DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

U.S. COAST GUARD (GMMT-5/82)
400 SEVENTH STREET SW.
WASHINGTON. DC 20590
PHONE: (202) 426-2187

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Subj: Intact Stability Criteria For Passenger And Cargo Ships Under 100 Meters In Length

1. Purpose. Enclosure (1), "Recommendation On Intact Stability For Passenger and Cargo Ships Under 100 Meters In Length", is derived from a document developed by the Intergovernmental Maritime Consultative Organization (IMCO) and is issued as information to naval architects, marine surveyors and others involved in the design of passenger and cargo vessels.

2. Discussion. Enclosure (1) does not in any way change the requirements for intact stability found in 46 CFR Part 74, Passenger Vessels; 46 CFR Part 93, Cargo and Miscellaneous Vessels; 46 CFR Part 151, Unmanned 3arges; 46 CFR Part 179, Small Passenger Vessels; 46 CFR Part 191, Oceanographic Vessels or any other stability criteria recently in force. Enclosure (1) was developed by IMCO as a general stability criteria and was recommended to governments for alternative use augmenting their national stability requirements. The Coast Guard will refer a designer to this Recommendation only when existing criteria cannot be applied due to unique design or special service.

G. H. READ
Captain, U. S. Coast Guard
Acting Chief, Office of Merchant Marine Safety

End: (1) Recommendation On Intact Stability For Passenger And Cargo Ships Under 100 Meters In Length

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RECOMMENDATION ON INTACT STABILITY FOR PASSENGER AND CARGO SHIPS UNDER 100 METERS IN LENGTH

1. Scope

1.1 The provisions given hereunder are recommended for new decked sea-going passenger and cargo ships (other than fishing vessels and ships carrying timber deck cargoes) under 100 meters in length.

2. General Precautions against Capsizing

2.1 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.

2.2 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. If necessary the amount should be limited to the extent that ballast weight may be required.

2.3 Before a voyage commences care should be taken to ensure that the cargo and sizable 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.

3. Calculation of Stability Curves

3.1 The methods and procedures employed for calculating stability righting arms should be in accordance with Appendix I, and the degree of accuracy obtained should be acceptable to the Administration.

4. Assessment of Compliance with Criteria

4.1 For the purpose of assessing in general whether the criteria are met, stability curves should be drawn for the main loading conditions intended by the owner in respect of the ship's operations.

4.2 If the owner does not supply sufficiently detailed information regarding such loading conditions, calculations should be made for the standard conditions given in Appendix II.

4.3 In all cases calculations should be based on the assumptions shown in Appendix I:.

5. Recommended Criteria

5.1 The following criteria are recommended for passenger and cargo ships:

(a) The area under the righting lever curve (GZ curve) should not be less than 0.055 meter-radians up to $=30^0$ angle of heel and not less than 0.09 meter-radians up

to $=40^0$ or the angle of flooding $_f$[1] if this angle is less than 40^0. Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30^0 and 40^0 or between 30^0 and if this angle is less than 40^0, should not be less than 0.03 meter-radians.

(b) The righting lever GZ should be at least 0.20 m. at an angle of heel equal to or greater than 300.

(c) The maximum righting arm should occur at an angle of heel at an preferably exceeding 30^0 but not less than 25^0.

(d) The initial metacentric height GM_0 should not be less than 0.15 m.

5.2 The following additional criteria are recommended for passenger ships:

(a) The angle of heel on account of crowding of passengers to one side as defined in Appendix II 2.(9) should not exceed 10^0.

(b) The angle of heel on account of turning should not exceed 10^0 when calculated using the following formula:

$$M_R = 0.02\frac{V_0^2}{L}\Delta\left(KG - \frac{d}{2}\right)$$

where:

M_R = heeling moment in meter-tons,
V_0 = service speed in m./sec,
L = length of ship at waterline in m.,
Δ = displacement in metric tons,
d = mean draught in m.,
KG = height of center of gravity above keel in m.

5.3 The criteria mentioned in 5.1 and 5.2 fix minimum values, but no maximum values are recommended. It is advisable to avoid excessive values, since these might lead to acceleration forces which could be prejudicial to the ship, its complement, its equipment and to the safe carriage of the cargo.

5.4 where anti-rolling devices are installed in a ship the Administration should be satisfied that the above criteria can be maintained when the devices are in operation.

5.5 A number of influences such as beam wind on ships with large windage area, icing of topsides, water trapped on deck, rolling characteristics, following seas, etc. adversely affect stability and the Administration is advised to take these into account so far as is deemed necessary.

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[1] $_f$ is an angle of heal at which openings in the hull, super-structures or deckhouses which cannot be closed weathertight immerse. In applying this .criterion, small openings through which progressive flooding cannot take place need not be considered as open.

5.6 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 Code of Safe Practice for Bulk Cargoes. Ships carrying grain in. bulk should comply with the criteria mentioned in 5.l in addition to the stability requirements in Chapter VI of the International Convention for the Safety of Life at Sea, 1960.

6. Inclining Test

6.1 When construction is finished, each ship should undergo an inclining test, actual displacement and co-ordinates of the center of gravity being determined for the light ship condition.

6.2 The Administration may allow the inclining test of an individual ship to be dispensed with, provided basic stability data are available from the inclining test of a sister ship.

7. Stability Information

7.1 The master of any ship to which the present Recommendation applies should receive information which will enable him to assess with ease and certainty the stability of his ship in different service conditions. A duplicate of this information should be communicated to the Administration.

7.2 Stability information should comprise:

(i) Stability characteristics of typical Loading conditions;

(ii) Information in the form of tables or diagrams which will enable the master to assess the stability of his ship and verify whether it is sufficient in all loading conditions differing from the standard ones. This information should include, in particular, a curve or table giving, as a function of the draughts, the required initial metacentric height GM (or any other stability parameter) which ensures that the stability is in compliance with the criteria given in 5.1 above;

(iii) Information on the proper use of anti-rolling devices if these are installed in the ship;

(iv) Notes on the corrections to be made to the initial metacentric height GM_0 to take account of free surface liquids.

APPENDIX I

CALCUTION OF STABILITY CURVES

General

(1) Hydrostatic and stability curves should normally be prepared on a designed trim basis. However, where the operating trim or the form and arrangement or the ship are such that change in trim has an appreciable effect on righting arms, such change in trim should be taken into account.

(2) The calculations should take into account the volume to the upper surface of the deck sheathing. In the case of wood ships the dimensions should be taken to the outside of the hull planking.

Superstructures, deckhouses, etc. which may be taken into account

(3) Enclosed superstructures complying with Regulation 3(l0)(b) of the 1966 Load Line Convention may be taken into account.

(4) The second tier of similarly enclosed superstructures may also be taken into account.

(5) Deckhouses on the freeboard deck may be taken into account, provided that they comply with the conditions for enclosed superstructures laid down in Regulation 3(l0)(b) of the 1966 Load Line Convention.

(6) Where deckhouses comply with the above conditions except that no additional exit is provided to a deck above, such deckhouses should not be taken into account; however, any deck openings inside such deckhouses shall be considered as closed even where no means of closure are provided.

(7) Deckhouses, the doors of which do not comply with the requirements of Regulation 12 of the 1966 Load Line Convention, should not be taken into account; however, any deck openings inside the deckhouse are regarded as closed where their means of closure comply with the requirements of Regulations 15, 17 or 18 of the 1966 Load Line Convention.

(8) Deckhouses on decks above the freeboard deck should not be taken into account, but openings within them may be regarded as closed.

(9) Superstructures and deckhouses not' regarded as enclosed can, however, be taken into account in stability calculations up to the angle at which their openings are flooded. (At this angle, the statical stability curve should show one or more steps, and in subsequent computations the flooded space should be considered non-existent.)

(10) In cases where the ship would sink due to flooding through any openings, the stability curve should be cut short at the corresponding angle of flooding and the ship should be considered to have entirely lost her stability.

(11) Small openings such as those for passing wires or chains, tackle and anchors, and also holes of scuppers, discharge and sanitary pipes should not be considered as open if they submerge at an angle of inclination more than 300. If they submerge at an angle of 300 or less, these openings should be assumed open if the Administration considers this to be a source of significant flooding.

(12) Trunks may be taken into account. Hatchways may also be taken into account having regard to the effectiveness of their closures.

Effect of liquid in tanks

(13) For all conditions, the initial metacentric height and the stability curves should be corrected for the effect of free surfaces of liquids in tanks in accordance with the following assumptions:

(i) Tanks which are taken into consideration when determining the effect of liquids on the stability at all angles of inclination should include single tanks or combinations of tanks for each kind of liquid (including those for water ballast) which according to the service conditions can simultaneously have fret surfaces.

(ii) For the purpose of determining this free surface correction, the tanks assumed slack should be those which develop the greatest free surface moment, $M_{f.s.}$ at a 30^0 inclination, when in the 50 per cent full condition.

(iii) The value of $M_{f.s.}$ for each tank may be derived from the formula

$$M_{f.s.} = vb\ k\sqrt{\ }$$

where:

$M_{f.s.}$ = the free surface moment at a 30^0 inclination in meter-tons,
v = the tank total capacity in m^3,
b = the tank maximum breadth in n,

= the specific weight of liquid in the tank in t/m^3,

$= \frac{v}{blh}$ = the tank block coefficient

h = the tank maximum height in m,
l = the tank maximum length in m,
k = dimensionless coefficient to be determined from Table 1 or Figure 1 according to the ratio b/h. The intermediate values are determined by interpolation (linear or graphic).

(iv) Small tanks, which satisfy the following condition using the value of k corresponding to the angle of inclination of 30^0, need not be included in computation:

$$vb\ k\sqrt{\ } \langle 0.01\Delta_{\min}$$

where:

$\Delta_{\min}$ = minimum ship displacement in tons (metric tons).

(v) The usual remainder of liquids in the empty tanks is not taken into account in computation.

APPENDIX II

STANDARD CONDITIONS OF LOADING TO BE EXAMINED

1. Loading Conditions

The standard loading conditions referred to in 4.2 of the Recommendation are as follows:

(1) Passenger ship

(i) ship in the fully Loaded departure condition with full stores and fuel and with the full number of passengers with their luggage;

(ii) ship in the fully Loaded arrival condition, with the full number of passengers and their luggage but with only 10 per cent stores and fuel remaining;

(iii) ship without cargo, but with full stores and fuel and the full number of passengers and their luggage;

(iv) ship in the same condition as at (iii) above but with only 10 per cent stores and fuel remaining.

(2) Cargo ship

(i) ship in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo spaces and with full stores and fuel.;

(ii) ship in the fully loaded arrival condition with cargo homogeneously distributed throughout all cargo spaces and with 10 per cent stores and fuel remaining;

(iii) ship in ballast in the departure condition, without cargo but with full stores and fuel;

(iv) ship in ballast in the arrival condition, without cargo and with 10 per cent stores and fuel remaining.

2. Assumptions for Calculating Loading Conditions

(1) For fully loaded conditions mentioned in l.(2)(i) and (2)(ii) of this Appendix if a dry cargo ship has tanks for liquid cargo, the effective deadweight in the loading conditions therein described should be distributed according to two assumptions, i.e. (i) cargo tanks full, and (ii) cargo tanks empty.

(2) In conditions mentioned in l.(l)(i) and (2)(i) of this Appendix, it should be assumed that the ship is loaded to her subdivision load line or summer load line with water ballast tanks empty.

(3) If in any loading condition water ballast is necessary, additional diagrams should be calculated taking into account the water ballast. Its quantity and disposition should be stated.

(4) In all cases the cargo is assumed to be fully homogeneous unless this condition is inconsistent with the practical service of the ship.

(5) In all cases when deck cargo is carried a realistic stowage weight should be assumed and stated, including the height of cargo.

(6) A weight of 75 kg. should be assumed for each passenger except that this value may be reduced to not less than 60 kg. where this can be justified. In addition the weight and distribution of the luggage should be determined by the Administration.

(7) The height of the centre of gravity for passengers should be assumed equal to:

(i) 1.0 meters above deck level for passengers standing upright. Account may be taken, if necessary, of camber and sheer of deck.

(ii) 0.30 meters above the seat in respect of seated passengers.

(8) Passengers and Luggage should be considered to be in the spaces normally at their disposal, when assessing compliance with the criteria at3.1(a), (b), (c) and (d) of the Recommendation.

(9) Passenger: without Luggage should be considered as distributed to produce the most unfavorable combination of passenger heeling moment and/or initial metacentric height, which may be obtained in practice, when assessing compliance with the criteria at 5.2(a) and (b) of the Recommendation respectively. In this connection it is anticipated that a value higher than 4 persons per square meter will not be necessary.

Table 1

VALUES OF DIMENSIONAL COEFFICIENT k FOR THE COMPUTATION OF FREE SURFACE CORRECTION

$k = \frac{\sin\theta}{12}\left(1 + \frac{\tan^2\theta}{2}\right) \times b/h$ where $\cot\theta \geq b/h$

$k = \frac{\cos\theta}{8}\left(1 + \frac{\tan\theta}{b/h}\right) - \frac{\cos\theta}{12(b/h)^2}\left(1 + \frac{\cot^2\theta}{2}\right)$ where $\cot\theta \leq b/h$

b/h	$\cot^{-1}(b/h)$	5°	10°	15°	20°	30°	40°	45°	50°	60°	70°	75°	80°	90°	b/h
20	(2.86°) 0.0833	0.11	0.12	0.12	0.12	0.11	0.10	0.09	0.09	0.07	0.05	0.04	0.03	0.01	20
10	(5.71°) 0.0833	0.07	0.11	0.12	0.12	0.11	0.10	0.10	0.09	0.07	0.05	0.04	0.03	0.01	10
5	(11.31°) 0.0833	0.04	0.07	0.10	0.11	0.11	0.11	0.10	0.10	0.08	0.07	0.06	0.05	0.03	5
3	(18.43°) 0.0834	0.02	0.04	0.07	0.09	0.11	0.11	0.11	0.10	0.09	0.08	0.07	0.06	0.04	3
2	(26.57°) 0.0839	0.01	0.03	0.04	0.06	0.09	0.11	0.11	0.11	0.10	0.09	0.09	0.08	0.06	2
1.5	(33.69°) 0.0847	0.01	0.02	0.03	0.05	0.07	0.10	0.11	0.11	0.11	0.11	0.10	0.10	0.08	1.5
1	(45.00°) 0.0894	0.01	0.01	0.02	0.03	0.05	0.07	0.09	0.10	0.12	0.13	0.13	0.13	0.13	1
0.75	(53.13°) 0.0944	0.01	0.01	0.02	0.02	0.04	0.05	0.07	0.08	0.12	0.15	0.16	0.16	0.17	0.75
0.5	(63.43°) 0.1180	0.00	0.01	0.01	0.02	0.02	0.04	0.04	0.05	0.09	0.16	0.18	0.21	0.25	0.5
0.3	(73.30°) 0.1570	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.05	0.11	0.19	0.27	0.42	0.3
0.2	(78.69°) 0.2206	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.04	0.07	0.13	0.27	0.63	0.2
0.1	(84.29°) 0.4229	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.04	0.06	0.14	1.25	0.1

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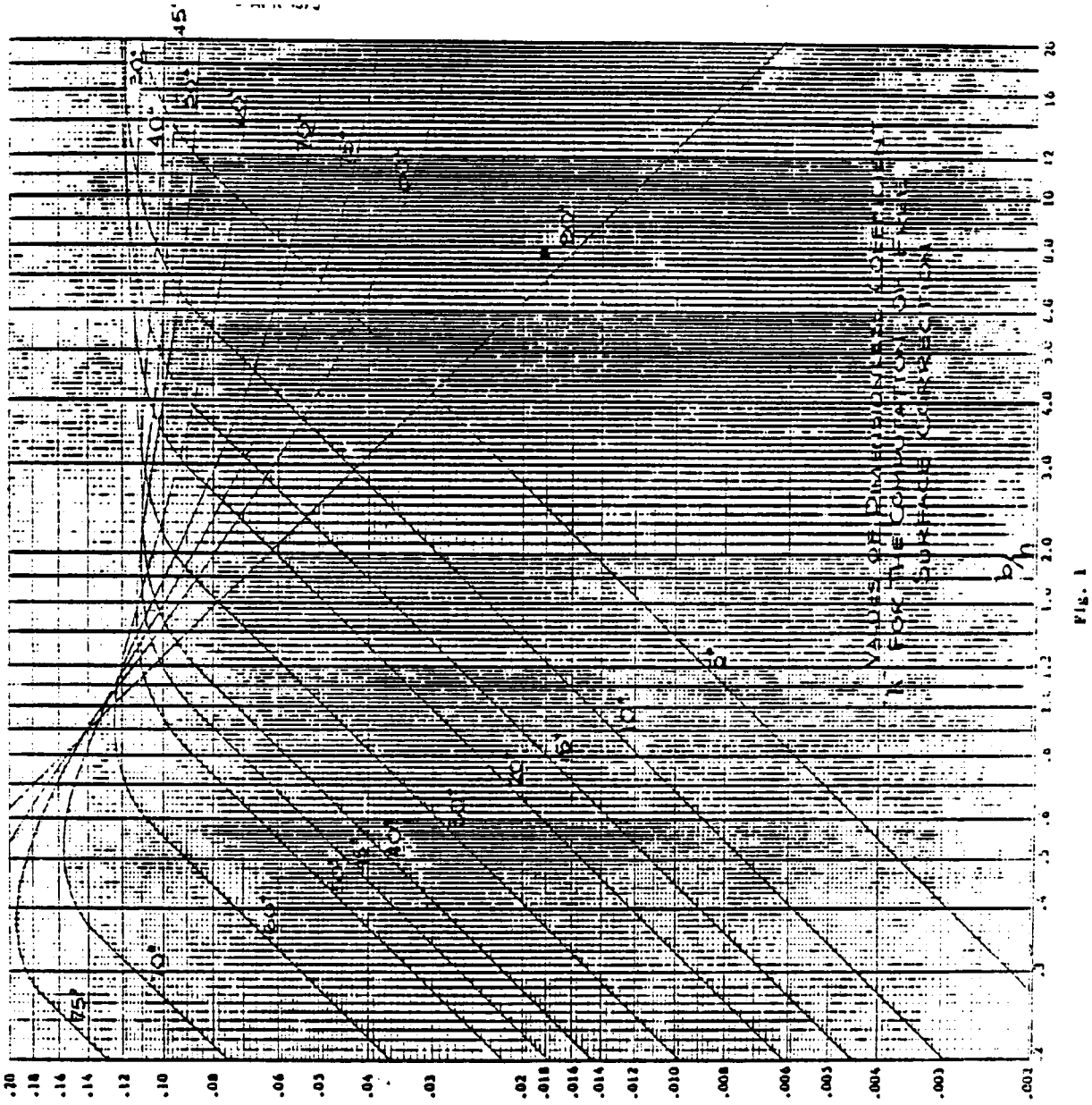

Fig. 1