas where icing is possible, stability under icing must be proven in all load cases. Alternative criteria are to be used where ships routinely operate with a high probability of ice accretion.

4.20.2 The following procedure is to be used to ascertain the stability of a ship under icing:

4.20.2.1 Assume 150mm of ice uniformly distributed over all exposed horizontal decks, platforms and roofs. The density of this ice is to be taken as 950kgm-3.

Note: Alternative procedures for determining ice distribution and sea areas where icing may occur are contained in Part 3.

4.20.2.2 The weight and centre of gravity of the ice is to be taken into account in the calculation of the righting lever curve.

4.20.2.3 The operational wind speed is to be taken as 70% of the wind speed used in the assessment of stability when subjected to beam winds and wave action.

4.20.2.4 Calculate the wind heeling lever curve ignoring the increased profile area due to the ice thickness, but allowing for the increased ship draught resulting from the increase in displacement due to icing.

4.20.2.5 A rollback angle of 25° is to be applied to represent the additional energy imparted on the ship by the rolling motion.

4.20.3 Criteria for adequate stability.

4.20.3.1 Apply the heeling lever as Curve B to the intact righting curve as shown in Figure 5.

4.20.3.2 Adequate stability is achieved when the following criteria are met:

a. Angle of inclination at C ≤ 30 degrees

b. Intact righting lever $GZc \leq 60\%\ GZ_{MAX}$

c. Area $A_1 \geq 140\%$ Area A_2

4.21 Stability assessment for lifting of heavy weights.

4.21.1 Calculations shall be undertaken to demonstrate that a ship fitted with cranes or other lifting gear has an acceptable level of stability while lifting weights. A heeling lever due to lifting of heavy weights shall therefore be superimposed onto the intact righting lever curve.

4.21.2 When assessing the effect of lifting heavy weights the weight must be included in the loading condition and is assumed to be on the centreline initially.

4.21.3 All possible positions of the jib/boom are to be considered.

4.21.4 The heeling lever is to be calculated as below:

$$Heeling\ lever\ [m] = \frac{w(a\cos\theta + d\sin\theta)}{\Delta}$$

Where:
w = Weight being lifted (tonnes)
a = Offset of point of suspension (top of lifting boom) from ship centreline (m)
d = Height of point of suspension above the weight's original position (m)
θ = Angle of inclination (degrees)
Δ = Displacement (including weight, w)(tonnes)

4.21.5 Criteria for adequate stability.

4.21.5.1 Apply the heeling lever as Curve B to the intact righting curve as shown in Figure 5.

4.21.5.2 Adequate stability is achieved when the following criteria are met:

a. Angle of inclination at C ≤ 15 degrees

b. Intact righting lever $GZc \leq 60\%\ GZ_{MAX}$

c. Area $A_1 \geq 40\%$ Area A_3

4.22 Stability assessment of crowding of embarked persons.

4.22.1 Calculations must be undertaken to demonstrate that the ship has an acceptable level of stability in the event of embarked persons crowding to an extreme of the ship's beam. A heeling lever due to embarked persons crowding must therefore be superimposed onto the intact GZ curve.

4.22.2 The weight of the crew should be included in the ships loading condition, whereas the weight of non-crew is considered as an additional load.

4.22.3 Curves of levers are to be calculated assuming all embarked persons are standing on the upper deck.

4.22.4 Assume worst case embarked persons shift to port/starboard of centreline and that each embarked person occupies $0.25m^2$. Each embarked person is assumed to weigh at least 80kg.

4.22.5 The heeling lever is to be calculated as below:

$$Heeling\ lever\ [m] = \frac{wa\cos\theta}{\Delta}$$

Where:
w = Weight of embarked persons
a = Distance of center of gravity of embarked persons from centreline (m)
θ = Angle of inclination (degrees)
Δ = Displacement (including weight, w)(tonnes)

4.22.6 Criteria for adequate stability.

4.22.6.1 Apply the heeling lever as Curve B to the intact righting curve as shown in Figure 5.

4.22.6.2 Adequate stability is achieved when the following criteria are met:

a. Angle of inclination at C ≤ 15 degrees

b. Intact righting lever $GZc \leq 60\%\ GZ_{MAX}$

c. Area $A_1 \geq 40\%$ Area A_3

4.23 Stability criteria for high-speed turning.

4.23.1 Calculations must be undertaken to demonstrate that a ship has an acceptable level of stability whilst conducting high-speed turns. The worst case heeling lever representing the effect of centrifugal force shall therefore be superimposed onto the intact righting lever curve.

4.23.2 The steady turn radius can be assumed to be one half of the tactical diameter. If the tactical diameter is not known an estimate can be made. For combatants a value of 2.5 times length between perpendiculars (LBP) is to be taken as the steady turn radius. For auxiliaries a value of 3.5 times length between perpendiculars (LBP) is to be taken as the steady turn radius.

4.23.3 The heeling lever is to be calculated as below:

$$Heeling\ lever\ [m] = \frac{V^2 a \cos\theta}{gR}$$

Where:
V = Ship speed in turn (65% of approach speed) (m/s)
a = Vertical separation of KG and centre of lateral resistance (estimated as distance from keel to half mean draught) (m)
θ = Angle of inclination (degrees)
g = Acceleration due to gravity (m/s^2)
R = Radius of turn (m)

4.23.4 Criteria for adequate stability.

4.23.4.1 Apply the heeling lever as Curve B to the intact righting curve as shown in Figure 5.

4.23.4.2 Adequate stability is achieved when the following criteria are met:

a. Angle of inclination at C ≤ 15 degrees

b. Intact righting lever $GZ_C \leq 60\%\ GZ_{MAX}$

c. Area $A_1 \geq 40\%$ Area A_3

4.24 Stability criteria for towline pull.

4.24.1 Calculations must be undertaken to demonstrate that a ship has an acceptable level of stability whilst undertaking towing activities. The most serious situation will usually be when the towline has been turned side on to the ship. The basic equation for the heeling lever (metres) is given by:

$$Heeling\ Lever = \frac{T(h_t \cos(\phi + \theta) - b \sin(\phi + \theta))}{\Delta}$$

Where:

$$T = \frac{P.S.\sin\delta}{\cos\phi}$$

P = bollard pull (tonnes)
S = effective fraction of propeller slipstream deflected by the rudder- assumed to be equal to that fraction of the propeller circle cylinder which would be intercepted by the rudder when turned to 45 degrees (typically about 0.6 for a rudder mounted centrally behind the propeller)

δ = maximum angle of resultant thrust (up to 90°) from the ship's centre-line - the maximum angle of rudders and nozzles is taken as the angle of thrust (degrees)
Φ = angle of the towing cable from the horizontal (degrees, +ve up)
h_t = vertical distance from centre of propeller to attachment point of the towing cable (metres)
Θ = heel angle (degrees)
b = horizontal distance from centre-line to attachment point of the towing cable (metres)
Δ = displacement (tonnes)

4.24.2 For rudders use S = 0.55 if no other value has been determined. For steerable thrusters and vertical axis propellers use S = 1. This formula considers the transverse bollard pull component to be constant irrespective of heel angle (i.e. the tension in the tow cable remains constant).

4.24.3 Towing will fall into one or more of the following three categories for the calculation of the heeling arm curve (refer to Figure 6 below):

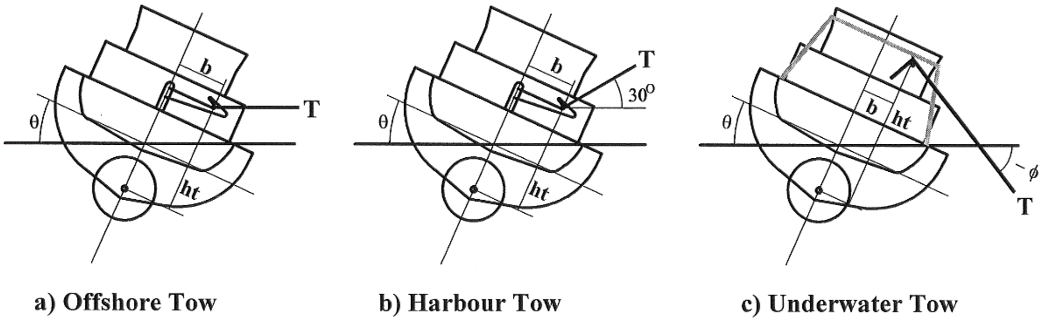


Figure 6: Offshore tow, harbour tow and underwater tow

4.24.4 All ships not designated as tugs (including those used for towing of underwater apparatus) may be required to perform emergency towing operations and so shall have an evaluation performed of their stability during these towing duties. In applying the towing heeling lever formula, set Φ = 0°. If the bollard pull is not known, then an estimate may be used based on either similar ships or calculations. An approximate formula that may be used for ships engaged in occasional towing duties is:

$$\ldots P = 0.077N(SHP \times D)^{\frac{2}{3}}\ tonnes$$

$$SHP = 0.96BHP\ (only\ if\ SHP\ is\ unknown)$$

Where:
P = bollard pull (tonnes)
N = number of propellers
SHP = shaft power per shaft (kilowatts)
D = propeller diameter (metres)
BHP = brake power (kilowatts)

4.24.5 Harbour tugs. In applying the towing heeling lever formula, set Φ = 30°. The actual bollard pull must be used and the righting arm curve is terminated at 40° or the angle of down flooding, whichever is less.

4.24.6 Offshore tugs. In applying the towing heeling lever formula, set Φ = 0°. The actual bollard pull must be used and the righting arm curve is terminated at 40° or the angle of down flooding, whichever is less.

4.24.7 Ships used for the boom towing of underwater apparatus must satisfy the following criteria as well as the occasional/emergency towing criteria. The operational heeling arm of these ships shall be calculated assuming that the underwater apparatus has been snagged and that the ship has turned such that the towing wire is perpendicular to the centre-line of the ship. In applying the towing heeling lever formula, set $\Phi = -10°$ or a steeper angle from a snagged towline if this is possible. If the breaking strain of the tow wire is less than the value of T as derived from the bollard pull, then the actual breaking strain may be used for T.

4.24.8 Criteria for adequate stability.

4.24.8.1 Apply the heeling lever as Curve B to the intact righting curve as shown in Figure 5.

4.24.8.2 Adequate stability is achieved when the following criteria are met:

a. Angle of inclination at C ≤ 15 degrees

b. Intact righting lever $GZc \leq 60\%\ GZ_{MAX}$

c. Area $A_1 \geq 40\%$ Area A_3

4.25 Stability criteria during docking operations

4.25.1 Calculations shall be undertaken to demonstrate that the ship has an acceptable level of stability during the docking operation for typical docking loading conditions.

4.25.2 At sueing, the GM_{fluid} shall not be less than 300mm.

4.26 Stability criteria during beaching operations

4.26.1 Where ships have a beaching requirement in their OSI, calculations shall be undertaken to demonstrate that the ship has an acceptable level of stability during each phase of the beaching operation as follows:

4.26.1.1 Stability at sea while in the liquid state ready for or just after beaching (perhaps a special liquid state to allow beaching close to the water edge). Clean ballast that would not be present during the actual beaching operation may be present to ensure adequate stability. The ship must comply with the normal operation limiting KG curve.

4.26.1.2 Stability in the immediate vicinity of the beach and immediately prior to or after the beaching operation. The clean ballast noted above would not be present. The environmental conditions should be those in which beaching is considered safe. Stability is considered satisfactory if the GZ curve requirements of Table 3 are met.

4.26.1.3 Stability while beached. The environmental conditions must be those in which beaching is considered safe. Stability is considered satisfactory if, with an upthrust load equal to the maximum beaching load (if unknown, this can be taken as the required load to cause a trim change of 0.25°), the GM_{fluid} is not less than 500mm.

Damage Stability

4.27 Ships whose OSI requires they survive foreseeable damage traditionally expected of constabulary and combat naval ships, shall comply with the following Solution 2 requirements.

4.28 The ship is to satisfy the safe return to port stability, flooding and any consequential watertight subdivision requirements of IMO MSC.1/Circ.1214, IMO MSC.1/Circ.1369 and IMO MSC.1/Circ.1400.

4.29 Damage stability shall be assessed against stability criteria appropriate to the ship's operational requirement for the full range of ship loading conditions. Typical damage stability criteria are given in paragraph 4.38.

4.30 Any unusual threats to damage stability shall be investigated separately, assuming the most unfavourable circumstances.

4.31 Non-watertight compartments, which would flood slowly, are to be assumed watertight if this degrades stability. For example, where water is initially present above a non-watertight deck and, in reality, would slowly drain, the worst case distribution of water (water remaining above the deck and not draining down) should be assessed.

4.32 Intermediate levels of flooding are to be checked as well as the final water level to establish the worst case. The lost buoyancy approach is to be used.

4.33 Cross-flooding arrangements may be used to correct large angles of heel. Where cross-flooding fittings are required they are to be self-acting i.e. without mechanical action, the time for equalisation shall not exceed 10 min.

Note: The recommended evaluation of cross-flooding arrangements is contained in IMO Resolution MSC.362(92).

4.34 The permeability of compartments is to be assumed as shown in Table 6, unless another permeability is justified or calculated directly for the space and approved by the ANC Authority:

Table 6: Compartment Permeabilities

Space	Permeability (%)		
	Full Load	**Light Arrival**	**Lim KG analysis**
Watertight void spaces, empty tanks	98	98	98
Accommodation spaces	95	95	95
Offices	95	95	95
Workshops	90	90	90
Store rooms	80	95	90
Refrigerated store rooms	70	85	80
Magazines: Powder and Shells	60	95	90
Magazines: Torpedoes	70	95	90
Magazines: Missiles	80	95	90
Magazines: Small arms	60	95	90
Cargo Holds	Calculate	98	98
Vehicle Holds	Calculate	98	98
Machinery Spaces	85	85	85
Electrical/electronic spaces	90	90	90
Chain Locker	65	65	65

Note: Assumptions made when directly calculating a space's permeability shall be stated.

Note: Linear interpolation should be used for intermediate conditions between Full Load and Light Arrival Conditions.

4.35 If any structure extends below the plane 1.5m above the baseline it is to be considered as damaged for the purposes of residual stability and buoyancy assessment.

4.36 Damage stability analysis shall consider the flooding of main watertight compartments that are penetrated by the damage extents described in paragraph 4.37.

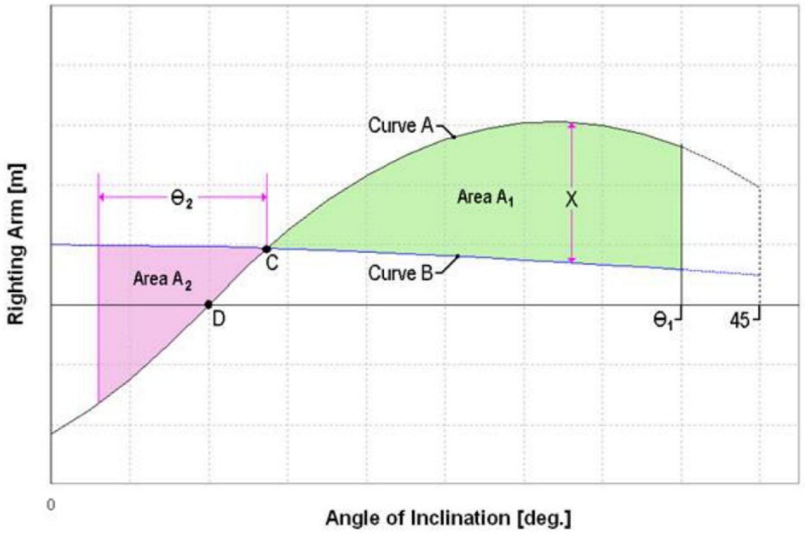
4.37 Two types of damage shall be considered; i) Bottom Damage and ii) Side Damage. The damage extents for each damage type shall be as indicated in Table 7 and, where applicable, as indicated by the damage from extreme threats identified for Chapter 01 *Integrated Platform Survivability*. In all cases of damage, the transverse and vertical extent of flooding is to be adopted which causes the worst stability. Only main transverse watertight bulkheads which are spaced at least (3.00 m + 0.03L) or 10.65 m apart, whichever is less, are to be considered as effective watertight boundaries.

Table 7: Damage Extents

Side Damage	**Combat Ships**	
	Waterline Length at design draught (m)	
Damage Extent	24m to 50m	>50m
Longitudinal	Any two adjacent Main Watertight Compartments with a minimum of 19% of LWL applied anywhere along the length of the ship	15% of LWL applied anywhere along the length of the ship
Transverse	From ship side up to but not including any watertight centreline bulkhead	
Vertical	From keel upwards without limit	
Side Damage	**Combat Support and Constabulary Ships**	
	Waterline Length at design draught (m)	
Damage Extent	24m to 70m	>70m
Longitudinal	Any two adjacent Main Watertight Compartments with a minimum of 16% of LWL applied anywhere along the length of the ship	12.5% of LWL applied anywhere along the length of the ship
Transverse	From ship side up to but not including any watertight centreline bulkhead	
Vertical	From keel upwards without limit	
Minor Side Damage	**All Ships**	
Damage Extent	Any Length	
Longitudinal	8% of LWL applied anywhere along the length of the ship	
Transverse	From the ships side extend inboard to 20% of waterline beam	
Vertical	10% of waterline beam above and below waterline	
Bottom Damage	**All Ships**	
Damage Extent	Any Length	
Longitudinal	23% of LWL applied anywhere forward of amidships	
Transverse	25% of maximum waterline beam applied anywhere across the beam	
Vertical	From keel upward 1.5m	

4.38 Criteria for adequate damage stability

4.38.1 The criteria for adequate stability under wind and sea conditions are based on a comparison of the ship's righting lever and wind heeling lever, shown as Curve A and Curve B respectively in Figure 7 below.



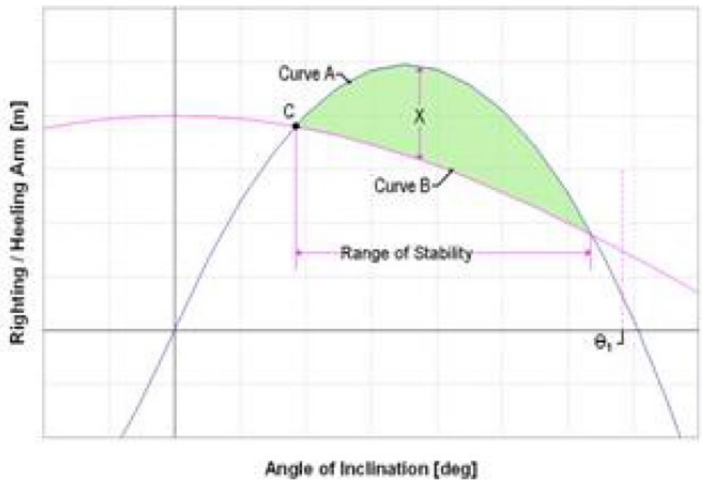
Curve A	Damaged righting lever curve
Curve B	Heeling lever hazard (i.e. wind)
Point C	Damaged equilibrium point (Curve A = Curve B)
Point D	Damaged list angle (no wind)
X	Maximum residual righting lever (value at Curve A minus value at Curve B)
Θ_1	The lesser of: (i) angle at which unrestricted down-flooding from the upper deck would occur (ii) the angle at which progressive flooding into adjacent compartments through nonwatertight openings in bulkheads would occur (iii) 45°.
Θ_2	Angle of rollback [deg] as shown in Figure above.
GZ_C	Righting lever at point C.
Area A_1	Area to the right of point C that is below Curve A, above Curve B and bounded by a vertical line at Θ_1. This area may be bound by point of vanishing GZ as shown in the Figure below. 
Area A_2	Area to the left of point C that is above Curve A, below Curve B and bounded by a vertical line Θ_2° to the left of point C.

Figure 7: Damage righting and heeling levers

4.38.2 Wind heeling levers (Curve B) shall be calculated using the wind speed as prescribed by the following equation. The wind speed is the wind speed at a reference height of 10m above waterline.

$$\text{Damage Wind Speed} = 30\left(\frac{\Delta + 12000}{12000}\right)^{0.38}$$

4.38.3 Criteria for adequate stability

4.38.3.1 Angle of list or loll at point D ≤ 15 degrees.

4.38.3.2 GZ at point C < 60% of GZ_{MAX}.

4.38.3.3 Area A_1 to be greater than the value given by the following equation..

$$\text{Minimum } A_1 = 0.4473 + \frac{6600}{5500 + \Delta} \quad \text{m-deg} \quad \text{for } \Delta \leq 50000 \text{ t}$$
$$= 0.5590 \quad \text{m-deg} \quad \text{for } \Delta > 50000 \text{ t}$$

4.38.3.4 Area A_1 >1.4 Area A_2

4.38.3.5 Maximum residual righting lever (X) is to be greater than 0.076m.

Rule 5. Not used

Rule 6. Safety of Embarked Persons and Seakeeping

6.1 The NVO shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. In the presentation and justification of a solution, the following must be considered.

Solution

6.2 The ship's guardrails, handrails, bulwarks and arrangements for protection of embarked persons from falling shall be designed, constructed and maintained to the rules of the ship's Classification Society applicable to the area(s) of operation defined in the OSI, and shall be certified with the relevant character/construction symbols, or marks, assigned by that society.

6.3 Deck areas, stairs and ladders where embarked persons stand, walk or climb shall have non-slip surfaces:

6.3.1 Where these are painted surfaces, the paint shall comply with CSIRO APAS Specification AP-S0071 *Smooth Non-Slip Deck Paint (Ships)* or AP-S0072 *Rough Finish Non-Skid Deck Paint (Ships)*.

6.3.2 Other surface finishes shall achieve equivalent or higher coefficients of friction to those given in paragraph 6.3.1 when tested in accordance with AS 4586 *Slip resistance classification of new pedestrian surface materials*.

6.4 Fixed stairs and step-type, or rung-type, ladders shall be designed to conform to the design and geometrical characteristics as defined in AS 1657 *Fixed Platforms, walkways, stairways and ladders – Design, construction and installation* or, where compliance with AS 1657 is justified as not being not reasonably practicable for the vessel's OSI, the National Standard for Commercial Vessels (NSCV) Part C Section 1 5.13 *Walkways, stairways and ladders*, as amended.

6.4.1 In general, internal and external access ladders shall be step-type except in way of tanks, void spaces and where it is impractical to install a step type ladder.

Note: Step type ladders are recommended to have an angle of 68 degrees with tread rise of 200-265mm.

Note: See Chapter 07 *Escape, Evacuation and Rescue* for the requirements relating to stairway widths and landing areas on escape routes.

6.5 Lifelines shall comply with the applicable requirements of AS/NZS1891 *Personal equipment for work at height*.

6.6 Workstations shall be fitted with handholds, seatbelts or other suitable arrangements to enable embarked persons to perform their duties when subjected to the accelerations derived from the seakeeping assessment.

6.7 The ship shall, as a minimum, meet the hull criteria and personnel criteria limits for transit and patrol given in STANAG 4154 *Common Procedures for Seakeeping in the Ship Design Process*.

6.8 The ship shall also meet the seakeeping criteria for replenishment at sea and specific missions and equipment given in STANAG 4154, where applicable to the ship's OSI.

6.9 Where the ship's OSI specifies equipment, systems or operations that require stricter criteria for seakeeping, these criteria shall take precedence over the STANAG 4154 criteria.

6.10 Methodologies, proven to the satisfaction of the ANC Authority, shall be used to verify the seakeeping performance of the ship against the criteria at both the design and acceptance trial stages of the lifecycle.

Rule 7. Preservation of Life

7.1 The NVO shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. In the presentation and justification of a solution, the following must be considered.

Solution

7.2 The ship shall have a margin of reserve of buoyancy and stability beyond the Foreseeable Operating Conditions that will allow embarked persons to evacuate the ship using available evacuation arrangements and lifesaving equipment as provided under Chapter 07 *Escape, Evacuation and Rescue.*

Rule 8. Provision of Operational Information

8.1 The NVO shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. In the presentation and justification of a solution, the following must be considered.

Solution

8.2 The operational information shall be approved by the ANC Authority as being compliant with the Part 1 Performance Requirements:

Watertight and weathertight boundaries

8.3 The content of this information shall contain as a minimum

8.3.1 The extent, location and capabilities of watertight and weathertight boundaries, including access trunks, tunnels & scuttles;

8.3.2 The locations of watertight and weathertight closing devices, including portable plates, for personnel & cargo/payload access;

8.3.3 The location of penetration closing devices including remote actuation points;

8.3.4 The locations of downflooding points;

8.3.5 The operational system & markings for opening closures at sea;

8.3.6 The drainage arrangements of enclosed spaces; and,

8.3.7 The location & capacity arrangements for the removal of liquids.

Stability and Buoyancy

8.4 The Commanding Officer shall be provided with information, in paper format, to maintain the safe operation of the vessel. The content of the buoyancy and stability information shall contain as a minimum:

8.4.1 Instructions on operation including:

8.4.2 The stability standard or requirements;

8.4.3 General precautions against capsize;

8.4.4 Loading & operating restrictions;

8.4.5 Crossflooding and downflooding arrangements [if fitted];

8.4.6 Verifying compliance with the stability standard;

8.4.7 Trim and draught limitations;

8.4.8 Free surface effects;

8.4.9 Payload heeling effects;

8.4.10 Loading and unloading precautions;

8.4.11 Securing arrangements;

8.4.12 Control of openings;

8.4.13 Loll;

8.4.14 Hull strength;

8.4.15 Stability or loading computer [if fitted];

8.4.16 Non sailing conditions [if applicable]; and

8.4.17 Particulars of the ship;

8.4.18 Details of the lightship & its derivation;

8.4.19 Details of hydrostatics & cross curves of stability;

8.4.20 Total capacity, centroid and maximum free surface moment of tanks stores & cargo spaces plus other payload data;

8.4.21 Sounding or ullage tables for each tank including capacity, centroid and free surface moment;

8.4.22 Example calculations of stability;

8.4.23 Example ship conditions compliant with stability requirements;

8.4.24 Damage stability information demonstrating ship survivability following foreseeable, extreme & catastrophic damage; and

8.4.25 Methods to recover margins of buoyancy and stability.

Note: The methods documented should assist the operator by providing recommended trigger points for the commencement of evacuation.

8.5 Stability or loading computer

8.5.1 The stability or loading computer shall calculate both intact stability and damage stability in accordance with IACS UR L5 – *Computer Software for Onboard Stability Calculations* Type 2 requirements.

8.5.1.1 IACS UR L5 Type 3 or Type 4 compliant stability software may be required, either additionally or alternatively to the Type 2 software, where necessary to meet Chapter 01 *Integrated Platform Survivability* requirements.

8.5.2 The stability or loading computer software shall be approved to IMO MSC/Circ.1229 – *Guidelines for the Approval of Stability Instruments*.

8.5.3 The particulars and data used in the stability or loading computer calculations shall be the same as that used in the development of the Stability Analysis for Rule 4 *Reserve of Stability*.

8.5.4 The stability or loading computer shall meet the objective of the Zoning, Separation and Redundancy requirements of Chapter 01 *General Requirements Rule 16 Minimise Vulnerability* as applicable to the ship's OSI. One of the loading computers shall meet the objective of the Zoning, Separation and Redundancy requirements of Chapter 01 *General Requirements* Rule 16 *Minimise Vulnerability* as applicable to the ship's OSI. One of the loading computers shall be the ship's dedicated stand-alone loading computer.

8.5.4.1 Where an IACS UR L5 Type 3 or Type 4 compliant stability software has been provided in accordance with paragraph 8.5.1.1, security requirements may dictate this to be installed only on stand-alone, network isolated, loading computers.

Note: Onboard stability or loading computers can be beneficial to determine the survivability of the ship in the event of foreseeable & extreme damage

Note: As a minimum, operational information to aid decision making following a flooding casualty should satisfy the IMO safe return to port requirements: IMO MSC.1/Circ.1214, IMO MSC.1/Circ.1369 and IMO MSC.1/Circ.1400.

Note: Where fitted, electronic inclinometers should comply with IMO Resolution MSC.363(92).

Dynamic Motions

8.6 The Commanding Officer shall be provided with information on dynamic motions, the content shall contain as a minimum information on:

8.6.1 The risk of broaching;

8.6.2 The shipping of green seas;

8.6.3 Slamming;

8.6.4 Heel in turn characteristics;

8.6.5 The impact of motions on the safety of the crew and essential safety functions; and

8.6.6 Practices or methods specific to the ship to reduce the impact of motions on the safety of the crew and equipment.

Rule 9. Limiting KG Curve

9.1 The NVO shall present and justify a solution for demonstrating compliance to Part 1 of the ANC Rules. In the presentation and justification of a solution, the following must be considered.

Solution

9.2 The limiting KG curve shall define the highest KG verses displacement that the ship can have and still comply with the reserve of buoyancy, stability and strength criteria.

9.3 The limit KG shall be calculated for each component of the intact and damage stability criteria.

9.4 The limiting draught shall define the deepest draught, including trim, that the ship can have and still comply with the reserve of buoyancy, stability and strength criteria.

9.5 The calculations deriving the limiting draught and limiting KG shall be performed using assumptions that will give a result applicable to the ship for the remainder of its life (unless a geometry change occurs).