Australian Government
Australian Maritime Safety Authority

CALCULATION OF STABILITY FOR SHIPS CARRYING BULK GRAIN

International requirements and Australian legislation require that ships intending to carry grain cargoes in bulk from Australian ports to demonstrate compliance with the International Grain Code. This form provides the means by which the Master can demonstrate compliance with the stability requirements of the Code.

INSTRUCTIONS TO MASTER FOR LOADING GRAIN IN AUSTRALIAN PORTS

Chapter VI of SOLAS 74, as amended, requires the shipper to provide the master or his representative with appropriate information on the cargo. Beyond this, it is the master's responsibility to take precautions for the proper stowage of the cargo.

Chapter VI further requires a cargo ship carrying grain to comply with the International Grain Code ("Code") and to have a document of authorization as required by that Code. Grain cargoes are generally loaded within the limitations of the vessel's Document of Authorization and the approved Grain Loading Manual. A ship without such documents is required to satisfy AMSA and its flag State that the ship complies with the Code in its proposed loading condition.

Precautions for the proper stowage of the cargo include:

- obtaining from the local agent or other authoritative source at the loading port, the quantity of, and accurate stowage factor for, the grain to be loaded and trimming methods available;
- cargo planning should allow for the possibility that the actual stowage factor could vary substantially from that expected;
- calculations of stability and shear force / bending moments for all conditions of loading and all stages of the voyage while carrying grain, from commencement of loading to arrival at the last port of discharge. These calculations should demonstrate compliance with the Code and all relevant statutory and classification society requirements. Please note that this form requires the stability to be calculated for the worst condition that can occur during the voyage;
- ensuring that all cargo space bilge wells are clean, suctions clear and pumping arrangements operating satisfactorily.
- ensuring bilge well covers have sufficient holes for drainage and, after pre-loading inspection by shore-based personnel, are covered with burlap or similar material to allow drainage while preventing loss of grain into the wells;
- ensuring that any necessary portable fittings and/or hinged partitions are securely erected and made suitably grain-tight, and
- ensuring that all light fittings, and other electrical circuits not required for the safe operation of the ship, within the cargo space are isolated from the power source.

AMSA requires the following interpretations to be followed in relation to compliance with the Code:

- the Code requires all compartments in which grain is stowed to be either "filled" (trimmed or untrimmed) or "partly filled" (trimmed only). AMSA does <u>not</u> accept "partly filled" compartments untrimmed, even if data for these is approved by the flag State Administration, as they are not provided for in the Code;
- AMSA cannot accept a compartment as being "filled" if the average ullage at the coaming exceeds the minimum required to accommodate the structure of hatch covers or 100mm, whichever is greater;
- untrimmed moments may only be used for filled compartments;
- calculations for any filled compartment are to be based on the full (ie. 100% cubic) capacity and corresponding maximum VCG of the compartment irrespective of whether the cargo is to be trimmed or untrimmed;
- AMSA accepts grain surfaces in which the height between the highest peaks and the lowest troughs in the compartment is not more than 1.0m as being "level" within the meaning of the Code and therefore trimmed to an acceptable standard;
- the surface of grain cargo in each partly filled compartment is to be evenly distributed and not used to remove a list;
- it is the responsibility of the master to ensure that the cargo is trimmed as required by the Code - AMSA will not determine the method by which this is achieved, and
- any list (heel) is to be corrected before the vessel sails.

AMSA has no objection to the engagement of a consultant or supercargo to assist ship's personnel in achieving compliance with the above requirements. However, if inspection by an AMSA surveyor reveals non-compliance with these requirements, it may be necessary for AMSA to insist on rectification, the possible engagement of a consultant or the implementation of the control provisions of STCW'95.

FLOW CHART FOR GUIDANCE IN COMPLETING CALCULATIONS

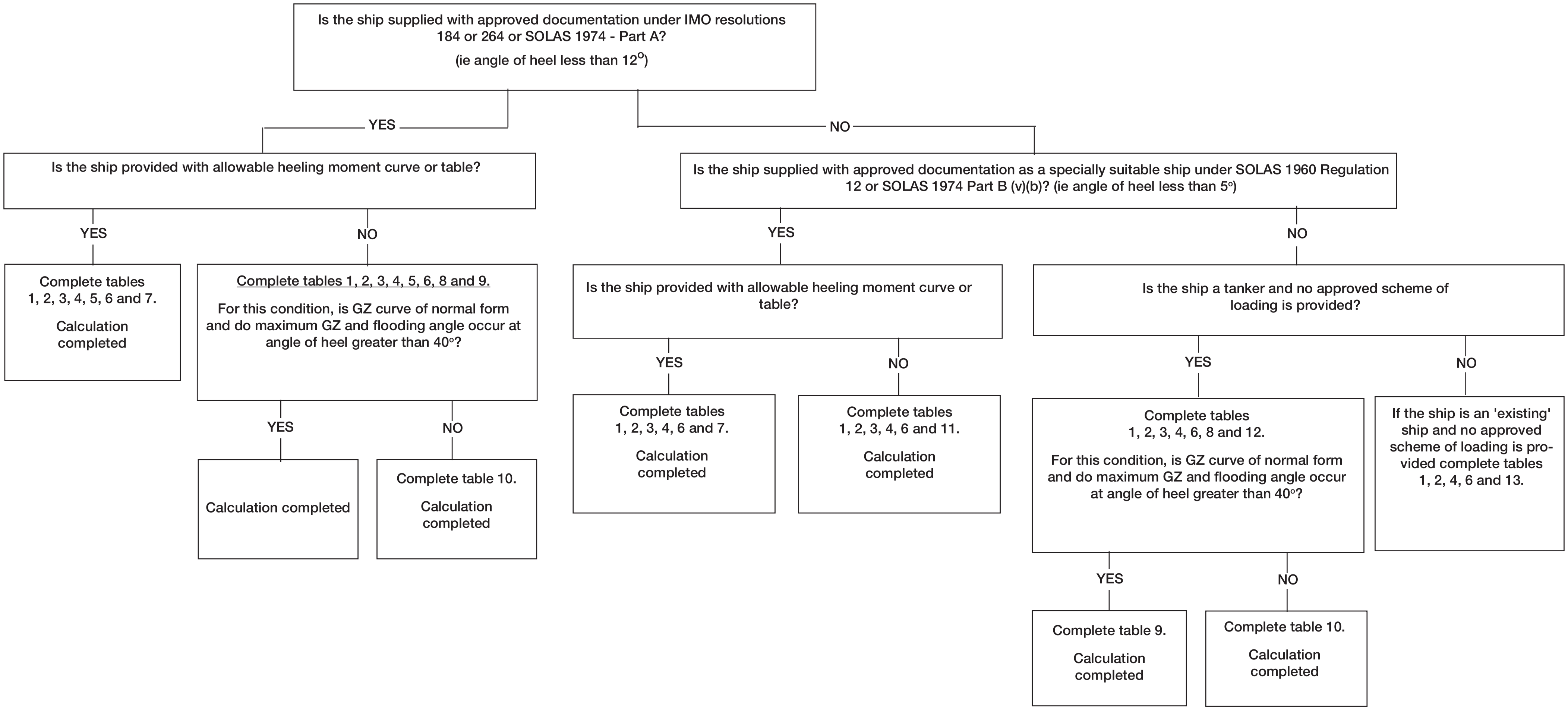


TABLE 1 - GENERAL PARTICULARS

Name of ship	Port of registry	Official number

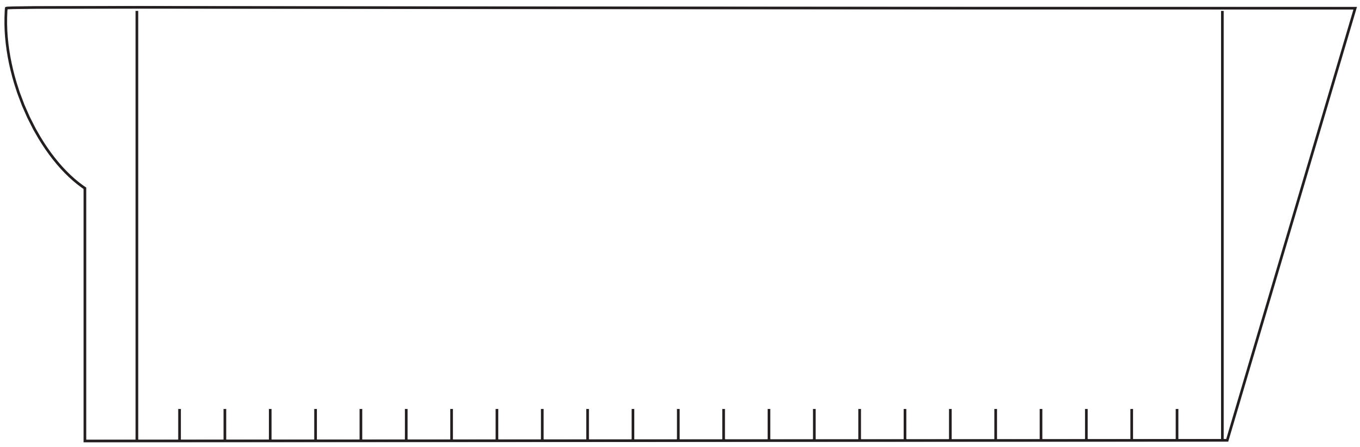
Type of ship
☐ Bulk carrier ☐ Tween decker ☐ Tanker ☐ Other - specify

Summer draft	Summer freeboard	Summer displacement tonnes/tons
Summer deadweight tonnes/tons	F.W.A. mm/in.	T.P.C. T.P.I.

Loading port(s)	Discharge port(s)

Grain stability information, approval authority and date.

Cargo plan: Indicate holds, tween decks, coamings/trunks, type of grain, secured and unsecured surfaces and ballast.



Departure conditions

Crew and stores (constant) ....

Bunkers ....

Fresh water ....

Ballast ....

Cargo ....

Total deadweight ....tonnes/tons

Draft F...................................

A ....

M..................................m/ft

I certify that :

- the ship will meet throughout the voyage the requirements of the International Grain Code;
- during loading, on departure, and throughout the voyage the bending moments and shear forces will not exceed the allowable limits.

Date .... / .... / ....

Port ....

Master ....

Received ....
AMSA Surveyor

Date .... / .... / ....

TABLE 2 - CALCULATION OF KG

This Table is to be completed for the worst condition that can occur during the voyage.

Table 4 must be completed to show movements of liquids during the voyage.

For full compartments indicate whether cargo centres "C" or volumetric centres "V" are used. If your grain stability information does not describe which are used, presume "V" values are used and use VCG given for the total volume of compartments.

Compartment number	Grain cubic m^3 / ft^3		Stowage factor	Weight tonnes / tons	VCG	C or V centres	Moments m tonnes / ft tons
	100%	Actual					
Lightship							
Crew/stores							
cargo							
			Sub-total (1) ►			Sub-total (2) ►	

S.F. cu ft / ton	S.F. m^3 / tonne	Den. tonne / m^3	S.F. cu ft / ton	S.F. m^3 / tonne	Den. tonne / m^3
40	1.115	.897	49.5	1.380	.725
41.5	1.157	.865	50	1.393	.718
42	1.171	.854	50.5	1.407	.711
42.5	1.184	.844	51	1.421	.704
43	1.199	.834	51.5	1.435	.697
43.5	1.212	.825	52	1.449	.690
44	1.226	.815	53	1.477	.677
44.5	1.240	.806	54	1.505	.664
45	1.254	.797	55	1.533	.652
45.5	1.268	.789	56	1.561	.641
46	1.282	.780	57	1.589	.629
46.5	1.296	.772	58	1.616	.619
47	1.310	.763	59	1.644	.608
47.5	1.324	.755	60	1.672	.598
48	1.338	.748	61	1.700	.588
48.5	1.352	.740	62	1.728	.579
49	1.366	.732			

TABLE 2 - LIQUID'S WORST CONDITION

Tank number	Content	Capacity m^3 / ft^3	S.G.	Weight tonnes / tons	VCG m / f	Moments m tonnes / ft tons	Free Surface (FS) Moments
		Sub-total (S - T) ▶ Sub-total (S - T) (1) ▶		+	S - T ▶ S - T (2) ▶	+	Total FS Moments
		DISPLACEMENT ▶			Total Moments ▶		

TABLE 3 - UPSETTING MOMENTS

NOTE:

Stowage Factor (column 3) Where two kinds of grain are stowed in the same compartment, use the stowage factor of the grain at the surface.

Correction Factor (column 5) Filled compartments:

(i) If 'V' centres have been used in Table 2 - no correction is needed.

(ii) If 'C' centres have been used in Table 2 - correction factor is 1.06.

(iii) Correction factor (column 5) - this is not to be applied in the case of ships loading as a specially suitable ship (5° criterion).

Partly filled compartments: Correction factor of 1.12 is to be used except -

(i) Where 'V' centre of full compartment has been used in Table 2.

(ii) Where table or curve of heeling moments has been adjusted for this correction.

1 Grain depth or ullage m / ft	2 Volumetric heeling moment m^4 / ft^4		3 Stowage factor m^3 / tonne or ft^3 / ton	4 Uncorrected heeling moment m tonnes / ft tons (2) ÷ (3)	5 Correction factor to allow for vertical shift of grain surface	6 Corrected heeling moments m tonnes / ft tons (4) x (5)
	Trimmed	Untrimmed				
			Total uncorrected heeling moments▶		Total corrected heeling moments▶	

S.F. cu ft / ton	S.F. m^3 / tonne	Den. tonne / m^3	S.F. cu ft / ton	S.F. m^3 / tonne	Den. tonne / m^3
40	1.115	.897	49.5	1.380	.725
41.5	1.157	.865	50	1.393	.718
42	1.171	.854	50.5	1.407	.711
42.5	1.184	.844	51	1.421	.704
43	1.199	.834	51.5	1.435	.697
43.5	1.212	.825	52	1.449	.690
44	1.226	.815	53	1.477	.677
44.5	1.240	.806	54	1.505	.664
45	1.254	.797	55	1.533	.652
45.5	1.268	.789	56	1.561	.641
46	1.282	.780	57	1.589	.629
46.5	1.296	.772	58	1.616	.619
47	1.310	.763	59	1.644	.608
47.5	1.324	.755	60	1.672	.598
48	1.338	.748	61	1.700	.588
48.5	1.352	.740	62	1.728	.579
49	1.366	.732			

TABLE 4 - MOVEMENT OF LIQUIDS

Table 2 has been completed for the worst conditions that will be experienced during the voyage.
The programme of use, transfer and addition or discharge of liquids during the voyage is expected to be as follows:

....

....

....

....

....

....

Estimated length of voyage .... days

Daily consumption of: Fuel .... tonnes / tons

Water .... tonnes / tons

TABLE 5 - ALTERNATIVE METHOD OF CORRECTING HEELING MOMENTS TO ALLOW FOR VERTICAL SHIFT OF GRAIN SURFACE

TABLE 6 - CALCULATION OF KG & GM

Uncorrected KG from: $\frac{\text{Total moments (Table 2)}}{\text{Displacement (Table 2)}}$ = ...

+

Liquid F.S. gain from: $\frac{\text{Total F.S. moments (Table 2)}}{\text{Displacement (Table 2)}}$ = ...

KG (KG + F.S. gain) = ...

KM (from ship's hydrostatic particulars) for Displacement shown in Table 2 = ...

GM (KM - KG) = ... Least GM (must not be less than 0.3m /12 inches)

TABLE 7 - MAXIMUM ALLOWABLE HEELING MOMENTS

Corrected KG or GM (from Table 6)	....	
Displacement (from Table 2)	....	
(A) Maximum allowable heeling moment (from ship's stability book)	A......................................	
(B) Actual corrected value of heeling moments (from Table 3)	B......................................	If (A) exceeds (B), ship complies

NOTE: Where the ship's data uses other short methods of presentation of compliance with the stability criteria, the space below Table 12 may be used.

TABLE 8 - ANGLE OF HEEL CALCULATION (FOR 12° CRITERION)

NOTE: Where the angle of heel is close to or above 12°, a more accurate angle of heel may be established by using graphic method in table 10.

Nat Tan angle of heel $= \dfrac{\text{Sum of corrected heeling moments (Table 3)}}{\text{Displacement (Table 2) x GM (Table 6)}}$

$= \dfrac{\quad}{\quad \text{x} \quad} =$

Angle of heel = ... If angle is not greater than 12°, ship complies

TABLE 9 - CORRECTED RIGHTING ARM AT 40° HEEL USING CROSS CURVE

KN or GZ for 40° from cross curves (ship's stability information) = ________________ ft / m

Where KN given:

Actual GZ at 40° = KN - [Corrected KG (Table 6) x Sin 40°]

= - [x 0.6428] = A ________________

or

or

Where GZ is given for assumed KG:

KG on which GZ curves are based (ship's stability information) =

Actual corrected KG (Table 6) = ________________

KG difference ± ________________

Actual GZ at 40° = GZ from curves ± [KG difference x Sin 40°]

= ± [x 0.6428] = A ________________

Heeling arm correction = $\dfrac{\text{Corrected heeling moments (Table 3)}}{\text{Displacement (Table 2)}}$ x 0.8

= ________________ x 0.8 = B ________________

A =

B = ________________

(A - B) corrected GZ at 40° heel = ________________

If corrected GZ exceeds 0.307 m or 1.008 ft, ship complies (see note below)

If GZ curve in the nearest typical loaded condition shown in stability booklet is of normal form and maximum GZ occurs at not less than 40°, or the Angle of Flooding occurs at not less than 40°, then the completion of table 9 is sufficient to demonstrate compliance with requirement for residual area. If any of these conditions are not met, Table 10 is to be completed.

TABLE 10 - TO DETERMINE RESIDUAL AREA BETWEEN THE HEELING ARM CURVE AND RIGHTING ARM CURVE

NOTE 1: The heeling arm curve is a straight line constructed between the following two values:

at 0° = $\dfrac{\text{Corrected heeling moments (Table 3)}}{\text{Displacement (Table 2)}}$

at 40° = 0.8 x (value at 0°)

NOTE 2: The values of GZ and heeling arm must be drawn on the same scale.

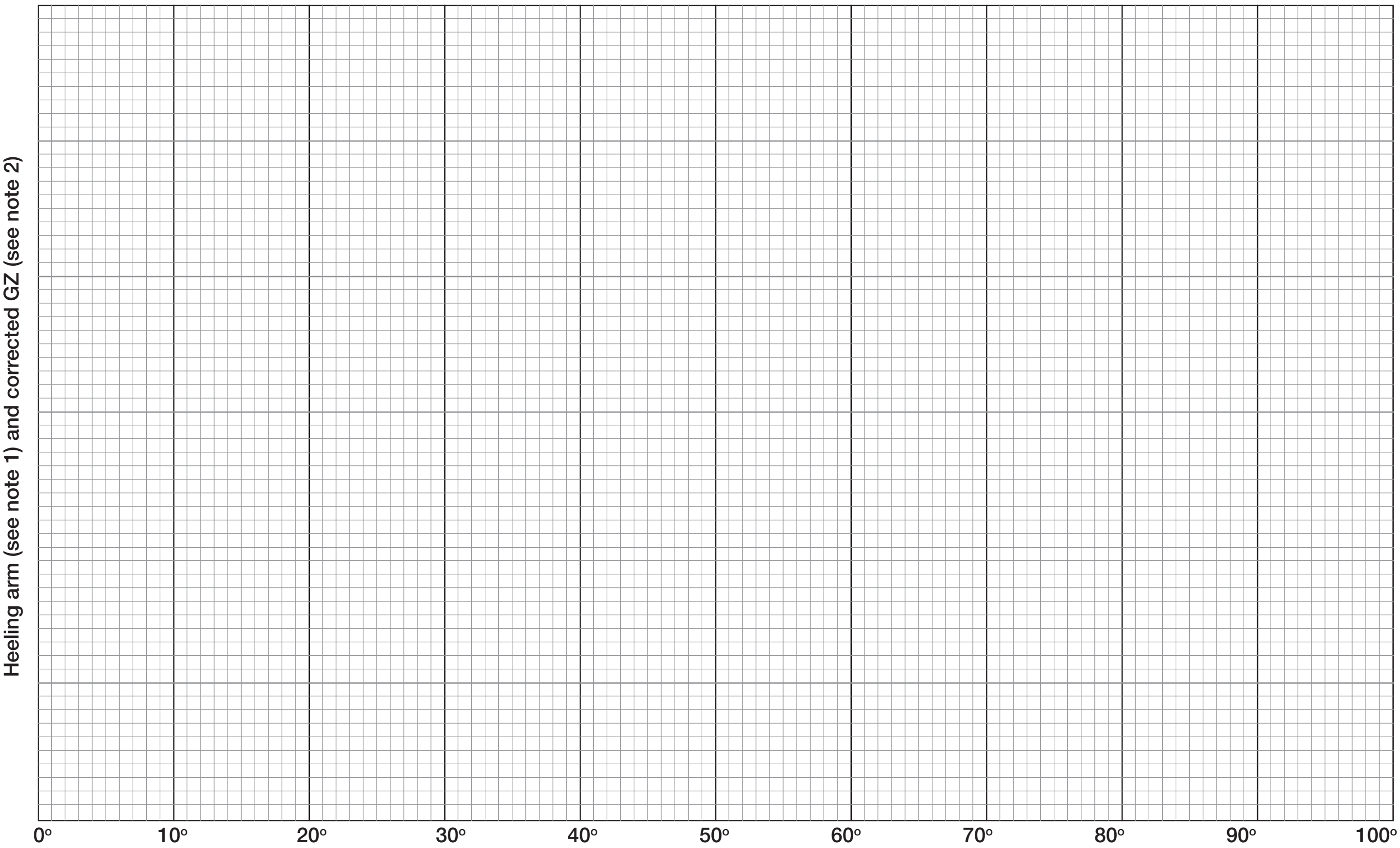
NOTE 3: If ship is provided with KN curves, the correction = (KG difference) Sin ø.
If ship is provided with GZ curves for assumed KG, the correction = ± (KG difference) Sin ø.

NOTE 4: The position of the selected ordinate shall be as follows:

(1) The first ordinate shall occur at the intersection of the heeling arm curve and the GZ curve.

(2) Other ordinates shall occur at equal intervals from the point of intersection of

1/6 { Number of degrees between point of intersection and limiting angle }



Correction of GZ values									
Angle of heel (θ)	10°	20°	30°	40°	50°	60°	70°	80°	90°
KN or GZ value from cross curves									
Correction for Diff. of KGs (see note 3) ±									
Corrected GZ values									

Simpson's product for area		
Selected ordinate (see Note 4)	S. M.	Product for area
0	1	0
	4	
	2	
	4	
	2	
	4	
	1	
SUM OF PRODUCTS ▶		

Area under curve = $\dfrac{\text{Selected interval}}{3}$ x sum of product

= $\dfrac{\_\_\_\_\_\_\_\_\_\_}{3}$ x

= __________ m degrees / ft degrees

Minimum requirement = 4,296m degrees
14, 104 ft degrees

TABLE 11 - ANGLE OF HEEL CALCULATION (FOR 5° CRITERION)

Nat Tan angle of heel = $\frac{\text{Sum of corrected heeling moments (Table 3, column 4)}}{\text{Displacement (Table 2) x GM (Table 6)}}$

= $\frac{\qquad\qquad}{\qquad \text{x} \qquad}$ =

∴ Angle of heel = ... If angle is not greater than 5°, ship complies

TABLE 12 - ANGLE OF HEEL CALCULATION FOR TANKERS (WHERE NO APPROVED DATA IS HELD ON BOARD)

Note: This method for tankers gives the worst condition ie all tanks are assumed to be partly filled. The KG of the cargo in a tank is to be assumed to be at the volumetric centre of the tank when calculating the KG of the ship in Table 2. Where a tank is less than 50% full, the actual KG of the grain may be used, provided the heeling moment for that tank is multiplied by 1.12.

Total combined length of all wing tanks to be loaded (L) = ft / m
(P. and S. tanks counted separately)

Maximum breadth of Wing Tanks to be loaded (B) =

Total combined length of all centre tanks to be loaded (L_1) =

Maximum breadth of centre tanks to be loaded (B_1) =

Wing tanks heeling moment

$$= \frac{0.0389\ LB^3}{\text{S.F.}} = \frac{0.0389 \times (L) \qquad \times (B) \qquad \times (B) \qquad \times (B)}{(\text{S.F.})} = +$$

Centre tanks heeling moment

$$= \frac{0.0389\ L_1B_1^{\,3}}{\text{S.F.}} = \frac{0.0389 \times (L_1) \qquad \times (B_1) \qquad \times (B_1) \qquad \times (B_1)}{(\text{S.F.})} = +$$

Total corrected heeling moment ______ m tonnes / ft tons

This total heeling moment is then used to show compliance by completing Tables 8, 9 and 10 as appropriate.

Space for additional calculations or information

TABLE 13 - CALCULATION FOR SHIP WITHOUT APPROVED DOCUMENTATION, OTHER THAN A TANKER

Distance from Hatch End or Hatch Side to boundary of compartment	Standard Void Depth
Metres	mm
0.5	570
1.0	530
1.5	500
2.0	480
2.5	450
3.0	440
3.5	430
4.0	430
4.5	430
5.0	430
5.5	450
6.0	470
6.5	490
7.0	520
7.5	550
8.0	590

For distance greater than 8.0 metres Standard Void Depth shall be linearly extrapolated at 80 mm increase for each 1.0 m increase in distance.

Average void depth (Vd) = Maximum standard void depth + 0.75 (girder depth mm - 600mm) from table

= + 0.75 (-600mm)

= mm

= m

NOTE: Maximum void depth occurring in any full compartment is to be used for the calculation below.

$$\text{Minimum required GM} = \frac{LB\,Vd\left(0.25\,B - 0.645\sqrt{Vd\,B}\right)}{SF \times \text{Displacement} \times 0.0875}$$

CALCULATION

Average void depth x moulded breadth of ship = [A]

x =

$0.645 \sqrt{[A]}$ = [B]

$0.645 \times \sqrt{\quad}$ =

0.25 x moulded breadth of ship = [C]

0.25 x =

[C] - [B] = [D]

- =

$$\text{Minimum required GM} = \frac{\text{Total combined length of all compartments} \times \text{Moulded breadth of ship} \times Vd \times [D]}{\text{Stowage factor} \times \text{Displacement (from table 2)} \times 0.0875}$$

$$= \frac{\quad \times \quad \times \quad \times \quad}{\quad \times \quad \times 0.0875}$$

Ship complies if actual GM is greater than minimum required GM or 1.0 metre, whichever is greater, throughout the voyage.