Part 6 Additional class notations

Chapter 5 Stability
FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

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CHANGES – CURRENT

This is a new document.
The rules enter into force 1 July 2016.
SECTION 1 STABILITY

1 Symbols

\[ L = \text{rule length [m] defined in Pt.3 Ch.1 Sec.1 [1]} \]
\[ L_{WL} = \text{length of the hull [m] measured at the maximum draught} \]
\[ B = \text{breadth [m] defined in Pt.3 Ch.1 Sec.1 [1]} \]
\[ D = \text{depth [m] defined in Pt.3 Ch.1 Sec.1 [1]} \]
\[ T = \text{draught [m] defined in Pt.3 Ch.1 Sec.1 [1]} \]
\[ \Delta = \text{displacement of the laden vessel [t]} \]
\[ v = \text{maximum speed of the vessel in relation to the water [m/s]} \]
\[ KG = \text{height [m] of the centre of gravity above base line} \]
\[ n = \text{navigation coefficient defined in Pt.3 Ch.3 Sec.1} \]
\[ = 0.85 \cdot H \]
\[ H = \text{significant wave height [m]} \]
\[ C_B = \text{block coefficient} \]

2 General

2.1 Application

2.1.1 Vessels complying with the requirements of this section are eligible for the assignment of one of the following additional Class Notations, as defined in Pt.1 Ch.2 Sec.2 [9.4]:

— Intact stability
— Damage stability

2.2 Definitions

2.2.1 Plane of maximum draught
Plane of maximum draught is the water plane corresponding to the maximum draught at which the vessel is authorized to navigate.

2.2.2 Bulkhead deck
Bulkhead deck is the deck up to which the required watertight bulkheads are carried and from which the freeboard is measured.

2.2.3 Freeboard (F)
Freeboard is the distance between the plane of maximum draught and a parallel plane passing through the lowest point of the gunwale or, in the absence of a gunwale, the lowest point of the upper edge of the vessel's side.

2.2.4 Residual freeboard
Residual freeboard is the vertical clearance available, in the event of the vessel heeling over, between the water level and the upper surface of the deck at the lowest point of the immersed side or, if there is no deck, the lowest point of the upper surface of the vessel's side shell.

2.2.5 Safety clearance
Safety clearance is the distance between the plane of maximum draught and the parallel plane passing through the lowest point above which the vessel is no longer deemed to be watertight.
2.2.6 Residual safety clearance
Residual safety clearance is the vertical clearance available, in the event of the vessel heeling over, between the water level and the lowest point of the immersed side, beyond which the vessel is no longer regarded as watertight.

2.2.7 Weathertight
Weathertight is the term used to describe a closure or structure which prevents water from penetrating into the vessel under any service conditions. Weathertight designates structural elements or devices which are so designed that the penetration of water into the inside of the vessel is prevented:
— for one minute when they are subjected to a pressure corresponding to a 1 m head of water, or
— for ten minutes when they are exposed to the action of a jet of water with a minimum pressure of 1 bar in all directions over their entire area

Following constructions are regarded as weathertight:
— weathertight doors complying with ISO 6042
— ventilation flaps complying with ISO 5778
— airpipe heads of automatic type and of approved design

Weathertightness shall be proven by hose tests or equivalent tests accepted by the Society before installing.

2.2.8 Watertight
Watertight designates structural elements or devices which meet all the conditions stated for weathertightness and also remain tight at the anticipated internal and external pressure.

Watertightness shall be proven by workshop testing and where applicable by type approvals in combination with construction drawings (e.g. watertight sliding doors, cable penetrations through watertight bulkheads).

2.2.9 Light ship
The light ship is a vessel complete in all respects, but without consumables, stores, cargo, and crew and effects, owners’ supply and without liquids on board except for machinery and piping fluids, such as lubricants and hydraulics, which are at operating levels.

2.2.10 Inclining test
The inclining test is a procedure which involves moving a series of known weights, normally in the transverse direction, and then measuring the resulting change in the equilibrium heel angle of the vessel. By using this information and applying basic naval architecture principles, the vessel’s vertical centre of gravity (VCG or KG) is determined.

2.3 Documents to be submitted for approval and for on board use

2.3.1 Documents to be provided on board
The following information shall be provided on board the vessel and shall be prepared in a clear and understandable format as a working document for the master.
— general description of the vessel
— general arrangement and capacity plans indicating the assigned use of compartments and spaces (cargo, passenger, stores, accommodation, etc.)
— a sketch indicating the position of the draught marks referred to the vessel’s perpendiculars
— hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the vessel, curves or tables corresponding to such range of trim shall be introduced
— cross curves or tables of stability calculated on a free trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions, with indication of the volumes which have been considered buoyant
— tank sounding tables or curves showing capacities, centres of gravity, and free surface data for each tank
— light ship data from the inclining test, including light ship displacement, centre of gravity co-ordinates, place and date of the inclining test, as well as the Society approval details specified in the inclining test report. It is suggested that a copy of the approved test report be included

Where the above-mentioned information is derived from a sister ship, the reference to this sister ship shall be clearly indicated, and a copy of the approved inclining test report relevant to this sister ship shall be included

— standard loading conditions and examples for developing other acceptable loading conditions using the information contained in the trim and stability booklet

— intact stability results (total displacement and its centre of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve, criteria reporting a comparison between the actual and the required values) shall be available for each of the above-mentioned operating conditions

— information on loading restrictions (maximum allowable load on double bottom, maximum specific gravity allowed in liquid cargo tanks, maximum filling level or percentage in liquid cargo tanks, possibilities for alternate loading of liquid cargo tanks, maximum KG or minimum GM curve or table which can be used to determine compliance with the applicable intact and damage stability criteria), when applicable

— information about openings (location, tightness, means of closure), pipes or other progressive flooding sources

— information concerning the use of any special cross-flooding fittings with descriptions of damage conditions which may require cross-flooding, when applicable

— damage control plan (in case a damage stability calculation is required) showing the watertight subdivision used for damage stability calculation, giving guidance on how to reduce a heeling angel resulting from water ingress, and showing all closing devices to be kept closed while sailing.

2.3.2 Documents to be submitted for approval

The following shall be submitted to the Society for approval:

— all documentation listed under [2.3.1]

— a lines plan respectively a hull definition such as offset table.

The Society may require further documentation with respect to the safe operation of the vessel.

2.4 Basic data for the stability calculation

2.4.1 The light ship displacement and the location of the centre of gravity shall be determined either by means of an inclining experiment (see Pt.7 Ch.2) or by detailed mass and moment calculation. In this latter case the light weight of the vessel shall be checked by means of a light weight test with a tolerance limit of about 5 % between the mass determined by calculation and the displacement determined by the draught readings.

The weight and centre of gravity calculation shall be submitted prior to the light weight survey.

2.5 Effects of free surfaces of liquids in tanks

2.5.1 For all loading conditions, the initial metacentric height and the righting lever curve shall be corrected for the effect of free surfaces of liquids in tanks.

2.5.2 Free surface effects shall be considered for any filling level of the tank. Free surface effects need not be considered where a tank is nominally full.
3 Tankers

3.1 General

3.1.1 Application
The following requirements apply to tankers which have been requested to receive the additional class notation Intact stability.

3.1.2 The centre longitudinal bulkhead may be dispensed of provided that sufficient stability can be proven.

3.2 Intact stability

3.2.1 Proof of sufficient intact stability shall be provided for all loading/unloading stages.

3.2.2 For vessels with cargo tanks of more than 0.70·B in width, the following intact stability requirements shall be complied with:
— a minimum righting lever GZ value of 0.10 m shall be reached within the range of positive stability, limited by the angle at which unprotected openings become submerged
— the area below the GZ curve within the range of positive stability, limited by the angle at which unprotected openings become submerged or 27 degrees whichever is the lesser, shall be not less than 0.024 m·radians
— the initial metacentric height GM₀ value shall be at least 0.10 m.

The stability reducing free surface effect shall be taken into account according to [2.5].

4 Container vessels

4.1 General

4.1.1 Application
The following requirements apply to container vessels which have been requested to receive the additional class notation Intact stability or Damage stability.

4.1.2 Secured containers

4.1.3 In case of vessels likely to carry either secured or non-secured containers, separate documents concerning stability are required for the carriage of each type of container.

Guidance note:
A cargo of containers is considered secured when each individual container is firmly secured to the hull of the vessel by means of rails or turnbuckles and its position cannot alter during the voyage.

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

4.2 Stability in case of non-secured containers

4.2.1 All methods of calculating a vessel’s stability in the case of non-secured containers shall meet the following limit conditions:

a) Metacentric height, GM, shall not be less than 1.00 m.
b) Under the joint action of the wind thrust, centrifugal force resulting from the vessel’s turning and the effect of free surfaces induced by the hold or double bottom fillings, the angle of heel shall not exceed 5° and the edge of the deck shall not be immersed.

4.2.2 The heeling lever \([m]\) resulting from the centrifugal force caused by the vessel turning shall be determined in accordance with the following formula:

\[
h_{KZ} = 0.04 \frac{v^2}{l_{WL}} \left( KG \frac{T}{2} \right)
\]

\(KG\) = height \([m]\) of centre of gravity of the loaded vessel above its base  
\(v\) = maximum speed of the vessel \([m/s]\)

4.2.3 The heeling lever \([m]\) resulting from the wind thrust shall be determined in accordance with the following formula:

\[
h_{KW} = p_{WD} \cdot \frac{A_W}{\ell_W} \left( \ell_W + \frac{T}{2} \right)
\]

\(p_{WD}\) = specific wind pressure \([t/m^2]\):
- for \(IN(0)\) and \(IN(0.6)\) : \(p_{WD} = 0.025\)
- for \(IN(1.2)\) and \(IN(2)\) : \(p_{WD} = 0.04 \cdot n\)

\(A_W\) = side surface above the water of the loaded vessel \([m^2]\)
\(\ell_W\) = height \([m]\) of the centre of gravity of the side surface \(A_W\) above the water related to the waterline.

4.2.4 The heeling lever \([m]\) resulting from the free surfaces of rainwater and residual water within the hold or the double bottom shall be determined in accordance with the following formula:

\[
h_{KF0} = \frac{0.015}{\Delta} \cdot \sum \left[ b \cdot \ell \cdot \left( b - 0.55 \cdot \sqrt{b} \right) \right]
\]

\(b\) = width of hold or section of the hold in question \([m]\)
\(\ell\) = length of hold or section of the hold in question \([m]\)

4.2.5 Half of the fuel and fresh water supply shall be taken into account for each load condition.

4.2.6 The stability of a vessel carrying non-secured containers shall be considered to be sufficient if the effective \(KG\) does not exceed the \(KG_Z\) resulting from the formula below mentioned.

The \(KG_Z\) shall be calculated for various displacements covering all of the possible draught variations.

\(KG \leq KG_Z\)

\(KG\) = effective height \([m]\) of vessel centre of gravity above its base  
\(KG_Z\) = maximum permissible height \([m]\) of the loaded vessel’s centre of gravity above its base, given by the formula:

\[
KG_Z = \frac{KM + \frac{b_{WL}}{2} \cdot \left( Z - \frac{T_m}{2} - h_{KW} - h_{KF0} \right)}{\frac{b_{WL}}{2} \cdot F \cdot Z^2 + 1}
\]
or

\[ \text{KM} - 1 \]

whichever is the lesser,

\[ \frac{B_{\text{WL}}}{2} \cdot F > 11.5 \]

**KM** = height of the metacentre above the base [m]

If no curve diagram is available the value of KM may be determined, for example, via the following approximation formulae:

- vessels in the form of a pontoon

\[
\frac{B_{\text{WL}}^2}{2} \left( \frac{T_m}{12.5 - \frac{T_m}{D}} \right) + \frac{T_m}{2}
\]

- other vessels

\[
\frac{B_{\text{WL}}^2}{2} \left( \frac{T_m}{12.7 - 1.2 \frac{T_m}{D}} \right) + \frac{T_m}{2}
\]

\( F \) = effective freeboard at 0.5 \( \cdot \) L

\( B_{\text{WL}} \) = vessel waterline breadth [m]

\( T_m \) = average draught [m]

\( Z_2 \) = parameter for the centrifugal force resulting from turning:

\[
0.04 \cdot \frac{V^2}{L_{\text{WL}}}
\]

### 4.3 Stability in the case of secured containers

**4.3.1** In the case of secured containers, all means of calculation used in order to determine vessel stability shall meet the following limit conditions:

- Metacentric height \( GM \) shall be not to be less than 0.50 m.
- No hull opening shall be immersed by the combined action of the centrifugal force resulting from the turning of the vessel, wind thrust and free surfaces of water.

**4.3.2** The heeling moments resulting from the wind thrust, centrifugal force due to the vessel’s turning and free surfaces of water shall be determined in accordance with [4.2].

Half of the supply of fuel and fresh water for each load condition shall be taken into account.

**4.3.3** The stability of a vessel carrying secured containers shall be considered to be adequate if the effective \( KG \) does not exceed the \( KG_2 \) resulting from the formula that has been calculated for the different displacements resulting from the possible height variations.

\[ KG \leq KG_2 \]

\( KG \) = effective height [m] of vessel centre of gravity above base line

\( KG_2 \) = maximum admissible height [m] of vessel centre of gravity above its base line, given by:

\[
= \frac{KM - KM_1 + KM_2}{0.75 - 2Z_2 + 1}
\]
or
\[ \text{KM} - 0.5 \]
whichever is the lesser,
\[ \text{KM}_1 = \frac{1 - i}{2 \cdot V} \left( 1 - 1.5 \cdot \frac{F}{F^*} \right) \geq 0 \]
\[ \text{KM}_2 = 0.75 \cdot \frac{B_{WL}}{F^*} \cdot \left( \frac{Z_2 \cdot T_m}{2} - h_{KW} - h_{KFO} \right) \]
\[ B_{WL} / F^* \geq 6.6 \]
\[ F^* = \text{ideal freeboard} \ [\text{m}] \]
\[ F_1^* = \text{MIN} (F_1^*, F_2^*) \]
\[ F_2^* = \frac{a \cdot B_{WL}}{2 \cdot b} \]
\[ a = \text{vertical distance between the lower edge of the opening that is first immersed in the event of heeling and the water line in the vessel's normal position} \ [\text{m}] \]
\[ b = \text{distance of the same opening as above from the centre of the vessel} \ [\text{m}] \]
\[ D^* = \text{ideal depth} \ [\text{m}] : \]
\[ D^* + \frac{q}{0.9 \cdot L \cdot B_{WL}} \]
\[ q = \text{sum of the volumes} \ [\text{m}^3] \text{ of the deckhouses, hatchways, trunk decks and other superstructures up to a height of 1.0 m above D or up to the lowest opening in the space under consideration, the lowest value shall be taken.} \]
\[ V = \text{displacement of the vessel at} \ T_m \ [\text{m}^3] \]
\[ i = \text{transverse moment of inertia} \ [\text{m}^4] \text{ of waterline parallel to the base, at height} \ [\text{m}] \text{ equal to:} \]
\[ h = T_m + 2 \cdot F^* / 3 \]
\[ I = \text{transverse moment of inertia} \ [\text{m}^4] \text{ of waterline} \ T_m \]
If there is no curve diagram the value needed for calculating lateral moment of inertia \( I \) of the water line may be obtained from the following approximation formulae:
— vessels in the form of a pontoon:
\[ = \frac{B_{WL}^2}{\left( 12.5 - \frac{T_m}{D} \right) T_m} \]
— other vessels:
\[ = \frac{B_{WL}^2}{\left( 12.7 - 1.2 \frac{T_m}{D} \right) T_m} \]

4.4 Damage stability

4.4.1 Application
In addition to the rules stated under [4.2] and [4.3], the requirements of this subsection apply to vessels exceeding 110 m in length and to vessels intended for the carriage of dangerous goods according to Ch.1 Sec.4.

4.4.2 The proof of sufficient stability after damage shall be produced for the most unfavourable loading condition.

The basic values for the stability calculation – the vessel’s light weight and location of the centre of gravity shall be determined:

— either by means of an heeling experiment, or
— by detailed mass and moment calculation, in which case the light weight of the vessel shall be verified by checking the draught, with a tolerance limit of ± 5 % between the mass determined by calculation and the displacement determined by the draught readings.

4.4.3 The proof of floatability after damage shall be produced for the fully loaded vessel.

For this purpose, calculated proof of sufficient stability shall be established for the critical intermediate stages of flooding and for the final stage of flooding. For critical intermediate stages of flooding, the righting lever curve shall show, beyond the equilibrium stage, a righting lever ≥ 0.03 m and a positive range ≥ 5°.

4.4.4 The following assumptions shall be taken into account for the damaged condition:

a) Extent of side damage:
   — longitudinal extent: at least 0.10 · L
   — transverse extent: 0.59 m
   — vertical extent: from base line upwards without limit

b) Extent of bottom damage:
   — longitudinal extent: at least 0.10 · L
   — transverse extent: 3.00 m
   — vertical extent: from base line to 0.39 m upwards, the sump excepted

c) Any bulkhead within the damaged area shall be assumed damaged, which means that the location of the bulkheads shall be chosen that the vessel remains afloat after flooding two or more adjacent compartments in the longitudinal direction.

   For the main engine room only a 1-compartment status needs to be taken into account, i.e. the end bulkheads of the engine room shall be assumed not damaged.

   For bottom damage, adjacent athwartship compartments shall also be assumed flooded.

d) Permeability:
   Permeability shall be assumed to be 95 %.

   Differing from the above documented assumption, the values of permeability stated in Table 1 may be assumed.

   If a calculation proves that the average permeability of any compartment is lower, the calculated value may be used.

e) At the final stage of flooding, the lower edge of any non-watertight opening (e.g. doors, windows, access hatches) shall, at the final stage of flooding, be not less than 100 mm above the damaged waterline.

Table 1 Permeability values [%]

<table>
<thead>
<tr>
<th>Spaces</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine and service rooms</td>
<td>85</td>
</tr>
<tr>
<td>Accommodation spaces</td>
<td>95</td>
</tr>
</tbody>
</table>
4.4.5 Given the assumptions in [4.4.4] the stability after damage is deemed sufficient provided: see also Figure 1:

a) At the final stage of flooding a safety clearance of not less than 100 mm remains and the angle of heel of the vessel does not exceed 5°; or

b) The positive range of the righting lever curve beyond the stage of equilibrium shall have an area under the curve of ≥ 0.0065 m·rad. The minimum values of stability shall be satisfied up to immersion of the first non-weathertight openings and in any event up to an angle of heel equal to 10° (see Figure 1). If non-weathertight openings are immersed before that stage, the corresponding spaces shall be considered as flooded for the purpose of stability calculation.

If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked accordingly; or

c) For vessels carrying dangerous goods, calculations in accordance with the procedure for damage stability specified in Section 3 or ADN, Part 9, shall produce a positive result.

4.4.6 When cross- or down-flooding openings are provided for reduction of unsymmetrical flooding, the time for equalization shall not exceed 15 minutes, if during the intermediate stages of flooding sufficient damaged stability has been demonstrated.

4.4.7 If openings through which undamaged compartments may additionally become flooded are capable of being closed watertight, the closing appliances shall be marked according to their operating instructions.

4.4.8 Where necessary in order to meet the requirements in [4.4.2] or [4.4.3], the plane of maximum draught shall be re-established.
5 Dredgers and pontoons

5.1 General

5.1.1 Application
The following requirements apply to dredgers and pontoons which have been requested to receive the additional class notation intact stability.

5.1.2 Documentation to be submitted for approval
Stability documentation shall include the following data and documents:

a) scale drawings of the floating equipment and working gear and the detailed data relating to these that are needed to calculate stability, such as content of the tanks, openings providing access to the inside of the vessel, etc.

b) hydrostatic data or curves

c) curves for the static stability lever arm effects

d) description of the situations of use together with the corresponding data concerning weight and centre of gravity, including its unladen state and the equipment situation as regards transport

e) calculation of the list, trim and righting moments, with statement of the list and trim angles and the corresponding residual freeboard and residual safety clearances

f) all of the results of the calculation with a statement of the use and load limits

Figure 1 Container vessels: proof of damage stability

5.2 Load assumptions
Stability assessment shall be based at least on the following load assumptions:

a) Density of dredged material for dredgers:
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— sands and gravels: 1.5 t/m³
— very wet sands: 2.0 t/m³
— soil, on average: 1.8 t/m³
— mixture of sand and water in the ducts: 1.3 t/m³

b) Clamshell dredgers:
The values given in a) shall be increased by 15 %.

c) Hydraulic dredgers:
The maximum lifting power shall be considered.

5.3 Intact stability

5.3.1 It shall be confirmed that, when account has been taken of the loads applied during the use and operation of the working gear, the residual freeboard and the residual safety clearance are adequate, i.e.:
— The residual safety clearance value is, at least:
  — 0.30 m for watertight and weathertight aperture
  — 0.40 m for non-weathertight openings
— The residual freeboard value is at least 0.30 m.
For that purpose the sum of the list and trim angles shall not exceed 10° and the bottom of the hull shall not emerge.

5.3.2 Stability checking shall take into account the heeling moments defined in [5.3.3] to [5.3.11]. The moments which may act simultaneously shall be added up.

5.3.3 Load induced moment
The load induced moment shall be defined by the designer.

5.3.4 Asymmetric structure induced moment
The asymmetric structure induced moment shall be defined by the designer.

5.3.5 Moment due to wind pressure
The moment caused by the wind pressure [tm] shall be calculated in accordance with the following formula:

\[ M_W = c \cdot P_{WD} \cdot A_W \cdot (\ell_W + T / 2) \]

\[ c \]
shape-dependent coefficient of resistance, taking account of gusts:
— for frameworks: \( c = 1.2 \)
— for solid section beam: \( c = 1.6 \)

\[ P_{WD} \]
specific wind pressure [t/m²]:
— for IN(0) and IN(0.6): \( P_{WD} = 0.025 \)
— for IN(1.2) and IN(2): \( P_{WD} = 0.04 \cdot n \)

\[ A_W \]
side surface area of the floating installation [m²]

\[ \ell_W \]
distance [m] of centre of gravity of area \( A_W \), from draught mark

5.3.6 Turning circle induced moment
For self-propelled vessels, the moment resulting from the turning of the vessel [tm] shall be determined by the following formula:
5.3.7 Cross-current induced moment
The moment resulting from the cross-current shall only be taken into account for floating equipment which is anchored or moored across the current while operating.

5.3.8 Ballast and supplies induced moment
The least favourable extent of tank filling on stability shall be determined and the corresponding moment introduced into the calculation when calculating the moments resulting from the liquid ballast and the liquid provisions.

5.3.9 Moment due to clear surfaces occupied by liquids
The moment [tm] due to clear surfaces occupied by liquids shall be determined in accordance with the following formula:

\[ M_{iQ} = 0.015 \cdot \sum b \cdot \ell \cdot (b - 0.55 \cdot \sqrt{b}) \]

\[ b = \text{width of the free surface or width of the free surface section considered [m]} \]
\[ \ell = \text{length of the free surface or length of the free surface section considered [m]} \]

5.3.10 Moment due to inertia forces
The moment resulting from the inertia forces shall be taken into account if the movements of the load and the working gear are likely to affect its stability.

5.3.11 Moment due to other mechanical equipment
The moment due to other mechanical equipment shall be defined by the designer.

5.3.12 The righting moments [tm] for floating installations with vertical side walls may be calculated via the formula:

\[ M_a = \Delta \cdot GM \cdot \sin \varphi \]

\[ GM = \text{metacentric height [m]} \]
\[ \varphi = \text{list angle.} \]

That formula shall apply up to list angles of 10° or up to a list angle corresponding to immersion of the edge of the deck or emergence of the edge of the bottom. In this instance the smallest angle shall be decisive. The formula may be applied to oblique side walls up to list angles of 5°.

If the particular shape of the floating installation(s) does not permit such simplification the lever-effect curves referred to in [5.1.2]] item c) shall be required.

5.4 Intact stability in case of reduced residual freeboard
If a reduced residual freeboard is taken into account, it shall be checked for all operating conditions that:

a) after correction for the free surfaces of liquids, the metacentric height GM is not less than 0.15 m

b) for list angles between 0° and 30°, there is a righting lever [m] of at least:

\[ h = 0.30 - 0.28 \cdot \varphi_n \]
φₙ = list angle [rad] from which the lever arm curve displays negative values (stability limit); it may not be less than 20° or 0.35 rad and shall not be inserted into the formula for more than 30° or 0.52 rad:

\[ 20° \leq \varphi_n \leq 30° \]

c) the sum of trim and list angles does not exceed 10°

d) the residual safety clearance value is, at least:
   — 0.30 m for watertight and weathertight openings
   — 0.40 m for non-weathertight openings

e) the residual freeboard is at least 0.05 m

f) for list angles between 0° and 30°, the residual lever arm [m] is at least:

\[ h = 0.20 - 0.23 \cdot \varphi_n \]

φₙ = list angle [rad] from which the lever arm curve displays negative values; this should not be inserted into the formula for more than 30° or 0.52 rad

Residual lever arm means the maximum difference existing between 0° and 30° list between the righting lever curve and the curve of the heeling lever. If an opening towards the inside of the vessel immerses at a list angle less than the one corresponding to the maximum difference between the lever arm curves, the lever arm corresponding to that list angle shall be taken into account.

5.5 Floating installations without confirmation of stability

The following floating installations may be exempted from requirements of [5.3] and [5.4]:
   — those whose working gear may in no way alter their list or trim and
   — those where there can in no way be any displacement of the centre of gravity

However:
   — At maximum load, the safety clearance shall be at least 0.30 m and the freeboard at least 0.15 m.
   — For apertures which cannot be closed in such a way as to exclude spray and bad weather, the safety clearance shall be at least 0.50 m.

6 Vessels carrying bulk dry cargo

6.1 General

6.1.1 Application

The following requirements apply to bulk dry cargo carriers which have been requested to receive the additional class notation **Intact stability**.

6.2 Heeling moments

6.2.1 Wind pressure induced moment

The moment [tm] due to lateral wind pressure shall be determined by the following formula:

\[ M_W = P_W \cdot A_W \cdot (\ell_W + T / 2) \]

\[ P_W = \text{specific wind pressure [kN/m}^2\text{]} \]
— for IN(0) and IN(0.6): \( P_W = 0.025 \)
— for IN(1.2) and IN(2): \( P_W = 0.04 \cdot n \)

\[ A_W = \text{lateral area above water} \quad [\text{m}^2] \]
\[ \ell_W = \text{distance} \quad [\text{m}] \text{ of centre of gravity of area } A_W, \text{ from draught mark} \]

6.2.2 Centrifugal force induced moment
The turning circle moment \([\text{tm}]\) shall be determined by the following formula:

\[
M_T = \frac{0.045 \cdot v^2 \cdot A}{L_{WL}} \left( KG - \frac{T}{2} \right)
\]

\( KG = \text{height} \quad [\text{m}] \text{ of centre of gravity above base line} \)

6.2.3 Cargo shift induced moment
For bulk dry cargo likely to redistribute itself if the vessel lists to an inclination greater than its angle of repose, such as grain or cement, the cargo shifting induced moment shall be taken into account.

The value of this moment shall be determined in relation with the hold or compartment geometry, assuming an angle to the horizontal of the resulting cargo surface after shifting of 12°.

6.3 Intact stability
The intact stability characteristics of any vessel carrying bulk dry cargo (see Figure 2), shall be shown to meet, throughout the voyage, at least the following criteria after taking into account the total heeling moment (as defined under [6.2]):

a) The angle of heel \( \varphi_1 \) shall be not greater than 12°.
b) In the statical stability diagram, the residual area between the heeling arm curve and the righting arm curve up to the angle of heel \( \varphi_2 \) is in all conditions of loading to be not less than 0.0065 m-rad.

\[ \varphi_2 = \text{angle of heel of maximum difference between the ordinates of the heeling arm curve and the righting arm curve, or 27° or the angle of flooding, whichever is the least.} \]

\[ \varphi_1 = \text{Angle of heel due to cargo shift} \]

Figure 2 Stability curve
6.4 Additional requirement

6.4.1 For bulk dry cargo likely to redistribute itself if the vessel lists to an inclination greater than its angle of repose, such as grain or cement, requirements [6.4.2] to [6.4.3] shall be additionally complied with.

6.4.2 Trimming
All necessary and reasonable trimming shall be performed to level all free cargo surfaces and minimize the effect of cargo shifting.

6.4.3 Cargo securing
Unless account is taken of the adverse heeling effect due to cargo shift according to these rules, the surface of the bulk cargo in any partially filled compartment shall be secured so as to prevent a cargo shift by overstowing.

Guidance note:
It is recommended to fit one or more temporary longitudinal subdivisions in the holds or compartments to minimize the possibility of shift of cargo.

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