

# RULES FOR CLASSIFICATION

## Ships

Edition July 2016  
Amended January 2017

### Part 3 Hull

### Chapter 15 Stability

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## 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 document supersedes the October 2015 edition.

Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

### Amendments January 2017

- **Sec.1 Stability**
  - **Sec.1 [2.1.1]:** Small adjustment of text regarding external watertight integrity survey, since this survey is not fully covered by a load line survey
  - **Sec.1 [5.1.2]** has been deleted.

### Main changes July 2016, entering into force as from date of publication

- **Sec.1 Stability**
  - Paragraph [1.1.5] deleted to remove mandatory application of crane requirements.

### Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.

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## SECTION 1 STABILITY

### Symbols

For symbols not defined in this section, refer to [Ch.1 Sec.4](#).

$L_w$  = waterline length of the ship in m.

## 1 General

### 1.1 Application

**1.1.1** All vessels with a length  $L_{LL}$  of 24 m and above shall comply with the stability requirements of this section, as applicable for the main class.

**1.1.2** The requirements in this section are in compliance with IMO 2008 Intact Stability Code (IMO Res. MSC.267(85)) and cover IACS UR L2.

**1.1.3** For vessels with service restrictions as described in [Pt.1 Ch.2 Sec.5](#), modified stability requirements may be considered if consistent with the applicable service restriction.

**1.1.4** If a loading instrument system is installed onboard the ship, the system shall be in accordance with the requirements given in [Pt.6 Ch.4 Sec.7](#).

### 1.2 Definitions

#### 1.2.1

**Table 1 Definitions**

<i>Terms</i>	<i>Definition</i>
<i>downflooding</i>	ingress of water through external openings to buoyancy volumes
<i>downflooding angle related to intact stability</i>	the minimum heel angle where an external opening without weathertight closing appliance is submerged
<i>external watertight integrity</i>	external watertight integrity means the capability of the hull structure and its external closing appliances to prevent downflooding to volumes assumed buoyant
<i>final stability documentation</i>	the stability documentation which is based on approved lightweight data obtained from an inclining test or lightweight survey
<i>lightweight</i>	<p>lightweight is defined in the Introduction to IMO 2008 Intact Stability Code (IMO Res. MSC.267(85)) in Definitions 2.23</p> <p>The lightweight definition shall be stated in the stability manual indicating which items are included or not included when this includes items such as permanent ballast.</p> <p><b>Guidance note:</b></p> <p>The approved lightweight data are the data which are approved for the purpose of stability approval and control but not necessarily for determination of the deadweight.</p> <p style="text-align: center;">---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---</p>

<i>Terms</i>	<i>Definition</i>
<i>maximum allowable vertical centre of gravity</i>	the maximum vertical centre of gravity of the vessel, corrected for free surface effect, which complies with the stipulated stability requirements for the draught in question
<i>preliminary stability documentation</i>	the stability documentation which is based on estimated lightweight data
<i>watertight</i>	capable of preventing ingress of water during static submersion under a head of water for which the surrounding structure is designed A watertight closing appliance is also considered weathertight.
<i>weathertight</i>	weathertight means that in any sea conditions water will not penetrate into the ship A watertight closing appliance is also considered weathertight.

### 1.3 Documentation requirements

**1.3.1** Documentation shall be submitted as required by [Table 2](#).

**Table 2 Documentation requirements**

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Stability	B010 – Lines plan and offset tables	<a href="#">Pt.1 Ch.3 Sec.3 [2]</a>	FI
	B020 – External watertight integrity plan	<a href="#">Pt.1 Ch.3 Sec.3 [2]</a>	FI
	B050 – Preliminary stability manual	<a href="#">Pt.1 Ch.3 Sec.3 [2]</a>	AP
	B100 – Inclining test and lightweight survey procedure	<a href="#">Pt.1 Ch.3 Sec.3 [2]</a>	AP, VS
	B110 – Inclining test or lightweight survey report	<a href="#">Pt.1 Ch.3 Sec.3 [2]</a>	AP, VS
	B120 – Final stability manual	<a href="#">Pt.1 Ch.3 Sec.3 [2]</a>	AP, VS
External watertight and weathertight integrity	B200 – Freeboard plan	<a href="#">Pt.1 Ch.3 Sec.3 [2]</a>	FI
AP = For approval; FI = For information; ACO = As carried out; L = Local handling; R = On request; TA = Covered by type approval; VS = Vessel specific			

**1.3.2** If the assignment of class shall be based on the approval of the flag administration according to [Pt.1 Ch.1 Sec.2](#), a copy of the final stability documentation stamped by the flag administration and the approval letter issued by the flag administration shall be submitted to the Society.

**1.3.3** For general requirements to documentation, including definition of documentation types, see [Pt.1 Ch.3 Sec.3](#) and the Society's document [DNVGL-CG-0157 Stability documentation for approval](#).

## 2 Surveys and tests

### 2.1 General

**2.1.1** The following surveys and tests shall be carried out:

- external watertight integrity survey with respect to unprotected and protected openings together with their closing appliances, alarms, indicators and signboards
- checking of draught marks
- remote draught measurement and tank gauging systems
- inclining test or lightweight survey, see [6].

## 3 General requirements

### 3.1 Stability book

**3.1.1** An approved stability booklet shall be provided onboard. The stability booklet shall include information as is necessary to enable the master by a rapid and simple process to obtain accurate guidance as to the stability of the ship under varying conditions of service.

**Guidance note:**

The format and content of the stability book is further described in the document [DNVGL-CG-0157 Stability documentation for approval](#) and IACS UI LL45.

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**3.1.2** Stability data and associated plans shall include a translation into English, if English is not used as official language.

### 3.2 Fixed ballast

**3.2.1** If used, fixed ballast shall be installed in a manner that prevents shifting of position.

### 3.3 Draught marks

**3.3.1** The ship shall have scale of draught marks at the bow and stern on both port and starboard side.

**Guidance note:**

The draught marks should reflect the extreme draught at the location where they are fitted. The stability manual should contain guidance on, from draught mark readings, how to utilise the stability information contained therein. Norwegian Standard NS6301 may be referenced for further guidelines on the size and location of draught marks.

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### 3.4 Loading computer system

**3.4.1** Loading computers for stability calculation shall be considered as supplementary to the approved stability booklet.

**3.4.2** Loading computers for stability control shall be in accordance with the requirements given in [Pt.6 Ch.4 Sec.7](#).

## 4 Intact stability criteria

### 4.1 General stability criteria

**4.1.1** The following criteria shall be satisfied:

- the area under the righting lever curve (*GZ* curve) shall not be less than 0.055 metre-radians up to  $\theta = 30^\circ$  angle of heel and not less than 0.09 metre-radians up to  $\theta = 40^\circ$  or the angle of flooding  $\theta_f$  if this angle is less than  $40^\circ$ . Additionally, the area under the righting lever curve between the angles of heel of  $30^\circ$  and  $40^\circ$  or between  $30^\circ$  and  $\theta_f$ , if this angle is less than  $40^\circ$ , shall not be less than 0.03 metre-radians
- the righting lever (*GZ*) shall be at least 0.20 m at an angle of heel equal to or greater than  $30^\circ$
- the maximum righting lever should occur at an angle of heel preferably exceeding  $30^\circ$  but not less than  $25^\circ$
- the initial metacentric height,  $GM_0$  shall not be less than 0.15 m.

**4.1.2** For ships carrying timber deck cargoes and provided that:

- the cargo extends longitudinally between superstructures end, or where there is no limiting superstructure at the after end, the timber deck cargo shall extend at least to the after end of the aftermost hatchway
- the cargo extends transversely for the full beam of the ship after due allowance for a rounded gunwale not exceeding 4% of the breadth of the ship
- supporting uprights are secured and remain securely fixed at large angles of heel,

the following criteria may be used instead of the criteria in [4.1.1]:

- the area under the righting lever curve (*GZ* curve) should not be less than 0.08 metre-radians up to  $\theta = 40^\circ$  angle of heel or the angle of flooding  $\theta_f$  if this angle is less than  $40^\circ$
- the maximum value of the righting lever (*GZ*) should be at least 0.25 m
- at all times during the voyage, the metacentric height  $GM_0$  should be positive after correction for the free surface effects of liquid in tanks and, where appropriate, the absorption of water by the deck cargo and/or ice accretion on the exposed surfaces. Additionally, in the departure condition, the metacentric height  $GM_0$  should not be less than 0.10 m.

**4.1.3** The following equivalent criteria are acceptable where a vessel's characteristics render compliance with impracticable (based on IMO 2008 IS Code Part B Ch.2.4.5):

- the area under the curve of righting levers (*GZ* curve) should not be less than 0.070 metre-radians up to an angle of  $15^\circ$  when the maximum righting lever (*GZ*) occurs at  $15^\circ$  and 0.055 metre-radians up to an angle of  $30^\circ$  when the maximum righting lever (*GZ*) occurs at  $30^\circ$  or above. Where the maximum righting lever (*GZ*) occurs at angles of between  $15^\circ$  and  $30^\circ$ , the corresponding area under the righting lever curve should be:

$$0.055 + 0.001 (30^\circ - \theta_{max}) \text{ metre-radians}$$

where:

$\theta_{max}$  = angle of heel in degrees at which the righting lever curve reaches its maximum

- the area under the righting lever curve (*GZ* curve) between the angles of heel of  $30^\circ$  and  $40^\circ$ , or between  $30^\circ$  and  $\theta_f$  this angle is less than  $40^\circ$ , should be not less than 0.03 metre-radians
- the righting lever (*GZ*) should be at least 0.20 m at an angle of heel equal to or greater than  $30^\circ$
- the maximum righting lever (*GZ*) should occur at an angle of heel not less than  $15^\circ$
- the initial transverse metacentric height ( $GM_0$ ) should not be less than 0.15 m.



**4.1.4** When anti-rolling devices are installed in a ship, the applicable intact stability criteria shall be satisfied when the devices are in operation.

**4.1.5** For certain ship types additional or alternative intact and damage stability criteria have been specified. These vessels (or class notations) are given in [Table 3](#).

**Table 3 Stability design requirements for different ship types and class notations**

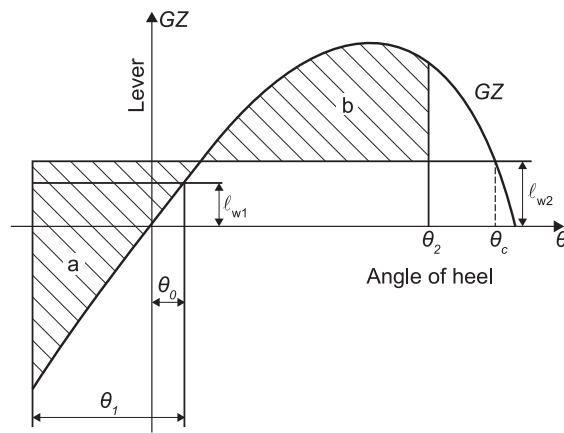
<i>Class notation/ship type</i>	<i>Intact</i>	<i>Damage</i>	<i>Class requirement</i>	<i>IMO reference</i>
<b>1A</b>	X		[4.1.1]	IMO 2008 IS Code Part A Ch. 2.2
<b>1A</b> (offshore/harbour service vessels)	X		[4.1.3]	IMO 2008 IS Code Part B Ch. 2.4.5
<b>1A</b> (wind)	X		[4.2.1]	IMO 2008 IS Code Part A Ch. 2.3
<b>1A</b> (timber)	X		[4.1.2]	IMO 2008 IS Code Part A Ch. 3.3
<b>Tanker for oil</b>	X		Pt.5 Ch.5 Sec.3 [1]	MARPOL 73/78 Reg. 27
<b>Offshore service vessel</b>	X		Pt.5 Ch.9 Sec.2 [5]	IMO Res. MSC.235(82) Ch.2
<b>SF</b>	X	X	Pt.6 Ch.5 Sec.6	IMO Res. MSC.235(82) Ch.3, alternatively as amended by IMO Res. MSC.335(90)
<b>Tug</b>	X		Pt.5 Ch.10 Sec.11 [5.1]	No IMO requirements
<b>Fire fighter I</b> (or <b>II</b> or <b>III</b> )	X		Pt.5 Ch.10 Sec.9 [9]	No IMO requirements
<b>Crane</b>	X		Pt.6 Ch.5 Sec.3 [5]	No IMO requirements
<b>Crane vessel</b>	X	X	Pt.5 Ch.10 Sec.2 [4]	No IMO requirements
<b>Diving support vessel(Surface), Diving support vessel(SAT)</b> (diving support vessel)	X	X	Pt.5 Ch.10 Sec.6 [3]  DNV-DSS-105 DNV-OS-E402	Intact stability: IMO Res. MSC.235(82) Ch.2 Damage stability: IMO Res. MSC.235(82) Ch.3, alternatively as amended by IMO Res. MSC.335(90)
<b>Well stimulation vessel</b>	X	X	Pt.5 Ch.10 Sec.8 [9]	Intact stability: IMO Res. MSC.235(82) Ch.2 Damage stability: IMO Res. MSC.235(82) Ch.3, alternatively as amended by IMO Res. MSC.335(90)
<b>Escort (n, V)</b>	X		Pt.5 Ch.10 Sec.11 [6.4] and Pt.5 Ch.10 Sec.11 [6.5]	No IMO requirements
<b>Standby vessel</b>	X	X	Pt.5 Ch.9 Sec.5 [5.1]	No IMO requirements
<b>Passenger ship, Ferry(A) or Ferry(B)</b>	X		Pt.5 Ch.4 Sec.4 [1]	IMO 2008 IS Code Part A Ch.3.1
<b>Fishing vessel or Stern trawler</b>	X		Pt.5 Ch.12 Sec.6 [1]	To cover IMO 2008 IS Code Part B Ch.2.1 Torremolinos International Conference Ch.III modified by the Torremolinos Protocol of 1993

Class notation/ship type	Intact	Damage	Class requirement	IMO reference
<b>Icebreaker/PC(1) to PC(7)</b>	X	X	Pt.5 Ch.10 Sec.10 [8] Pt.6 Ch.6 Sec.5 [13]	IMO Res. A.1024(26)
<b>Barge or Pontoon</b>	X		Pt.5 Ch.11 Sec.5 [1]	IMO 2008 IS Code Part B Ch.2.2
<b>SPS (&lt; 240 persons)</b> <b>SPS (240 persons or more)</b> All <b>SPS</b> ships	X	X	Pt.6 Ch.5 Sec.7 [2.2]	IMO 2008 IS Code IMO 2008 IS Code IMO Res. MSC.266(84)
<b>Semi-submersible heavy transport vessel</b>	X	X	Pt.5 Ch.10 Sec.5 [4]	No IMO requirements
<b>Winterized</b>	X		Pt.6 Ch.6 Sec.3 [6]	No IMO requirements
<b>Naval/Naval support</b>	X	X	Pt.5 Ch.13 Sec.5	No IMO requirements

## 4.2 Weather criterion

**4.2.1** For all ships with a length  $L_{LL}$  of 24 m and above, the criteria listed below shall be complied with (based on IMO 2008 IS Code Part A Ch.2.3):

- 1) The ability of a ship to withstand the combined effects of beam wind and rolling shall be demonstrated for each standard condition of loading, with reference to [Figure 1](#) as follows:
  - a) the ship is subjected to a steady wind pressure acting perpendicular to the ship's centreline which results in a steady wind heeling lever  $\ell_{w_1}$
  - b) from the resultant angle of equilibrium ( $\theta_0$ ), the ship is assumed to roll owing to wave action to an angle of roll ( $\theta_1$ ) to windward. Attention should be paid to the effect of steady wind so that excessive resultant angles of heel are avoided.  
The angle of heel under action of steady wind ( $\theta_0$ ) should be limited to a certain angle to the satisfaction of the Society. As a guide, 16° or 80% of the angle of deck edge immersion, whichever is less, is suggested
  - c) the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever  $\ell_{w_2}$
  - d) under these circumstances, area "b" should be equal to or greater than area "a"
  - e) free surface effects shall be accounted for in the standard conditions of loading as set out in [\[4.3.1\]](#).



**Figure 1 Severe wind and rolling**

The angles in Figure 1 are defined as follows, in deg.:

$\theta_0$  = angle of heel under action of steady wind (see 1.b) and 2)

$\theta_1$  = angle of roll to windward due to wave action

$\theta_2$  = angle of downflooding ( $\theta_f$ ) or  $50^\circ$  or  $\theta_c$  whichever is less

$\theta_f$  = angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open

$\theta_c$  = angle of second intercept between wind heeling lever  $l_{w2}$  and GZ curves.

2) The wind heeling levers  $l_{w1}$  and  $l_{w2}$ , in m, referred to in 1.a) and 1.c) are constant values at all angles of inclination and should be calculated as follows:

$$l_{w1} = \frac{P \cdot A \cdot Z}{1000 \cdot g \cdot \Delta} \quad \text{and}$$

$$l_{w2} = 1.5 l_{w1}$$

where:

$P$  = 504 N/m<sup>2</sup> (wind speed = 29 m/s). The value of  $P$ , used for ships in restricted service and/or for ships with very large windage areas (due to coherence length for wind speed), may be reduced subject to the approval of the Society

$A$  = projected lateral area of the portion of the ship and deck cargo above the waterline, in m<sup>2</sup>

$Z$  = vertical distance from the centre of  $A$  to the centre of the underwater lateral area or approximately to a point at one half the draught, in m.

3) The angle of roll  $\theta_1$  <sup>i)</sup>, in degrees, referred to in 1.b) should be calculated as follows:

$$\theta_1 = 109\kappa \cdot X_1 \cdot X_2 \cdot \sqrt{rs}$$

i) The angle of roll for ships with anti-rolling devices should be determined without taking into account the operation of these devices.

$X_1$  = factor as shown in [Table 4](#)

$X_2$  = factor as shown in [Table 5](#)

$\kappa$  = 1.0 for round-bilged ship having no bilge or bar keels

= 0.7 for a ship having sharp bilges

= as shown in [Table 6](#) for a ship having bilge keels, a bar keel or both

$r$  =  $0.73 \pm 0.6 OG/d$

$OG$  = distance between the centre of gravity and the waterline, in m, (+ if centre of gravity is above the waterline, – if it is below)

$d$  = mean moulded draught of the ship in m

$s$  = factor as shown in [Table 7](#).

**Table 4 Values of factor  $X_1$**

$B/d$	$X_1$
$\leq 2.4$	1.0
2.5	0.98
2.6	0.96
2.7	0.95
2.8	0.93
2.9	0.91
3.0	0.90
3.1	0.88
3.2	0.86
3.3	0.84
3.4	0.82
$\geq 3.5$	0.80

**Table 5 Values of factor  $X_2$**

$C_B$	$X_2$
$\leq 0.45$	0.75
0.50	0.82
0.55	0.89
0.60	0.95
0.65	0.97
$\geq 0.70$	1.0

**Table 6 Values of factor  $\kappa$**

$\frac{A_k 100}{L_w B}$	$\kappa$
0	1.05
1.0	0.98
1.5	0.95
2.0	0.88
2.5	0.79
3.0	0.74
3.5	0.72
$\geq 4.0$	0.70

**Table 7 Values of factor  $s$**

$T$	$s$
< 6	0.100
7	0.098
8	0.093
12	0.065
14	0.053
16	0.044
18	0.038
$\geq 20$	0.035

In Table 4 to Table 7, intermediate values are obtained by linear interpolation.

Rolling period, in seconds:

$$T = \frac{2C \cdot B}{\sqrt{GM}}$$

The symbols in Table 4 to Table 7 and the formula for the rolling period are defined as follows:

$C = 0.373 + 0.023 (B/d) - 0.043 (L_w/100)$

$d =$  mean moulded draught of the ship in m

$A_k =$  total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas in  $m^2$

$GM =$  metacentric height corrected for free surface effect in m.

**4.2.2** Other calculation methods of equivalent safety level may be accepted as an alternative to the above.

**Guidance note:**

For some ships, the formulas may over-estimate the roll angle. As an alternative, the roll angle can be determined by model tests or direct calculations carried out for sea-states corresponding to the recommended wind speed.

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## 4.3 Assumptions concerning intact stability criteria and calculations

**4.3.1** For all loading conditions the initial metacentric height and the stability curves shall be corrected for the effect of free surface of liquid in tanks.

**Guidance note:**

The free surface should be taken into account as described in the IACS UI LL61.

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**4.3.2** Compliance with the stability criteria shall be checked for the main loading conditions intended by the owner in respect of the vessel's operation.

**4.3.3** If the owner does not supply sufficiently detailed information regarding such loading conditions, calculations shall be made for the standard loading conditions in [4.3.4] and [4.3.5].

**4.3.4** The following standard loading conditions apply to cargo ships:

- ship in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo spaces and with full stores and fuel
- ship in the fully loaded arrival condition, with cargo homogeneously distributed throughout all cargo spaces and with 10% stores and fuel remaining
- ship in ballast in departure condition, without cargo but with full stores and fuel
- ship in ballast in arrival condition, without cargo and with 10% stores and fuel remaining.

**4.3.5** The following additional loading conditions apply to cargo ships intended to carry deck cargoes:

- ship in the fully loaded departure condition with cargo homogeneously distributed in the holds and with cargo specified in extension and weight on deck, with full stores and fuel
- ship in the fully loaded arrival condition with cargo homogeneously distributed in the holds and with cargo specified in extension and weight on deck, with 10% stores and fuel.

**4.3.6** In the fully loaded departure conditions in [4.3.4] and [4.3.5] the ship shall be assumed loaded to the summer load waterline, or if intended to carry timber deck cargo, to the summer timber load line. The water ballast tanks should normally be assumed empty.

**4.3.7** In all cases, the cargo in holds is assumed fully homogeneous unless this is inconsistent with the practical service of the ship.

**4.3.8** Where timber deck cargoes are carried, the amount of cargo and ballast shall correspond to the worst service condition in which all the stability criteria in [4.1] are met. In the arrival condition it shall be assumed that the weight of the deck cargo has increased by 10% due to water absorption.

**4.3.9** In all cases, when deck cargo is carried, a realistic stowage weight shall be assumed and stated, including the height of the cargo.

**Guidance note:**

For ships carrying timber deck cargoes conditions should be shown indicating the maximum permissible amount of deck cargo having regard to the lightest stowage rate likely to be met in service.

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**4.3.10** Only those parts of the ship that are adequately protected by weathertight closing are accepted to be included as buoyant in the stability calculations.

**Guidance note:**

Reference is made to IMO Intact Code IMO 2008 IS Code Part B Ch.3.5 and the IACS UI LL62.

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**4.3.11** The Society may allow account to be taken in stability calculations of the buoyancy of the deck cargo if such cargo has a permeability not greater than 0.25.

## 5 Damage stability

### 5.1 Damage stability

**5.1.1** Vessels with additional class notations, see [Table 3](#), shall comply with the additional damage stability requirements as given in the appropriate rule chapters.

## 6 Determination of lightweight data

### 6.1 Application

**6.1.1** Every passenger ship and cargo ship with length more than 24 metres shall be inclined upon its completion and the lightweight displacement and centre of gravity determined.

**6.1.2** The inclining test required in [\[6.1.1\]](#) may be waived if basic stability data are available from the inclination test of a sister ship and it is shown that reliable stability information for the exempted ship can be obtained from such basic data.

**Guidance note 1:**

Dispensation according to [\[6.1.2\]](#) is not considered applicable to passenger ships and other ships where the lightweight is more than 75% of the total displacement.

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**Guidance note 2:**

The criteria for dispensation according to [\[6.1.2\]](#) are given in SOLAS Reg. II-1/5.2.

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**6.1.3** A lightweight survey shall be carried out if an inclining test has been dispensed with according to [\[6.1.2\]](#).

### 6.2 Procedure

**6.2.1** Inclining tests and lightweight surveys shall be carried out in accordance with an approved test procedure or "Yard's checklist for planning and execution of lightweight survey and inclining test" given in the Society's document [DNVGL-CG-0157 App.A](#). The inclining test or lightweight survey shall be carried out in the presence of the Society's representative.

**Guidance note:**

Guidelines for conducting inclining test or lightweight survey are given in IACS Rec. No. 31.

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**6.2.2** The inclining test or lightweight survey report shall be signed by the person responsible for the test and be endorsed by the Society's representative.

**6.2.3** The approved lightweight and centre of gravity shall be used in the final stability booklet.





## CHANGES – HISTORIC

### October 2015 edition

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This is a new document.

The rules enter into force 1 January 2016.

### Amendments January 2016

- General
  - Only editorial corrections have been made.

**DNV GL**

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