STABILITY INFORMATION MANUAL

Including longitudinal strength

SHIPTYPE

SHIPNAME

SHIPYARD

Newbuilding No. XXXX

IMO No. XXXX

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Revision No.	Revision Summary	Date
0	Final edition	xxxxxx

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Computer calculations for the present data have been prepared by:

xxxxxxxxx

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Data list

NAPA Release Bxxxxx
NAPA project no. XXXX/ Arrangement xxxxxx

XXX/t&s.doc

XXX/t&s.pdf

Reference list:

Lines Plan	xxxxxxx rev..xxx
Freeboard plan	xxxxxxx rev. xxx
Capacity plan	xxxxxxx rev. xxx
Docking plan	xxxxxxx rev. xxx
Draught marks and position	xxxxxxx rev. xxx
Wind profile and area	xxxxxxx rev. xxx
General arrangement	xxxxxxx rev. xxx
Damage stability manual	xxxxxxx rev. xxx
Damage control manual	xxxxxxx rev. xxx
Cargo loading manual	xxxxxxx rev. xxx
Cargo securing manual	xxxxxxx rev. xxx
Ballast water management plan	xxxxxxx rev. xxx

1 GENERAL INTRODUCTION

This ***Booklet*** is prepared for the ship's Master for obtaining information and suitable instructions as guidance to calculate the stability of the ship under varying conditions of service.

Relevant requirements in the **International Code on Intact Stability, 2008 (2008 IS Code)** of IMO, and the relevant Class requirements of *CLASS* are to be referred to in the usage of this manual.

This ***Booklet*** comprises the following contents: General information and instruction are given for calculation and evaluation of stability of the ship accompanied by a number of loading conditions. Data, such as those of free surface moment of tanks (initial and large inclination), wind capsizing lever, immersing and flooding angles, limit height of centre of gravity, etc., and those of the maximum still water bending moments are included.

Lightweight and longitudinal centre of gravity were determined at a lightweight survey during inclining test, dated xxxxx.
(Lightweight and longitudinal centre of gravity were determined at a lightweight survey dated XXXX. The vertical centre of gravity was determined during inclining test dated xxxxxx for the sister vessel XXXX, XXXX).

Light ship:	XXXXX	Xxxxx
Lightweight	x t	x t
Longitudinal centre of gravity from AP	x m	x m
Transverse centre of gravity from CL	x m	x m
Vertical centre of gravity from B.L.	x m	x m

General hydrostatic data of the vessel, such as displacement, deadweight, centre of buoyancy, centre of floating, metacentre, displacement per centimetre of draught etc, are tabulated against the vessel's mean moulded draught, unless stated otherwise. Cross stability data, excluding the buoyancy effects of timber deck cargoes or the similar, are provided therein.

It is necessary to ensure a satisfactory safety of the ship at any time during each of its voyages. Therefore, prior to the loading operation, the Master shall make a calculation in order to verify that during the forthcoming voyage the following ***will not occur***

- unacceptable stresses in the ship's structure
- insufficient stability
- inappropriate floating state

1.1 INSTRUCTION TO THE MASTER

A stamped copy of this booklet must be kept on board the vessel at all times, be complete, legible and readily available for use. If this booklet should be lost or become unusable, a replacement copy should be obtained immediately from the Owners, classification society or the Maritime Authorities.

The loading conditions shown in this booklet are typical for the intended service of the vessel and are intended as guidance. It is thus emphasised that a separate calculation is necessary for all actual loading conditions.

This booklet contains all necessary data for the calculation of the ship's stability under various service conditions but does not as an example include grain loading, as this is included in the Grain Stability Manual, if grain loading is relevant for the ship.

It must be observed that if the ship is sailing under circumstances where the GM/KG limiting value is exceeded; the ship's stability might be insufficient.

Furthermore, the following should be noted:

1) Compliance with the stability criteria does not ensure immunity against capsizing, regardless of the circumstances, or absolve the master from his responsibilities. Masters should therefore exercise prudence and good seamanship having regard to the season of the year, weather forecasts and the navigational zone and should take the appropriate action as to speed and course warranted by the prevailing circumstances.

2) Care should be taken that the cargo allocated to the ship is capable of being stowed so that compliance with the criteria can be achieved (maximum KG and minimum GM value according to the enclosed tables not exceeded). If necessary, the amount should be limited to the extent that ballast weight may be required.

3) Before a voyage commences, care should be taken to ensure that the cargo, cargo handling cranes and sizeable pieces of equipment have been properly stowed or lashed so as to minimize the possibility of both longitudinal and lateral shifting, while at sea, under the effect of acceleration caused by rolling and pitching.

4) It must be emphasised that the conditions calculated in this booklet are only to be regarded as guiding conditions. Immediately before the start of a new voyage the master must determine the vessel's trim and stability to ensure that all requirements concerning the stability are fulfilled.

See Cargo Loading and Securing Manual for detailed loading information. For grain loading, please refer to the Grain Stability Manual.

General Precautions:

According to the International Code on Intact Stability, 2008 (Resolution MSC.267(85)) the following should be noted:

5.1.4. A ship, when engaged in towing operations, should possess an adequate reserve of stability to withstand the anticipated heeling moment arising from the tow line without endangering the towing ship. Deck cargo on board the towing ship should be so positioned as not to endanger the safe working of the crew on deck or impede the proper functioning of the towing equipment and be properly secured. Tow line arrangements should include towing springs and a method of quick release of the tow.

5.1.5 The number of partially filled or slack tanks should be kept to a minimum because of their adverse effect on stability. The negative effect on stability of filled pool tanks should be taken into consideration.

5.1.6 The stability criteria set minimum values of GM, but no maximum values are recommended. It is advisable to avoid excessive values of metacentric height, since these might lead to acceleration forces which could be prejudicial to the ship, its complement, its equipment and to safe carriage of the cargo. Slack tanks may, in exceptional cases, be used as a means of reducing excessive values of metacentric height. In such cases, due consideration should be given to sloshing effects.

5.1.7 Regard should be paid to the possible adverse effects on stability where certain bulk cargoes are carried. In this connection, attention should be paid to the IMO Code of Safe Practice for Solid Bulk Cargoes.

Operational Precautions in Heavy Weather:

According to the International Code on Intact Stability, 2008 (Resolution MSC.267(85)) the following should be noted:

According to the International Code on Intact Stability, 2008 (Resolution MSC.267(85)) the following should be noted:

5.2.1 All doorways and other openings, through which water can enter into the hull or deckhouses, forecastle, etc., should be suitably closed in adverse weather conditions and accordingly all appliances for this purpose should be maintained on board and in good condition.

5.2.2 Weathertight and watertight hatches, doors, etc., should be kept closed during navigation, except when necessarily opened for the working of the ship, and should always be ready for immediate closure and be clearly marked to indicate that these fittings are to be kept closed except for access. All portable deadlights should be maintained in good condition and securely closed in bad weather.

5.2.3 Any closing devices provided for vent pipes to fuel tanks should be secured in bad weather.

5.3.1 In all conditions of loading, necessary care should be taken to maintain a seaworthy freeboard.

5.3.2 In severe weather the speed of the ship should be reduced if propeller emergence, shipping of water on deck or heavy slamming occurs.

5.3.3 Special attention should be paid when a ship is sailing in following, quartering or head seas because dangerous phenomena such as parametric resonance, broaching to, reduction of stability on the wave crest, and excessive rolling may occur singularly, in sequence or simultaneously in a multiple combination, creating a threat of capsize. The ship's speed and/or course should be altered appropriately to avoid the above-mentioned phenomena. Please refer to the Revised Guidance to the master for avoiding dangerous situations in adverse weather and sea conditions (MSC.1/Circ.1228).

5.3.4 Reliance on automatic steering may be dangerous as this prevents ready changes to course, which may be needed in bad weather.

5.3.5 Water trapping in deck wells should be avoided. If freeing ports are not sufficient for the drainage of the well, the speed of the ship should be reduced or the course changed, or both. Freeing ports provided with closing appliances should always be capable of functioning and are not to be locked.

5.3.6 Masters should be aware that steep or breaking waves may occur in certain areas, or in certain wind and current combinations (river estuaries, shallow water areas, funnel shaped bays, etc.). These waves are particularly dangerous, especially for small ships.

5.3.7 In severe weather, the lateral wind pressure may cause a considerable angle of heel. If anti-heeling measures (e.g., ballasting, use of anti-heeling devices, etc.) are used to compensate for heeling due to wind, changes of the ship's course relative to the wind direction may lead to excessive angles of heel or capsizing. Therefore, heeling caused by the wind should not be compensated with anti-heeling measures, unless, subject to the approval by the Administration, the vessel has been proven by calculation to have sufficient stability in worst case conditions (i.e. under improper or incorrect use, mechanism failure, unintended course change, etc.).

Operational Measures for Ships Carrying Timber Deck Cargoes:

According to the International Code on Intact Stability, 2008 (Resolution MSC.267(85)) the following should be noted:

3.7.1 The stability of the ship at all times, including during the process of loading and unloading the timber deck cargo, should be positive and to a standard acceptable to the Administration. It should be calculated having regarded to:

.1 the increased weight of timber deck cargo due to:
.1.1 absorption of water in dried or seasoned timber, and
.1.2 ice accretion;
.2 variations in consumables;
.3 the free surface effect of liquid in tanks; and
.4 weight of water trapped in broken spaces within the timber deck cargo and especially logs.

3.7.2 The master should:

.1 cease all loading operations if a list develops for which there is no satisfactory explanation and it would be imprudent to continue loading;
.2 before proceeding to sea, ensure that:
.2.1 the ship is upright;
.2.2 the ship has an adequate metacentric height; and
.2.3 the ship meets the required stability criteria.

3.7.4 Ships carrying timber deck cargoes should operate, as far as possible, with a safe margin of stability and with a metacentric height which is consistent with safety requirements.

Icing Considerations:

According to the International Code on Intact Stability, 2008 (Resolution MSC.267(85)) the following should be noted:

6.3.3.1 The master should bear in mind that ice formation adversely affects the seaworthiness of the vessel as ice formation leads to:

.1 an increase in the weight of the vessel due to accumulation of ice on the vessel's surfaces which causes the reduction of freeboard and buoyancy;
.2 a rise of the vessel's centre of gravity due to the high location of ice on the structures with corresponding reduction in the level of stability;
.3 an increase of windage area due to ice formation on the upper parts of the vessel and hence an increase in the heeling moment due to the action of the wind;
.4 a change of trim due to uneven distribution of ice along the vessel's length;
.5 the development of a constant list due to uneven distribution of ice across the breadth or the vessel;
.6 impairment of the manoeuvrability and reduction of the speed of the vessel.

Finally, it should be pointed out to the ship's master that in case the ship undergoes a conversion, which will influence the stability conditions, new corrected stability information must be prepared.

2 MAIN PARTICULARS

Ship type	:	SHIP TYPE
Ship's name	:	SHIPNAME
Flag	:	XXXX
IMO number	:	xxxxxx
Call signal	:	xxxx
Builders	:	XXXX
Yard No.	:	XXXX
Keel laying date	:	XXXXX
Rules and Regulations	:	The vessel is built according to the rules of 'International Convention for safety of life at sea 1974' including protocol 1978 and all amendments thereto up to and including the 2009 Consolidated Edition, and 'International Convention on Load Lines 1966'. Intact stability are according to the International Code on Intact Stability, 2008 (2008 IS Code)
Class	:	XXXX
Class identification	:	XXXX

Main dimensions

Length overall	approx. xxxxx	m
Length Load Line	xxxxx	m
Length pp (centre of rudder stock to forward perpendicular)	xxxxx	m
Breadth moulded	xxxxx	m
Depth to bulkhead deck moulded	xxxxx	m
Draught at design waterline moulded	xxxxx	m
Draught at summer load line moulded	xxxxx	m
Draught extreme, to underside propeller / dome	xxxxx	m
Scantling draught moulded	xxxxx	m
Keel plate thickness	xxxxx	m
Displacement to design draught	xxxxx	t
Displacement to summer load line draught	xxxxx	t
Propeller diameter	xxxxx	m
Number of passenger's	xxxxx	
Number of person's onboard	xxxxx	

Draught and trim restrictions

The vessel has to meet the following minimum draught restrictions:

Min. draught fore	x.xx m *
Min. draught aft	x.xx m
Min. draught aft	x.xx m (heavy ballast condition only)
Allowable trim range	x.xx m (aft) to x.xx m (fwd)

***** “Scantlings approved for a minimum draught forward of x.xx m. In heavy weather conditions the forward draught should not be less than this value. If, in the opinion of the Master, sea conditions are likely to cause regular slamming, then other appropriate measures such as change in speed, heading or increase in draught forward may also need to be taken.”

Light ship and COG

Weight..x t
LCG from AP ....x m
TCG from CL (positive to PS)...x m
VCG from BL ....x m

Deadweight

Deadweight to design draught
(even keel and density of seawater of 1.025 t/m³)................................xxxxx t

Deadweight to summer load line draught
(even keel and density of seawater of 1.025 t/m³)................................xxxxx t

Tonnage

Gross tonnage ....xxxxx GT
Net tonnage ....xxxxx NT

Units

Lengths are measured in metres (m)
Weights are measured in tons (t) each 1000 kg

The reference system for the ship in this manual is:

Origin is positioned as follows
X-direction: *Frame 0 (Aft perpendicular), Positive forward*
Y-direction: Centreline. *Right-handed coordinate system (PS Positive)*
Z-direction: Base line in Z = 0 i.e. upper side of keel plate

Trim: Positive trim by stern when draft at AP is greater than draft at FP

Frame spacing:

Aft to fr.20	0.600 m
fr.20 to fr.167	0.800 m
fr.167 to fr.200	0.700 m
fr.200 to fwd.	0.600 m

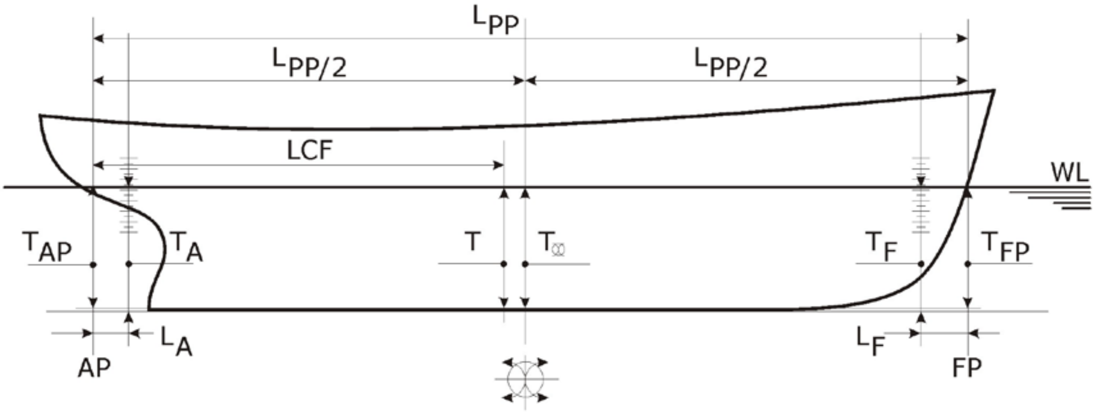
3 DEFINITIONS AND CONVERSION TABLE

The metric system is used in the definitions and assumptions, which apply in this Stability Information Manual. The following definitions and assumptions apply:
TO BE ADJUSTED TO THE GIVEN PROJECT......................

SYMBOL	DESCRIPTION	UNIT
A	Area	m^2
AP	Aft perpendicular	
ATTV	Attained value	-
B	Moulded breath	M
Base line	Base line (BL) of the ship is the upper side of the keel plate.	
BD	Buoyancy distribution	t
BEND	Bending moment	t*m
CB	Block coefficient at actual draught	-
CI	Common angle in interval	degrees
CM	Midship section coefficient at actual draught	-
CP	Prismatic coefficient at actual draught	-
CW	Waterplane coefficient at actual draught	-
BD	Depth to freeboard deck (moulded)	m
Delta	Angle of heel	degrees
Delta-f	Flooding angle	degrees
Delta-max	Angle where GZ occurs at maximum level	degrees
DGM	Reduction in GM	m
DGZ	Reduction in GZ	m
Disp	Displacement including shell plating and appendage	t
DW	Deadweight	t
EPHI	Area below GZ curve	t
FA	Flooding angle	degrees
FP	Forward perpendicular	m
FRA	Total frame area	m^2
FRSM	Free surface moment	m^4, t*m
FSM	Free surface moment	m^4, t*m
FSMOM	Free surface moment	m^4, t*m
GM	Metacentric height corrected for free surface	m
GM0	Initial metacentric height	m
GT	Gross tonnage	-
GZ	Righting lever	m
HPHI	Righting lever curve	m
IMAX	Maximum moment	degrees
IMMA	Immersion angle to marginline, deckedge, opening, etc.	degrees
IMMR	Reserve freeboard to immersion of marginline, deckedge, opening, etc.	m

KG	Distance from keel to centre of gravity (moulded)	m
KGmax	Maximum distance from keel to centre of gravity (moulded)	m
KM	Transverse metacentre above BL (KM_T) (moulded)	m
KN	Distance from base line to metacentric axis	m
L	Length 'International Load Line convention'	m
L_A	Distance from AP to aft draught mark. Positive value if draft mark is positioned forward of AP.	m
LCF	Longitudinal centre of flotation (from AP)	m
LCB	Longitudinal centre of buoyancy (from AP)	m
LCG	Longitudinal centre of gravity (from AP)	m
L_F	Distance from FP to fwd draft mark. Positive value if draft mark is positioned aft of FP	m
L_M	Distance from Load Line mark to draft mark amid ship. Positive value if draft mark is positioned aft of LL	m
LPP	Length between perpendiculars	m
LREF	Distance between AP and FP	m
LWL	Length of waterline at actual draught	m
MCT	Moment to change trim one centimetre	t*m/cm
MINGM	Minimum metacentric height	m
ML	Longitudinal moment of weights	t*m
MS	Residual stability	m
MT	Transversal moment of weights	m
MV	Vertical moment of weight	t*m
NT	Net tonnage	-
PHI	Angle of heel	degrees
PI	Propeller Immersion	m
REDPD	Reduction per one degree	m
REQ	Requirement	-
RHO	Density of liquid	t/m^3
Shell Plating	The average thickness of the shell plates is estimated at xxx mm and has been used as allowance in the hydrostatic calculations together with the keel plate thickness.	m
SHEAR	Shear force	t
SM	Simpsons multiplicator	
SWL	Draught at summer water line (moulded)	m
$T_{\otimes}$	Draught at midship (moulded)	m
T_A	Draught at aft draft mark from underside keel	m
T_{AP}	Draught at AP (moulded)	m
TCG	Transversal centre of gravity from CL	m
TPC	Weight to change draught one centimetre	t/cm
T_F	Draught at forward draft mark from underside keel	m
T_{FP}	Draught at FP mld.	m

TRIM	TRIM=T_{AP}-T_{FP}	m
	TRIM is positive when T_{AP} is larger than T_{FP}, i.e. the ship has an aft trim	
TK	Draught to underside keel	m
TRF	Trim factor = Disp/(100*MCT)	-
V	Displacement volume	m^3
VCB	Vertical centre of buoyancy above base line	m
VCG	Vertical centre of gravity above base line	m
VOLT	Total displacement volume/ Displacement in fresh water	m^3, t
WD	Weight distribution	t
WLA	Waterline area	m^2
WSA	Wetted surface area	m^2
X	Distance in longitudinal direction	m
XM	Longitudinal centre of gravity of load	m
XREF	Distance from AP to midship	m
Y	Distance in transverse direction	m
YM	Transversal centre of gravity of load	m
Z	Distance in vertical direction	m
ZM	vertical centre of gravity of load	m



Metric Conversion Table

Multiply by	To convert from	To obtain	
0.03937	mm	inch	25.4
0.3937	cm	inch	2.54
3.2808	m	feet	0.3048
2.2046	kg	lb	0.45359
0.9842	metric ton (1000 kilos)	long tons (2440 lbs)	1.0160
2.4998	tons per centimetre (immersion) [t/cm]	long tonnes per inch (immersion) [lt/inch]	0.40
8.2014	Moment to change trim one centimetre (tm/cm)	Moment to change trim one inch (foot-ton/inch)	0.1220
187.9767	m*rad	feet*degrees	0.0053
0.01745	m*degrees	m*rad	57.30
35.3147	m^3	$feet^3$	0.0283
	To obtain	**To convert from**	**Multiply by**

Relationship between weight and volume:

1000 cubic millimetres		=	1 cm^3
1 cubic centimetre of fresh water	(RHO=1.000)	=	1 g
1000 cubic centimetre of fresh water	(RHO =1.000)	=	1 kg
1 cubic metre of fresh water	(RHO =1.000)	=	1 t
1 cubic metre of seawater	(RHO =1.025)	=	1.025 t
1 ton of seawater	(RHO =1.025)	=	0.975 m^3

Conversion between cubic feet per tonnes or long tonnes and tonnes per cubic metre:

1/(0.0283 * x cu.ft/t) = y t/m^3
1/(0.0279 * x cu.ft/lt) = y t/m^3

35.316 * (1/x t/m^3) = y cu.ft/t
35.881 * (1/x t/m^3) = y cu.ft/lt

4 NOTES REGARDING STABILITY AND LOADING OF THE SHIP

4.1 STABILITY

The stability of a vessel in general is its ability to maintain an upright position or to re-establish this after a disturbance. For the seaworthiness of an undamaged vessel it is sufficient to investigate the stability in the transverse direction. This depends on the position of two points relative to each other, the centre of gravity (G) and the transverse metacentre M, see figure on page 4-2.

The metacentric height GM, the distance between the points G and M, means the stability for small angles and is given by the following equation:

$$GM = KM_T - KG$$

The centre of gravity (KG) above keel depends on the distribution of cargo and liquids in tanks in the vessel. By adding the single weights and their moments related to base line and by division of the total moments with the total weights, the centre of gravity KG (=VCG) may be obtained. The transverse metacentre (M) above keel (K), only dependent on the lines of the vessel, may be obtained from the hydrostatic tables.

In order to obtain a positive stability ($GM > 0$) the centre of gravity must lie below the transverse metacentre (KM_T). In the event of critical loading conditions (consumed stores or "iced-up" vessel), this condition can be achieved by filling the double bottom tanks.

4.2 CURVES OF RIGHTING LEVERS

Curves of righting levers are generally used to represent the stability during inclinations. To ensure that the vessel's stability is positive, the stability arm GZ must be positive.

To illustrate the righting levers at various inclinations of the vessel in a condition, the effective righting lever GZ is derived from:

$$GZ = GM \times \sin \Theta + MS, \text{ where}$$

MS = Residual stability arm
GM = Metacentric height as defined above
Θ = Angle of inclination

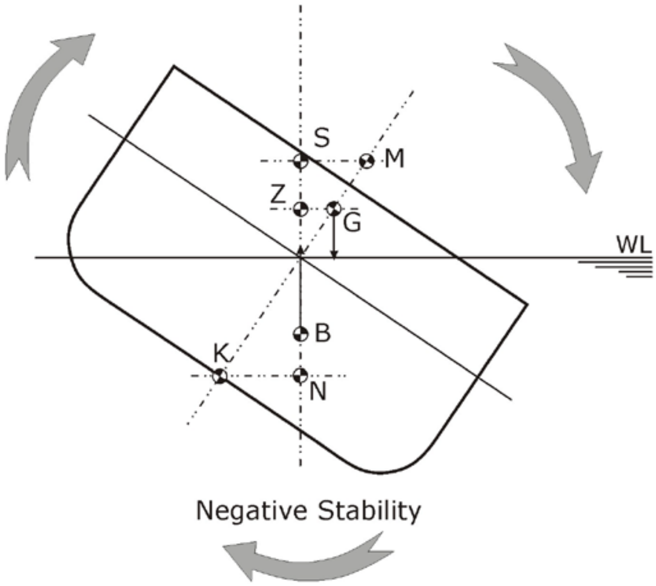
Alternatively,

$$GZ = KN - KG \times \sin \Theta, \text{ where}$$

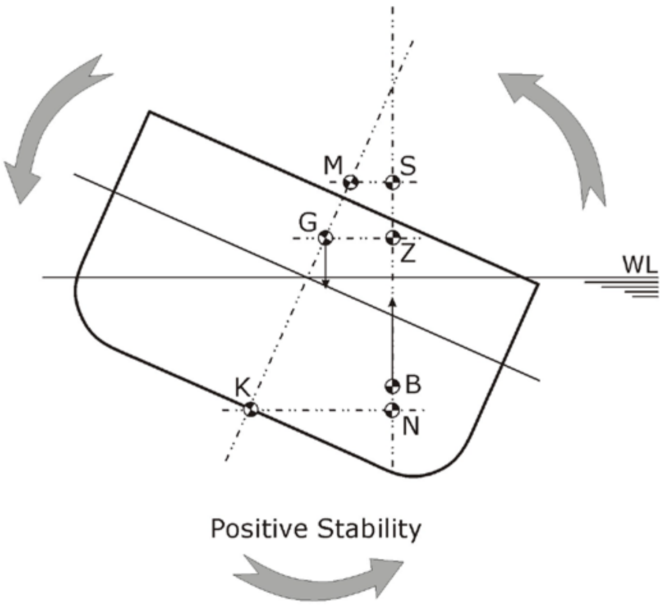
KN = The horizontal distance from the centre of gravity to base line
KG = Centre of gravity as defined above
Θ = Angle of inclination

The righting levers GZ calculated in accordance with the mentioned formula are plotted over the angle of inclination.

An example of the derivation of the curve of righting levers is shown on every condition sheet in this booklet in section 7.



Negative Stability



Positive Stability

4.3 FREE SURFACE EFFECTS

Provided a tank is completely filled with liquid, no movement of the liquid is possible and the effect on the ship's stability is precisely the same as if the tank contained solid material.

When a quantity of liquid is drained from the tank, the situation changes completely and the stability of the ship is adversely affected by what is known as the "free surface effect". This adverse effect on the stability is referred to as a "loss in GM" or as a "virtual rise in KG" and is calculated as follows:

Free surface moment = I x RHO = FSM

where I = transverse inertia moment of tank in m^4

where RHO = density of tank cargo in t/m^3

The free surface moment is measured in tons x metres (t x m)

Loss in GM due to Free Surface Effects (in metres) =

$$\frac{\text{Sum of Free Surface Moments in tons x metres}}{\text{Displacement of Vessel in tons}}$$

The 'Free Surface Effect' of all oil, fuel, freshwater, feed water and service tanks should be taken into account in all conditions, when these tanks are not completely filled.

In calculating the effect of free surfaces of consumable liquids, it shall 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 to be taken into account shall be those where the effect of free surfaces is the greatest.

It is of great importance to the safety of the vessel that all tanks are included in calculations regarding the corrected GM.

If the contents of one or more ballast tanks will change during the voyage, this has to be considered in the stability calculations.

4.4 HYDROSTATIC AND ISOCLINE STABILITY DATA

The data given in the hydrostatic tables and in the isocline stability tables (MS- and KN-tables) are presented as a function of the ship's moulded draught amidships $T_{\otimes}$
for the following trim values: ***-1.0, 0.0, 1.0, 2.0 and 3.0 metres*** (positive trim is trim aft).

If the vessel has a trim exceeding the range of tabulated trims, the values of the hydrostatic data and the righting levers will vary from those given in, or interpolated from, the tables. Extrapolating of values should therefore be avoided. This means that it is important to keep the vessel within a range of trim corresponding to the tabulated trims.

The hull definition used in the calculations is based on the faired lines. The stability model is defined with appendages (both positive and negative) such as rudder, propeller(s), thruster(s), sea chests, forecastle and deckhouses which can be closed weathertight, breakwater, cargo hatch coaming and cargo hatches.

4.5 USE OF TABLES

The tables for hydrostatics, form stability and maximum permissible KG should be entered with the ship's moulded draught amidships, $T_{\otimes}$, measured from the upper side of the keel plate.

i.e.: $$T_{\otimes} = \frac{T_{AP} - T_{FP}}{2}$$

When used in connection with stability calculations the height of all centres of gravity must refer to the same reference line.

4.6 IMMERSION OF PROPELLER

Propeller immersion PI is expressed as follows:

$$PI\,(\%) = \frac{I * 100}{D} = \frac{(T_{AP} - a) * 100}{D}$$

Where

- I : Vertical distance from bottom of propeller to water line at the propeller centre (m)
- D : Diameter of propeller (m) = x.xx m
- a : Vertical distance from bottom of keel to the lowest point of the tip (m) = x.xx m
- T_{AP} : Aft draught (m)

When PI > 100 %, the propeller is sufficiently immerged. This is the case for T_{AP} > x.xx m.

4.7 AIR DRAUGHT

The air draught can be calculated by the following formula:

$$\text{Air draught} = H - \left(T_{AP} - \frac{X * \text{Trim}}{L_{pp}} \right)$$

where,

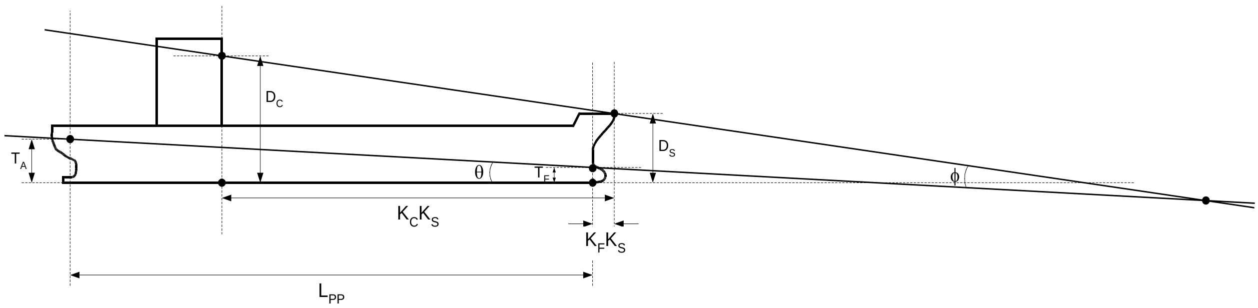
H is the height above BL to the relevant point
X is the distance from AP to the relevant point

T_{AP} is the draught at AP
Trim is the difference between draught aft and draught forward.

4.8 VISIBILITY

According to SOLAS 1974, Chapter V, Safety of Navigation, Regulation 22, Navigation Bridge Visibility as well as Panama Canal restrictions, the following visibility requirements shall be obtained by taking draught and trim into account.

Panama – full load, to be less that one ships length	xxx m
Panama – ballast, to be less that 1.5 times the ships length	xxx m
IMO requirement general, to be less than two times the ships length	xxx m



Length overall	L_{OA}:	xxx m
Length between perpendiculars	L_{PP}:	xxx m
Height of conning position	D_C:	xxx m
Height of position 'S'	D_S:	xxx m
Horizontal distance from conning position to position 'S'	K_CK_S:	xxx m
Horizontal distance from FP to position 'S'	K_FK_S:	xxx m

The visibility can be calculated by the following formula:

$$\frac{\sin(90-\varphi-\theta)}{\sin\varphi}\left(D_S - T_F + K_FK_S \cdot \frac{T_A - T_F}{L_{PP}}\right) \leq 2 \cdot L_{OA} \;\; ; \;\; 1.5 \cdot L_{OA} \;\; ; \;\; L_{OA}$$

where

$$\theta = \arctan\left(\frac{T_A - T_F}{L_{PP}}\right) \quad ;$$

T_A = Draught at AP ; T_F = Draught at FP

$$\varphi = \arctan\left(\frac{D_C - D_S}{K_CK_S}\right) - \theta$$

4.9 DRAUGHT AND TRIM CALCULATION

For calculation of trim and draught based on a loading condition calculation, the following data are required for ascertaining trim and draft:

a) Longitudinal centre of gravity of the ship calculated as follows:

$$\mathrm{LCG} = \frac{\text{Summation of longitudinal weight moments}}{\text{Displacement}}$$

b) Longitudinal centre of buoyancy, LCB

c) Displacement, DISP
d) Moment to change trim, MCT

e) Longitudinal centre of flotation, LCF

LCB, LCF, and MCT are taken from the hydrostatic tables (trim = 0 metres) corresponding to the actual displacement.

The trim is calculated according to the following formula:

$$\mathrm{TRIM} = \frac{\mathrm{DISP} \cdot (\mathrm{LCB} - \mathrm{LCG})}{\mathrm{MCT} \cdot 100}$$

The moulded draughts at AP (T_{AP}) and FP (T_{FP}) are calculated according to the following formulas:

$$T_{AP} = \frac{\mathrm{LCF} \cdot \mathrm{TRIM}}{L_{pp}} + T_{\otimes}$$

$$T_{FP} = T_{AP} - \mathrm{TRIM}$$

Where T is the draught taken from the hydrostatic tables (trim = 0 m) corresponding to the actual displacement.

The draught at the reading marks is as follows:

$$T_A = T_{AP} - \frac{\mathrm{TRIM} \cdot L_A}{L_{pp}} + \text{keelplate thickness}$$

$$T_F = T_{FP} + \frac{\mathrm{TRIM} \cdot L_F}{L_{pp}} + \text{keelplate thickness}$$

If the righting lever curve (GZ curve) has to be established, the KM_T and MS values to be used for this purpose are calculated for the actual trim value. This is done by interpolation for the KM_T and MS values, respectively, between the two tabulated trim values nearest to the actual trim.

4.10 DISPLACEMENT FROM DRAUGHT READINGS

Following procedure can be used to calculate the vessels actual displacement from the draft mark readings T_A and T_F:

1) The mean draft, T, which is used to enter the hydrostatic tables, is calculated as follows:

$$\mathrm{TRIM} = \frac{(T_A - T_F) \cdot L_{pp}}{L_{pp} - L_A - L_F}$$

$$T_{AP} = T_A + \frac{L_A \cdot \mathrm{TRIM}}{L_{pp}} - \text{keelplate thickness}$$

$$T_{FP} = T_F - \frac{L_F \cdot \mathrm{TRIM}}{L_{pp}} - \text{keelplate thickness}$$

$$T_{\otimes} = \frac{T_{AP} - T_{FP}}{2}$$

2) The displacement $DISP_0$ at zero trim according to the above mentioned draft T is read from the hydrostatic tables for <u>trim = 0 m</u>. Similarly, LCF and TPC are read from the hydrostatic tables for trim = 0 m.

3) The actual displacement, DISP, taking into account the trim, is calculated by use of the following formula:

$$\mathrm{DISP} = \mathrm{DISP}_0 + \frac{\frac{L_{pp}}{2} - \mathrm{LCF}}{L_{pp}} \cdot \mathrm{TRIM} \cdot \mathrm{TPC} \cdot 100$$

For instructions on the actual use of the formulas and interpolation of values from the hydrostatic tables, please refer to section 5 with worked example.

4.11 MINIMUM ANGLE OF FLOODING

When the vessel has a large angle of heel, unprotected openings in the hull, superstructure or deck can be immersed. This will result in a progressive flooding of the hull and in a reduction of GM.

According to the regulations of the International Code on Intact Stability, 2008 (2008 IS Code) it is only permissible to calculate the stability up to the angle where flooding occurs. In section 4.12 this angle is called X or 40 degrees.

Unprotected and weathertight openings have been taken into account when calculating the maximum allowable KG (minimum allowable GM) limit curves. All unprotected openings are beyond 40 degrees of heel and will not affect the stability range. Opening type and position is shown in section 11.

4.12 INTACT STABILITY CRITERIA

As the ship is required to comply with the International Code on Intact Stability, 2008 (2008 IS Code), any sailing condition has to comply with the following minimum stability criteria:

A The area under the righting lever curve (GZ curve) shall not be less than 0.055 metre-radians up to $\varphi = 30°$ angle of heel

B The area under the righting lever curve (GZ curve) shall not be less than 0.09 metre-radians up to $\varphi = 40°$ or the angle of down-flooding φ_f if this angle is less than 40°.

C The area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and φ_f, if this angle is less than 40°, shall not be less than 0.03 metre radians.

D The righting lever GZ shall be at least 0.2 m at an angle of heel equal to or greater than 30°.

E The maximum righting lever shall occur at an angle of heel preferably exceeding 30° but not less than 25°. If this is not practicable, alternative criteria, based on an equivalent level of safety, may be applied subject to the approval of the Administration.

F The initial metacentric height GM0 shall not be less than 0.15 m.

Severe Wind and Rolling Criterion (Weather Criterion)

The ability of a ship to withstand the combined effects of beam wind and rolling shall be demonstrated, with reference to figure 4-1 “Weather Criterion”, as follows:

.1 the ship is subjected to a steady wind pressure acting perpendicular to the ship’s centreline which results in a steady wind heeling lever (l_{w1});

.2 from the resultant angle of equilibrium (φ_0), the ship is assumed to roll owing to wave action to an angle of roll (φ_1) to windward. The angle of heel under action of steady wind (φ_0) should not exceed 16° or 80% of the angle of deck edge immersion, whichever is less;

.3 the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever (l_{w2}); and

.4 under these circumstances, area *b* shall be equal to or greater than area *a*, as indicated in figure 4-1 "Weather Criterion" below:

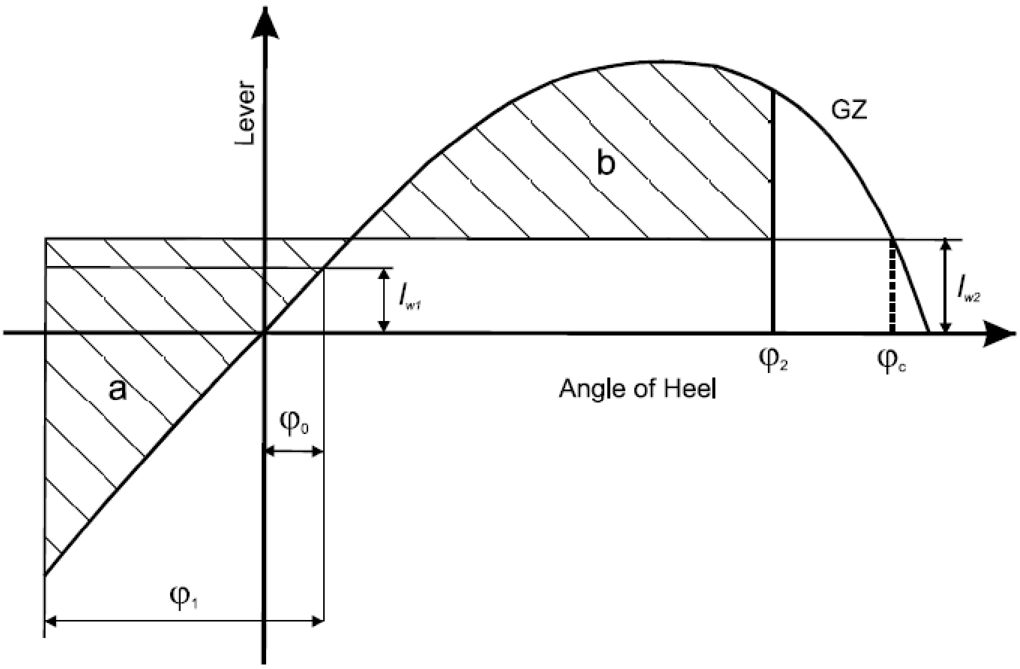


Figure 4-1 Weather criterion

Compliance with the above mentioned stability criteria are readily established by use of the diagrams and tables of maximum allowable KG in section 10 of this booklet.

To fulfil the demands regarding the intact stability the vessel should at all times comply with the tables and curves of maximum allowable KG and/or minimum allowable GM in section 10.

As the vessel has to comply at all times with both the intact and the damage stability requirements, it is important to note that the tables and curves of minimum allowable GM shown in section 10 are the resulting minimum allowable GM of both the intact and the damage stability requirements.

See also section 4.13 regarding the damage stability requirements.

4.13 DAMAGE STABILITY REQUIREMENTS

The vessel is built according to the rules of the 'International Convention for safety of life at sea 1974' (SOLAS) including protocol 1978 and all amendments thereto up to and including the 2009 Consolidated Edition.

The damage stability result is presented in section 10 together with the intact stability limit curves. All documentation and calculations on damage stability is presented in the Damage Stability Manual.

In order to fulfil the demands regarding both the intact stability and the damage stability, the vessel shall comply at all times with the tables and curves of maximum allowable KG and/or minimum allowable GM in section 10.

4.14 BALLAST WATER EXCHANGE

As IMO recommends that a ship shall be provided with a Ballast Water Management Plan detailing the way the ship can comply with ballast water management measures demanded by a port state, such a plan has been prepared to meet the recommendations of the following regulations and guidelines:

- REGULATION B-1 OF THE INTERNATIONAL CONVENTION FOR THE CONTROL AND MANAGEMENT OF SHIPS' BALLAST WATER AND SEDIMENTS, 2004;

- IMO RESOLUTION MEPC.127(53) 'GUIDELINES FOR BALLAST WATER MANAGEMENT AND THE DEVELOPMENT OF BALLAST WATER MANAGEMENT PLANS'.

For ballast water exchange – please refer to the Ballast Water Management Plan.

4.15 LOAD AND STRENGTH CALCULATION

Class notation: xxxx

For detailed loading information, including maximum deck load and tanktop load – please refer to the Cargo Loading Manual and the Cargo Securing Manual.

4.15.1 ALLOWABLE STILL WATER SHEAR FORCE

Allowable Shear Force Seagoing = xxxx t / -xxxx t
Allowable Shear Force harbour = xxxx t / -xxxx t

Position Dist. from AP	Fr. xx xx.xx m	Fr. xx xx.xx m	Fr. xx xx.xx m	Fr. xx xx.xx m	Fr. xx xx.xx m
Allowable S.F (Seagoing)	+xxxx ton - xxxx ton	+xxxx ton - xxxx ton	+xxxx ton - xxxx ton	+xxxx ton - xxxx ton	+xxxx ton – xxxx ton
Allowable S.F (Seagoing)	+xxxx ton - xxxx ton	+xxxx ton - xxxx ton	+xxxx ton - xxxx ton	+xxxx ton - xxxx ton	+xxxx ton - xxxx ton

4.15.2 ALLOWABLE STILL WATER BENDING MOMENTS

Min. Bending Moment Seagoing (Sagging)	=	-xxxxxx tm
Max. Bending Moment Seagoing (Hogging)	=	+xxxxxx tm
Min. Bending Moment Harbour (Sagging)	=	-xxxxxx tm
Max. Bending Moment Harbour (Hogging)	=	+xxxxxx tm

Position Dist. from AP	Fr. xx xx.xx m	Fr. xx xx.xx m	Fr. xx xx.xx m	Fr. xx xx.xx m	Fr. xx xx.xx m
Allowable Sagging (Seagoing)	-xxxxxx tm	-xxxxxx tm	-xxxxxx tm	-xxxxxx tm	-xxxxxx tm
Allowable Hogging (Seagoing)	+xxxxxx tm	+xxxxxx tm	+xxxxxx tm	+xxxxxx tm	+xxxxxx tm
Allowable Sagging (Harbour)	-xxxxxx tm	-xxxxxx tm	-xxxxxx tm	-xxxxxx tm	-xxxxxx tm
Allowable Hogging (Harbour)	+xxxxxx tm	+xxxxxx tm	+xxxxxx tm	+xxxxxx tm	+xxxxxx tm

4.15.3 SLOSHING

(Delete this section if not relevant)
For this vessel sloshing will only be a problem when water ballast is filled into hold no. 3 while at sea.

Consequently, filling or emptying of hold no. 3 should be avoided while at sea or only under-taken in calm weather with little or no risk of rolling and pitching. When used for water ballast it should be ascertained that the hold has been pumped totally full.

Filling degrees between 20% and 90% shall in all circumstances be avoided as sloshing can arise in these conditions with possible serious damage to the vessel's structure.

4.15.4 LOADING OF TIMBER DECK CARGO

(Delete this section if not relevant)
Ships carrying timber deck cargoes should operate, as far as possible, with a safe margin of stability and with a metacentric height that is consistent with the safety requirements.

At all time during a voyage, the metacentric height GM should fulfil the stability criteria's after correction for the free surface effects, the absorption of water of 10% by the deck cargo, and ice accretion.

When carrying timber deck cargo, the strength of the timber lashings should be observed and the stowage practice according to the Code of Safe Carrying of Timber should be noted.

4.15.5 LIGHT SHIP WEIGHT AND DISTRIBUTION

Lightweight and longitudinal centre of gravity has been determined at a lightweight survey during inclining test dated xxxxxx. Please see details in section 16.

The lightweight distribution is estimated from the “Weight Calculation”. Steel, machinery and equipment are divided into several lightweight elements. The elements and distribution are presented in section 12.

5 WORKING EXAMPLE INCL. EMPTY SHEETS

On the following pages is shown a worked example where a typical loading condition has been calculated 'by hand'. It is also shown how and where the different hydrostatic and stability data are taken from the appropriate tables.

For the sake of completeness the formula for interpolation shall be mentioned:

$$Y = Y_1 + (X - X_1) \cdot \frac{Y_2 - Y_1}{X_2 - X_1}$$

where;

Y = interpolated value corresponding to the value X
Y_1 = tabulated value corresponding to X_1
Y_2 = tabulated value corresponding to X_2
X_1 = to be less than X and
X_2 = to be higher than X

<u>Notes regarding worked example</u>

<u>Page 1</u>

1. All weights incl. the light ship, the corresponding KG, LCG and free surface moments (FSM) are entered into the sheet.

2. The vertical and the longitudinal moment are calculated.

3. The following are summed:

WEIGHT	[A]	(Displacement)
V-MOM	[B]	(Actual KG · W)
L-MOM	[C]	(Actual LCG· W)
FSM	[D]	(Actual total free surfaces)

4. Actual KG· W.
   Actual KG · W [E] = FSM + V-MOM =[D] +[B]

5. The vertical and the longitudinal center of gravity.

$$\mathrm{KG}[\mathrm{F}] = \frac{\text{Actual W} \cdot \text{KG}}{\text{Displacement}} = \frac{[\mathrm{E}]}{[\mathrm{A}]}$$

$$\mathrm{LCG}[\mathrm{G}] = \frac{(\text{Actual LCG} \cdot \text{W})}{\text{Displacement}} = \frac{[\mathrm{C}]}{[\mathrm{A}]}$$

<u>Page 2</u>

1. The LCG [G] is taken from page 1.

2. Mean draught [K], LCF [H], LCB [I] and MCT [J] are taken from tables for hydrostatic data (section 8).
   The tables are entered with the displacement and zero trim.

3. Trim

$$\text{Trim}[\text{L}] = \frac{(\text{LCB} - \text{LCG}) \cdot \text{Displacement}}{\text{MCT} \cdot 100} = \frac{([\text{I}] - [\text{G}]) \cdot [\text{A}]}{[\text{J}] \cdot 100}$$

4. Draught aft, forward and at $L_{PP}/2$.

$$\text{Draught aft } [\text{M}] = \text{Draught mean} + \frac{\text{LCF} \cdot \text{Trim}}{\text{L}_{\text{PP}}} = [\text{K}] + \frac{[\text{H}] \cdot [\text{L}]}{\text{L}_{\text{PP}}}$$

$$\text{Draught forward } [\text{N}] = \text{Draught aft - Trim} = [\text{M}] - [\text{L}]$$

$$\text{Draught at } L_{PP}/2 \text{ [O]} = \frac{\text{Draught forw.} + \text{draught aft}}{2} = \frac{[\text{M}] + [\text{N}]}{2}$$

5. The draught aft and forward are corrected for keel plate thickness [P] and distance from the perpendiculars to the draught marks [Q,R].

$$\text{Draught aft [S]} = \text{Draught aft} + \text{plate thickness} - \frac{\text{L}_{\text{A}} \cdot \text{Trim}}{\text{L}_{\text{PP}}} = [\text{P}] + [\text{M}] - \frac{[\text{Q}] \cdot [\text{L}]}{\text{L}_{\text{PP}}}$$

$$\text{Draught for [T]} = \text{Draught fore} + \text{plate thickness} + \frac{\text{L}_{\text{F}} \cdot \text{Trim}}{\text{L}_{\text{PP}}} = [\text{P}] + [\text{M}] + \frac{[\text{R}] \cdot [\text{L}]}{\text{L}_{\text{PP}}}$$

6. The KG [F] is taken from page 1.

7. Maximum allowable KG (VCG) or minimum allowable GM is taken from the tables and curves in section 10 according to the intact and damage stability.

   The tables are entered with trim and mean draught.

8. Stability criteria.
   If KG < (Max. allowable KG) or GM > (Min. allowable GM) the stability of the ship is sufficient.

Ship :	Date :	Sign. :
Condition :	File :	

Description :

	WEIGHT [t]	VCG [m]	V-MOM [tm]	LCG [m]	L-MOM [tm]	FSM [tm]
Light ship						
Total	A		B		C	
Total FSM			D	←		D
Actual VCG*W [(B)+(D)]			E	Incl. FSM		
VCG [(E)/(A)]		F				
LCG [(C)/(A)]				G		

Ship :			
Condition :			
Description			
Hydrostatic data: (Table values for trim = 0)			
LCG	(G) from page 1	G	
LCF	Table values (Stability Manual 055-01 section 8)	H	
LCB	Table values (Stability Manual 055-01 section 8)	I	
TRIMMOM.	Table values (Stability Manual 055-01 section 8)	J	
Draught and trim		Lpp =	
Mean draught	Table values (Stability Manual 055-01 section 8)	K	
Trim	$= \frac{([I]-[G])\cdot[A]}{[J]\cdot 100}$	L	
Draught at AP (mld.)	$= [K] + \frac{[L]\cdot[H]}{L_{pp}}$	M	
Draught at FP (mld.)	$= [M]-[L]$	N	
Draught at $L_{pp}/2$ (mld.)	$= \frac{[M]+[N]}{2}$	O	
Keel plate thickness		P	
L_a	(dist. from draught marks aft, positive=fore of AP)	Q	
L_f	(dist. from draught marks fore, positive=aft of FP)	R	
Draught at marks aft	$= [P]+[M]-\frac{[L]\cdot[Q]}{L_{pp}}$	S	
Draught at marks fore	$= [P]+[N]+\frac{[L]\cdot[R]}{L_{pp}}$	T	
Max. allowable VCG according to intact and damage stability			
Actual VCG (KG)	(F) from page 1	F	
Max. VCG x = XX.X	Table values (Stability Manual 055-01 section 10)	U	
Max. VCG y = YY.Y	Table values (Stability Manual 055-01 section 10)	V	
Max. allowable VCG	$= [U] + \frac{[K]-[x]}{[y]-[x]}\cdot([V]-[U])$	W	
(F) < (W) : The stability of the ship is sufficient acc. to intact and damage stability			

6 TANK AND CAPACITY INFORMATION

For the purpose of manual calculation of loading conditions it is recommended to include tank calibration tables for all tanks showing tank particulars for at least 10 heights.

7 LOADING CONDITIONS

A summary table showing the main data for all loading conditions should be included in the forward part of this section. This should include items such as condition name and number, mean draft, trim, heel, displacement, deadweight, weight of cargo, bunker, water ballast, actual KG (GM) corrected for free surfaces, max. allowable KG (GM), longitudinal strength data and compliance.

The sketch in each loading condition showing deadweight items should include a legend of each deadweight group.

All deadweight items, including crew, stores, deck cargo etc must be included on the sketch. (depending on size of vessel)

All tanks included in the tank capacity list must be listed in all loading conditions, even if considered empty.

In addition to the curves of longitudinal strength, a table of longitudinal forces, presenting both actual and relative (%) values at each calculation station must be included in the strength evaluation in each loading condition.

Where water ballast tanks, including anti-rolling tanks and anti-heeling tanks, are to be filled or discharged during a voyage, the free surface effects of such tanks must be taking into account using the most onerous transitory stage, i.e. if a water ballast tank is considered empty in the departure condition and completely filled in the arrival condition, the maximum free surface of such tank must be taken into account in both conditions.

It is recommended that HFO and GO service tanks are always calculated with the maximum FSM.

Concerning the use of tanks with consumable liquids, there must be consistency on how the free surfaces are handled, i.e. if tanks are to be emptied during the voyage, the free surface of the tank or tank pairs having the greatest free surface should be taken into account. According to IMO 2008 IS Code, part B the following procedure should be used:

"3.1.4. In calculating the free surface effects in tanks containing consumable liquids, it should 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 should be those where the effect of free surfaces is the greatest."

In this case, at least free surfaces of the largest FW tanks, HFO tanks, DO tanks and other consumable tanks must be taken into account in all loading conditions.

It is recommended but not mandatory to include a docking condition and additional conditions with 50% consumables

8 HYDROSTATIC DATA AND PLOT OF THE HULL

It is recommended to include hull definition information such as plot of body plan, profile or 3D view and description of frame numbering and frame spacing.

9 STABILITY DATA (MS AND KN TABLES)

10 MAXIMUM KG AND MINIMUM GM LIMIT CURVES

11 RELEVANT OPENINGS AND POSITIONS / FLOODING ANGLES

12 LIGHTWEIGHT DISTRIBUTION

13 BC-A LOADING CONDITIONS

(Delete this section if not relevant)

14 INTERMEDIATE CONDITIONS

(Delete this section if not relevant)

15 DRAWINGS

This section contains drawings, which is relevant and needed for stability review. The following drawings are included in this Stability Information Manual.

Draught Marks and Position
Wind profile and area
Freeboard Plan
Capacity Plan
Docking Plan

16 INCLINING EXPERIMENT

This section must contain the approved Inclining Experiment Report.