Contents

Resolution MSC.23(59)
(adopted on 23 May 1991)

Adoption of the International Code for the Safe Carriage of Grain in Bulk

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING part C of revised chapter VI of the International Convention for the Safety of Life at Sea, 1974 (SOLAS 74), adopted by resolution MSC.22(59) which, *inter alia*, makes the provisions of the International Code for the Safe Carriage of Grain in Bulk mandatory under that Convention,

HAVING CONSIDERED the text of the proposed Code,

1.   ADOPTS the International Code for the Safe Carriage of Grain in Bulk, the text of which is set out in the Annex to the present resolution;

2.   DECIDES that the Code shall take effect on 1 January 1994*; and

3.   REQUESTS the Secretary-General to transmit to the Members of the Organization and all Contracting Governments to SOLAS 74 certified copies of the present resolution and the Code.

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* Date of entry into force of amendments to SOLAS chapter VI.

Annex

International Code
for the Safe Carriage of Grain in Bulk

Part A
Specific requirements

1 Application

1.1   This Code applies to ships regardless of size, including those of less than 500 tons gross tonnage, engaged in the carriage of grain in bulk, to which part C of chapter VI of the 1974 SOLAS Convention, as amended, applies.

1.2   For the purpose of this Code, the expression "ships constructed" means "ships the keels of which are laid or which are at a similar stage of construction".

2 Definitions

2.1   The term *grain* covers wheat, maize (corn), oats, rye, barley, rice, pulses, seeds and processed forms thereof, whose behaviour is similar to that of grain in its natural state.

2.2   The term *filled compartment, trimmed,* refers to any cargo space in which, after loading and trimming as required under A 10.2, the bulk grain is at its highest possible level.

2.3   The term *filled compartment, untrimmed,* refers to a cargo space which is filled to the maximum extent possible in way of the hatch opening but which has not been trimmed outside the periphery of the hatch opening either by the provisions of A 10.3.1 for all ships or A 10.3.2 for specially suitable compartments.

2.4   The term *partly filled compartment* refers to any cargo space wherein the bulk grain is not loaded in the manner prescribed in A 2.2 or A 2.3.

2.5   The term *angle of flooding* (θ_1) means the angle of heel at which openings in the hull, superstructures or deckhouses, which cannot be closed weathertight, immerse. In applying this definition, small openings through which progressive flooding cannot take place need not be considered as open.

2.6 The term *stowage factor*, for the purposes of calculating the grain heeling moment caused by a shift of grain, means the volume per unit weight of the cargo as attested by the loading facility, i.e. no allowance shall be made for lost space when the cargo space is nominally filled.

2.7 The term *specially suitable compartment* refers to a cargo space which is constructed with at least two vertical or sloping, longitudinal, grain-tight divisions which are coincident with the hatch side girders or are so positioned as to limit the effect of any transverse shift of grain. If sloping, the divisions shall have an inclination of not less than 30° to the horizontal.

3 Document of authorization

3.1 A document of authorization shall be issued for every ship loaded in accordance with the regulations of this Code either by the Administration or an organization recognized by it or by a Contracting Government on behalf of the Administration. It shall be accepted as evidence that the ship is capable of complying with the requirements of these regulations.

3.2 The document shall accompany or be incorporated into the grain loading manual provided to enable the master to meet the requirements of A 7. The manual shall meet the requirements of A 6.3.

3.3 Such a document, grain loading stability data and associated plans may be drawn up in the official language or languages of the issuing country. If the language used is neither English nor French, the text shall include a translation into one of these languages.

3.4 A copy of such a document, grain loading stability data and associated plans shall be placed on board in order that the master, if so required, shall produce them for the inspection of the Contracting Government of the country of the port of loading.

3.5 A ship without such a document of authorization shall not load grain until the master demonstrates to the satisfaction of the Administration, or of the Contracting Government of the port of loading acting on behalf of the Administration, that, in its loaded condition for the intended voyage, the ship complies with the requirements of this Code. See also A 8.3 and A 9.

4 Equivalents

Where an equivalent accepted by the Administration in accordance with regulation I/5 of the International Convention for the Safety of Life at Sea, 1974, as amended, is used, particulars shall be included in the document of authorization or in the grain loading manual.

5 Exemptions for certain voyages

The Administration, or a Contracting Government on behalf of the Administration, may, if it considers that the sheltered nature and conditions of the voyage are such as to render the application of any of the requirements of this Code unreasonable or unnecessary, exempt from those particular requirements individual ships or classes of ships.

6 Information regarding ship's stability and grain loading

6.1 Information in printed booklet form shall be provided to enable the master to ensure that the ship complies with this Code when carrying grain in bulk on an international voyage. This information shall include that which is listed in A 6.2 and A 6.3.

6.2 Information which shall be acceptable to the Administration or to a Contracting Government on behalf of the Administration shall include:

.1 ship's particulars;

.2 light-ship displacement and the vertical distance from the intersection of the moulded baseline and midship section to the centre of gravity (KG);

.3 table of liquid free surface corrections;

.4 capacities and centres of gravity;

.5 curve or table of angle of flooding, where less than 40°, at all permissible displacements;

.6 curves or tables of hydrostatic properties suitable for the range of operating draughts; and

.7 cross curves of stability which are sufficient for the purpose of the requirements in A 7 and which include curves at 12° and 40°.

6.3 Information which shall be approved by the Administration or by a Contracting Government on behalf of the Administration shall include:

.1 curves or tables of volumes, vertical centres of volumes, and assumed volumetric heeling moments for every compartment, filled or partly filled, or combination thereof, including the effects of temporary fittings;

.2 tables or curves of maximum permissible heeling moments for varying displacements and varying vertical centres of gravity to allow the master to demonstrate compliance with the requirements of A 7.1; this requirement shall apply only to ships the keels of which are laid on or after the entry into force of this Code;

.3 details of the scantlings of any temporary fittings and, where applicable, the provisions necessary to meet the requirements of A 7, A 8 and A 9;

.4 loading instructions in the form of notes summarizing the requirements of this Code;

.5 a worked example for the guidance of the master; and

.6 typical loaded service departure and arrival conditions and where necessary intermediate worst service conditions.*

7 Stability requirements

7.1 The intact stability characteristics of any ship carrying bulk grain shall be shown to meet, throughout the voyage, at least the following criteria after taking into account in the manner described in part B of this Code and, in figure A 7, the heeling moments due to grain shift:

.1 the angle of heel due to the shift of grain shall not be greater than 12° or in the case of ships constructed on or after 1 January 1994 the angle at which the deck edge is immersed, whichever is the lesser;

.2 in the statical stability diagram, the net or residual area between the heeling arm curve and the righting arm curve up to the angle of heel of maximum difference between the ordinates of the two curves, or 40° or the angle of flooding (θ_1), whichever is the least, shall in all conditions of loading be not less than 0.075 metre-radians; and

.3 the initial metacentric height, after correction for the free surface effects of liquids in tanks, shall be not less than 0.30 m.

7.2 Before loading bulk grain the master shall, if so required by the Contracting Government of the country of the port of loading, demonstrate the ability of the ship at all stages of any voyage to comply with the stability criteria required by this section.

7.3 After loading, the master shall ensure that the ship is upright before proceeding to sea.

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* It is recommended that loading conditions be provided for three representative stowage factors, e.g. 1.25, 1.50, and 1.75 cubic metres per tonne.
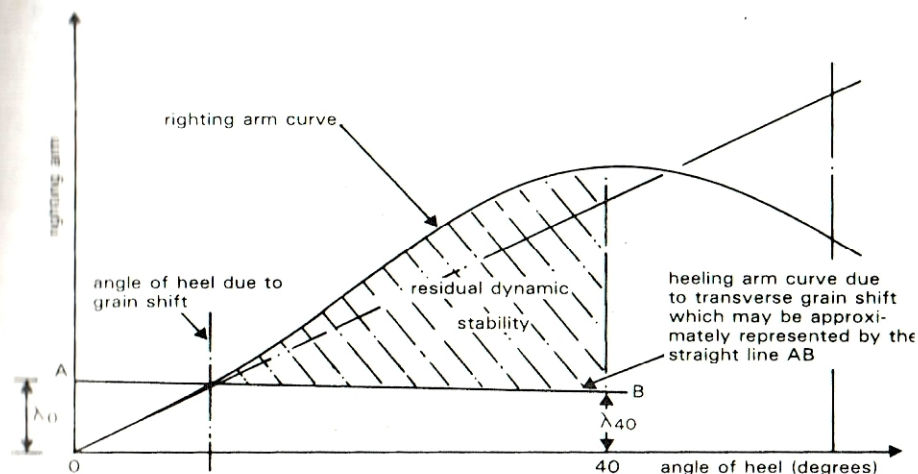
Figure A 7

(1) Where:

$\lambda_0 = \dfrac{\text{assumed volumetric heeling moment due to transverse shift}}{\text{stowage factor} \times \text{displacement}}$;

$\lambda_{40} = 0.8 \times \lambda_0$;

Stowage factor = volume per unit weight of grain cargo;

Displacement = weight of ship, fuel, fresh water, stores etc. and cargo.

(2) The righting arm curve shall be derived from cross-curves which are sufficient in number to accurately define the curve for the purpose of these requirements and shall include cross-curves at 12° and 40°.

8 Stability requirements for existing ships

8.1 For the purposes of this section the term *existing ship* means a ship, the keel of which is laid before 25 May 1980.

8.2 An existing ship loaded in accordance with documents previously approved under regulation 12 of chapter VI of SOLAS 1960, IMO resolutions A.184(VI) or A.264(VIII) shall be considered to have intact stability characteristics at least equivalent to the requirements of A 7 of this Code. Documents of authorization permitting such loadings shall be accepted for the purposes of A 7.2.

8.3   Existing ships not having on board a document of authorization issued in accordance with A 3 of this Code may apply the provisions of A 9 without limitation on the deadweight which may be used for the carriage of bulk grain.

9   Optional stability requirements for ships without documents of authorization carrying partial cargoes of bulk grain

9.1   A ship not having on board a document of authorization issued in accordance with A 3 of this Code may be permitted to load bulk grain provided that:

.1   the total weight of the bulk grain shall not exceed one third of the deadweight of the ship;

.2   all filled compartments, trimmed, shall be fitted with centreline divisions extending, for the full length of such compartments, downwards from the underside of the deck or hatch covers to a distance below the deck line of at least one eighth of the maximum breadth of the compartment or 2.4 m, whichever is the greater, except that saucers constructed in accordance with A 14 may be accepted in lieu of a centreline division in and beneath a hatchway except in the case of linseed and other seeds having similar properties;

.3   all hatches to filled compartments, trimmed, shall be closed and covers secured in place;

.4   all free grain surfaces in partly filled cargo space shall be trimmed level and secured in accordance with A 16, A 17 or A 18;

.5   throughout the voyage the metacentric height after correction for the free surface effects of liquids in tanks shall be 0.3 m or that given by the following formula, whichever is the greater:

$$GM_R = \frac{L\,B\,Vd\,(0.25\,B - 0.645\,\sqrt{Vd\,B})}{SF \times \Delta \times 0.0875}$$

Where:

L =   total combined length of all full compartments (metres)

B =   moulded breadth of the vessel (metres)

SF =   stowage factor (cubic metres per tonne)

Vd =   calculated average void depth calculated in accordance with B 1 (metres — Note: not millimetres)

Δ =   displacement (tonnes); and

.6   the master demonstrates to the satisfaction of the Administration or the Contracting Government of the port of loading on behalf of the Administration that the ship in its proposed loaded condition will comply with the requirements of this section.

10   Stowage of bulk grain

10.1   All necessary and reasonable trimming shall be performed to level all free grain surfaces and to minimize the effect of grain shifting.

10.2   In any filled compartment, trimmed, the bulk grain shall be trimmed so as to fill all spaces under the decks and hatch covers to the maximum extent possible.

10.3   In any filled compartment, untrimmed, the bulk grain shall be filled to the maximum extent possible in way of the hatch opening but may be at its natural angle of repose outside the periphery of the hatch opening. A filled compartment may qualify for this classification if it falls into one of the following categories:

.1   the Administration issuing the document of authorization may, under B 6, grant dispensation from trimming in those cases where the underdeck void geometry resulting from free flowing grain into a compartment, which may be provided with feeder ducts, perforated decks or other similar means, is taken into account when calculating the void depths; or

.2   the compartment is "specially suitable" as defined in A 2.7, in which case dispensation may be granted from trimming the ends of that compartment.

10.4   If there is no bulk grain or other cargo above a lower cargo space containing grain, the hatch covers shall be secured in an approved manner having regard to the mass and permanent arrangements provided for securing such covers.

10.5   When bulk grain is stowed on top of closed 'tween-deck hatch covers which are not grain-tight, such covers shall be made grain-tight by taping the joints, covering the entire hatchway with tarpaulins or separation cloths, or other suitable means.

10.6   After loading, all free grain surfaces in partly filled compartments shall be level.

10.7   Unless account is taken of the adverse heeling effect due to the grain shift according to this Code, the surface of the bulk grain in any partly filled compartment shall be secured so as to prevent a grain shift by overstowing as described in A 16. Alternatively, in partly filled compartments, the bulk grain surface may be secured by strapping or lashing as described in A 17 or A 18.

10.8   Lower cargo spaces and 'tween-deck spaces in way thereof may be loaded as one compartment provided that, in calculating transverse heeling moments, proper account is taken of the flow of grain into the lower spaces.

10.9   In filled compartments, trimmed; filled compartments, untrimmed; and partly filled compartments, longitudinal divisions may be installed as a device to reduce the adverse heeling effect of grain shift provided that:

.1   the division is grain-tight;

.2   the construction meets the requirements of A 11, A 12 and A 13; and

.3   in 'tween-decks the division extends from deck to deck and in other cargo spaces the division extends downwards from the underside of the deck or hatch covers, as described in B 2.8.2, note (2); B 2.9.2, note (3); or B 5.2, as applicable.

11   Strength of grain fittings

11.1   *Timber*

All timber used for grain fittings shall be of good sound quality and of a type and grade which has been proved to be satisfactory for this purpose. The actual finished dimensions of the timber shall be in accordance with the dimensions specified below. Plywood of an exterior type bonded with waterproof glue and fitted so that the direction of the grain in the face plies is perpendicular to the supporting uprights or binder may be used provided that its strength is equivalent to that of solid timber of the appropriate scantlings.

11.2   *Working stresses*

When calculating the dimensions of divisions loaded on one side, using tables A 13-1 to A 13-6, the following working stresses should be adopted:

For divisions of steel: 19.6 kN/cm^2
For divisions of wood: 1.57 kN/cm^2

(1 newton is equivalent to 0.102 kilograms).

11.3   *Other materials*

Materials other than wood or steel may be approved for such divisions provided that proper regard has been paid to their mechanical properties.

11.4   *Uprights*

.1   Unless means are provided to prevent the ends of uprights being dislodged from their sockets, the depth of housing at each end of each upright shall be not less than 75 mm. If an upright is not secured at the top, the uppermost shore or stay shall be fitted as near thereto as is practicable.

.2   The arrangements provided for inserting shifting boards by removing a part of the cross-section of an upright shall be such that the local level of stresses is not unduly high.

.3   The maximum bending moment imposed upon an upright supporting a division loaded on one side shall normally be calculated assuming that the ends of the uprights are freely supported. However, if an Administration is satisfied that any degree of fixity assumed will be achieved in practice, account may be taken of any reduction in the maximum bending moment arising from any degree of fixity provided at the ends of the upright.

11.5   *Composite section*

Where uprights, binders or any other strength members are formed by two separate sections, one fitted on each side of a division and interconnected by through bolts at adequate spacing, the effective section modulus shall be taken as the sum of the two moduli of the separate sections.

11.6   *Partial division*

Where divisions do not extend to the full depth of the cargo space such divisions and their uprights shall be supported or stayed so as to be as efficient as those which do extend to the full depth of the cargo space.

12   Divisions loaded on both sides

12.1   *Shifting boards*

.1   Shifting boards shall have a thickness of not less than 50 mm and shall be fitted grain-tight and where necessary supported by uprights.

.2 The maximum unsupported span for shifting boards of various thicknesses shall be as follows:

Thickness	Maximum unsupported span
50 mm	2.5 m
60 mm	3.0 m
70 mm	3.5 m
80 mm	4.0 m

If thicknesses greater than these are provided the maximum unsupported span will vary directly with the increase in thickness.

.3 The ends of all shifting boards shall be securely housed with 75 mm minimum bearing length.

12.2 Other materials

Divisions formed by using materials other than wood shall have a strength equivalent to the shifting boards required in A 12.1.

12.3 Uprights

.1 Steel uprights used to support divisions loaded on both sides shall have a section modulus given by

$$W = a \times W_1$$

Where:

W = section modulus in cubic centimetres

a = horizontal span between uprights in metres.

The section modulus per metre span W_1 shall be not less than that given by the formula:

$$W_1 = 14.8 \, (h_1 - 1.2) \text{ cm}^3/\text{m}$$

Where:

h_1 is the vertical unsupported span in metres and shall be taken as the maximum value of the distance between any two adjacent stays or between a stay and either end of the upright. Where this distance is less than 2.4 m the respective modulus shall be calculated as if the actual value were 2.4 m.

.2 The moduli of wood uprights shall be determined by multiplying by 12.5 the corresponding moduli for steel uprights. If other materials are used their moduli shall be at least that required for steel increased in proportion to the ratio of the permissible stresses for steel to that of the material used. In such cases attention shall be paid also to the relative rigidity of each upright to ensure that the deflection is not excessive.

.3 The horizontal distance between uprights shall be such that the unsupported spans of the shifting boards do not exceed the maximum span specified in A 12.1.2.

12.4 Shores

.1 Wood shores, when used, shall be in a single piece and shall be securely fixed at each end and heeled against the permanent structure of the ship except that they shall not bear directly against the side plating of the ship.

.2 Subject to the provisions of A 12.4.3 and A 12.4.4, the minimum size of wood shores shall be as follows:

Length of shore (m)	Rectangular section (mm)	Diameter of circular section (mm)
Not exceeding 3 m	150 × 100	140
Over 3 m but not exceeding 5 m	150 × 150	165
Over 5 m but not exceeding 6 m	150 × 150	180
Over 6 m but not exceeding 7 m	200 × 150	190
Over 7 m but not exceeding 8 m	200 × 150	200
Exceeding 8 m	200 × 150	215

Shores of 7 m or more in length shall be securely bridged at approximately mid-length.

.3 When the horizontal distance between the uprights differs significantly from 4 m the moments of inertia of the shores may be changed in direct proportion.

.4 Where the angle of the shore to the horizontal exceeds 10° the next larger shore to that required by A 12.4.2 shall be fitted provided that in no case shall the angle between any shore and the horizontal exceed 45°.

12.5 Stays

Where stays are used to support divisions loaded on both sides, they shall be fitted horizontally or as near thereto as practicable, well secured at each end and formed of steel wire rope. The sizes of the wire rope shall be determined assuming that the divisions and upright which the stay supports are uniformly loaded at 4.9 kN/m². The working load so assumed in the stay shall not exceed one third of its breaking load.

13 Divisions loaded on one side only

13.1 *Longitudinal divisions*

The load (P) in kilonewtons per metre length of the divisions shall be taken as follows:

.1   *Table A 13-1*

	B (m)							
h (m)	2	3	4	5	6	7	8	10
1.50	8.336	8.826	9.905	12.013	14.710	17.358	20.202	25.939
2.00	13.631	14.759	16.769	19.466	22.506	25.546	28.733	35.206
2.50	19.466	21.182	23.830	26.870	30.303	33.686	37.265	44.473
3.00	25.644	27.900	30.891	34.323	38.099	41.874	45.797	53.740
3.50	31.823	34.568	37.952	41.727	45.895	50.014	54.329	63.008
4.00	38.148	41.286	45.013	49.180	53.691	58.202	62.861	72.275
4.50	44.473	47.955	52.073	56.584	61.488	66.342	71.392	81.542
5.00	50.847	54.623	59.134	64.037	69.284	74.531	79.924	90.810
6.00	63.498	68.009	73.256	78.894	84.877	90.859	96.988	109.344

h = height of grain in metres from the bottom of the division. When the cargo space is filled, the height (h) shall be taken to the overhead deck in way of the division. In a hatchway or where the distance from a division to a hatchway is 1 m or less, the height (h) shall be taken to the level of the grain in the hatchway.

B = transverse extent of the bulk grain in metres.

.2   Linear interpolation within table A 13-1 may be used for intermediate values of B and for intermediate values of h when h is equal to or less than 6.0 m.

.3   For values of h exceeding 6.0 m the load (P) in kilonewtons per metre length of the divisions may be determined from table A 13-2 by entering with the ratio B/h and utilizing the formula:

$$P = f \times h^2$$

.4   *Table A 13-2*

B/h	f	B/h	f
0.2	1.687	2.0	3.380
0.3	1.742	2.2	3.586
0.4	1.809	2.4	3.792
0.5	1.889	2.6	3.998
0.6	1.976	2.8	4.204
0.7	2.064	3.0	4.410
0.8	2.159	3.5	4.925
1.0	2.358	4.0	5.440
1.2	2.556	5.0	6.469
1.4	2.762	6.0	7.499
1.6	2.968	8.0	9.559
1.8	3.174		

13.2 Transverse divisions

The load (P) in kilonewtons per metre length of the divisions shall be taken as follows:

.1 Table A 13-3

h(m)	L (m)										
	2	3	4	5	6	7	8	10	12	14	16
1.50	6.570	6.767	7.159	7.649	8.189	8.728	9.169	9.807	10.199	10.297	10.297
2.00	10.199	10.787	11.474	12.209	12.994	13.729	14.416	15.445	16.083	16.279	16.279
2.50	14.318	15.347	16.426	17.456	18.437	19.417	20.349	21.673	22.408	22.604	22.604
3.00	18.878	20.251	21.624	22.948	24.222	25.399	26.429	27.900	28.684	28.930	28.930
3.50	23.781	25.546	27.164	28.733	30.155	31.430	32.558	34.127	35.010	35.255	35.255
4.00	28.930	30.989	32.901	34.667	36.187	37.559	38.736	40.403	41.286	41.531	41.580
4.50	34.274	36.530	38.638	40.501	42.120	43.542	44.767	46.582	47.562	47.856	47.905
5.00	39.717	42.218	44.473	46.434	48.151	49.622	50.897	52.809	53.839	54.182	54.231
6.00	50.749	53.593	56.094	58.301	60.164	61.782	63.204	65.263	66.440	66.832	66.930

h = height of grain in metres from the bottom of the division. When the cargo space is filled, the height (h) shall be taken to the overhead deck in way of the division. In a hatchway, or where the distance from a division to a hatchway is 1 m or less, the height (h) shall be taken to the level of the grain in the hatchway.

L = longitudinal extent of the bulk grain in metres.

.2

Intermediate values of L and intermediate values of h when h is equal to or less than 6.0 m may be determined by linear interpolation using table A 13-3.

.3

For values of h exceeding 6.0 m the load (P) in kilonewtons per metre length of the divisions may be determined from table A 13-4 by entering with the ratio L/h and utilizing the formula:

$$P = f \times h^2$$

.4 Table A 13-4

L/h	f	L/h	f
0.2	1.334	2.0	1.846
0.3	1.395	2.2	1.853
0.4	1.444	2.4	1.857
0.5	1.489	2.6	1.859
0.6	1.532	2.8	1.859
0.7	1.571	3.0	1.859
0.8	1.606	3.5	1.859
1.0	1.671	4.0	1.859
1.2	1.725	5.0	1.859
1.4	1.769	6.0	1.859
1.6	1.803	8.0	1.859
1.8	1.829		

13.3 The total load per unit length of divisions shown in tables A 13-1 to A 13-4 inclusive may, if considered necessary, be assumed to have a trapezoidal distribution with height. In such cases, the reaction loads at the upper and lower ends of a vertical member or upright are not equal. The reaction loads at the upper end expressed as percentages of the total load supported by the vertical member or upright may be taken to be those shown in tables A 13-5 and A 13-6.

.1 **Table A 13-5:** *Longitudinal divisions loaded on one side only*

Bearing reaction at the upper end of upright as a percentage of load from A 13.1

	B (m)							
h (m)	2	3	4	5	6	7	8	10
1.5	43.3	45.1	45.9	46.2	46.2	46.2	46.2	46.2
2.0	44.5	46.7	47.6	47.8	47.8	47.8	47.8	47.8
2.5	45.4	47.6	48.6	48.8	48.8	48.8	48.8	48.8
3.0	46.0	48.3	49.2	49.4	49.4	49.4	49.4	49.4
3.5	46.5	48.8	49.7	49.8	49.8	49.8	49.8	49.8
4.0	47.0	49.1	49.9	50.1	50.1	50.1	50.1	50.1
4.5	47.4	49.4	50.1	50.2	50.2	50.2	50.2	50.2
5.0	47.7	49.4	50.1	50.2	50.2	50.2	50.2	50.2
6.0	47.9	49.5	50.1	50.2	50.2	50.2	50.2	50.2
7.0	47.9	49.5	50.1	50.2	50.2	50.2	50.2	50.2
8.0	47.9	49.5	50.1	50.2	50.2	50.2	50.2	50.2
9.0	47.9	49.5	50.1	50.2	50.2	50.2	50.2	50.2
10.0	47.9	49.5	50.1	50.2	50.2	50.2	50.2	50.2

B = transverse extent of the bulk grain in metres.

For other values of *h* or *B* the reaction loads shall be determined by linear interpolation or extrapolation as necessary.

.2 **Table A 13-6:** *Transverse divisions loaded on one side only*

Bearing reaction at the upper end of upright as a percentage of load from A 13.2

	L (m)										
h (m)	2	3	4	5	6	7	8	10	12	14	16
1.5	37.3	38.7	39.7	40.6	41.4	42.1	42.6	43.6	44.3	44.8	45.0
2.0	39.6	40.6	41.4	42.1	42.7	43.1	43.6	44.3	44.7	45.0	45.2
2.5	41.0	41.8	42.5	43.0	43.5	43.8	44.2	44.7	45.0	45.2	45.2
3.0	42.1	42.8	43.3	43.8	44.2	44.5	44.7	45.0	45.2	45.3	45.3
3.5	42.9	43.5	43.9	44.3	44.6	44.8	45.0	45.2	45.3	45.3	45.3
4.0	43.5	44.0	44.4	44.7	44.9	45.0	45.2	45.4	45.4	45.4	45.4
5.0	43.9	44.3	44.6	44.8	45.0	45.2	45.3	45.5	45.5	45.5	45.5
6.0	44.2	44.5	44.8	45.0	45.2	45.3	45.4	45.6	45.6	45.6	45.6
7.0	44.3	44.6	44.9	45.1	45.3	45.4	45.5	45.6	45.6	45.6	45.6
8.0	44.3	44.6	44.9	45.1	45.3	45.4	45.5	45.6	45.6	45.6	45.6
9.0	44.3	44.6	44.9	45.1	45.3	45.4	45.5	45.6	45.6	45.6	45.6
10.0	44.3	44.6	44.9	45.1	45.3	45.4	45.5	45.6	45.6	45.6	45.6

L = longitudinal extent of the bulk grain in metres.

For other values of *h* or *L* the reaction loads shall be determined by linear interpolation or extrapolation as necessary.

.3 The strength of the end connections of such vertical members or uprights may be calculated on the basis of the maximum load likely to be imposed at either end. These loads are as follows:

Longitudinal divisions

Maximum load at the top	50% of the appropriate total load from A 13.1
Maximum load at the bottom	55% of the appropriate total load from A 13.1

Transverse divisions

Maximum load at the top	45% of the appropriate total load from A 13.2
Maximum load at the bottom	60% of the appropriate total load from A 13.2.

.4 The thickness of horizontal wooden boards may also be determined having regard to the vertical distribution of the loading represented by tables A 13-5 and A 13-6 and in such cases

$$t = 10a \sqrt{\frac{p \times k}{h \times 2.0918}}$$

Where:

t = thickness of board in millimetres

a = horizontal span of the board, i.e. distance between uprights in metres

h = head of grain to the bottom of the division in metres

p = total load per unit length derived from the tables in kilonewtons

k = factor dependent upon vertical distribution of the loading.

When the vertical distribution of the loading is assumed to be uniform, i.e. rectangular, k shall be taken as equal to 1.0. For a trapezoidal distribution

$$k = 1.0 + 0.06 (50 - R)$$

Where:

R is the upper end bearing reaction taken from table A 13-5 or A 13-6.

.5 Stays or shores

The sizes of stays and shores shall be so determined that the loads derived from tables A 13-1 to A 13-4 inclusive shall not exceed one third of the breaking loads.

14 Saucers

14.1 For the purpose of reducing the heeling moment a saucer may be used in place of a longitudinal division in way of a hatch opening only in a filled, trimmed, compartment as defined in A 2.2, except in the case of linseed and other seeds having similar properties, where a saucer may not be substituted for a longitudinal division. If a longitudinal division is provided, it shall meet the requirements of A 10.9.

14.2 The depth of the saucer, measured from the bottom of the saucer to the deck line, shall be as follows:

.1 For ships with a moulded breadth of up to 9.1 m, not less than 1.2 m.

.2 For ships with a moulded breadth of 18.3 m or more, not less than 1.8 m.

.3 For ships with a moulded breadth between 9.1 m and 18.3 m, the minimum depth of the saucer shall be calculated by interpolation.

14.3 The top (mouth) of the saucer shall be formed by the underdeck structure in way of the hatchway, i.e. hatch side girders or coamings and hatch end beams. The saucer and hatchway above shall be completely filled with bagged grain or other suitable cargo laid down on a separation cloth or its equivalent and stowed tightly against adjacent structure so as to have a bearing contact with such structure to a depth equal to or greater than one half of the depth specified in A 14.2. If hull structure to provide such bearing surface is not available, the saucer shall be fixed in position by steel wire rope, chain, or double steel strapping as specified in A 17.4 and spaced not more than 2.4 m apart.

15 Bundling of bulk grain

As an alternative to filling the saucer in a filled, trimmed compartment with bagged grain or other suitable cargo a bundle of bulk grain may be used provided that:

.1 The dimensions and means for securing the bundle in place are the same as specified for a saucer in A 14.2 and A 14.3.

.2 The saucer is lined with a material acceptable to the Administration having a tensile strength of not less than 2,687 N per 5 cm strip and which is provided with suitable means for securing at the top.

.3 As an alternative to A 15.2, a material acceptable to the Administration having a tensile strength of not less than 1,344 N per 5 cm strip may be used if the saucer is constructed as follows:

.3.1 Athwartship lashings acceptable to the Administration shall be placed inside the saucer formed in the bulk grain at intervals of not more than 2.4 m. These lashings shall be of sufficient length to permit being drawn up tight and secured at the top of the saucer.

.3.2 Dunnage not less than 25 mm in thickness or other suitable material of equal strength and between 150 mm and 300 mm in width shall be placed fore and aft over these lashings to prevent the cutting or chafing of the material which shall be placed thereon to line the saucer.

.4 The saucer shall be filled with bulk grain and secured at the top except that when using material approved under A 15.3 further dunnage shall be laid on top after lapping the material before the saucer is secured by setting up the lashings.

.5 If more than one sheet of material is used to line the saucer they shall be joined at the bottom either by sewing or by a double lap.

.6 The top of the saucer shall be coincidental with the bottom of the beams when these are in place and suitable general cargo or bulk grain may be placed between the beams on top of the saucer.

16 Overstowing arrangements

16.1 Where bagged grain or other suitable cargo is utilized for the purpose of securing partly filled compartments, the free grain surface shall be level and shall be covered with a separation cloth or equivalent or by a suitable platform. Such platform shall consist of bearers spaced not more than 1.2 m apart and 25 mm boards laid thereon spaced not more than 100 mm apart. Platforms may be constructed of other materials provided they are deemed by the Administration to be equivalent.

16.2 The platform or separation cloth shall be topped off with bagged grain tightly stowed and extending to a height of not less than one sixteenth of the maximum breadth of the free grain surface or 1.2 m, whichever is the greater.

16.3 The bagged grain shall be carried in sound bags which shall be well filled and securely closed.

16.4 Instead of bagged grain, other suitable cargo tightly stowed and exerting at least the same pressure as bagged grain stowed in accordance with A 16.2 may be used.

17 Strapping or lashing

When, in order to eliminate heeling moments in partly filled compartments, strapping or lashing is utilized, the securing shall be accomplished as follows:

.1 The grain shall be trimmed and levelled to the extent that it is very slightly crowned and covered with burlap separation cloths, tarpaulins or the equivalent.

.2 The separation cloths and/or tarpaulins shall overlap by at least 1.8 m.

.3 Two solid floors of rough 25 mm × 150 mm to 300 mm lumber shall be laid with the top floor running longitudinally and nailed to an athwartships bottom floor. Alternatively, one solid floor of 50 mm lumber, running longitudinally and nailed over the top of a 50 mm bottom bearer not less than 150 mm wide, may be used. The bottom bearers shall extend the full breadth of the compartment and shall be spaced not more than 2.4 m apart. Arrangements utilizing other materials and deemed by the Administration to be equivalent to the foregoing may be accepted.

.4 Steel wire rope (19 mm diameter or equivalent), double steel strapping (50 mm × 1.3 mm and having a breaking load of at least 49 kN), or chain of equivalent strength, each of which shall be set tightly by means of a 32 mm turnbuckle, may be used for lashings. A winch tightener, used in conjunction with a locking arm, may be substituted for the 32 mm turnbuckle when steel strapping is used, provided suitable wrenches are available for setting up as necessary. When steel strapping is used, not less than three crimp seals shall be used for securing the ends. When wire is used, not less than four clips shall be used for forming eyes in the lashings.

.5 Prior to the completion of loading the lashing shall be positively attached to the framing at a point approximately 450 mm below the anticipated final grain surface by means of either a 25 mm shackle or beam clamp of equivalent strength.

.6 The lashings shall be spaced not more than 2.4 m apart and each shall be supported by a bearer nailed over the top of the fore and aft floor. This bearer shall consist of lumber of not less than 25 mm × 150 mm or its equivalent and shall extend the full breadth of the compartment.

.7 During the voyage the strapping shall be regularly inspected and set up where necessary.

18 Securing with wire mesh

When, in order to eliminate grain heeling moments in partly filled compartments, strapping or lashing is utilized, the securing may, as an alternative to the method described in A 17, be accomplished as follows:

.1 The grain shall be trimmed and levelled to the extent that it is very slightly crowned along the fore and aft centreline of the compartment.

.2   The entire surface of the grain shall be covered with burlap separation cloths, tarpaulins, or the equivalent. The covering material shall have a tensile strength of not less than 1,344 N per 5 cm strip.

.3   Two layers of wire reinforcement mesh shall be laid on top of the burlap or other covering. The bottom layer is to be laid athwartships and the top layer is to be laid longitudinally. The lengths of wire mesh are to be overlapped at least 75 mm. The top layer of mesh is to be positioned over the bottom layer in such a manner that the squares formed by the alternate layers measure approximately 75 mm × 75 mm. The wire reinforcement mesh is the type used in reinforced concrete construction. It is fabricated of 3 mm diameter steel wire having a breaking strength of not less than 52 kN/cm^2 welded in 150 mm × 150 mm squares. Wire mesh having mill scale may be used but mesh having loose, flaking rust may not be used.

.4   The boundaries of the wire mesh, at the port and starboard side of the compartment, shall be retained by wood planks 150 mm × 50 mm.

.5   Hold-down lashings, running from side to side across the compartment, shall be spaced not more than 2.4 m apart except that the first and the last lashing shall not be more than 300 mm from the forward or after bulkhead, respectively. Prior to the completion of the loading, each lashing shall be positively attached to the framing at a point approximately 450 mm below the anticipated final grain surface by means of either a 25 mm shackle or beam clamp of equivalent strength. The lashing shall be led from this point over the top of the boundary plank described in A 18.4, which has the function of distributing the downward pressure exerted by the lashing. Two layers of 150 mm × 25 mm planks shall be laid athwartships centred beneath each lashing and extending the full breadth of the compartment.

.6   The hold-down lashings shall consist of steel wire rope (19 mm diameter or equivalent), double steel strapping (50 mm × 1.3 mm and having a breaking load of at least 49 kN), or chain of equivalent strength, each of which shall be set tight by means of a 32 mm turnbuckle. A winch tightener, used in conjunction with a locking arm, may be substituted for the 32 mm turnbuckle when steel strapping is used, provided suitable wrenches are available for setting up as necessary. When steel strapping is used, not less than three crimp seals shall be used for securing the ends. When wire rope is used, not less than four clips shall be used for forming eyes in the lashings.

7   During the voyage the hold-down lashings shall be regularly inspected and set up where necessary.

Part B
Calculation of assumed heeling moments and general assumptions

1   General assumptions

1.1   For the purpose of calculating the adverse heeling moment due to a shift of cargo surface in ships carrying bulk grain it shall be assumed that:

.1   In filled compartments which have been trimmed in accordance with A 10.2, a void exists under all boundary surfaces having an inclination to the horizontal less than 30° and that the void is parallel to the boundary surface having an average depth calculated according to the formula:

$$Vd = Vd_1 + 0.75 (d - 600) \text{ mm}$$

Where:

Vd = average void depth in millimetres
Vd_1 = standard void depth from table B 1-1 below
d = actual girder depth in millimetres.
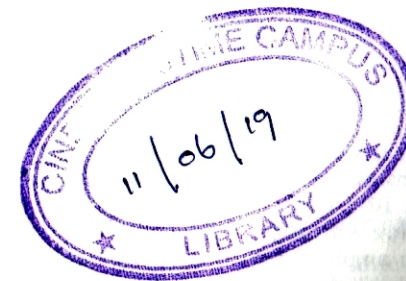
In no case shall Vd be assumed to be less than 100 mm.

Table B 1-1

Distance from hatch end or hatch side to boundary of compartment (metres)	Standard void depth (Vd_1) (millimetres)
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

(1) For boundary distances greater than 8.0 m the standard void depth (Vd_1) shall be linearly extrapolated at 80 mm increase for each 1.0 m·increase in length.

(2) In the corner area of a compartment the boundary distance shall be the perpendicular distance from the line of the hatch side girder or the line of the hatch end beam to the boundary of the compartment, whichever is the greater. The girder depth (d) shall be taken to be the depth of the hatch side girder or the hatch end beam, whichever is the less.

(3) Where there is a raised deck clear of the hatchway the average void depth measured from the underside of the raised deck shall be calculated using the standard void depth in association with a girder depth of the hatch end beam plus the height of the raised deck.

.2 Within filled hatchways and in addition to any open void within the hatch cover there is a void of average depth 150 mm measured down to the grain surface from the lowest part of the hatch cover or the top of the hatch side coaming, whichever is the lower.

.3 In a filled compartment, untrimmed, which is exempted from trimming outside the periphery of the hatchway by the provisions of A 10.3.1, it shall be assumed that the surface of the grain after loading will slope into the void space underdeck, in all directions, at an angle of 30° to the horizontal from the edge of the opening which establishes the void.

.4 In a filled compartment, untrimmed, which is exempted from trimming in the ends of the compartment under the provisions of A 10.3.2, it shall be assumed that the surface of the grain after loading will slope in all directions away from the filling area at an angle of 30° from the lower edge of the hatch end beam. However, if feeding holes are provided in the hatch end beams in accordance with table B 1-2, then the surface of the grain after loading shall be assumed to slope in all directions, at an angle of 30° from a line on the hatch end beam which is the mean of the peaks and valleys of the actual grain surface as shown in figure B 1.

Table B 1-2

Diameter (mm) minimum	Area (cm²)	Spacing (m) maximum
90	63.6	0.60
100	78.5	0.75
110	95.0	0.90
120	113.1	1.07
130	133.0	1.25
140	154.0	1.45
150	177.0	1.67
160	201.0	1.90
170 or above	227.0	2.00 maximum

1.2 The description of the pattern of grain surface behaviour to be assumed in partly filled compartments is contained in B 5.

1.3 For the purpose of demonstrating compliance with the stability criteria in A 7, the ship's stability calculations shall normally be based upon the assumption that the centre of gravity of cargo in a filled compartment, trimmed, is at the volumetric centre of the whole cargo space. In those cases where the Administration authorizes account to be taken of the effect of assumed underdeck voids on the vertical position of the centre of gravity of the cargo in filled compartments, trimmed, it will be necessary to compensate for the adverse effect of the vertical shift of grain surfaces by increasing the assumed heeling moment due to the transverse shift of grain as follows:

total heeling moment = 1.06 × calculated transverse heeling moment.

In all cases the weight of cargo in a filled compartment, trimmed, shall be the volume of the whole cargo space divided by the stowage factor.
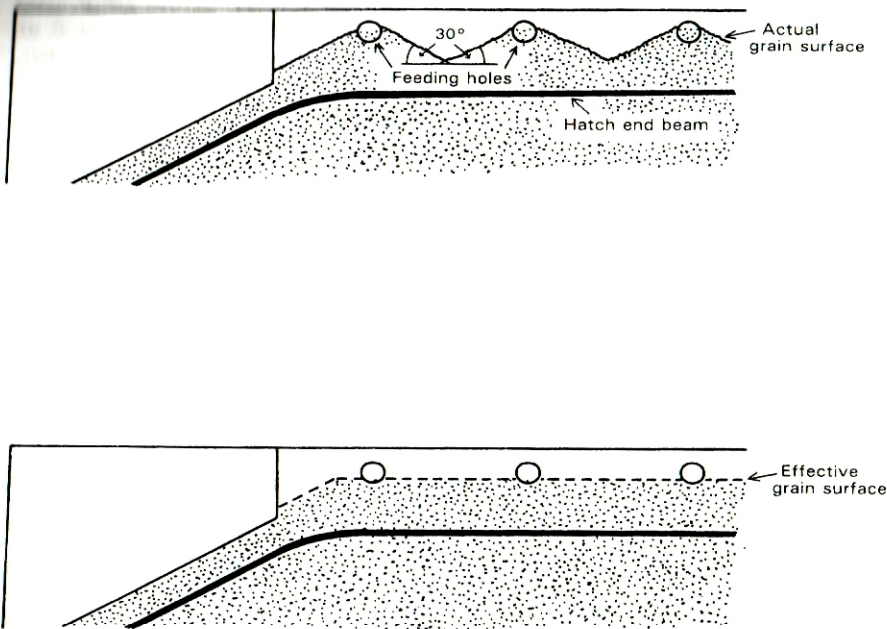
Figure B 1

1.4 The centre of gravity of cargo in a filled compartment, untrimmed, shall be taken to be the volumetric centre of the whole cargo compartment with no account being allowed for voids. In all cases the weight of cargo shall be the volume of the cargo (resulting from the assumptions stated in B 1.1.3 or B 1.1.4) divided by the stowage factor.

1.5 In partly filled compartments the adverse effect of the vertical shift of grain surfaces shall be taken into account as follows:

total heeling moment = 1.12 × calculated transverse heeling moment.

1.6 Any other equally effective method may be adopted to make the compensation required in B 1.3 and B 1.5.

2 Assumed volumetric heeling moment of a filled compartment, trimmed

General

2.1 The pattern of grain surface movement relates to a transverse section across the portion of the compartment being considered and the resultant heeling moment should be multiplied by the length to obtain the total moment for that portion.

2.2 The assumed transverse heeling moment due to grain shifting is a consequence of final changes of shape and position of voids after grain has moved from the high side to the low side.

2.3 The resulting grain surface after shifting shall be assumed to be at 15° to the horizontal.

2.4 In calculating the maximum void area that can be formed against a longitudinal structural member, the effects of any horizontal surfaces, e.g. flanges or face bars, shall be ignored.

2.5 The total areas of the initial and final voids shall be equal.

2.6 Longitudinal structural members which are grain-tight may be considered effective over their full depth except where they are provided as a device to reduce the adverse effect of grain shift, in which case the provisions of A 10.9 shall apply.

2.7 A discontinuous longitudinal division may be considered effective over its full length.

Assumptions

In the following paragraphs it is assumed that the total heeling moment for a compartment is obtained by adding the results of separate consideration of the following portions:

2.8 Before and abaft hatchways:

.1 If a compartment has two or more main hatchways through which loading may take place, the depth of the underdeck void for the portion or portions between such hatchways shall be determined using the fore and aft distance to the midpoint between the hatchways.

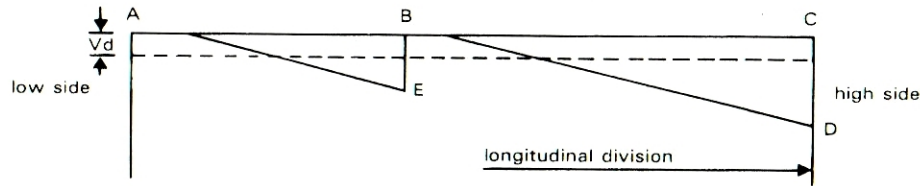.2 After the assumed shift of grain the final void pattern shall be as shown in figure B 2-1.

Figure B 2-1

(1)   If the maximum void area which can be formed against the girder at B is less than the initial area of the void under AB, i.e. AB × Vd, the excess area shall be assumed to transfer to the final void on the high side.

(2)   If, for example, the longitudinal division at C is one which has been provided in accordance with A 10.9, it shall extend to at least 0.6 m below D or E, whichever gives the greater depth.

2.9   In and abreast of hatchways

After the assumed shift of grain the final void pattern shall be as shown in figure B 2-2 or figure B 2-3:
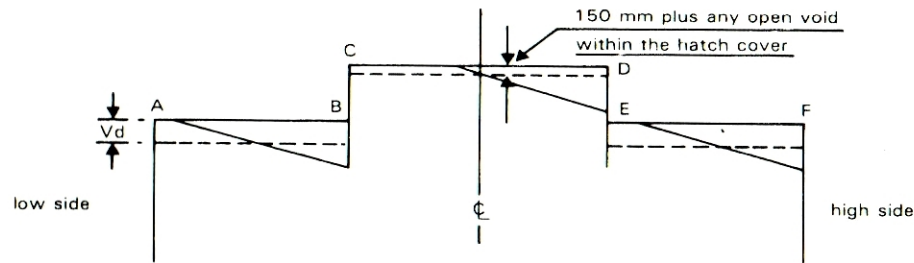
.1   Without longitudinal division:

Figure B 2-2

(1)   AB   Any area in excess of that which can be formed against the girder at B shall transfer to the final void area in the hatchway.

(2)   CD   Any area in excess of that which can be formed against the girder at E shall transfer to the final void area on the high side.

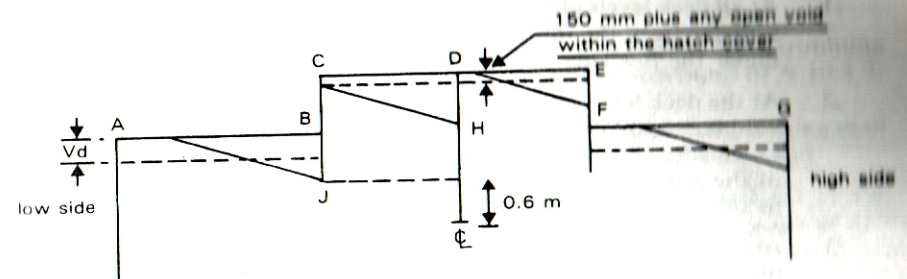.2   With longitudinal division:

Figure B 2-3

(1)   The excess void area from AB shall transfer to the low side half of the hatchway in which two separate final void areas will be formed, viz. one against the centreline division and the other against the hatch side coaming and girder on the high side.

(2)   If a bagged saucer or bulk bundle is formed in a hatchway it shall be assumed for the purpose of calculating the transverse heeling moment that such a device is at least equivalent to the centreline division.

(3)   If the centreline division is one which has been provided in accordance with A 10.9, it shall extend to at least 0.6 m below H or J, whichever gives the greater depth.

Compartments loaded in combination

The following paragraphs describe the pattern of void behaviour which shall be assumed when compartments are loaded in combination:

2.10   Without effective centreline divisions:

.1   Under the upper deck — as for the single deck arrangement described in B 2.8.2 and B 2.9.1.

.2   Under the second deck — the area of void available for transfer from the low side, i.e. original void area less area against the hatch side girder, shall be assumed to transfer as follows: one half to the upper deck hatchway and one quarter each to the high side under the upper and second deck.

.3   Under the third and lower decks — the void areas available for transfer from the low side of each of these decks shall be assumed to transfer in equal quantities to all the voids under the decks on the high side and the void in the upper deck hatchway.

2.11   With effective centreline divisions which extend into the upper deck hatchway:

.1   At all deck levels abreast of the division the void areas available for transfer from the low side shall be assumed to transfer to the void under the low side half of the upper deck hatchway.

.2   At the deck level immediately below the bottom of the division the void area available for transfer from the low side shall be assumed to transfer as follows: one half to the void under the low side half of the upper deck hatchway and the remainder in equal quantities to the voids under the decks on the high side.

.3   At deck levels lower than those described in B 2.11.1 or B 2.11.2, the void area available for transfer from the low side of each of those decks shall be assumed to transfer in equal quantities to the voids in each of the two halves of the upper deck hatchway on each side of the division and the voids under the decks on the high side.

2.12   With effective centreline divisions which do not extend into the upper deck hatchway:

Since no horizontal transfer of voids may be assumed to take place at the same deck level as the division, the void area available for transfer from the low side at this level shall be assumed to transfer above the division to voids on the high side in accordance with the principles of B 2.10 and B 2.11.

3   Assumed volumetric heeling moment of a filled compartment, untrimmed

3.1   All the provision for filled compartments, trimmed, set forth in B 2 shall also apply to filled compartments, untrimmed, except as noted below.

3.2   In filled compartments, untrimmed, which are exempted from trimming outside the periphery of the hatchway under the provisions of A 10.3.1:

.1   the resulting grain surface after shifting shall be assumed to be at an angle of 25° to the horizontal. However, if in any section of the compartment, forward, aft, or abreast of the hatchway the mean transverse area of the void in that section is equal to or less than the area which would obtain by application of B 1.1, then the angle of grain surface after shifting in that section shall be assumed to be 15° to the horizontal; and

.2   the void area at any transverse section of the compartment shall be assumed to be the same both before and after the grain shift, i.e. it shall be assumed that additional feeding does not occur at the time of the grain shift.

3.3   In filled compartments, untrimmed, which are exempted from trimming in the ends, forward and aft of the hatchway, under the provisions of A 10.3.2:

.1   the resulting grain surface abreast of the hatchway after shifting shall be assumed to be at an angle of 15° to the horizontal; and

.2   the resulting grain surface in the ends, forward and aft of the hatchway after shifting shall be assumed to be at an angle of 25° to the horizontal.

4   Assumed volumetric heeling moments in trunks

After the assumed shift of grain the final void pattern shall be as shown in figure B 4:
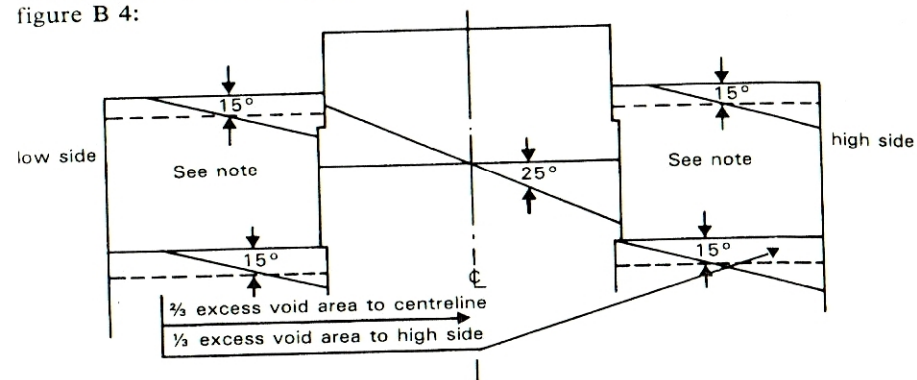

Figure B 4

If the wing spaces in way of the trunk cannot be properly trimmed in accordance with A 10, it shall be assumed that a 25° surface shift takes place.

5   Assumed volumetric heeling moment of a partly filled compartment

5.1   When the free surface of the bulk grain has not been secured in accordance with A 16, A 17 or A 18, it shall be assumed that the grain surface after shifting is at 25° to the horizontal.

5.2 In a partly filled compartment, a division, if fitted, shall extend from one eighth of the maximum breadth of the compartment above the level of the grain surface and to the same distance below the grain surface.

5.3 In a compartment in which the longitudinal divisions are not continuous between the transverse boundaries, the length over which any such divisions are effective as devices to prevent full width shifts of grain surfaces shall be taken to be the actual length of the portion of the division under consideration less two sevenths of the greater of the transverse distances between the division and its adjacent division or ship's side. This correction does not apply in the lower compartments of any combination loading in which the upper compartment is either a filled compartment or a partly filled compartment.

6   Other assumptions

An Administration or a Contracting Government on behalf of an Administration may authorize departure from the assumptions contained in this Code in those cases where it considers this to be justified having regard to the provisions for loading or structural arrangements provided the stability criteria in A 7 are met. Where such authorization is granted under this regulation, particulars shall be included in the document of authorization or grain loading data.

Appendix

At its fifty-ninth session, the Maritime Safety Committee adopted by resolution MSC.22(59) amendments to the 1974 SOLAS Convention including a revised chapter VI. These amendments are contained in publication IMO-168E.

Part C of the revised chapter VI deals with the carriage of grain, and is supplemented by the present publication, the International Code for the Safe Carriage of Grain in Bulk, adopted at the same session by resolution MSC.23(59).

For ease of reference, part C of the revised chapter VI of the 1974 SOLAS Convention is reproduced below.

PART C — CARRIAGE OF GRAIN

Regulation 8
Definitions

For the purposes of this part, unless expressly provided otherwise:

1   *International Grain Code* means the International Code for the Safe Carriage of Grain in Bulk adopted by the Maritime Safety Committee of the Organization by resolution MSC.23(59) as may be amended by the Organization, provided that such amendments are adopted, brought into force and take effect in accordance with the provisions of article VIII of the present Convention concerning the amendment procedures applicable to the Annex other than chapter I.

2   The term *grain* includes wheat, maize (corn), oats, rye, barley, rice, pulses, seeds and processed forms thereof whose behaviour is similar to that of grain in its natural state.

Regulation 9
Requirements for cargo ships carrying grain

1   In addition to any other applicable requirements of the present regulations, a cargo ship carrying grain shall comply with the requirements of the International Grain Code, and hold a document of authorization as required by that Code. For the purpose of this regulation, the requirements of the Code shall be treated as mandatory.

2   A ship without such a document shall not load grain until the master satisfies the Administration, or the Contracting Government of the port of loading on behalf of the Administration, that the ship will comply with the requirements of the International Grain Code in its proposed loaded condition.