RESOLUTION MSC.141(76)
(adopted on 5 December 2002)
REVISED MODEL TEST METHOD UNDER RESOLUTION 14
OF THE 1995 SOLAS CONFERENCE

MSC 76/23/Add.1

ANNEX 17

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THE MARITIME SAFETY COMMITTEE,

RECALLING Article 38(c) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution 14 on Regional agreements on specific stability requirements for ro-ro passenger ships, adopted by the Conference of Contracting Governments to the International Convention for the Safety of Life at Sea, 1974 (the 1995 SOLAS Conference),

NOTING that resolution 14 of the 1995 SOLAS Conference includes an option whereby the Administration may, as an alternative to calculation of the stability properties of a ship, accept model tests carried out for an individual ship in accordance with the model test method developed by the Organization, as appended to the Annex to the said resolution,

BEING AWARE of the experience gained from model tests carried out in the past by Administrations using the aforementioned model test method,

BEARING IN MIND the compelling need to keep pace with new technology and knowledge,

HAVING CONSIDERED the recommendation made by the Sub-Committee on Stability and Load Lines and on Fishing Vessels Safety at its forty-fifth session,

1.   ADOPTS the Revised Model Test Method under resolution 14 of the 1995 SOLAS Conference, including the associated Guidance Notes appended thereto, the text of which is set out in the Annex to the present resolution;

2.   INVITES Member Governments which are party to regional agreements under resolution 14 of the 1995 SOLAS Conference to use the annexed Revised Model Test Method and associated Guidance Notes in lieu of the original model test method appended to the said resolution.

ANNEX

REVISED MODEL TEST METHOD

1   Objectives

This revised model test method is a revision of the method contained in the Appendix to the Annex to resolution 14 of the 1995 SOLAS Conference. Since the entry into force of the Stockholm Agreement a number of model tests has been carried out in accordance with the test method previously in force. During these tests a number of refinements in the procedures have been identified. This new model test method aims to include these refinements and, together with the appended Guidance Notes, provide a more robust procedure for the assessment of survivability of a damaged ro-ro passenger ship in a seaway. In this respect, the model should prove capable of withstanding the seaway defined in paragraph 4 below, in the worst damage case scenario.

2   Definitions

L_{BP} is the length between perpendiculars

H_S is the significant wave height

B   is the moulded breadth of the ship

T_P is the peak period

T_Z is the zero crossing period

3   Ship model

3.1.1   The model should copy the actual ship for both outer configuration and internal arrangement − in particular all damaged spaces having an effect on the process of flooding and shipping of water. Intact draught, trim, heel and limiting operational KG corresponding to the worst damage case should be used. Furthermore, the test case(s) to be considered should represent the worst damage case(s) defined in accordance with SOLAS regulation II-1/8.2.3.2 (SOLAS 90) with regard to the total area under the positive GZ curve and the centreline of the damage opening should be located within the following range:

.1 $\pm$ 35 % L_{BP} from midship;

.2   an additional test will be required for the worst damage within $\pm10\%$ L_{BP} from midship if the damage case referred to in .1 is outside of $\pm10\%$ L_{BP} from midship.

3.2   The model should comply with the following:

.1   the length between perpendiculars (L_{BP}) should be at least 3 m or a length corresponding to a model scale of 1:40, whichever is greater, and the vertical extent up to at least 3 superstructure standard heights above the bulkhead (freeboard) deck;

.2   hull thickness of flooded spaces should not exceed 4 mm;

RESOLUTION MSC.141(76)
(adopted on 5 December 2002)
REVISED MODEL TEST METHOD UNDER RESOLUTION 14
OF THE 1995 SOLAS CONFERENCE

MSC 76/23/Add.1
ANNEX 17
Page 3

.3   in both intact and damaged conditions, the model should satisfy the correct displacement and draught marks (T_A, T_M, T_F, port and starboard) with a maximum tolerance in any one draught mark of +2 mm. Draught marks forward and aft should be located as near FP and AP as practicable;

.4   all damaged compartments and ro-ro spaces should be modelled with the correct surface and volume permeabilities (actual values and distributions) ensuring that floodwater mass and mass distribution are correctly represented;

.5   the actual ship characteristics of motion should be modelled properly, paying particular attention to the intact GM tolerance and radii of gyration in roll and pitch motion. Both radii should be measured in air and be in the range of 0.35B to 0.4B for roll motion, and $0.2L_{OA}$ to $0.25L_{OA}$ for pitch motion;

.6   main design features such as watertight bulkheads, air escapes, etc., above and below the bulkhead deck that can result in asymmetric flooding should be modelled properly as far as practicable, to represent the real situation. Ventilating and cross-flooding arrangements should be constructed to a minimum cross section of 500 mm^2;

.7   the shape of the damage opening at side should be as follows:

   .1   trapezoidal profile with side at 15° slope to the vertical and the width at the design waterline defined according to SOLAS regulation II-1/8.4.1;

   .2   isosceles triangular profile in the horizontal plane with the height equal to B/5 according to SOLAS regulation II-1/8.4.2. If side casings are fitted within B/5, the damaged length in way of the side casings should not be less than 25 mm;

   .3   notwithstanding the provisions of subparagraphs .7.1 and .7.2 above, all compartments taken as damaged in calculating the worst damage case(s) referred to in paragraph 3.1 should be flooded in the model tests.

3.3   The model in the flooded equilibrium condition should be heeled by an additional angle corresponding to that induced by the heeling moment $M_h = \max(M_{pass}; M_{launch})-M_{wind}$, but in no case should the final heel be less than 1° towards damage. M_{pass}, M_{launch} and M_{wind} are as specified in SOLAS regulation II-1/8.2.3.4.   For existing ships this angle may be taken as 1º.

4   Procedure for experiment

4.1   The model should be tested in a long-crested irregular seaway defined by the JONSWAP spectrum with significant wave height H_S, a peak enhancement factor $\gamma =3.3$ and a peak period $T_P = 4\sqrt{H_s}$, ($T_Z = T_P /1.285$). H_S is the significant wave height for the area of operation, which is not exceeded by a probability of more than 10% on a yearly basis, but limited to a maximum of 4 m.

Furthermore,

   .1   the basin width should be sufficient to avoid contact or other interaction with the sides of the basin and is recommended not to be less than $L_{BP}+ 2$ m;

.2   the basin depth should be sufficient for proper wave modelling but should not be less than 1 m;

.3   for a representative wave realisation to be used, measurements should be performed prior to the test at 3 different locations within the drift range;

.4   the wave probe closer to the wave maker should be located at the position where the model is placed when the test starts;

.5   variation in H_S and T_P should be within ±5% for the three locations; and

.6   during the tests, for approval purposes, a tolerance of +2.5% in H_S, ±2.5% in T_P and ±5% in T_Z should be allowed with reference to the probe closer to the wave maker.

4.2   The model should be free to drift and placed in beam seas (90° heading) with the damage facing the oncoming waves, with no mooring system permanently attached to the model used. To maintain a beam sea heading of approximately 90° during the model test the following requirements should be satisfied:

.1   heading control lines, intended for minor adjustment, should be located at the centre line of the stem and stern, in a symmetrical fashion and at a level between the position of KG and the damaged waterline; and

.2   the carriage speed should be equal to the actual drift speed of the model with speed adjustment made when necessary.

4.3   At least 10 experiments should be carried out. The test period for each experiment should be of a duration such that a stationary state is reached, but not less than 30 min in full-scale. A different wave realisation train should be used for each experiment.

5   Survival criteria

5.1   The model should be considered as surviving if a stationary state is reached for the successive test runs required in 4.3.

5.2   The model should be considered as capsized if angles of roll of more than 30° to the vertical axis or steady (average) heel greater than 20° for a period longer than 3 minutes full-scale occur, even if a stationary state is reached.

6   Test documentation

6.1   The model test programme should be approved by the Administration in advance.

6.2   Tests should be documented by means of a report and a video or other visual records containing all relevant information on the model and the test results, which are to be approved by the Administration. These should include, as a minimum, the theoretical and measured wave spectra and statistics (H_S, T_P, T_Z) of the wave elevation at the 3 different locations in the basin for a representative realisation, and for the tests with the model, the time series of main statistics of the measured wave elevation close to the wave maker and records of model roll, heave and pitch motions, and of the drift speed.

RESOLUTION MSC.141(76)
(adopted on 5 December 2002)
REVISED MODEL TEST METHOD UNDER RESOLUTION 14
OF THE 1995 SOLAS CONFERENCE

MSC 76/23/Add.1
ANNEX 17
Page 5

ATTACHMENT

GUIDANCE NOTES ON THE REVISED MODEL TEST METHOD

The purpose of these notes is to ensure uniformity in the methods employed in the construction and verification of the model as well as the undertaking and analyses of the model tests, while appreciating that available facilities and costs will affect in some way this uniformity.

The contents of paragraphs 1 and 2 of the Revised Model Test Method are considered self-explanatory.

Paragraph 3 - Ship model

3.1   The material of which the model is made is not important in itself, provided that the model, both in the intact and damaged condition, is sufficiently rigid to ensure that its hydrostatic properties are the same as those of the actual ship and also that the flexural response of the hull in waves is negligible.

It is also important to ensure that the damaged compartments are modelled as accurately as practicably possible to ensure that the correct volume of floodwater is represented.

Since ingress of water (even small amounts) into the intact parts of the model will affect its behaviour, measures must be taken so that this ingress does not occur.

In model tests involving worst SOLAS damages near the ship ends, it was observed that progressive flooding was not possible because of the tendency of the water on deck to accumulate near the damage opening and hence flow out. As such models were able to survive very high sea states, while they capsized in lesser sea states with less onerous SOLAS damages, away from the ends, the limit ±35% was introduced to prevent this.

Extensive research carried out for the purpose of developing appropriate criteria for new vessels has clearly shown that in addition to the GM and freeboard being important parameters in the survivability of passenger ships, the area under the residual stability curve is also another major factor. Consequently in choosing the worst SOLAS damage for compliance with the requirement of paragraph 3.5.1 the worst damage is to be taken as that which gives the least area under the residual stability curve.

3.2   Model particulars

.1   In recognising that scale effects play an important role in the behaviour of the model during tests it is important to ensure that these effects are minimised as much as practically possible. The model should be as large as possible since details of damaged compartments are easier constructed in larger models and the scale effects are reduced. It is therefore required that the model length is not less than that corresponding to 1:40 scale or 3 m, whichever is greater.

It has been found during tests that the vertical extent of the model can affect the results when tested dynamically. It is therefore required that the ship be modelled to at least three superstructure standard heights above the bulkhead (freeboard) deck so that the large waves of the wave train do not break over the model.

.2 The model in way of the assumed damages should be as thin as practically possible to ensure that the amount of floodwater and its centre of gravity are adequately represented. The hull thickness should not exceed 4 mm. It is recognised that it may not be possible for the model hull and the elements of primary and secondary subdivision in way of the damage to be constructed with sufficient detail and due to these constructional limitations it may not be possible to calculate accurately the assumed permeability of the space.

.3 It is important that not only the draughts in the intact condition are verified but also that the draughts of the damaged model are accurately measured for correlation with those derived from the damaged stability calculation. For practical reasons a tolerance of +2 mm in any draught is accepted.

.4 After measuring the damaged draughts it may be found necessary to make adjustments to the permeability of the damaged compartment by either introducing intact volumes or by adding weights. However, it is also important to ensure that the centre of gravity of the floodwater is accurately represented. In this case any adjustments made must err on the side of safety.

If the model is required to be fitted with barriers on deck and their height is less than the bulkhead height indicated below, the model should be fitted with CCTV so that any "splashing over" and any accumulation of water on the undamaged area of the deck can be monitored. In this case a video recording of the event should form part of the tests records.

The height of transverse or longitudinal bulkheads which are taken into account as effective to confine the assumed accumulated sea water in the compartment concerned in the damaged ro-ro deck should be at least 4 m in height unless the height of water is less than 0.5 m. In such cases the height of the bulkhead may be calculated in accordance with the following:

$$B_h = 8h_w$$

where B_h is the bulkhead height; and
h_w is the height of water.

In any event, the minimum height of the bulkhead should be not less than 2.2 m. However, in the case of a ship with hanging car decks, the minimum height of the bulkhead should be not less than the height to the underside of the hanging car deck when in its lowered position.

.5 In order to ensure that the model motion characteristics represent those of the actual ship it is important that the model is inclined in the intact condition so that the intact GM is verified. The mass distribution should be measured in air. The transverse radius of gyration of the actual ship should be in the range 0.35B to 0.4B and the longitudinal radius of gyration should be in the range 0.2L to 0.25L.

Note: While inclining and rolling the model in the damage condition may be accepted as a check for the purpose of verifying the residual stability curve, such tests should not be accepted in lieu of the intact tests.

.6 It is assumed that the ventilators of the damaged compartment of the actual ship are adequate for unhindered flooding and movement of the floodwater. However in trying to scale down the ventilating arrangements of the actual ship undesirable scale effects may be introduced. In order to ensure that these do not occur it is

RESOLUTION MSC.141(76)
(adopted on 5 December 2002)
REVISED MODEL TEST METHOD UNDER RESOLUTION 14
OF THE 1995 SOLAS CONFERENCE

MSC 76/23/Add.1
ANNEX 17
Page 7

recommended to construct the ventilating arrangements to a larger scale than that of the model, ensuring that this does not affect the flow of water on the car deck.

.7 It is deemed appropriate to consider a damage shape representative of a cross section of the striking ship in the bow region. The 15° angle is based on a study of the cross section at a distance of B/5 from the bow for a representative selection of vessels of different types and sizes.

The isosceles triangular profile of the prismatic damage shape is that corresponding to the load waterline.

Additionally, in cases where side casings of width less than B/5 are fitted and in order to avoid any possible scale effects, the damage length in way of the side casings should not be less than 25 mm.

3.3 In the original model test method of resolution 14 of the 1995 SOLAS Conference the effect of heeling induced by the maximum moment deriving from any of passenger crowding, launching of survival craft, wind and turning was not considered even though this effect was part of SOLAS. Results from an investigation have shown however that it would be prudent to take these effects into account and to retain the minimum of 1° heel towards the damage for practical purposes. It is to be noted that heeling due to turning was considered not to be relevant.

3.4 In cases where there is a margin in GM in the actual loading conditions compared to the GM limiting curve (derived from SOLAS 90), the Administration may accept that this margin is taken advantage of in the model test. In such cases the GM limiting curve should be adjusted. This adjustment can be done as follows:
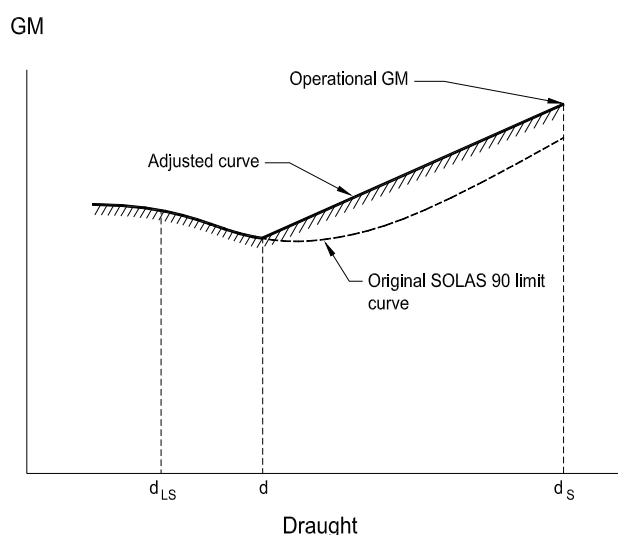
$$d = d_S - 0.6 \, (\, d_S - d_{LS} \,)$$

where: d_S is the subdivision draught; and
d_{LS} is the lightship draught.

The adjusted curve is a straight line between the GM used in the model test at the subdivision draught and the intersection of the original SOLAS 90 curve and draught d.

Paragraph 4 - Procedure for experiments

4.1   Wave spectra

The JONSWAP spectrum should be used as this describes fetch and duration in limited seas, which correspond to the majority of the conditions worldwide. In this respect it is important that not only the peak period of the wave train is verified but also that the zero crossing period is correct.

It is required that for every test run the wave spectrum be recorded and documented. Measurements for this recording should be taken at the probe closest to the wave making machine.

It is also required that the model be instrumented so that its motions (roll, heave and pitch) as well as its attitude (heel, sinkage and trim) are monitored and recorded.

It has been found that it is not practical to set absolute limits for significant wave heights, peak periods and zero crossing periods of the model wave spectra, therefore an acceptable margin has been introduced.

4.2   To avoid interference of the mooring system with the ship dynamics, the towing carriage (to which the mooring system is attached) should follow the model at its actual drifting speed. In a sea state with irregular waves the drift speed will not be constant; a constant carriage speed would result in low frequency, large amplitude drift oscillations, which may affect the model behaviour.

4.3   A sufficient number of tests in different wave trains are necessary to ensure statistical reliability, i.e. the objective is to determine with a high degree of confidence that an unsafe ship will capsize in the selected conditions. A minimum number of 10 runs are considered to provide a reasonable level of reliability.

Paragraph 5 - Survival criteria

The contents of this paragraph are considered self-explanatory.

Paragraph 6 - Test approval

The following documents should be part of the report to the Administration:

> .1   damage stability calculations for worst SOLAS and midship damage (if different);
>
> .2   general arrangement drawing of the model together with details of construction and instrumentation;
>
> .3   inclining experiment and measurements of radii of gyration;
>
> .4   nominal and measured wave spectra (at the 3 different locations for a representative realisation and for the tests with the model from the probe closest to the wave maker);
>
> .5   representative records of model motions, attitude and drift; and
>
> .6   relevant video recordings.
>
> **Note:** All tests must be witnessed by the Administration.

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