1989

Draft code of ship stability

José Miguel Torres Fuentes
World Maritime University

WORLD MARITIME UNIVERSITY

MALMÖ, SWEDEN

DRAFT CODE OF SHIP STABILITY

by

José Miguel TORRES Fuentes

Chile

A paper submitted to the Faculty of the WORLD MARITIME UNIVERSITY in partial satisfaction of the requirements for the award of a

MASTER OF SCIENCE DEGREE

in

MARITIME SAFETY ADMINISTRATION

(Marine Engineering)

The contents of this paper reflect my own personal views and are not necessarily endorsed by the UNIVERSITY.

Signature: [signature]

Date: October 30th, 1989

Supervised and assessed by:

Ernst Hansen-Tangen [signature]

Professor

World Maritime University

Co-assessed by:

Jan-Åke Jönsson

M.Sc. Naval Architecture

& Marine Engineering

Visiting Professor

World Maritime University

INTRODUCTION

This thesis is a Draft Code of Ship Stability which sets down the necessary subsidiary legislation on stability in connection with the implementation in Chile of the SOLAS 74, LOADLINES 66, TORRE-MOLINOS 77 and MARPOL 73 Conventions as amended.

The aforesaid conventions, with the exception of MARPOL 73, have already been ratified by Chile and as far as Marpol 73 is concerned a formal ratification is soon expected.

The Code describes in detail the whole process of stability control to be performed by the Chilean Maritime Directorate (Ch.M.D.), in such a way that shipyards, surveyors and everyone involved in the different phases of the process will find a useful tool in it.

The first chapter deals with the Preliminary Stability Booklet which is a feasibility study of stability to be submitted to the Ch.M.D.for approval prior to the construction of the ship. It is also a requirement for the ship to become registered in the Chilean Register of Ships Under Construction.

The different stability criteria to consider are stated in Chapter 3.

The second chapter deals with the Stability Test and states the way to handle it at each single stage so as to ensure a uniform procedure and reliable data for the further calculation of KG and metacentric height.

Special forms have been designed for the Test Report in order to collect the required information, on which all the calculations of the Stability Booklet, as described in Chapter 3, will be based.

The third and final chapter sets down the instructions for the elaboration of the Stability Booklet and includes the assumptions and criteria to consider for the assessment of both the intact and damage stability for different kinds of ship. The Stability Booklet is intended not only to serve as a useful guide for the Master and Skipper when it comes to assessing the ship stability in any loading condition but also to provide the Chilean Administration with valuable information when performing analyses of the ship stability in Casualty Investigations. The existence of the Stability Booklet on board is also a requirement for the issuance and validity of a number of National and International Safety Certificates as listed in Chapter 3.

Delegation to Classification Societies in the field of stability is limited to the approval of Subdivision and Damage Stability calculations. The criteria and rules to consider are also stated in Chapter 3.

Finally the author wants to explain that this thesis has been conceived as a Draft Code of Ship Stability and as a such was structured to be a complete set of regulations. Due to this no conclusions have been made.

Prior to acceptance by the Ch.M.D. and further inclusion by reference in the Merchant Shipping Act (Ley de Navegacion), this draft code should be studied, mainly as to the intact and damage stability criteria proposed, by a technical committee. In this connection, it must be noted that Chapter 3 considers specially strengthened criteria for purse seiner fishing vessels since they have to counteract free surfaces and strong fish capsizing moments under normal operations. The aforesaid committee should include engineers of the Ch.M.D. and technical representatives of the shipyards, shipowners and seafarer's unions (merchant and fishing vessels).

The author hopes that this thesis will also serve as a guidance for certain other countries' Administrations when drafting their own subsidiary legislation on ship stability.

INDEX

REFERENCE TABLES AND FIGURES

Chapter 2 : The Stability Test

Chapter 3 : The Stability Booklet

CHAPTER 1

THE PRELIMINARY STABILITY BOOKLET

1.1. GENERAL

In order to register a ship under construction in the Chilean Register of Ships Under Construction the Preliminary Stability Booklet shall previously be approved by the Chilean Maritime Directorate (Ch.M.D.)*. The Preliminary Stability Booklet shall be submitted to the Ch.M.D. in three copies. One of them will remain in the main office of the Ch.M.D., a second will remain in the local office of the Ch.M.D. if applicable and the third will be sent back to the Shipyard or Professional responsible after revision or approval.

The following information shall be included in the Preliminary Stability Booklet:

- Hull Form Drawing (Body Plan)
- Hydrostatic Data
- Stability Levers
- Expected Lightweight condition data.
- Volume, Centre of gravity, and Free Surface Moment of cargo holds and tanks for various loading conditions, including the volume of hatchways in fully loaded condition.
- GZ curves for various loading conditions.
- Analysis of Intact Stability Criteria for every loading condition according to section 3.3.
- Analysis of Damage Stability Criteria when applicable, according to section 3.5.

* Ch.M.D.= General Directorate of the Maritime Territory and Merchant Marine (Chilean Maritime Directorate).

The only difference between the Preliminary Stability Booklet and the Stability Booklet described in Chapter 3 is that the former is based on the Expected Lightweight data and the latter is based on the Actual Lightweight data obtained by means of the Stability Test described in Chapter 2.

The rules for the drawing of hull forms and calculation of hydrostatic data and stability levers are stated in the following sections. They include the relevant provisions of IMO Resolution A.167(ES.IV), IMO Resolution A.168(ES.IV) and IMO Resolution A.267(VIII).

1.2. DRAWING OF HULL FORMS

At least 6 waterline half breadths at a minimum of 11 stations should be used for the hull definitions.

The intersection point between the base line and the keel line is denoted "K" and serves as a base for the calculations.

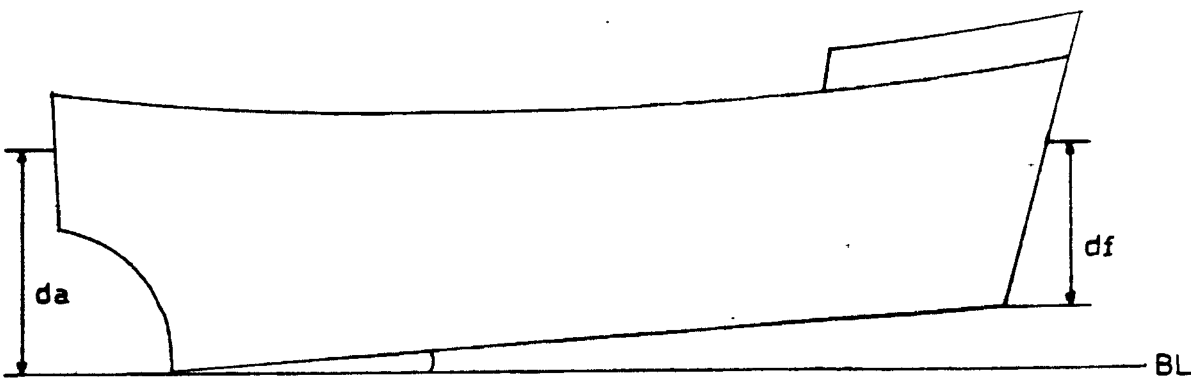


Fig. D

Designed Trim = (df − da)

For vessels with a metal shell, the constant used to include apendages and shell plating in the moulded displacement shall be stated. This constant allows getting the actual ship displacement from the moulded one.

The angle between the base line and the keel line, which defines the designed trim condition shall be marked, see fig.0.

1.3. SUPERSTRUCTURES TO INCLUDE IN CALCULATIONS

The following superstructures , deckhouses, etc., may be considered in the calculations mentioned in section 1.4:

a) Enclosed superstructures complying with Regulation 3(10)(b) of the 1966 Load Lines Convention. (In fishing vessels, door sills complying with paragraph 1.3.k) can also be considered).

b) The second tier of similarly enclosed superstructures.

c) 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(10)(b) of the 1966 Load Lines Convention. (In fishing vessels, door sills complying with paragraph 1.3.k) can also be considered).

d) 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. Such deckhouses where, due to the smallness of the vessel an additional exit would be impracticable, may be taken into account.

e) Deckhouses, the doors of which do not comply with the requirements of Regulation 12 of the 1966 Load Lines 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 Lines Convention.

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

g) Superstructures and deckhouses not regarded as enclosed may under special circumstances be taken into account in stability calculations up to the angle at which the openings are flooded, provided this does not lead to subsequent serious flooding of the vessel. (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).

h) 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.

i) 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 of more than 30 degrees. If they submerge at an angle of 30 degrees or less these openings should be assumed open.

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

k) Hatch Coamings and Door Sills on Fishing Vessels:

Hatchway coamings and door sill heights should comply with the following standards:

1: On upper decks to be at least 600 mm. However, in locations on the upper deck which are shielded from the full force of the sea (with the exception of doors giving direct access to engine rooms), these heights may be reduced to 400 mm.

2: On superstructure decks to be at least 300 mm. However, in locations on the upper deck which are shielded from the full force of the sea (with the exception of doors giving direct access to engine rooms), these heights may be reduced to 150 mm.

3: A restricted number of small watertight scuttles on upper decks and watertight hatches on superstructure decks may be fitted without sills but these must be found essential for fishing operations.

1.4. HYDROSTATIC DATA AND "GZ" CALCULATIONS

1.4.a) General

The method of calculation used to produce both hydrostatic data and stability levers (cross curves) shall be checked by the Ch.M.D. The calculations should take into account the volume to the upper surface of the deck sheathing. In the case of wooden ships the dimensions should be taken to the outside of the hull plates.

1.4.a)1 Calculations by electronic computer programs:

Electronic computer programs shall be type approved by the Ch.M.D. An extensive description of the computer program as well as a complete listing shall be submitted to the Ch.M.D. together with the results of the calculation for a "standard vessel".

In order to get the Type Approval of the program the details of the software development, structure and documentation shall be included.

Once the program and the results are accepted by the Ch.M.D. the computer program can be employed for subsequent calculations. Subsequent changes in the program or in the procedure shall be reported to and approved by the Ch.M.D.

1.4.a)2 Integrator calculations:

The general procedure of the integrator method employed shall be submitted together with the results of a calculation for a "standard vessel".

If the procedure and the results are accepted by the Ch.M.D., the procedure can be employed for subsequent calculations.

1.4.a)3 Documents to be submitted:

The following shall always be submitted to the Ch.M.D.:

- A declaration of the Professional* responsible stating that he has performed the calculations and duly checked all data employed on them.

- The lines plan or list of offsets used for the calculations or for lifting data.

- A general arrangement drawing showing positions of openings and details of their closing appliances. (This is required in connection with the determination of the flooding angle as stated in paragraph 3.2.e).

1.4.b) Hydrostatic Data

The following hydrostatic data calculated for the designed trim and various relevant trims referred to in subparagraph 1.4.c)1 shall always be submitted:

1) Displacement (Δ,∇)

2) Vertical centre of buoyancy "KB"

3) Transverse metacentric radius "BMt"

4) Longitudinal centre of buoyancy "LCB"

* Naval Architect or Naval Engineer holding the corresponding University degre or equivalent.

5) Longitudinal metacentric radius "BMl"

6) KB for various relevant trims

7) BMt for various relevant trims

8) Coefficients (cb, cw, cp, cm)

cb = block coefficient

cw = water coefficient

cp = prismatic coefficient

cm = moulded coefficient

The data shall be calculated for a number of draughts covering the full range of operating displacements. They shall be presented as curves or tables.

1.4.c) Stability Levers

Calculations of stability levers GZ shall include the light and maximum load conditions and at least four intermediate displacements.

Superstructures, deckhouses, and trunks which can be considered in the calculations are indicated in section 1.3.

1.4.c)1 Relevant Trims:

Like the hydrostatic data the stability curves should normally be prepared on a designed trim basis. However, where the operating trim or the form and arrangement of the ship are such that a change in trim has an appreciable effect on righting arms, such change in trim shall be included in the calculations submitted to the Ch.M.D. Thus, righting levers GZ and hydrostatic data for initial trims covering the full range of operational trims shall be submitted.

Normally the calculations need not take into account the change in trim when heeled to assess whether the ship complies with the stability criteria or not. However, when due to the arrangement of superstructures the influence of trim at heeled condition causes considerable deviations from the calculations with constant trim, the calculations of hydrostatic data and GZ shall be prepared at different heeling angles.

1.4.c)2 <u>Heeling Angles:</u>

Heeling angles shall be taken at intervals of not more than 5 degrees in the range 0 to 10 degrees, and not more than 10 degrees in the range 10 to 60 degrees. However when calculations are performed with an electronic computer , calculations at approximately 2 degrees shall be carried out in order to compare the results of the programs for righting levers GZ and hydrostatic data.

Ships intended to carry grain shall include righting lever calculations for 12 and 40 degrees.

The results of the calculations shall be presented as curves or tables.

CHAPTER 2

THE STABILITY TEST

This chapter emphasizes a rigorous check at every step of the Stability Test, describing in detail the whole procedure to be performed in order to ensure the achievement of reliable values for the displacement, metacentric height and centre of gravity of the ship at the test condition, since they directly affect the accuracy and therefore trustability of all the later calculations of the Stability Booklet. The relevant provisions of Circular USCG NVIC 15-81 and IMO Resolution A.267(-VIII) have been taken into account.

The author's practical experience conducting tests as an Engineer Surveyor of the Ch.M.D. and attending tests during a training period in the Swedish and Norwegian Administrations have been taken into account.

2.1. GENERAL

Each ship to be registered in the Chilean National Ship Register shall undergo a Stability Test upon its completion according to the provisions of this chapter, in order to determine the position of the centre of gravity and the lightship condition.

2.1.a) Alterations

Where any alterations are to be made on a Chilean ship a Preliminary Study of Stability shall be submitted to the Ch.M.D. This Study shall clearly show how the lightship displacement, KG and the longitudinal centre of gravity of the ship, will be changed.

The Preliminary Study of Stability shall contain the information indicated for the Preliminary Stability Booklet in section 1.1 and shall be approved by the Ch.M.D. before the alteration work on the ship is started. After the alteration has been carried out the ship shall undergo a new Stability Test according to the provisions of this chapter, and a new Stability Booklet, verifying compliance with the relevant Intact and Damage Stability Criteria, shall be approved by the Ch.M.D.

2.1.b) Passenger Vessels

At periodical intervals not exceeding five years, a lightweight survey shall be carried out on all passenger ships to verify any changes in lightship displacement and longitudinal centre of gravity. The ship shall undergo a new Stability Test whenever, in comparison with the approved stability information, a deviation from the lightship displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of L is found or anticipated.

2.2. NOTIFICATION OF STABILITY TEST

The Ch.M.D. should be informed in writing at least two weeks in advance of the intention to performe the Stability Test. The written Notification of Stability Test should include the following information:

a) Name of the vessel and shipyard hull number if applicable.

b) Date, time and location of the test, tidal range, and depth of water during the test.

c) Inclining weight data:

(1) Type
(2) Amount
(3) Certification
(4) Method of handling

d) Schema of Weight Movements, showing clearly the weights arrangement and shifting distances after each movement to perform.

e) Pendulums data: approximate location and length. If one of the pendulums is going to be substituted by an inclinometer or other measuring device, prior approval shall be requested. The Ch.M.D. will probably require that the device be used additionally to the pendulum in order to verify its accuracy before allowing actual substitution for a pendulum.

f) Expected deviations of pendulums after each movement, measured from the zero position of the pendulums in the battens (upright ship).

g) Angle of inclination after every movement, with respect to the center line.

h) Estimated displacement.

i) Expected GM value. (A positive GM>.2 m. is recommended).

j) Approximate Trim and List.

k) Condition of tanks.

l) Estimated weights to deduct, to complete and to relocate in order to place the vessel in its true lightship condition. The centres of gravity of these weights shall be accurately estimated otherwise the Ch.M.D. may decide to postpone the test until the ship is completed or in the required condition.

m) Name and phone number of the Professional responsible for conducting the test.

2.3. PLANS AND EQUIPMENT REQUIRED

2.3.a) Plans

The following plans shall be submitted to the Ch.M.D. well in advance of the test. The Professional in charge of the test shall also have available a copy of the following drawings at the time of the stability test:

1. Lines Plan.
2. Curves of Form or Hydrostatics.
3. General Arrangement Plan of decks, holds, inner bottoms, etc.
4. Outboard Profile.
5. Inboard Profile.
6. Midship Section.
7. Capacity Plan showing vertical and longitudinal centres of gravity of cargo spaces, tanks, etc.
8. Tanks sounding tables.
9. Draft marks location.

2.3.b) Equipment

Besides the physical equipment necessary such as the inclining weights, pendulums, small boat, etc., the following are necessary and should be provided or made available to the Professional in charge of the test:

1) 2 millimeter scales for measuring pendulum deflections.
2) 2 pencils for marking pendulum deflections.
3) Chalk for marking the various positions of the inclining weights.
4) A long measuring tape for measuring the movement of the weights and locating different items on board.
5) A sufficiently long measuring tape for sounding tanks and taking freeboard readings.
6) One hydrometer to measure the specific gravity of the water the ship is floating on.
7) Other hydrometers to measure the specific gravity of any liquids on board.
8) Graph paper to plot the Total Inclining Moments versus the Tangents of the Total Inclination Angles after every movement of weights.
9) A straight edge to draw the waterline on the lines drawing, a pad of paper to record data and a flame safety lamp to check for sufficient oxygen in tanks.

2.4. CONDITION OF THE VESSEL AT THE TEST

2.4.a) General

2.4.a)1 Movable weights:

All movable weights on board shall be secured in their right place or stowed in their "at sea" position.

2.4.a)2 Boilers and Piping Systems:

Boilers, piping systems and others shall be filled as in the normal service condition.

2.4.a)3 Surplus and Missing Weights:

The vessel should be complete in all respects in order to obtain accurate data from the test. If this is not so the weight and centre of gravity of each item to be deducted, added or relocated must be accurately determined and their cummulative effect considered. As is mentioned in section 2.2 this information must be detailed in the Notification of Stability Test submitted to the Ch.M.D. prior to the test.

If the condition of the vessel is not clearly stated in the Notification of Stability Test and at the time of the experiment the Ch.M.D.'s surveyor considers that the vessel is in such a condition that an accurate Stability Test cannot be conducted, he may refuse to witness the test and require that it be rescheduled to a later date.

In general the inaccuracy of the lightweight of the ship and the KG must not exceed 0.5%. To achieve this a 10% accuracy must be ensured in determining the weights of the surplus and missing loads and its absolute total weight must not exceed 4% of the lightweight of the vessel.

Furthermore, a 7.5% accuracy must be ensured in determinating the centre of gravity of the surplus and missing loads and they shall not cause a total shift of the position of the centre of gravity exceeding 4% of KG.

2.4.a)4 <u>Lightweight of the Ship:</u>

For the Ch.M.D. the lightweight of a ship is defined as the weight of the ship complete and ready for sea in all respects, including:

- All fixed equipment.
- All fixed and portable instruments of navigation.
- Anchors, cables, hawsers.
- Nets and auxiliary embarkation in fishing vessels.
- Furniture, silver, linen, china.
- Fully equiped workshops. (For engineers, electrician, carpenter, boatswain, etc.)
- Boilers, piping systems and others filled as in the normal service condition.
- Machinery fluids (water, lubricants, hydraulics, etc.,) at operating level in machinery and piping.
- Spare parts according to Classification Societies Regulations and respective maker's standards.

The following are not included:

- Fuel oil in dairy, settling and storage tanks.
- Lubrication oil in dairy and storage tanks.
- Fresh water in culinary or fresh water tanks.
- Water in ballast tanks.
- Consumables, refrigerated or dry stores.
- Crew and their effects.

2.4.a)5 <u>Fishing Vessels:</u>

In fishing vessels all fishing gear shall be installed on board including winches, cables, auxiliary boats and nets. In Purse Seiners a formal document certifying that the net and the auxiliary boat laying on board are the ones the ship is going to operate with must be signed by the Skipper and the Shipowner and shall be presented to the Ch.M.D.'s surveyor. This document shall also include dimensions and particulars of the net and must be signed by the surveyor. A copy of it shall be kept on board and another copy shall be included in the Stability Test Report.

An increase in the net weight in Purse Seiners shall be considered an alteration and a new Stability Test shall be performed as stated in paragraph 2.1.a).

For the purposes of the stability control performed by the Ch.M.D. the lightweight of a fishing vessel includes the complete fishing gear, winches, cables, auxiliary boats, nets and so on. This is particularly important since those weights are on board in all the loading conditions to be assessed in the Stability Booklet.

At the time of the test Purse Seiner vessels shall have the net stowed on board in the wet condition after having sunk it not more than 12 hours prior to the test, in order to approach the actual weight of the net on board when the ship is in operation.

2.4.b) Tanks

All tanks should be empty. If tanks must contain liquid they should be completely full. The number of tanks containing liquids shall be kept to a minimum. A minimum number of slack tanks may be permitted only if the liquid level in the tank, the viscosity of the liquid and the shape of the tank are such that the free surface effect can be accurately determined.

2.4.b)1 <u>Slack Tanks:</u>

The number of slack tanks should be limited to one port/starboard pair or one centerline of the following:

- Reserve feed tanks.
- Fuel oil storage tanks.
- Fuel oil settlers.

These tanks should be of a rectangular cross section and be 20% to 80% full if deep tanks and 40% to 60% full if double bottom tanks so as to avoid pocketing. Soundings must be corrected for the effect of trim.

Slack tanks containing liquids of sufficient viscosity so as to prevent free movement as the vessel is inclined (such as Bunker C at low temperature) should be avoided since the free surface is indeterminate. A free surface correction for such tanks cannot be allowed. Liquids in tanks may be heated to reduce viscosity.

Cross connections, including those via manifolds, must be closed. Unequal liquid levels in slack tank pairs can be used as a check against open cross connections.

2.4.b)2 <u>Pressed up tanks:</u>

"Pressed up" means completely full with no voids caused by trim or inadequate venting. Fig. 1 illustrates a double bottom tank in slack condition. However due to the trim the sounding indicates a full tank. Anything less than 100% full, as for example the 98% condition regarded

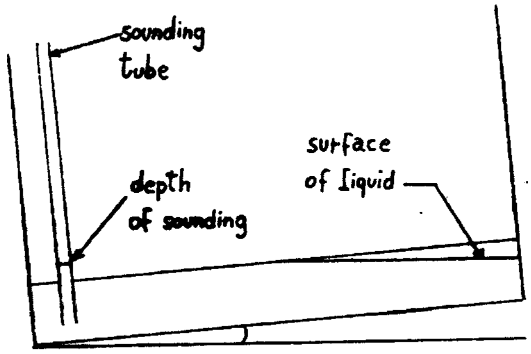


Fig. 1

as full for operational purposes, is not acceptable. The vessel should be rolled from side to side to eliminate entrapped air before taking the final sounding.

2.4.b)3 Empty Tanks:

It is not enough to simply pump tanks until suction is lost. It may be necessary to enter tanks and perform final stripping with portable pumps or by hand. The exemptions are very narrow tanks or tanks where there is a sharp deadrise where the free surface would be negligible. All empty tanks will be inspected by the Ch.M.D.'s surveyor; therefore, all manholes must be open and gas free and well ventilated for safety entry. A flame safety lamp should be on hand to test for sufficient oxygen.

2.4.b)4 Trim Corrections:

In general when sounding tanks, care shall be taken in order to carry out the necessary corrections for the effect of trim.

2.4.b)5 Bilges:

In the engine room, cargo holds and other compartments bilge wells must be dry, to avoid free surface effects while carrying out the test.

2.4.c) Mooring Arrangements:

The mooring arrangement is of a great importance. In order to get accurate readings of the pendulums deviations the mooring arrangement shall not affect the vessel at the time of the readings.

The arrangement selection depends upon many factors. Amongst the most important are: depth of water, wind and current effects.

2.4.c)1 Depth of Water:

The depth of water under the hull should be sufficient to ensure that the hull will be entirely free of the bottom of the sea at all times during the test. The tide conditions, the trim and listing of the vessel must be taken into account.

2.4.c)2 Trim and List:

In order to simplify calculations, the vessel shall be on an even keel or trimmed aft not in excess of 1% LBP (Length Between Perpendiculars), and if the absolute value of the trim "T", i.e. total trim minus designed trim exceeds 0.001 LBP, the Ch.M.D. will require the calculations of hydrostatic data and GZ levers for the actual trim at the test condition.

The vessel should ideally be upright at the time of the test. However, with the inclining weights in the initial position, up to 0.5 degrees of list is permitted. If the list exceeds this, levelling weights may be used to put the vessel in an acceptable condition.

2.4.c)3) <u>Sea Conditions and Currents:</u>

The inclining test shall be carried out in calm weather on smooth water with no currents. The vessel should be moored in a quiet, sheltered area free from extraneous forces such as propeller wash from passing vessels or boats, or sudden discharges from shoreside pumps.

2.4.c)4 <u>Wind:</u>

Ideally the test should be performed with no wind at all but as this condition seldom occurs in practice it is acceptable to perform the experiment with a wind velocity of up to 3 m/s (5.8 knots) if the ship is parallel to the wind direction.

It must be noted however that wind and/or currents may cause a superimposed heeling moment to act on the vessel throughout the test. For steady conditions this will not affect the test results. Gusty wind or uniformly varying wind and/or current will cause these superimposed heeling moments to change, which may necessitate additional test points so as to obtain a valid test. This can be easily realized by plotting the test points as they are obtained on the graph Total Inclining Moments vs. Tan θ which must be performed during the test.

2.4.c)5 <u>Mooring Arrangement 1:</u>

The vessel should preferably be held by lines at the bow and the stern attached at the centerline near dock level.

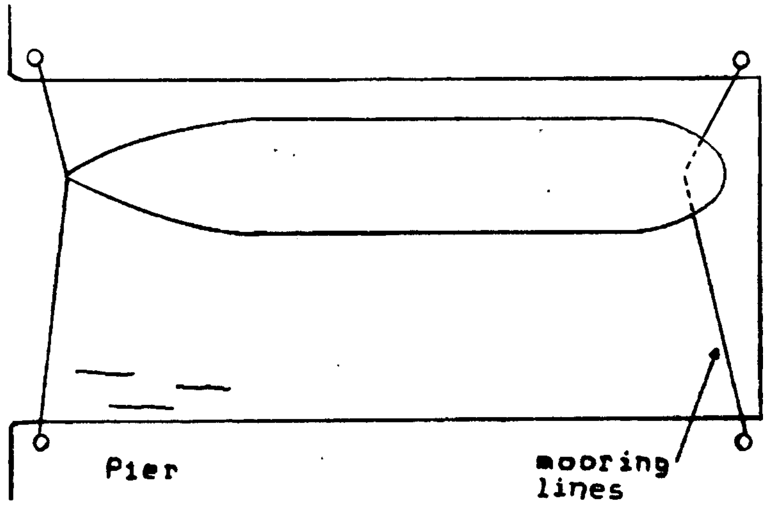


Fig. 2

The preferred arrangement is with the vessel lying in a slip where it can be moored to both sides as shown in Fig. 2. In this case, the lines can be kept taut holding the vessel in place, yet allowing unrestrained heeling. Note, however, that heeling moments due to wind and/or current as described in the subparagraph 2.4.c)4 may affect the readings. Therefore, a careful check of the test points plotted in the graph Total Inclining Moment vs. Tan Θ must be performed.

2.4.c)6 <u>Mooring Arrangement 2:</u>

Where the vessel can be moored to one side only it is generally necessary to supplement the bow and the stern lines with two spring lines in order to maintain positive control of the vessel as shown in Fig. 3. The leads of the spring lines should be as long as is practicable. Cylindrical camels should be provided between the vessel and the dock.

If conditions allow it, all lines should be slack, with

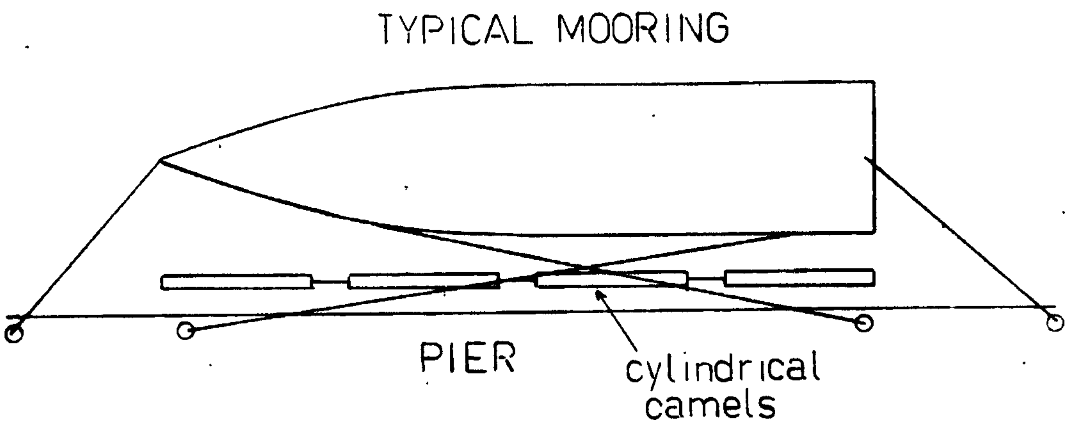


Fig. 3

the vessel free of the pier and the camels, when taking readings. If the vessel is held off the pier by the combined effect of wind and current and the bow and the stern lines are secured at centerline near dock level, they can be taut. This is essentially the same mooring arrangement as described in subparagraph 2.4.c)5, so it must be considered that varying wind and/or current will cause distortions in the graph "M vs. Tan Θ" (see subparagraph 2.4.c)4).

If the vessel is pressed against the camels by wind and/or current, all lines should be slack. The cylindrical camels will prevent binding, but again there will be an unavoidable superimposed moment due to the ship bearing against the camels.

2.4.c)7 <u>Mooring Arrangement 3:</u>

Another acceptable arrangement is where the combined wind and current are such that the vessel may be control-led by only one line at either the bow the stern. In this case the control line need not be attached near dock level, but it should be led from on or near the centerline. With all lines but one slack the vessel is free to veer at the whim of the wind and/or current during readings. This can sometimes be troublesome.

2.4.c)8 Alternate Mooring Arrangements:

Alternate mooring arrangements can also be considered. Such arrangements should ensure that the vessel will be free to list without restraint long enough for the pendulums to damp out the readings to be recorded.

2.4.c)9 Other Lines:

Power and communication lines, hoses, etc.,connected to shore should be removed and those which are unavoidable should be kept slack at all times.

Gangways have to be lifted clear of the vessel.
Accommodation ladders should be in their "at sea" stowed position.
The brow shall be removed.

A floating crane moored by lines to the vessel cannot be used for handling inclining weights.

2.5 ELEMENTS OF THE TEST

Important elements are the test weights to be used to incline the ship and the devices used to measure the tangent of the total angle of inclination "θ".

2.5.a) Test Weights

2.5.a)1 General:

The test weights should be compact and of such a configuration that the vertical centre of gravity of the weights can be accurately determined. Weights such as porous concrete, that will absorb a significant amount of moisture, must be avoided.

Each weight should be marked with an identification number and weight. Each weight should be certified and a copy of the document made available to the Ch.M.D.'s surveyor.

For small vessels, capped oil drums completely filled with water may be used. In such cases, the weight may be weighed in the presence of the surveyor using a recently calibrated scale.

A crane of sufficient capacity or some other means, must be available during the Stability Test to shift weights on the deck in an expeditious manner.

Precautions should be taken to ensure that the decks are not overloaded during weight movements.

The test weights should be on board and in place prior to the scheduled time of the test.

2.5.a)2 Calculation of Test Weights:

The total weight used to incline the ship should provide a maximum total deviation of the pendulums of at least

18 cm. when heeling during the test. The inclination, however, should never exceed 3.5 degrees measured from the upright position. (Total angle of inclination θ).

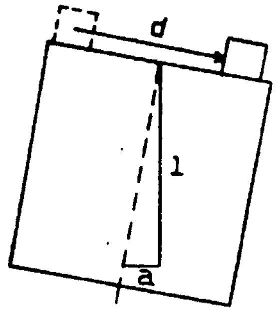


Fig. 4

l = length of pendulum, at least 3 m.
d = weight shifting distance.
a = total deviation, measured from upright position.
θ = total angle of inclination, $\theta<3.5^\circ$.

The calculation of weights w, w1, w3, w4, etc., to be used in the experiment can be made by means of the following equations:

$$w = \frac{GM \tan\theta}{d}$$, if one weight is producing the Inclining Moment.

$$w1 \cdot d1 + w2 \cdot d2 = GM \tan\theta$$, if two weights are producing the Inclining Moment.

The displacement can be obtained by estimating the draught the vessel will have at the time of the test.

GM can be obtained by estimating the KG of the vessel and substracting that value from KM corresponding to the draught the vessel will have at the time of the test.

d, d1, d2, are the weight shifting distances athwartships which are available on deck to move the weights and get the required Total Inclining Moments.

$Tan\theta = \frac{A}{l}$, where A = Total Pendulum Deviation expected.

A is measured from the zero position of the pendulum (upright vessel).

l = length of the pendulums able to be installed on board. "l" should be at least 3 m. in length.

2.5.b) Pendulums

2.5.b)1 General:

Two pendulums should be used to allow for possible bad readings of deviations at one pendulum station. They should be located in an area protected from the wind. If this is not possible, then a screen should be erected around the exposed portions of the pendulums.

The pendulums should be as long as possible. A minimum deviation of 18 cm. at the maximum inclination should be achieved. In order to ensure this deviation without heeling the vessel too far, the pendulums should be at least 3 m. long.

If the rolling period of the vessel (T_φ) at the condition of the test is known, the following pendulum length intervals should be avoided in order to ensure that there is no troublesome synchronism between the oscillations of the pendulums and the vessel:

(i) $\frac{1}{16} T\ell^2 - 0.5\ \text{m} > \text{"l"} > \frac{1}{16} T\ell^2 + 0.5\ \text{m}$

(ii) $\frac{1}{4} T\ell^2 - 0.5\ \text{m} > \text{"l"} > \frac{1}{4} T\ell^2 + 0.5\ \text{m}$

(iii) $T\ell^2 - 0.5\ \text{m} > \text{"l"} > T\ell^2 + 0.5\ \text{m}$

Range (ii) is the most important.

The accuracy of pendulum length measurements should be within + 1 cm.

Fig. 5 on the next page shows a practical arrangement of the pendulum during the test. The pendulums do not have to be on the centerline. The saw horse should be long enough to allow the bucket to be shifted athwartship if contact of the pendulum with the bucket is to be avoided after a weight movement.

To avoid confusion the zero position (upright) and the different readings must be clearly marked in the thin wood batten so that they can be easily recapitulated afterwards. It is also advisable not to throw away the battens until the result of the test has been calculated and found to be satisfactory.

The saw horse must be securely anchored against inadvertent movements.

The battens should be securely tacked in place.

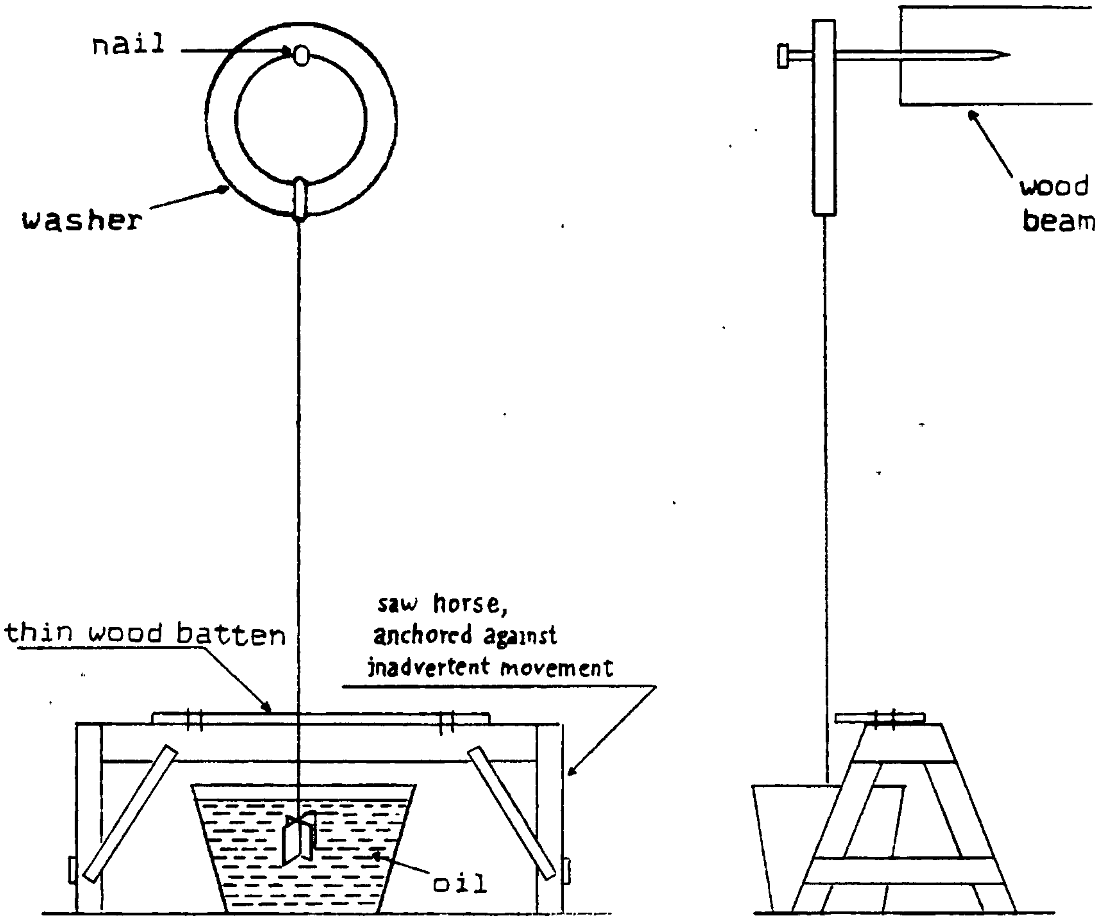


Fig. 5

The arrangement for the pendulums or for the alternative device authorized by the Ch.M.D. shall be in place prior to the scheduled time of the test.

2.5.b)2 <u>Alternative Device:</u>

The Ch.M.D. may approve the arrangement of an alternative device to replace one of the pendulums.
Fig. 6 on the next page shows a possibility of an alternative device to be installed on board which consists of a transparent hose with water inside. The level of the water measured from the zero mark (ship upright),

shows the total deviation to be recorded after every weight movement.

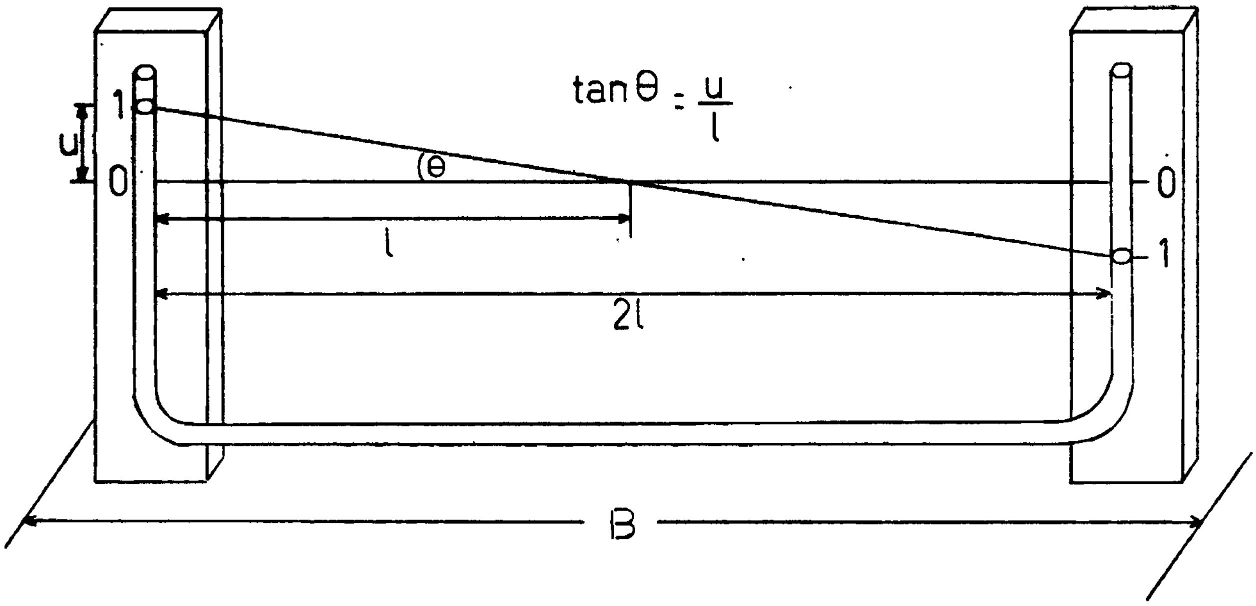


Fig. 6

The material needed to arrange the waterhose device is as follows:

- A transparent plastic hose 1/2 inch diameter. The necessary length of hose is three times the breadth of the vessel.
- 2 pieces of board for marking. The hose is secured to these boards.

2.5.c) <u>Communications Arrangement</u>

One person at a central control station should have complete control over all personnel involved in the test.

There must be efficient two way communication between central control and the weight handlers, between central control and each pendulum station and between the central control and the station on shore in charge of watching that the mooring lines are slack at the time of the readings.

The central control station should be sheltered from the elements and have adequate lighting so that the plot of Total Inclining Moment vs. Tangent of the Total Inclination Angle (M vs. Tanθ) can be made right away after each movement of the weights. It is desirable that the weight handlers be directly observed from the control station.

2.5.d) <u>Equipment to measure Drafts/Freeboards</u>

A small rowing boat should be made available to go to the positions where the drafts and the freeboards are to be measured.

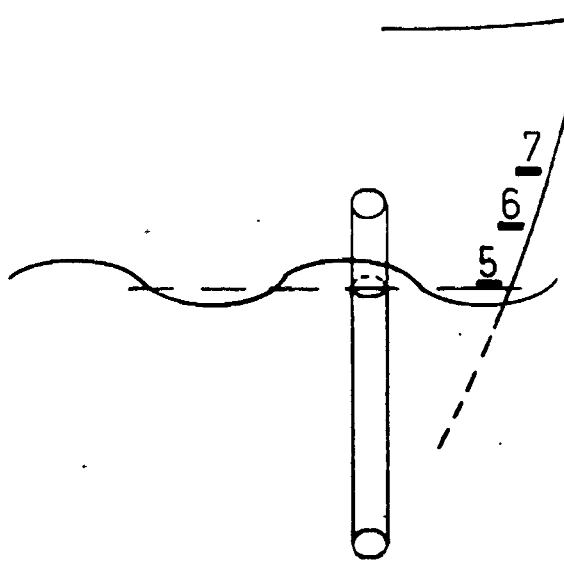


Fig.7

A tubular device with glass against a measuring scale at the upper end should be used to measure drafts in order to minimize the inaccuracies caused by surface waves. A transparent hose 2 inches in diameter can be used as is shown in Fig. 7 for this purpose.

2.6. PERFORMANCE OF THE STABILITY TEST

An Engineer Surveyor of the Ch.M.D. must witness the test and check that everything is arranged and performed in accordance with the instructions set down in this chapter. At the scheduled time of the test everything shall be ready.

The three tasks of the Stability Test should be performed in the following sequence:

First : Initial Walk-Through and Survey.

Second : Draft and Freeboard Readings.

Third : Inclining Experiment.

2.6.a) Initial Walk-Through and Survey

The Professional* in charge of the test should arrive on board the vessel well in advance to ensure that she is properly prepared for the test. Among other things he should check that all compartments are open, clean and dry, tanks are well ventilated and gas free, pendulums are in place, weights are on board at the initial position (vessel upright), a crane or other method for moving weights is available, and the necessary plans and equipment are available.

* See page 13.

It must be understood by the Professional in charge of the test that not having everything arranged will only cause a waste of time and unnecessary delay or could even make necessary to postpone the test. Likewise, if a private crane has been hired it must be used while it is available otherwise this could also impede the test.

Once the Ch.M.D.'s Surveyor has arrived, he and the Professional should check:

2.6.a)1 The Weather Conditions:

The combined effect of wind, current and sea may result in a difficult or even invalid test due to:

- the inability to accurately record freeboard and drafts;

- excessive or irregular oscillations of the pendulums;

- variations in unavoidable superimposed moments.

In some instances, unless conditions can be sufficiently improved by mooring the vessel to a better location, it may be necessary to delay or postpone the test. If these adverse conditions are detected early enough and the weather forecast does not call for improving conditions, the Surveyor should be advised prior to his departure from his office and an alternative date scheduled.

When judging the weather conditions, subparagraphs 2.4.c)4 and 2.4.c)5 should be taken into account and the corresponding data filled in in the Test Report.

2.6a)2 Vessel's Condition:

A quick overall survey of the vessel shall be made to make sure the vessel is complete enough to conduct the test and to ensure that all equipment is in place.

The Chief Engineer of the vessel shall accompany the Surveyor and the Professional in this survey.

All the conditions and instructions regarding the condition of the vessel set down in paragraphs 2.4.a), 2.4.b) and 2.4.c) shall be carefully observed, particularly those regarding tanks and mooring arrangements.

The entire vessel shall be surveyed to identify all surplus and missing weights and those weights which will have to be relocated on the vessel to place it in the lightship condition.

Each weight must be clearly identified and its weight and vertical and longitudinal location on board accurately determined and entered on the special forms of the Test Report.

Among the items to be deducted the test weights and the people on board at the time of the deviation readings must be considered.

It must be remembered that the person working with the Stability Test Report or reviewing it may not have attended the test and must therefore be able to determine the exact location of the items from the data recorded and the vessel's drawings. Any tanks containing liquids must be accurately sounded and registered in the special forms of the Test Report.

It is recognized that the weight of some items on board, or that are to be added, may have to be estimated. If this is necessary, it is in the best interest of safety to be on the conservative side when estimating.

Thus, the following rules of thumb should be followed:

(i) When estimating weights to be added;

- estimate high for items to be added high in the vessel.
- estimate low for items to be added low in the vessel.

(ii) When estimating weights to be removed;

- estimate low for items to be removed from high in the vessel.
- estimate high for items to be removed from low in the vessel.

(iii) When estimating weights to be relocated;

- estimate high for items to be relocated to a higher point in the vessel.
- estimate low for items to be relocated to a lower point in the vessel.

The Tables in the next pages are an example of how to fill in the data on the forms "Items to Deduct", "Items to Add" and "Items to Relocate".

The forms are also part of the Test Report described in paragraph 2.6.d).

ITEMS TO DEDUCT

Item	weight (tons)	vertical c.g.	longitudinal c.g.
test weight 1	3	0.9 m. above main deck.	3.2 m. fwd. frame 32.
test weight 2	3	0.9 m. above main deck..	3.2 m. fwd. frame 32.
2 men	0.14	1 m. above main deck.	frame 40.
pendul.1(total set up and 1man)	0.1	0.8 m. above bottom.	1.1 m. fwd. eng. room bhd.
pendul.2(total set up and 1man)	0.1	0.8 m. above bottom.	frame 46.
Ballast tank 4P. 27 m. sounding.	*	*	*

* Can be determined later from drawings or sounding tables.

ITEMS TO ADD

emerg. generat.	0.9	0.6 m. above main deck.	1.1 m. aft fr. 66
purse seine winch	1.5	0.6 m. above main deck.	1 m. aft deckhouse.

ITEMS TO RELOCATE

item	weight (tons.)	from vert.	from long.	to vert.	to long.
liferaft	0.2	main deck	fr. 60	boats deck	fr. 52
anchor	10	main deck	fr. 63	main deck	fr. 65

2.6.a)3 Tanks:

All empty tanks shall be entered after it has been determined that they are well ventilated and gas free to ensure that they are dry and free of debris. It must also be ensured that any pressed up tanks are indeed full and free of air pockets. All the instructions contained in paragraph 2.4.b) shall be taken into account.

All tanks containing liquid are to be sounded and recorded in order to be able to calculate the free surfaces present at the time of the test.

2.6.a)4 Elements of the Test:

All the instructions regarding the elements of the test, stated in section 2.5, shall be observed.

2.6.a)5 Flooding Opening Locations:

The location of the flooding openings, which must be considered when determining the Flooding Angle (see paragraph 3.2.e), shall be clearly marked on a drawing such as the one shown in Fig. 8 on the next page.

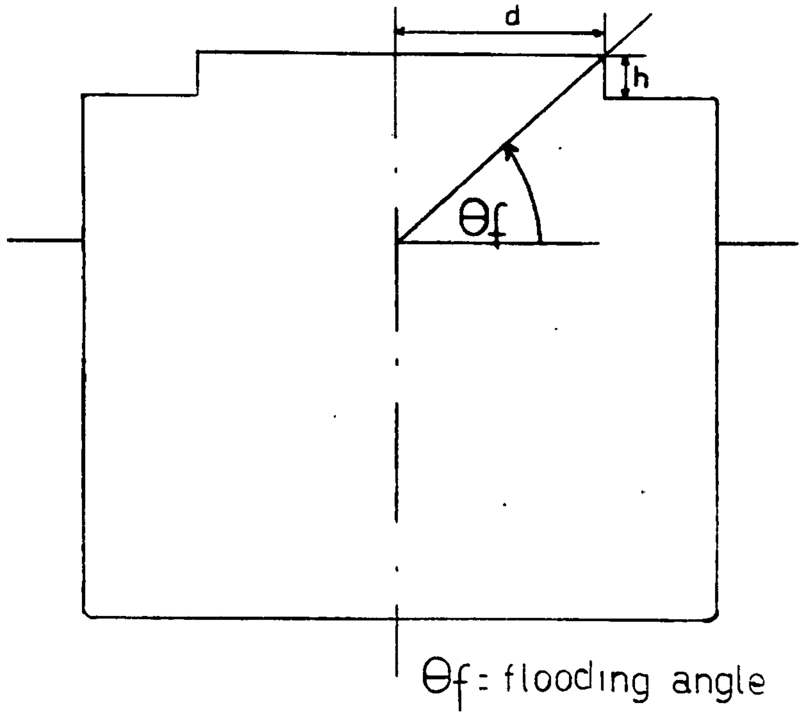


Fig. 8

The drawing shall indicate the height of the opening over the deck and the distance from the centerline to the edge of the opening which will first be in contact with the water when the ship heels.

2.6.b) Draft and Freeboard Readings

The reason for making the freeboard readings is to determine the position of the waterline at the test condition in order to obtain the displacement of the ship from the drawings.

The drafts shall also be recorded in order to check their accuracy by comparing them with the drafts obtained from the drawings after depicting the waterline by means of the freeboard readings.

Draughts and freeboards should be measured to an accuracy of 10 mm.

The equipment described in paragraph 2.4.d) shall be made available.

2.6.b)1 <u>People on Board:</u>

Only the people required to make the pendulum deviation readings may be allowed on board. They shall be in the same position they will be at the time of the readings, this means at the central control station or pendulum stations.

If the Professional or the Surveyor are personally taking the draft and freeboard readings, they should be replaced on board by people around their weight and located in the stations they should be at the time of the deviation readings.

The weight handlers shall not be on board.

2.6.b)2 <u>Readings:</u>

The location of draft marks forward and aft shall be clearly marked on the sketch in the special draft forms for the Stability Test Report.

Likewise, the location of the freeboard readings shall be indicated in the forms.

Fig. 9 shows the way to indicate location of draft and freeboard readings.

Draft and freeboards should be read to an accuracy of 10 mm.

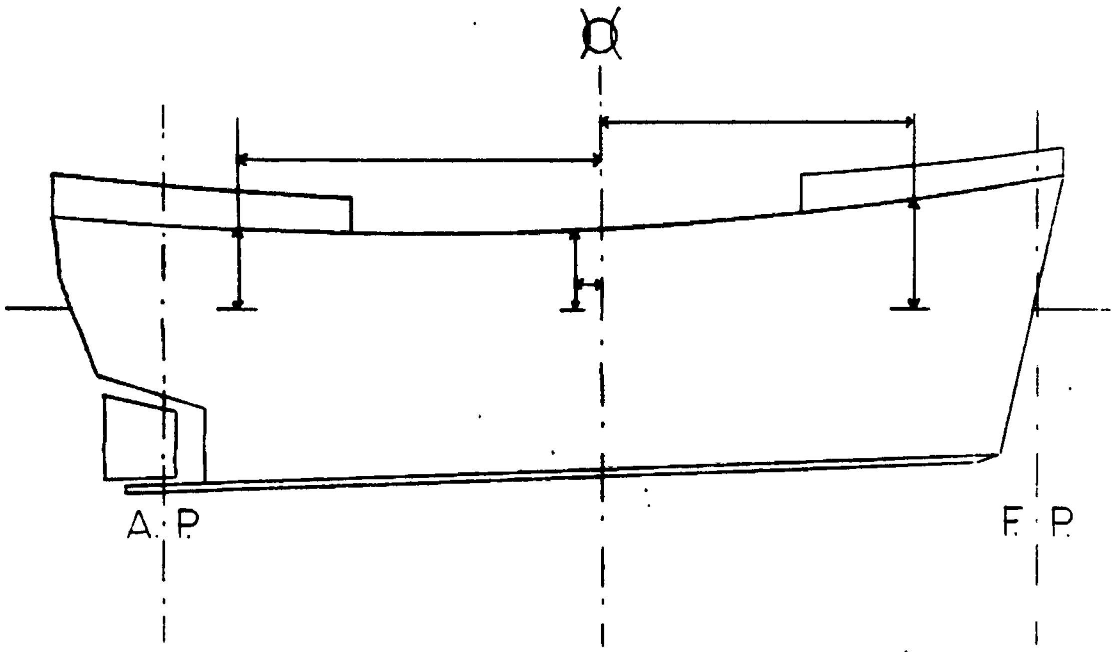


Fig. 9

The readings of drafts and freeboards should be taken at the bow, stern and amidships. The Surveyor may ask for additional intermediate freeboard measurements, it is recommended that at least 5 readings, approximately equally spaced, be taken on each side of the vessel.

Before commencing, the locations for the readings should be selected and clearly marked. The longitudinal location along the vessel must be accurately determined and recorded since the moulded depth at each point will be obtained from the lines drawing.

The mooring lines shall be slack so that the vessel floats freely.

The dimensions given on a vessel's lines drawing are moulded dimensions. The moulded depth "Dm", means the distance from the inside of the bottom shell to the inside of the deck plate.

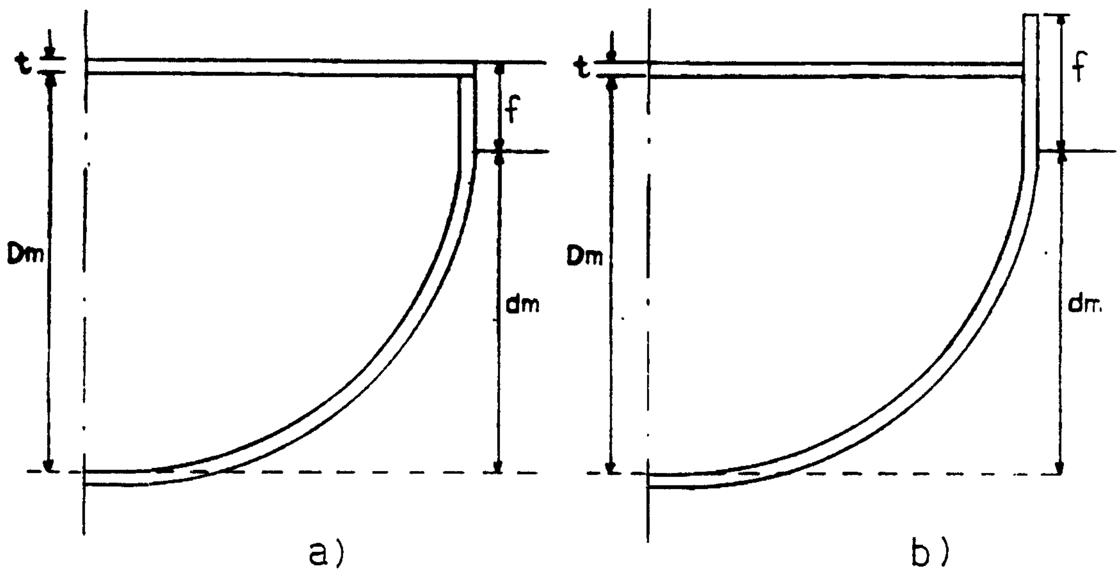


Fig. 10

In Fig. 10 a) it can be appreciated that the moulded draft "dm" is given by the equation:

$$dm = Dm + t - f$$

In Fig. 10 b) it can be appreciated that the moulded draft "dm" is given by the equation:

$$dm = Dm + t + b - f$$

where:

Dm = moulded depth (from lines drawing)

dm = moulded draft

f = freeboard reading

t = deck thickness
b = bulwark height

The freeboard readings and corresponding moulded drafts shall be recorded on the sketch shown below for each location of reading. The point "K" shall be defined in the hydrostatics.

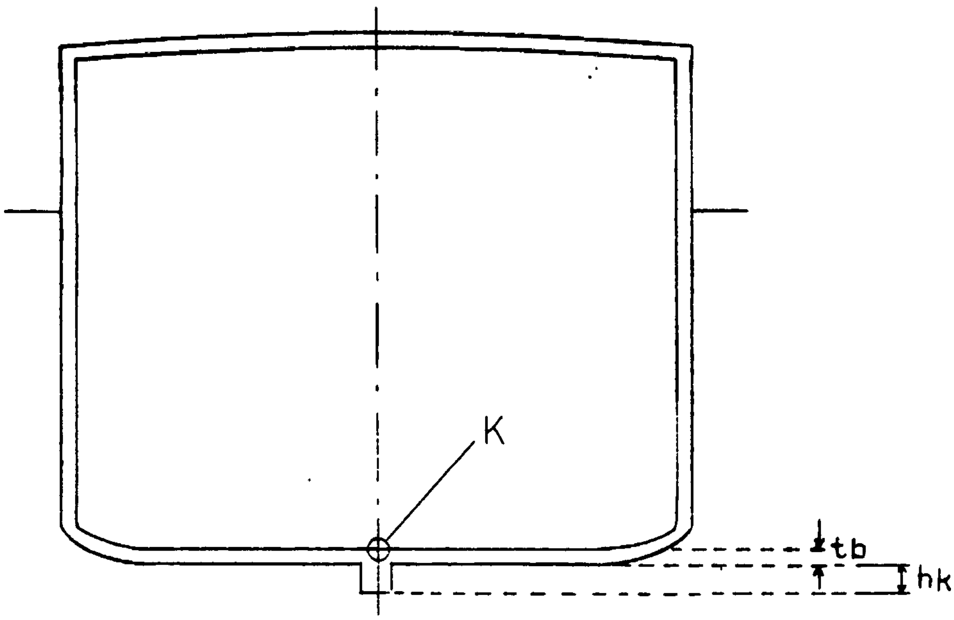


Fig. 11

The draft marks readings (average of port and starboard) shall also be transformed into moulded draft by deducting the bottom plate thickness "tb" and the keel height "hk"

$$dm = draft - tb - hk$$

2.6.b)3 Plotting of the Waterline:

Once the moulded drafts have been obtained for each location of reading the vessel's waterline shall be plotted on the lines drawing. In order to do this, the mean draft (average of port and starboard readings) shall be calculated for each location.

The plotting must be made in order to detect immediately the consistency of the result, in other words to check if the readings are satisfactory. If they are found to be wrong new readings will have to be made.

The plotting of the mean draft should yield either a straight line or a waterline which is either hogged (‿) or sagged (⁀).

Once the waterline is drawn, the draft marks readings should be plotted as a check on their accuracy. If the draft marks are in error, they should be corrected accordingly.

From the waterline the mean draft can be easily determined and through the hydrostatic curves of the ship the displacement can be obtained. This must be carefully done, checking if the mean draft of the hydrostatics is measured from the base line or from the keel. The position of the point "K" in the hydrostatics must also be considered.

2.6.b)4 <u>Specific Gravity of the Flotation Water:</u>

The specific gravity of the flotation water shall be determined. The best way to do this is by obtaining a sample. Then, by means of the hydrometer the specific gravity of the water can be read and recorded.

As the specific gravity fluctuates with the distance to the water surface it is advantageous to obtain the sample at half of the water depth.

2.6.b)5 Displacement at the Test Condition:

The displacement of the ship during the test condition shall be registered in the special form of the Test Report. The corresponding corrections for shell, trim, sagging/hogging, and specific gravity of water shall also be made and indicated in the Test Report.

2.6.c) The Inclining Experiment

2.6.c)1 Length of the Pendulums:

The length of the pendulums shall be measured and recorded. The length of the pendulums shall not be less than 3 m. (see paragraph 2.5.b). The pendulums should be aligned so that when the vessel heels, the line will be close enough to the batten to ensure an accurate reading but it will not come in contact with the batten.

2.6.c)2 Marking of the Zero Position:

The Inclining Experiment shall start with the marking of the zero position (upright vessel) in the thin wood battens where the pendulum deviations will be marked (see Fig. 5). The order to mark will be given by the central control stations when the ship is completely upright, floating freely with slack mooring lines.

At the time of marking the zero position the weight handlers must not be on board. Only the necessary people at the central control station and pendulum control stations will be allowed on board.

Prior to the marking of the zero position the station on shore watching the mooring lines will report to the control station that they are slack. Likewise, each pendulum station will report to the control station when its pendulum has stopped swinging. The control station will then verify that the ship is upright and will give the order to mark.

When the command "mark" is given, the battens at each pendulum station must be simultaneously marked at the point where the wire of the pendulum has stopped. If the wire keeps oscillating slightly between two definite points separated by not more than 30 mm., the centre of the distance between those two points should be taken as the mark.

If any one of the pendulum readers does not think the marking was good, he should advise the control station and the zero point should be retaken for both pendulum stations.

Once the zero position has been marked the remainder of the experiment should be performed as quickly as possible in order to minimize the possibility of changing environmental conditions during the test.

2.6.c)3 <u>Arrangement and Movements of Weights:</u>

The initial position of the weights shall be marked on the deck. This can be done by tracing the outline of the weights on the deck with chalk.

Each weight movement must be made transversely so as not to change the trim of the vessel.

The total angle of inclination θ, measured from the centerline, shall be between 1 and 3.5 degrees after every movement, except for those movements made to come back to the zero position since for upright ship θ=0.

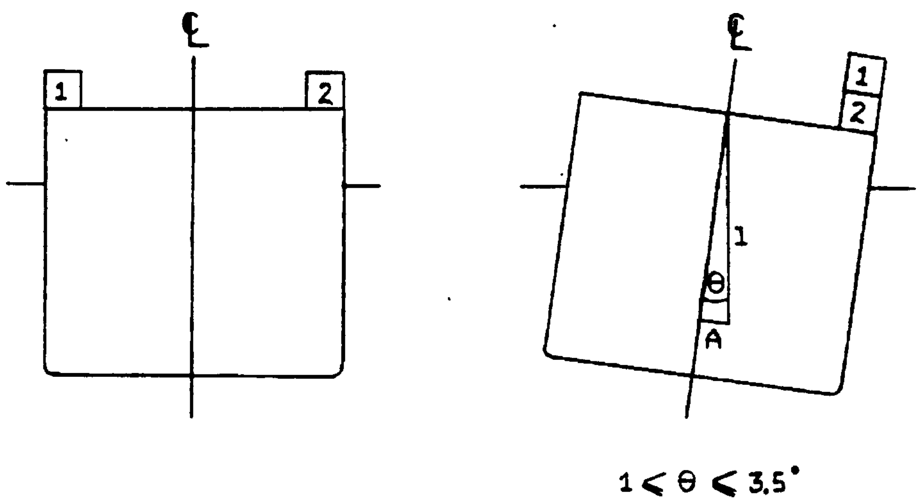


Fig. 12

At least three movements with θ between 1 and 3.5 degrees shall be performed on each side of the vessel, without counting the movements performed to come back to and check the zero position.

The three minimum movements on each side shall be plotted in the graph Total Inclining Moment vs. Tanθ approximately as indicated in Fig. 18.

Intermediate movements of weight to come back and check the zero position shall be performed if the Ch.M.D.'s surveyor deems it necessary.

The following Figs. 13 to 17 show the different weight arrangements which can be chosen for the initial position (upright vessel) and marking of the zero position in the pendulum battens.

Arrangement with 1 weight:

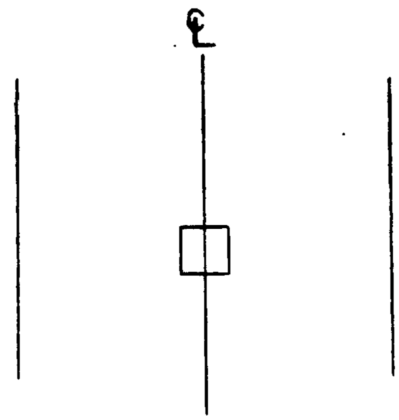


Fig. 13

Arrangement with 2 weights:

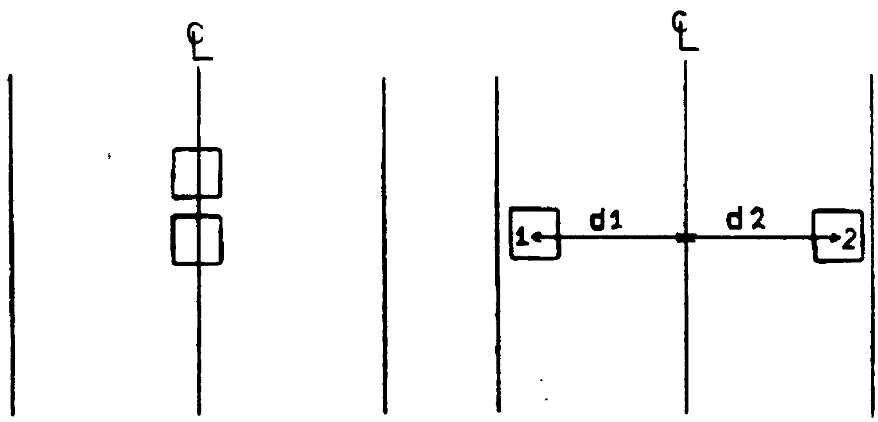


Fig. 14

Arrangement with 3 weights:

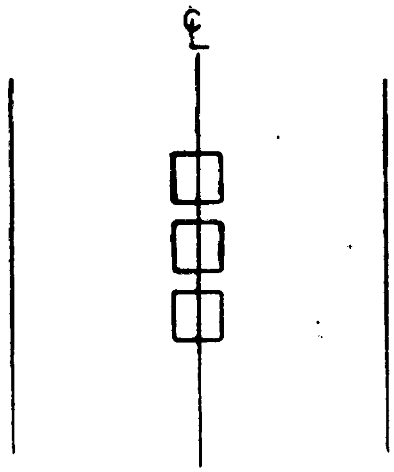


Fig. 15

Arrangement with 4 weights:

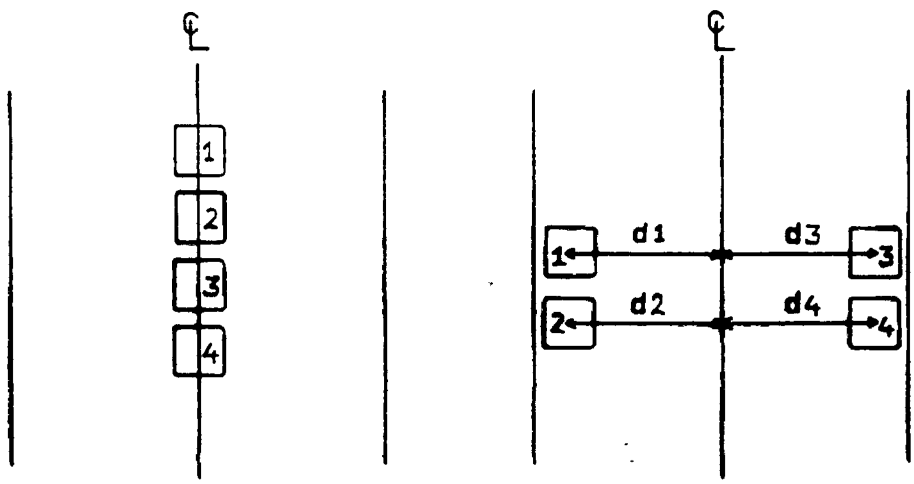


Fig. 16

Arrangement with 6 weights:

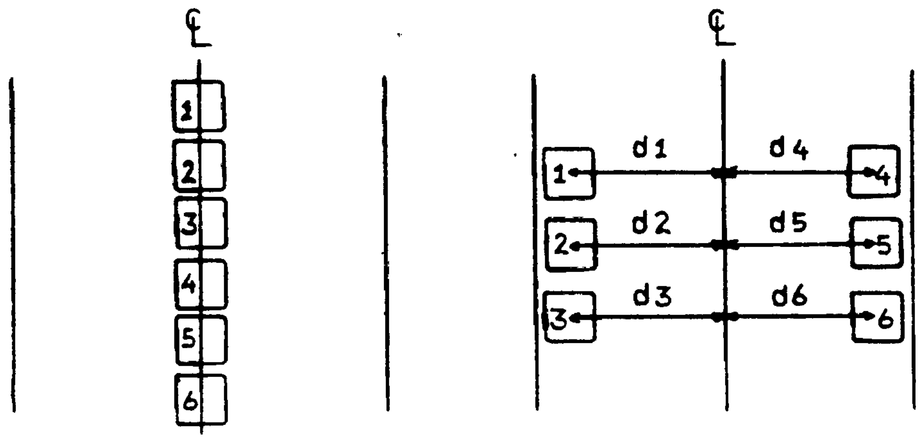


Fig. 17

The weights and their arrangement should be chosen after careful study of the inclining moments which are required to be produced during the Inclining Experiment. How to calculate the required weights is explained in paragraph 2.4.a).

It must always be kept in mind that at least three total inclining moments are to be produced on each side of the ship and they must be plotted in the graph "M vs. Tanθ" as shown in Fig. 18.

2.6.c)4 <u>Marking of Pendulum Deviations:</u>

At the time of marking the pendulum deviations the weight handlers shall not be on board, only the necessary people in the central control station and the pendulum stations will be allowed on board.

Prior to the marking of the pendulum deviations the station on shore watching the mooring lines will report to the control station that lines are slack. Likewise, each pendulum station will report to the control station when its pendulum has stopped swinging. The control station will then give the "mark" command.

When the order is given, the batten at each pendulum station must be simultaneously marked at the point where the wire of the pendulum rests. If the wire keeps oscillating slightly between two points separated by a distance not greater than 30 mm., the centre of that distance should be taken as the mark.

If anyone of the pendulum readers does not think the marking was a good one, he should advise the control station and the mark for that reading should be retaken at both pendulum stations.

2.6.c)5 Reading of Pendulum Deviations:

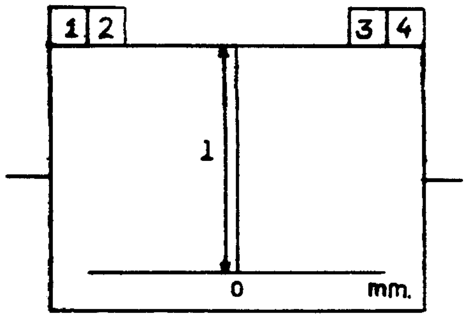
After a movement of weights has been made and the corresponding deviation has been marked, the reading of the total deviation "A" and the partial deviation "a" corresponding to that movement shall be registered. The Example Schema of Weights Movements in pages 57 and 58 illustrates these concepts.

It must be noted that Starboard deviations shall be considered positive and Port deviations shall be considered negative.

i) Total deviation of the pendulum, "A":

Is the deviation of the pendulum measured from the zero position (upright vessel).

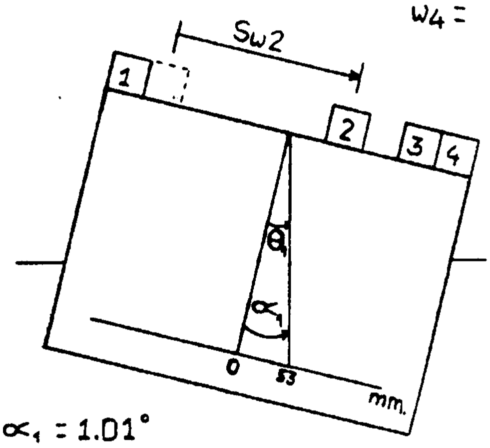
EXAMPLE SCHEMA OF WEIGHTS MOVEMENTS AND DATA TO RECORD



$l = 3000$ mm.
$w_1 = 2.8$ T
$w_2 = 2.8$ T
$w_3 = 2.8$ T
$w_4 = 2.8$ T

Initial Position

$a_0 = 0$	$A_0 = 0$
$\alpha_0 = 0$	$\theta_0 = 0$
$m_0 = 0$	$M_0 = 0$



$\alpha_1 = 1.01°$
$\theta_1 = 1.01°$

Movement 1

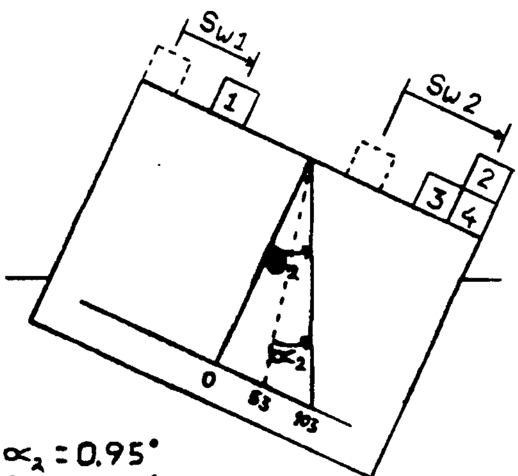
$a_1 = 53$ mm. $A_1 = 53$ mm.

$\tan\alpha_1 = 53/l$ $\tan\theta_1 = 53/l$

$\tan\alpha_1 = .0177$ $\tan\theta_1 = .0177$

$S_{w2} = 2.3$m $m_1 = 2.8 \times 2.3 = 6.44$Tm

$M_1 = 6.44$Tm



$\alpha_2 = 0.95°$
$\theta_2 = 1.97°$

Movement 2

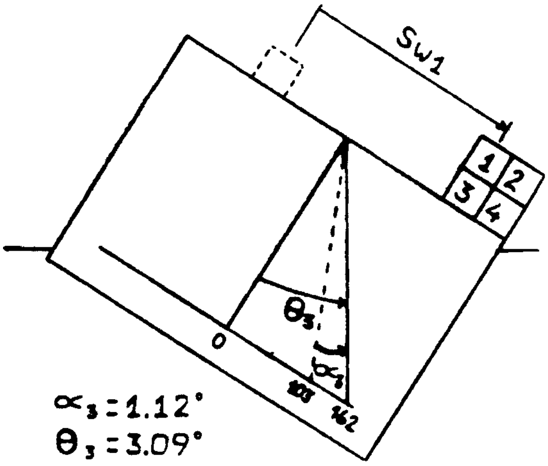
$a_2 = 50$ mm. $A_2 = A_1 + a_2 = 103$ mm.

$\tan\alpha_2 = 50/l$ $\tan\theta_2 = 103/l$

$\tan\alpha_2 = .0167$ $\tan\theta_2 = .0343$

$S_{w2} = 1.2$m $m_2 = 2.8 \times 1.2 + 2.8 \times .96 = 6.05$Tm

$S_{w1} = .96$m $M_2 = M_1 + m_2 = 12.49$Tm



Movement 3

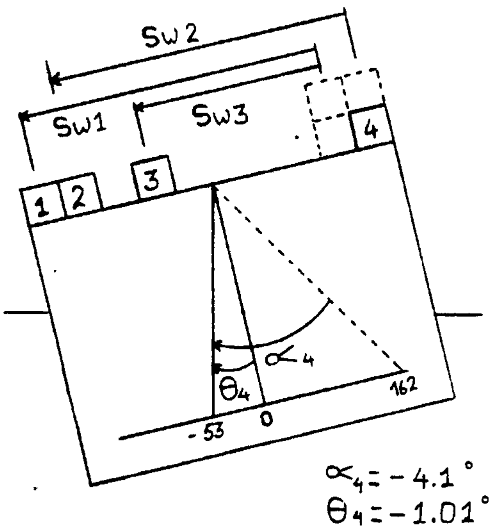
$a_3 = 59$ mm. $A_3 = A_2 + a_3 = 162$ mm.

$\tan\alpha_3 = 59/1$ $\tan\theta_3 = 162/1$

$\tan\alpha_3 = .0197$ $\tan\theta_3 = .0540$

$S_{w1} = 2.54$m $m_3 = 2.8\times 2.54 = 7.11$Tm

$M_3 = M_2 + m_3 = 19.6$Tm



Movement 4

$a_4 = -215$ mm. $A_4 = A_3 + a_4 = -53$ mm.

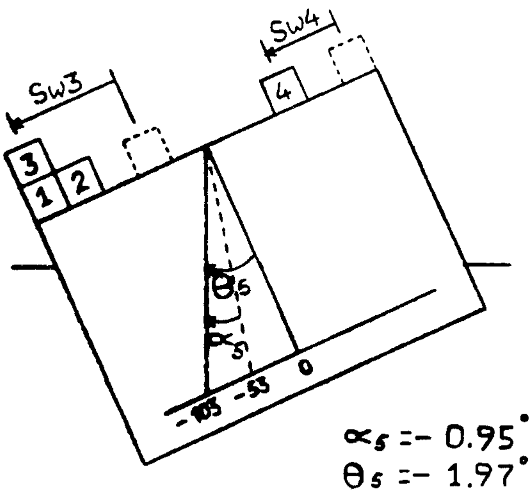
$\tan\theta_4 = .0177$

$S_{w1} = -3.5$m $m_4 = -2.8\times 3.5 - 2.8\times 3.5 - 2.8\times 2.3$

$S_{w2} = -3.5$m $m_4 = -26.04$Tm

$S_{w3} = -2.3$m

$M_4 = M_3 + m_4 = -6.44$Tm



Movement 5

$a_5 = -50$ mm. $A = A_4 + a_5 = -103$ mm.

$\tan\theta_5 = -.0343$

$S_{w3} = -1.2$m $m_5 = -2.8\times 1.2 - 2.8\times .96 = -6.05$Tm

$S_{w4} = -.96$m

$M_5 = M_4 + m_5 = -12.49$Tm

ii) Partial deviation of the pendulum, "a":

Is the deviation of the pendulum measured from the previous position of the pendulum, in other words it is the deviation measured from the position the pendulum had at the previous movement.

The example schema of weights movements on pages 57 and 58 shows clearly the difference between the two concepts, total and partial deviations.

2.6.c)6 Data Recording after every Movement:

The following data shall be registered immediately after every movement of weights in the special form of the Test Report. In order to illustrate how this must be done the data of the example schema of weight movements from pages 57 and 58 has been registered in the example sheet of data records shown on page 61.

i) Partial deviation of the pendulum, "a":

Defined in the previous sub-paragraph.

ii) Total deviation of the pendulum, "A":

Is the deviation of the pendulum measured from the zero position (upright vessel).

iii) Total angle of inclination, "Θ":

Is the inclination angle of the vessel measured from the centerline and is positive when the ship heels to starboard and negative when the ship heels to port side.

The angle "θ" corresponding to every movement shall be neither less than 1 degree nor more than 3.5 degrees.

The angle "θ" shall not be confused with the angle "α", which is the partial angle of inclination after every movement. There is no need to register the angle "α". The example schema of weights movements on pages 57 and 58 includes the angle "α" just to clarify the difference between the angles "θ" and "α".
It can be noted in the schema that "α">3.5° for movement 4. This has no importance at all since the requirement is for "θ" to be between 1 and 3.5 degrees.

iv) Tangent of the total inclination angle, "Tanθ":

Is the value of A/l, where "l" is the length of the pendulum. This value shall be plotted in the graph "M vs. Tanθ" after each single movement, and shall be positive when the ship heels to starboard side and negative when she heels to port side.

The value of Tanθ shall be registered with four decimals.

v) Weight shifting distance, "Sw":

Is the distance a specific weight "w" has been moved in order to produce an inclining moment on the vessel.

INCLINING EXPERIMENT DATA RECORD

vement θ°	Weight "W" Tonn.	Shift. dist. Sw m.	Partial moment m Tm.	Total mom. M= Σm	Pendulum 1, l_1 = 3000 mm. Part. dev. a mm.	Total dev. A= Σa	$Tan\theta_1$ A/l_1	Pendulum 2, l_2 = mm. Part. dev. a mm.	Total dev. A= Σa	$Tan\theta_2$ A/l_2	Average Tangent Tanθ
≤θ≤3.5°	(1)	(2)	(1)X(2)				**			**	**
1.01°	w_2=2.8	Sw_2= 2.3	6.44	6.44	53	53	0.0177				
1.97°	w_2 = 2.8 w_1 = 2.8	Sw_2 = 1.2 Sw_1 = 0.96	6.05	12.49	50	103	0.0343				
3.09°	w_1 = 2.8	Sw_1 = 2.54	7.11	19.6	59	162	0.0540				
-1.01°	w_1 = 2.8 w_2 = 2.8 w_3 = 2.8	Sw_1 = -3.5 Sw_2 = -3.5 Sw_3 = -2.3	-26.04	- 6.44	-215	- 53	-0.0177				
-1.97°	w_3 = 2.8 w_4 = 2.8	Sw_3 = -1.2 Sw_4 = -0.96	- 6.05	- 12.49	- 50	-103	-0.0343				

Movement of weights to starboard means positive "a", "Sw" and "m".
Angle of inclination to starboard means positive "θ", "A", "M" and "Tanθ".

Tanθ with four decimals.

"Sw" represents the arm of the inclining moment "m" and it is positive when the weight "w" has been shifted to starboard and negative when the weight "w" has been shifted to port. If more than one weight has been moved to produce a partial moment "m", the shifting distance "Sw" corresponding to each moved weight shall be recorded (see movement 4 of the example schema of weight movements on page 58).

vi) Partial inclining moment, "m":

Is the partial inclining moment imposed on the vessel after a single movement of one or more weights. It is positive when the vessel is inclined to the starboard side and negative when the vessel is inclined to port side.

vii) Total inclining moment, "M":

Is the total moment causing the vessel to heel "θ" degrees.
"M" is positive when it heels the ship to the starboard side and negative when it heels the ship to port side.
The value of "M" shall be plotted on the graph "M vs. Tanθ" after each movement of weights.

2.6.c)7 <u>The Graph "M vs. Tanθ":</u>

The plotting of results after every movement shall be run to ensure that acceptable data is obtained. In order to do this every movement shall be depicted in the graph Total Inclining Moment "M" vs. Tangent of the Total Inclination Angle "θ".

At least three points shall be plotted on each side of the ship as it is shown in Fig. 18.

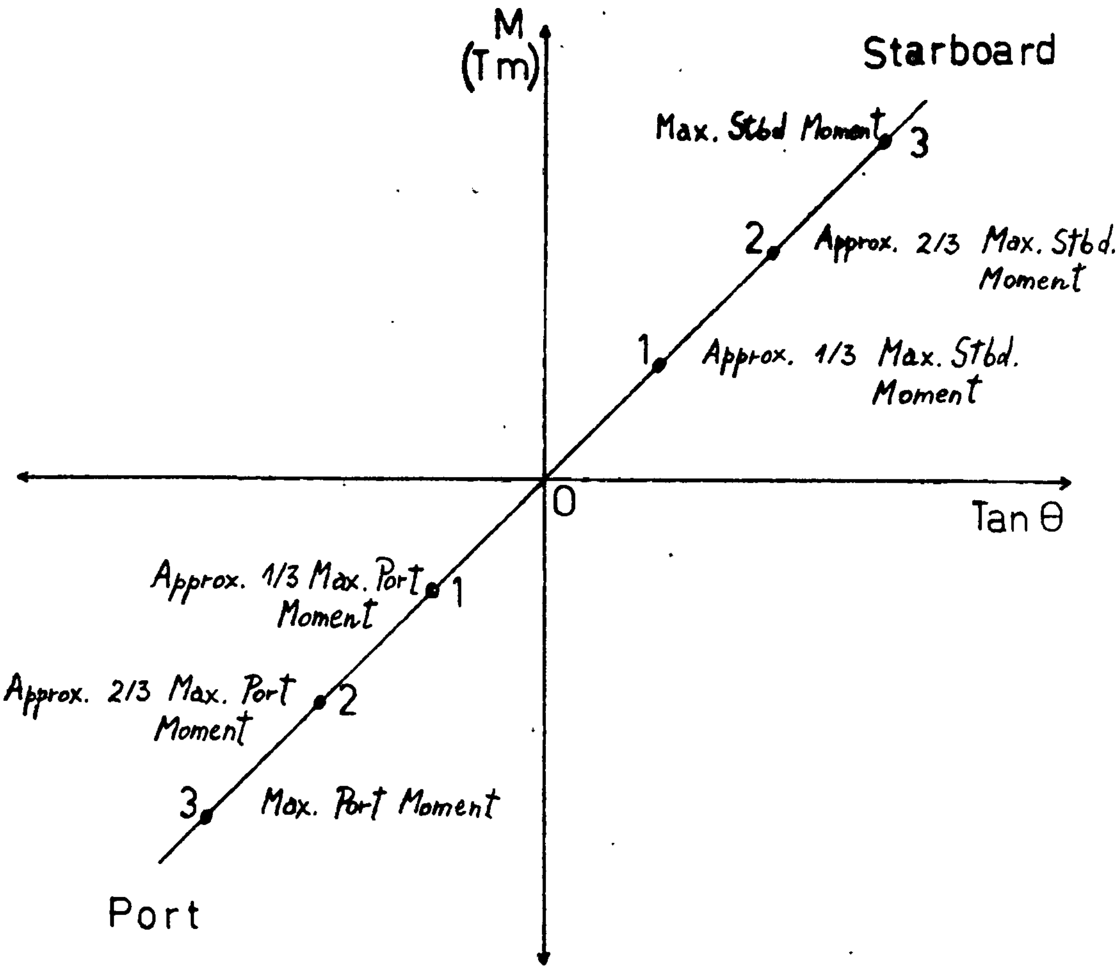


Fig. 18

If one or more of the points on the graph are not plotted on a straight line through origin with accuracy within 4% the reason should be found and the experiment should be repeated until a minimum of three satisfactory points on each side of the vessel are obtained.

The advantage of plotting the points right away after every movement is that it is possible to easily confirm the linearity of the relationship M/Tanθ. This allows the people working in the experiment to immediately realize when something is going wrong.

As is shown in Fig. 18 Moment 1 and Moment 2 should be approximately 1/3 and 2/3 of Moment 3 respectively. Moment 3 is the maximun moment to starboard.
Likewise Moment 4 and Moment 5 should approximately be 1/3 and 2/3 of Moment 6 respectively. Moment 6 is the maximum moment to port.

The values for Tanθ registered in the graph shall be the average between tanθ obtained at pendulum station 1 and tanθ obtained at pendulum station 2.

Point zero on the graph represents the Initial Position of the test weights (M=0; θ=0). If the Ch.M.D.'s Surveyor deems it necessary the zero position shall be rechecked at anytime of the experiment. For this purpose the weights should be rearranged at their initial position at any intermediate stage during the experiment.

If for some reason it is not possible to relocate the weights at their exact initial position the remaining moment "M" and Tanθ should be plotted at their actual position on the graph.

If after coming back to the exact Initial Position of the test weights it is found that the pendulums do not come back to the original zero mark in the battens, the cause shall be determined and the experiment reinitiated in order to get accurate points in the graph.

2.6.c)8 <u>Calculation of GM:</u>

The calculation of GM shall be made by means of the graph M/Tanθ with the following equation:

i) $$GM = \frac{AB}{\Delta \cdot BC}$$

where Δ=displacement of the ship.

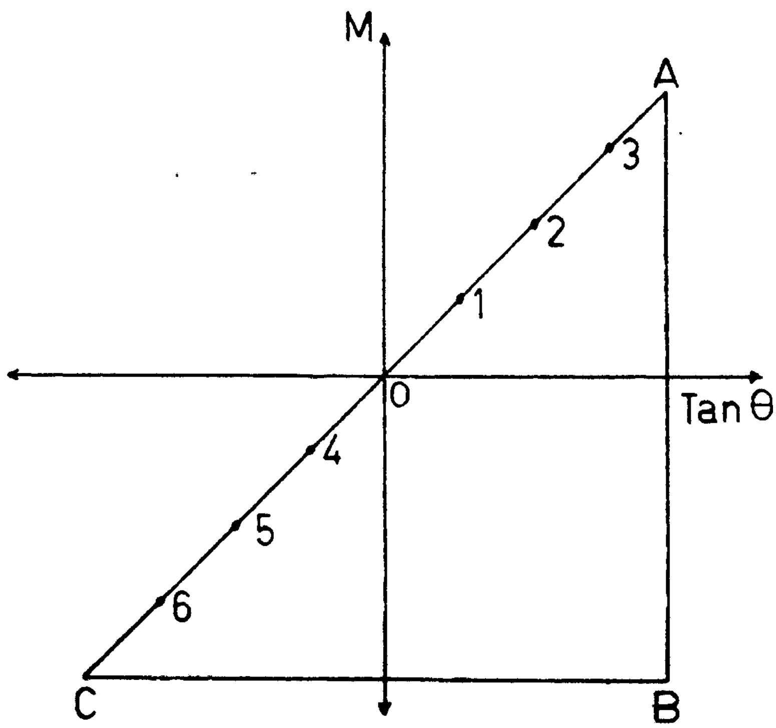


Fig. 19

Fig. 19 illustrates the use of the graph to get the values of the distances $\overline{AB}$ and $\overline{BC}$. The relationship $\overline{AB}/\overline{BC}$ is equivalent to the relationship M/Tanθ.

Adequate scales should be selected for M and Tanθ in the graph paper (millimetric paper).

Commonly two approaches have been used to calculate GM at the Inclining Experiment. They are the following:

$$\text{ii) } GM = \frac{\sum \frac{m\ l}{\Delta \cdot A} = \frac{m}{\Delta \cdot \tan\alpha}}{n} \qquad \text{iii) } GM = \frac{\sum \frac{M\ l}{\Delta \cdot A} = \frac{M}{\Delta \cdot \tan\theta}}{n}$$

The equation ii) calculates GM by using the partial inclining moments "m" and the partial deviations "a".

The equation iii) calculates GM by using the total inclining moments "M" and the total deviations "A", see subparagraphs 2.6.c)5 and 2.6.c)6.

Both equations should arrive at the same results since (m/a)=(M/A). However in practice they often give different values for GM. This problem arises from the fact that in the field it is sometimes difficult to record the data with optimum accuracy. In particular it has been noted that the small values of "A" are more difficult to read accurately.

This is due to the fact that the conditions at the test are usually not as ideal as is expected and the deviation readings are taken as the average distance between two points around which the pendulum is swaying (see Fig. 20).

In order to avoid small "A" readings, the angle of inclination "θ" shall never be less than 1 degree.

Anyway, the calculation of GM by means of the equations

ii) and iii) shall also be included in the special form of the Test Report as a reference since the GM values

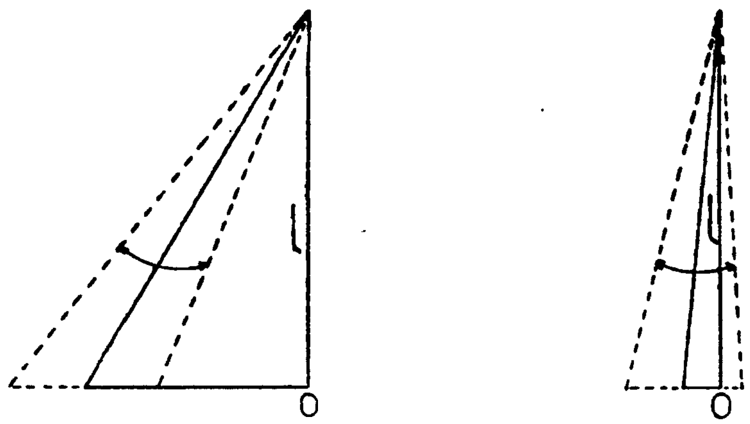


Fig. 20

they give help to realize which are the points out of the relationship M/Tanθ. This makes it easier to draw and analyze the graph.

When doing this it must be noted that by working with the m/a relations (equation ii) it is possible to get a GM value for the movements made to come back to the zero position, while by working with the M/A relations (equation iii) this is not possible since at the zero position M=0 and A=0.

However, the final and valid value for GM at the test shall be the one calculated through equation i), by means of graph M vs.Tanθ.

It must be understood that in the graph M vs.Tanθ both, the m/a and the M/A relationships are represented. Fig. 21 shows the graph corresponding to the schema of weight movements on page 57.

The graph is easily made by registering the M/Tanθ values after every movement and just by doing this the

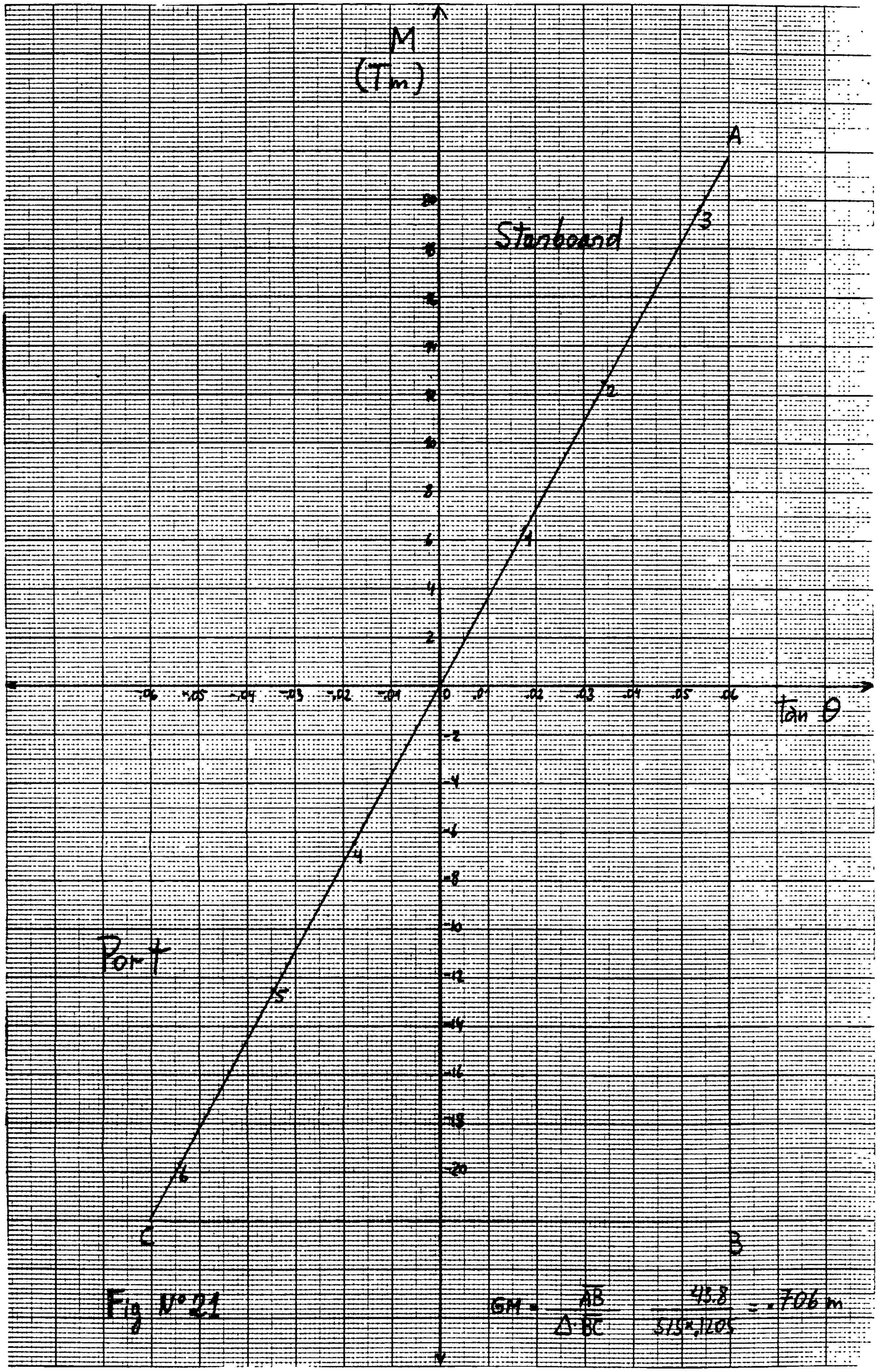

M
(Tm)
A
Starboard
3
2
1
0
4
5
6
Port
C
B
tan θ
-.06
-.05
-.04
-.03
-.02
-.01
.01
.02
.03
.04
.05
.06
2
4
6
8
10
12
14
16
18
20
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
GM = AB / (Δ·BC) = 43.8 / (515×.1205) = .706 m

Fig N° 21

m/TanΘ values are simultaneously recorded. To make it clear it is helpful to check a couple of movements. For example, from point 2 (M_2=12.49Tm; TanΘ_2=.0343) just by adding the partial moment m_3=7.11Tm and the tangent of the partial inclination angle Tanα_3=.0197, point 3 is obtained.

In the same way by deducting m_4 and Tanα_4 from point 3, point 4 is obtained.

So, graph "M vs.TanΘ" not only represents exactly how the different moments incline the vessel during the experiment but also allows the easy calculation of GM, taking into account both the m/a and M/A relationships.

Corrections to GM: The GM value shall be corrected for free surfaces if they affect the vessel at the time of the experiment (see paragraph 3.2.f). This correction shall be included in the Test Report.

Finally, if the value of GM obtained at the time of the experiment does not fulfil the applicable stability criteria considered in Chapter 3 or it is expected that in some of her service conditions the ship may not eventually fulfil the criteria, the ship shall not be allowed to sail until the complete Stability Booklet, as described in Chapter 3, has been approved by the Ch.M.D.

2.6.d) <u>The Stability Test Report</u>

The Stability Test Report shall be submitted in triplicate by the Professional in charge of the test to the Ch.M.D.

The Stability Test Report shall include all the stability information of the ship at the test and lightship conditions with a table showing clearly compliance to the relevant intact stability criteria for both conditions.

A scale section drawing showing the flooding angle corresponding to the test and lightship draughts shall be part of the test report.

2.6.d)1 Chilean Standard Forms for the Test Report:

The Test Report shall include the following information, in accordance with the provisions of Chapter 1:

- Hull Form Drawing (Body Plan)
- Hydrostatic Data
- Stability Levers GZ
- Volume, Centre of Gravity and Free Surface Moment of cargo holds and tanks for various loading conditions, including the volume of hatchways in fully loaded condition.

The following forms, which are shown in pages 72 to 89, shall be included:

1. Stability Test General Data, page 1.
2. Stability Test General Data, page 2.
3. Items to Add
4. Items to Deduct
5. Items to Relocate
6. Tanks Sounding and Freesurfaces at the Test.
7. Draft Readings
8. Freeboard Readings (shell plating)
9. Freeboard Readings (wooden hull)

10. Location of Flooding Openings
11. Displacement at the Test Condition
12. Schema of Weight Movements
13. Inclining Experiment Data Record
14. Graph M vs.Tanθ
15. Calculation of GM
16. Ship at the Test Condition
17. Calculation of Lightweight Condition
18. Draughts and Trim Lightweight Condition

The Ch.M.D.'s Surveyor will also fill in the forms 1 to 16 at the time of the test. These forms shall be taken into account when reviewing the Stability Test Report submitted by the Professional in charge of the test.

Furthermore, the Test Report will include the following additional information:

- Flooding Angle at the Test condition

- GZ curve at the Test condition

- Table showing compliance with the relevant intact stability criteria at the Test condition.

- Flooding Angle at the Lightweight condition

- GZ curve at the Lightweight condition

- Table showing compliance with the relevant intact stability criteria at the Lightweight condition.

FORM 1

page 1

STABILITY TEST GENERAL DATA

Owner (name and adress): ....
....
....
Shipyard: ....
....
Yard Number and Vessel's name: ....
Year of building: ....
Signal letters: ....
Gross Tonnage: .... Net Tonnage: ....
Class Notation: ....
For existing ships the reason for the new test should be stated: ....
....
....
Date and place of the test: ....
Time commenced: .... Time completed: ....
Mooring arrangement during test (sketch):

Weather: .... Sea: ....
Wind: .... Current: ....
Sea water specific gravity: ....
Sea water temperature: ....
Professional in charge (name, adress and phone number): ....
....
....
Surveyor of the Ch.M.D.: ....

FORM 1

page 2

STABILITY TEST GENERAL DATA

Main dimensions:

Registered Length (Length accord. 1966 Loadlines Convention): ....m
Length overall: L.O.A.: ....m
Length between perpendiculars: L.B.P.: ....m
Moulded breadth midship: Bm: ....m
Moulded depth midship: Dm: ....m
Trim at design waterline betw. A.P. and F.P. (rake of keel): ....m
Length of weathertight enclosed superst. betw. A.P. AND B.P.: ....m

Last alteration of the length (year): ....
....
Last other alteration (year): ....
....
Permanent ballast (tonnes): ....

Special notations:...
....
....
....
....
....
....

Sister ship (Yard Number, name and signal letters):

1) ....
2) ....
3) ....

FORM 2 ITEMS TO ADD

ITEM	weight (tonnes)	VERTICAL C.G.	LONGIT. C.G.

FORM 3 ITEMS TO DEDUCT

ITEM	weight (tonnes)	VERTICAL C.G.	LONGIT. C.G.

FORM 4 ITEMS TO RELOCATE

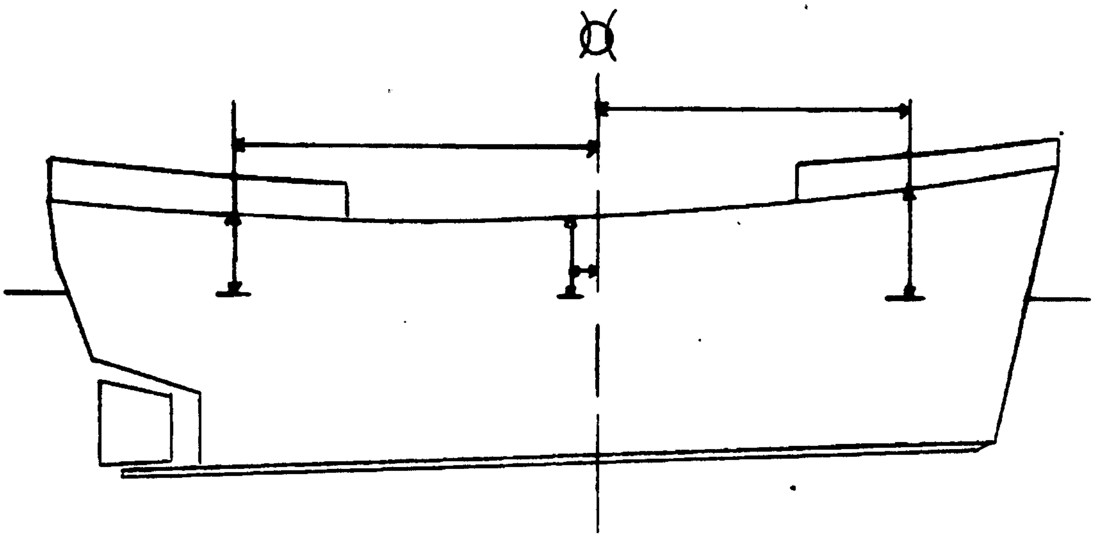
ITEM	weight (tonnes)	from		to	
		vert. C.G.	long. C.G.	vertic. C.G.	long. C.G.

FORM 5 TANKS SOUNDING AND FREESURFACES

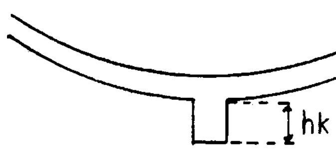
DESCRIPTION	Location	Sounding	Volume m^3	Specific Gravity "γ"	Weight	KG	Vertical Moment	LCG	Longitud. Moment	Moment of Inertia "i"	$\gamma \cdot i$
		GM Correction = $\sum(\gamma \cdot i)$ / [illegible] = ______ m								$\sum$ = ______	

FORM 6

DRAFT MARK READINGS



Mark on the sketch, (with refer. to ⌀):
  Location of draft marks fwd and aft.
  Location of freeboard readings.



Draft mark readings

draft fwd (df): Port .... Stbd. .... df (mean)=.......

-keel height, hk=-......

(for steel hulls) -keel plate, tb=-......

mean moulded draft forward, dm fwd=.......

draft aft (da): Port .... Stbd. .... **da** (mean)=.......

-keel height, hk=-......

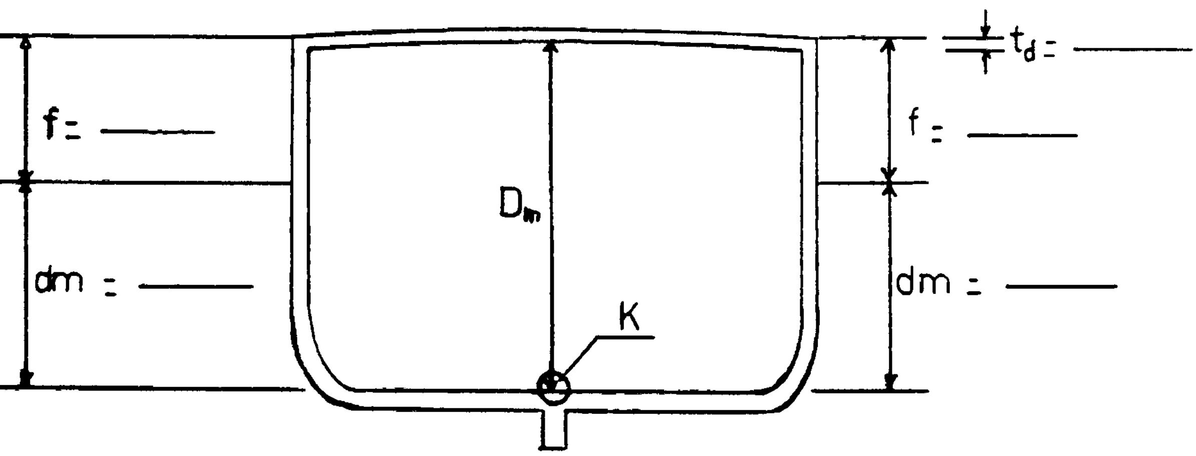
(for steel hulls) **-keel plate,** tb=-......

mean moulded draft aft, dm aft=.......

List: ....degrees.

dm fwd: .... dm aft: .... mean moulded draft=.......

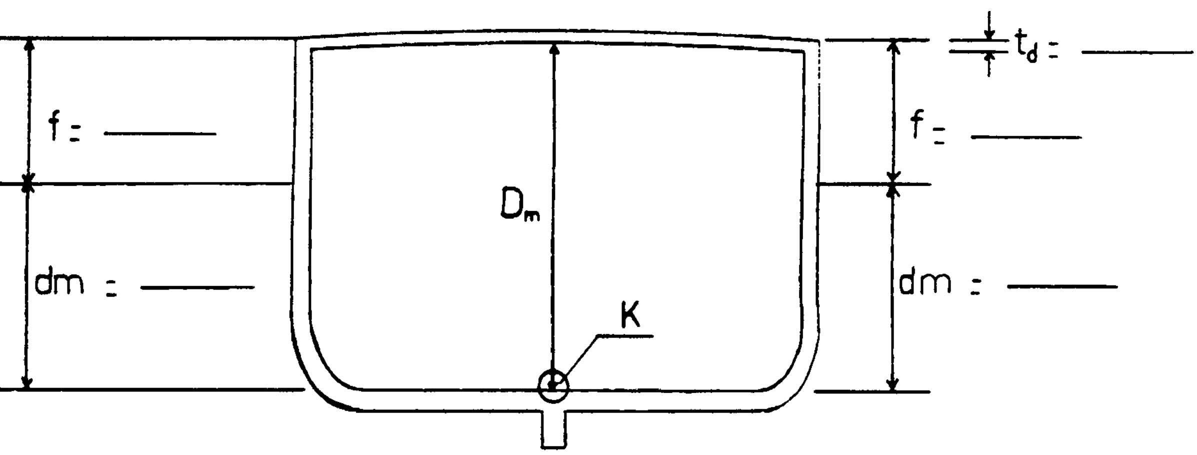
FORM 7 FREEBOARD READINGS (shell plating)



$f_m = f - t_d$ = ______ Port $f_m = f - t_d$ = ______ Stbd $f_{m_{fwd}}$ = ______ (mean)

$d_m = D_m - f_m$ = ______ Port $d_m = D_m - f_m$ = ______ Stbd $d_{m_{fwd}}$ = ______ (mean)

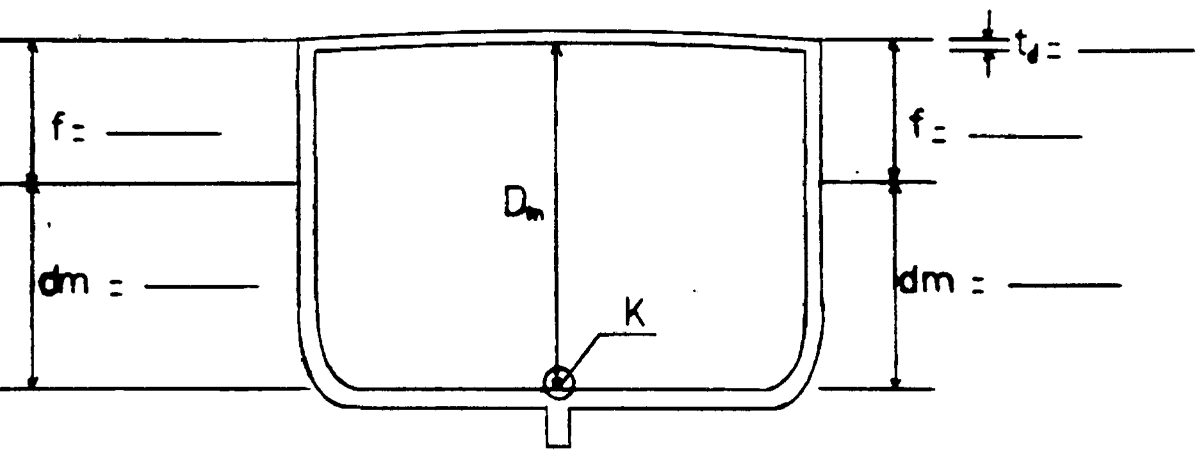
List = ______



$f_m = f - t_d$ = ______ Port $f_m = f - t_d$ = ______ Stbd $f_{m_{⌀}}$ = ______ (mean)

$d_m = D_m - f_m$ = ______ Port $d_m = D_m - f_m$ = ______ Stbd $d_{m_{⌀}}$ = ______ (mean)

List = ______

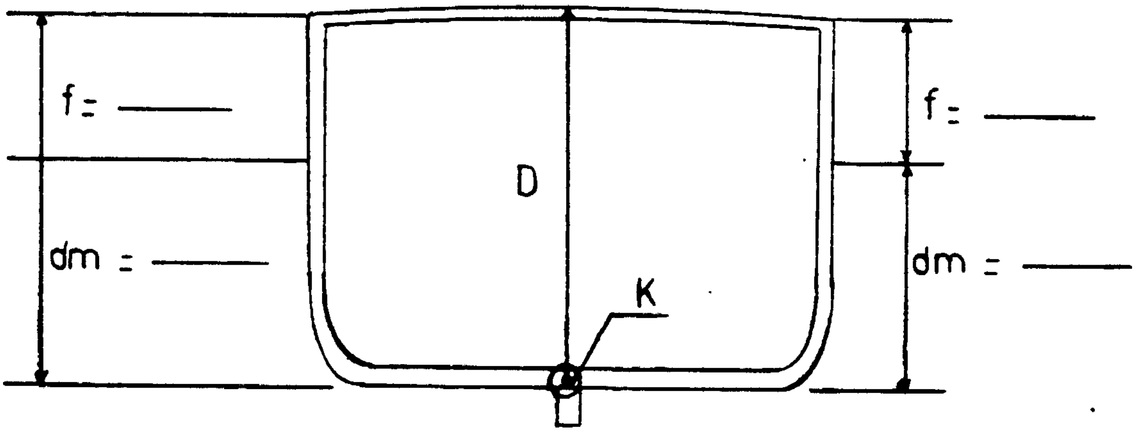


$f_m = f - t_d$ = ______ Port $f_m = f - t_d$ = ______ Stbd $f_{m_{aft}}$ = ______ (mean)

$d_m = D_m - f_m$ = ______ Port $d_m = D_m - f_m$ = ______ Stbd $d_{m_{aft}}$ = ______ (mean)

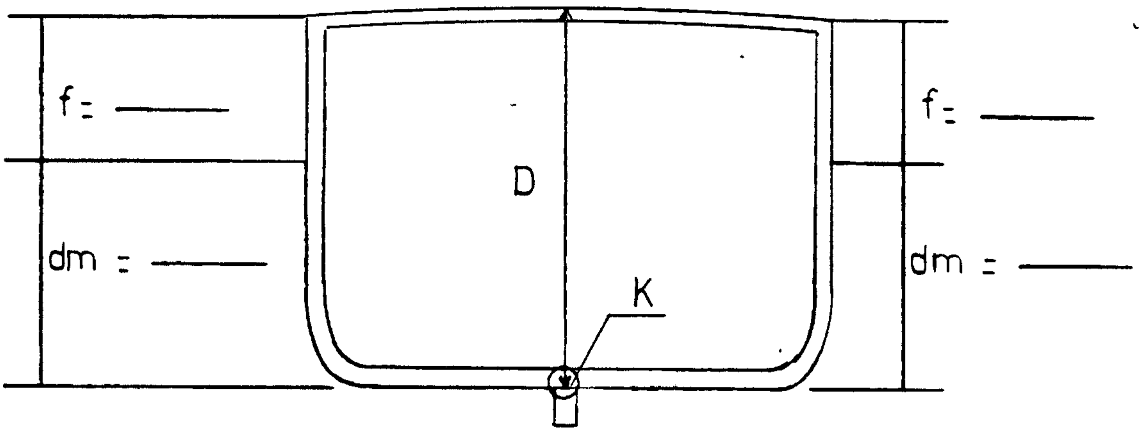
List =

FORM 8 FREEBOARD READINGS (wooden hull)



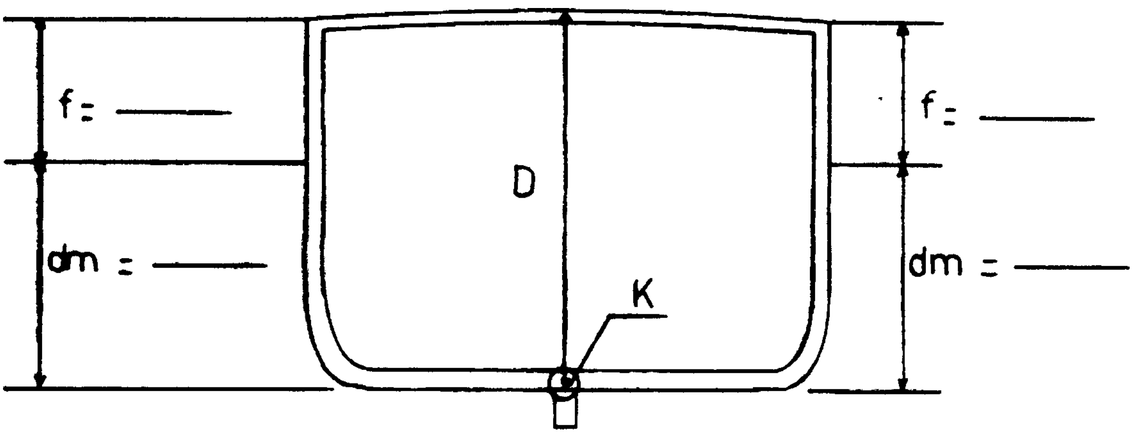
dm = D - f = ______ Port   dm = D - f = ______ Stbd dm_{fwd} = ______ (mean)

LIST = ______



dm = D - f = ______ Port   dm = D - f = ______ Stbd $dm_{\otimes}$ = ______ (mean)

LIST = ______



dm = D - f = ______ Port   dm = D - f = ______ Stbd dm_{aft} = ______ (mean)

LIST = ______

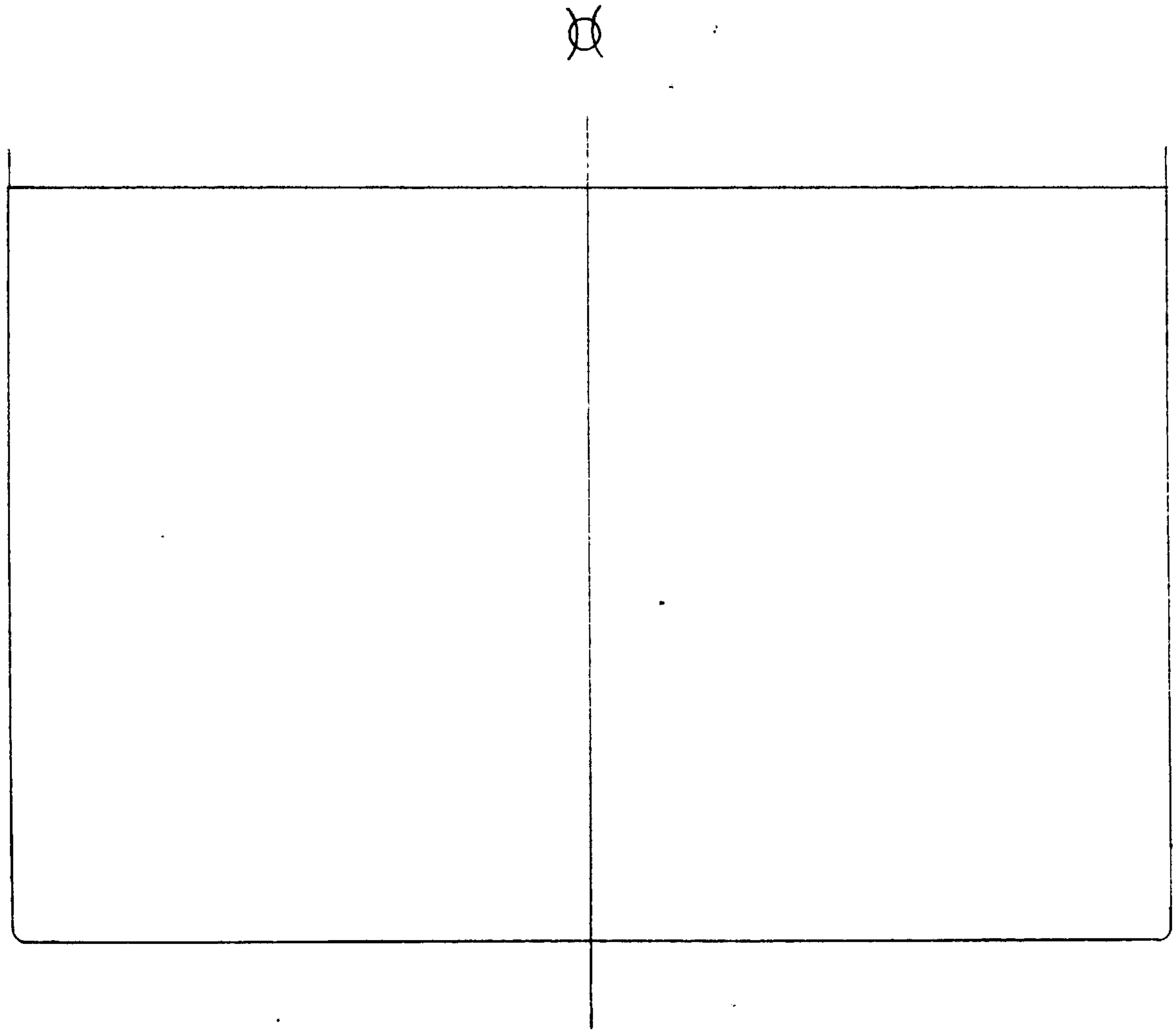
Sagging / Hogging = ______ = mean mould. draft − $dm_{\otimes}$
(+) indic. sagging

dm_{fwd} = ______
dm_{aft} = ______

mean moulded draft = ______

FORM 9

Flooding Openings



*Indicate distance from the opening to the bulwark and flooding angle at Test drafts.

FORM 10

DISPLACEMENT AT THE TEST CONDITION

1) Were the Draft Mark Readings found in accordance with the Freeboard Readings ?

   Answer (YES or NO): ....

2) Mean Moulded Draft (from Freeboard Readings, Form 8 or 9):

   (dm fwd + dm aft)/2 = ...

3) Δ from hydrostatics at Mean Moulded Draft= ....tonnes.

   Corrections:

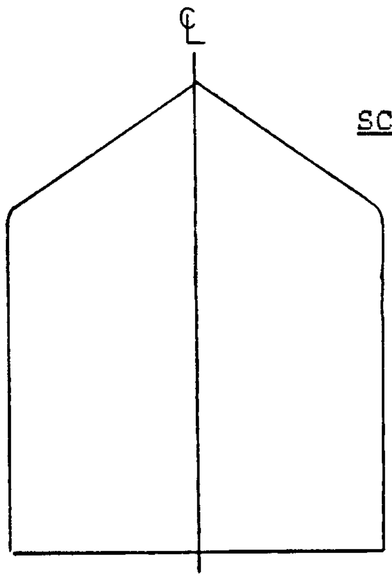
   for shell : ....
   for trim* : ....
   for sagging/hogging : ....
   for specific gravity of water: ....

   Corrected displacement at the test condition: ....tonnes.

* Trim "T" = (dm aft-dm fwd) minus design trim (rake of keel).

  "T" = (dm aft-dm fwd)-(rake of keel) = ...

FORM 11



Initial Position

(depict position of weights and distances to ℄)

SCHEMA OF WEIGHT MOVEMENTS

weight 1 .....tonnes weight 5 .....tonnes

weight 2 .....tonnes weight 6 .....tonnes

weight 3 .....tonnes weight 7 .....tonnes

weight 4 .....tonnes weight 8 .....tonnes

Pendulums		
N°	length (mm)	Location
1		
2		

Movement 1	Movement 4	Movement 7
Movement 2	Movement 5	Movement 8
Movement 3	Movement 6	Movement 9

FORM 12

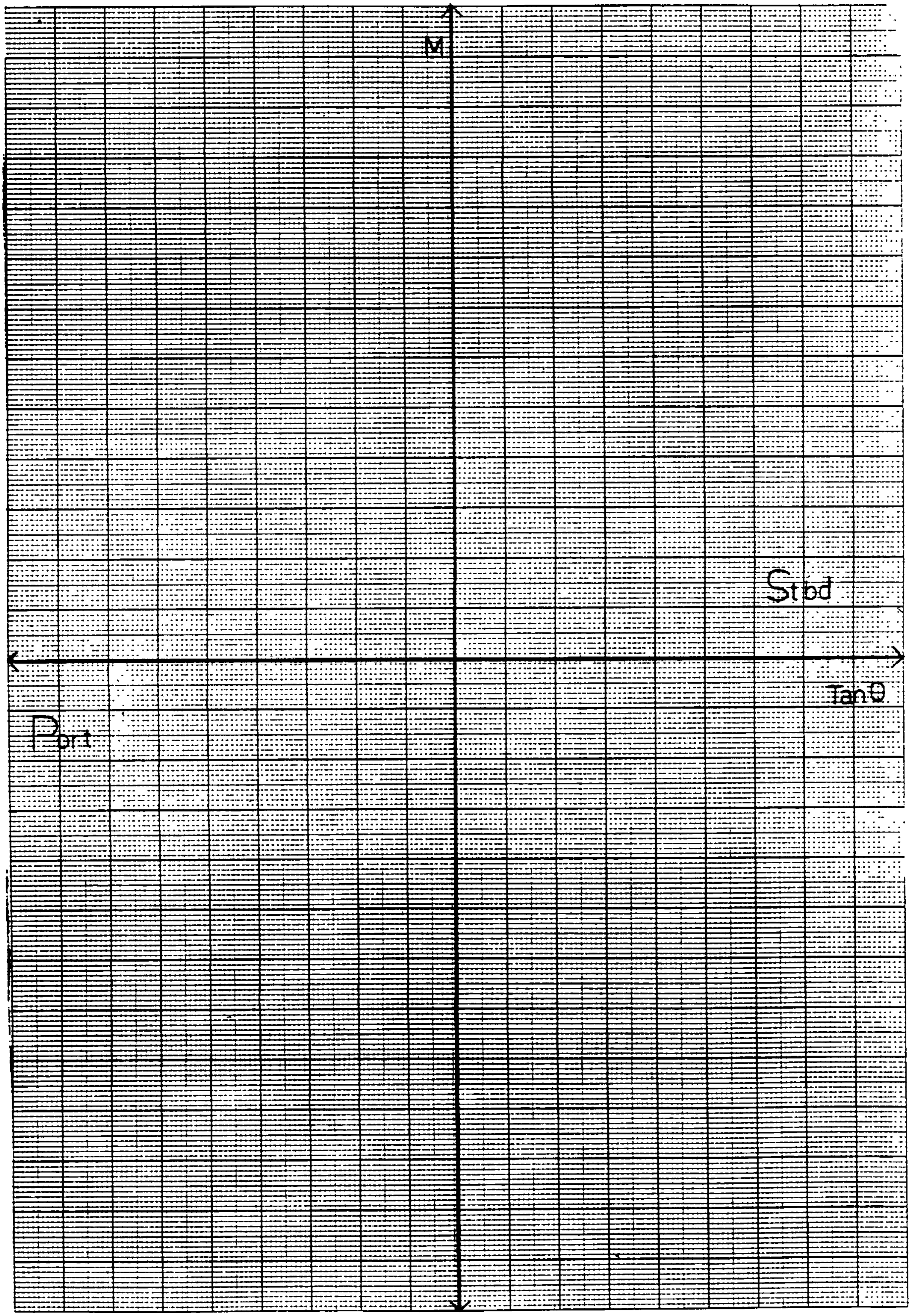
INCLINING EXPERIMENT DATA RECORD

					Pendulum 1 l_1 = mm.			Pendulum 2 l_2 = mm.			
ement θ°	Weight "W" Tonn.	Shift. dist. Sw m.	Partial moment m Tm.	Total mom. M= $\sum m$	Part. dev. a mm.	Total dev. A= $\sum a$	$Tan\theta_1$ A/l_1	Part. dev. a mm.	Total dev. A= $\sum a$	$Tan\theta_2$ A/l_2	Average Tangent Tanθ
θ≤3.5°	(1)	(2)	(1)×(2)				**			**	**

lovement of weights to starboard means positive "a", "Sw" and "m".
ngle of inclination to starboard means positive "θ", "A", "M" and "Tanθ".

anθ with four decimals.

Form 13 Graph M vs Tan θ



FORM 14

CALCULATION OF GM

Δ = ...tonnes	Pendulum 1 l_1 = ...mm.		Pendulum 2 l_2 = ...mm.	
$GM = \frac{\overline{AB}}{\Delta \cdot \overline{BC}}$	$GM = \frac{m\ l_1}{\Delta \cdot a_1}$	$GM = \frac{M\ l_1}{\Delta \cdot A_1}$	$GM = \frac{m\ l_2}{\Delta \cdot a_2}$	$GM = \frac{M\ l_2}{\Delta \cdot A_2}$
GM = ______ = ______	GM = ______	GM = ______	GM = ______	GM = ______
	GM = ______	GM = ______	GM = ______	GM = ______
	GM = ______	GM = ______	GM = ______	GM = ______
	GM = ______	GM = ______	GM = ______	GM = ______
	GM = ______	GM = ______	GM = ______	GM = ______
	GM = ______	GM = ______	GM = ______	GM = ______
	GM = ______	GM = ______	GM = ______	GM = ______
	GM = ______	GM = ______	GM = ______	GM = ______
Average :				

GM must be calculated in m. with 3 decimals.

FORM 15

SHIP AT THE TEST CONDITION

GM from graph M/Tanθ, Form 13.. = ...
Correction for free surface effect= +..........
Corrected GM = ...

Mean Moulded Draft forward, dm fwd= ....
Mean Moulded Draft aft, dm aft= .... Trim= ....
Mean Moulded Draft, dm= ....

(corrected) = ...
KMt (from hydrostatics) = ...
KMt corrected for Trim* = ...
KG = ...

KMl (from the hydrostatics) = ...
GMl = ...
LCB* (from the hydrostatics) = ...

trimming lever h*** $h = \frac{t \cdot GMl}{Lpp}$

LCG = LCB + h = ...

* If KG is not corrected for the ship at the test condition no trim correction for GMt lightship will be allowed.

** LCB positive means that it is located aft of ⌽.

*** Trimming lever positive means that the ship trims by the stern.

FORM 16

CALCULATION OF LIGHTWEIGHT CONDITION

ITEM	weight (tonnes)	KG	Moment about keel	LCG from ⊗	Moment about ⊗	Moment of inert. "i"
Test Condition						
Weights to add						
Sum						
Weights to deduct						
Sum						
Lightweight						

DRAFTS AND TRIM LIGHTWEIGHT CONDITION

Δ= ....

Mean Moulded Draft, dm= ....

LCB = ...

LCG = ...

Trimming lever, $h=\overline{BG}$= ....

KMl = ...

KG = ...

GMl = ...

Trim $t = \frac{L \cdot h}{GMl}$

LCF = ...

$t\ aft = \frac{0.5L \overset{\oplus *}{-} LCF}{L} \times t$

$t\ fwd = \frac{0.5L \overset{\ominus *}{+} LCF}{L} \times t$

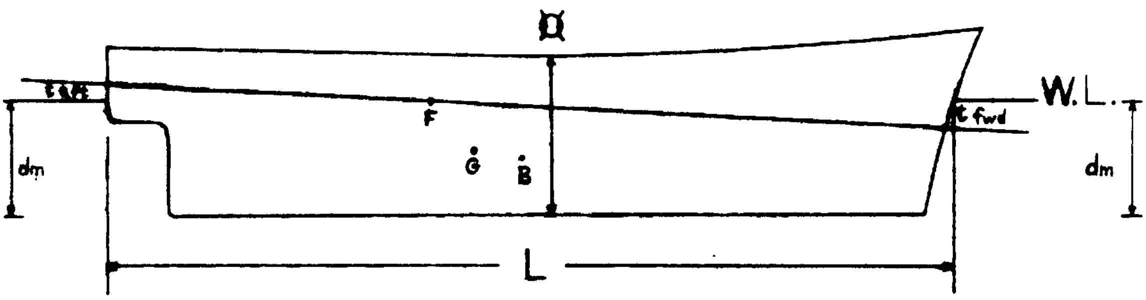
Moulded Draft Aft, dm aft

$dm\ aft = dm \overset{\ominus **}{+} t\ aft =$ ......

Moulded Draft Forward, dm fwd

$dm\ fwd = dm \overset{\oplus **}{-} t\ fwd =$ ......

Sketch of LCF, LCB, LCG and Drafts and Trim:



t = t fwd + t aft

* If LCF is ahead of L/2, change signs.

** If B is aft of G ship trims by the stem, change signs.

CHAPTER 3

THE STABILITY BOOKLET

3.1 GENERAL

The Stability Booklet shall be submitted to the Ch.M.D. for approval in four copies. One copy shall remain in the main office of the Ch.M.D., a second copy shall be filed with the local office of the Ch.M.D. if applicable, a third copy shall be sent back to the shipyard or Professional responsible after revision or approval and the fourth copy shall always be kept on board.

Every ship entitled to flag the Chilean flag shall have on board the Stability Booklet approved by the Ch.M.D. This is a main requisite for the issuance of the following certificates:

- National Ship General Safety Certificate* (Chilean Regulations).

- International Passenger Ship Safety Certificate (SOLAS 74 Convention).

- International Cargo Ship Safety Construction Certificate (SOLAS 74 Convention).

* Certificate valid for 1 year issued by the Ch.M.D. after survey of the construction, machinery, navigational and life-saving equipment, radio equipment, manning, food and catering and conditions of health on board.

- International Oil Pollution Prevention Certificate (MARPOL 73/78 Convention).

- International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk (IBC Code).

- International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk (IGC Code).

- International Certificate of Loadlines (LOADLINES 66 Convention).

The Stability Booklet shall include the complete Stability Test Report as indicated in subparagraph 2.6.d)1 and the following additional information according to the provisions in this chapter:

- Calculation of GZ curves for all applicable loading conditions, including:

  Determination of the Flooding Angle,
  Free Surfaces Correction,
  Icing Allowance,

- Analysis of compliance with the relevant Intact Stability Criteria, for each loading condition, i.e.,

  Dynamic Stability,
  Righting Lever,
  Initial Metacentric Height,
  Crowding Heeling Angle,
  Turning Heeling Angle,
  Alternative Criteria for Dry Cargo Ships,

Net Winch Heeling Moment,
Timber on Deck,
Wind and Beam Seas Rolling,
Water Trapped on Deck,

- Calculation of Grain Loading Stability and Analysis of Compliance with the Grain Shift Criteria for each loading condition.

- Calculation of Damage Stability and Analysis of Compliance with the Survival Criteria for each loading condition.

3.1.a) Loadlines Assignment:

The 66 Loadlines Convention or the applicable National Freeboard Rules shall govern the assignment of loadlines. However, the draught associated with the loadline assigned shall not be greater than the maximum draught otherwise permitted by the relevant stability criteria applicable to the ship.

Therefore, the Stability Booklet approved by the Ch.M.D. is a prerequisite for the issuance of any Loadlines Certificate or Assignment of Freeboard.

3.1.b) Definition of Length:

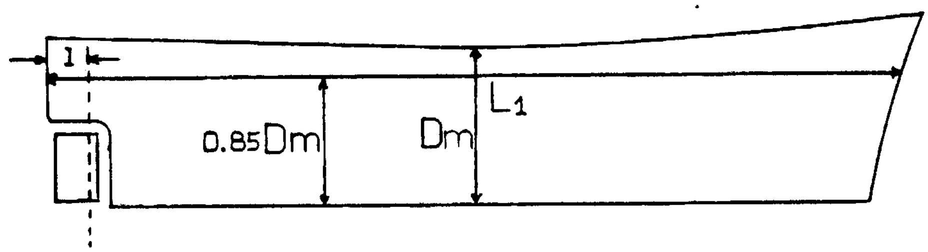
As far as the applicability of the stability criteria is concerned the length of the ship shall be considered as defined in the 66 Loadlines Convention (the same definition is found in the Tonnage 69, Marpol 73, Solas 74 chapter III and Torremolinos Conventions).

Thus, the length of the ship is:

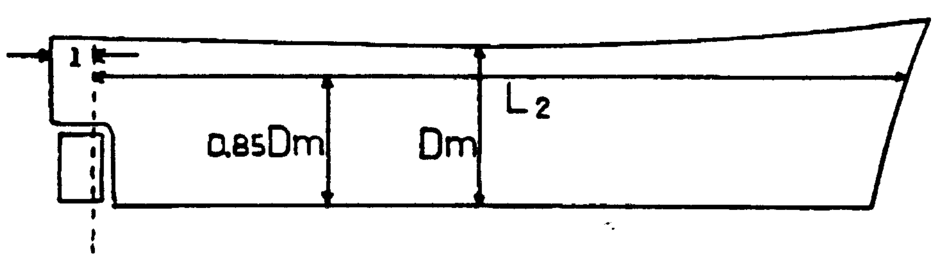
i) 96% of the total length on the waterline at 85% of the least moulded depth measured from the top of the keel, or

ii) The length from the fore side of the stem to the axis of the rudder stock on that waterline, if that be greater than i),

In ships designed with a rake of keel the waterline on which the length is measured shall be parallel to the designed waterline.



i) Length of ship=$0.96L_1$, if $0.96L_1 \geqslant L_2$.



ii) Length of ship=L_2, if $L_2 \geqslant 0.96L_1$.

Fig. 22

Fig. 22 clarifies the definition of length. From this it can be realized that:

i) Length of ship=$0.96L_1$, when $l \leqslant 0.04L_1$.

ii) Length of ship=$L_2=L_1-l$ when $l \geqslant 0.04L_1$.

3.2 CALCULATION OF GZ CURVES

3.2.a) General

The calculation of GZ curves shall be made for all the loading conditions the ship is intended for, including the conditions stated in paragraphs 3.2.b), 3.2.c) and the loading conditions corresponding to all the loadlines assigned to the ship according to the Loadlines Convention 66 or the applicable National Loadlines or Freeboard Standards.

The calculation of GZ curves shall consider the influence of beam rolling and wind, free surfaces, icing, water trapped on deck, flooding angle, etc., and all the necessary calculations to verify compliance with the relevant intact stability criteria, grain stability criteria and survival criteria for damage stability.

More detailed information on each topic must be observed in the corresponding sections.

In cases where the ship would sink due to flooding through any openings, the GZ curve shall be cut short at the corresponding angle of flooding θ_f and the ship shall be considered to have entirely lost her stability, see paragraph 3.2.e).

3.2.b) Loading Conditions for Pass. and Cargo Ships

The following conditions are valid for passenger and cargo ships over 24 m. in length.

All the loading conditions the ship is intended for shall be considered including the ones corresponding to all the loadlines assigned for the ship. Furthermore, the following conditions, mainly based on IMO Resolutions A.167(ES.IV) and A.168(ES.IV), shall be considered:

3.2.b)1 Passenger Ships:

i) Fully loaded departure:

Ship in the fully loaded departure condition with full stores and fuel and with the full number of passengers and their luggage.

ii) Fully loaded arrival:

Ship in the fully loaded arrival condition, with the full number of passengers and their luggage but with only 10% stores and fuel remaining.

iii) Full passenger no cargo departure:

Ship without cargo, but with full stores and fuel and the full number of passengers and their luggage.

iv) Full passenger no cargo arrival:

Ship in the same condition as in iii) above but with only 10% stores and fuel remaining.

. crew, passengers and their luggage	100%	100%	100%	100%
cargo	100%	100%	0	0
stores	100%	10%	100%	10%
fuel	100%	10%	100%	10%

Loading Conditions Pass. Ships

3.2.b)2 Cargo Ships:

i) Fully loaded departure:

Ship in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo spaces and with full stores and fuel.

ii) Fully loaded arrival:

Ship in the fully loaded arrival condition with cargo homogeneously distributed throughout all cargo spaces and with 10% stores and fuel remaining.

iii) Ballast departure:

Ship in ballast in the departure condition without cargo but with full stores and fuel.

iv) Ballast arrival:

Ship in ballast in the arrival condition without cargo and with 10% stores and fuel remaining.

For a ship which can carry cargo on deck the following additional conditions shall be considered:

v) Fully loaded departure plus deck cargo:

Ship in the fully loaded departure condition, with full cargo in holds and on deck and full stores and fuel. Weight, extension and height of deck cargo shall be clearly stated.

vi) Fully loaded arrival plus deck cargo:

Ship with full cargo in holds and on deck and 10% stores and fuel. Weight, extension and height of deck cargo shall be clearly stated.

	i)	ii)	iii)	iv)	v)	vi)
crew,	100%	100%	0	0	100%	100%
cargo: holds	100%	100%	0	0	100%	100%
cargo: tanks	0	50%	0	0	50%	50%
cargo: deck	50%	0	0	0	0	0
stores	100%	10%	100%	100%	100%	10%
fuel	100%	10%	100%	10%	100%	10%

Loading Conditions Cargo Ships

3.2.b)3 <u>Assumptions for calculat. Pass. and Cargo ships</u>

The ship shall have enough structural strength for all the intended loading conditions. A ship which is classed by a Classification Society recognized by the Ch.M.D. may be regarded as having enough structural strength.

The distribution of cargo need not be assumed such that the strength of the deck is exceeded or it is in some other way inconsistent with the intended service of the ship.

<u>Tanks for liquid cargo in dry cargo ships:</u>

For the fully loaded conditions for cargo ships i), ii), v) and vi), if a dry cargo ship has tanks for liquid cargo the effective deadweight in the loading conditions should be distributed according to the following assumptions: cargo tanks are full, cargo tanks are empty and cargo tanks are 50% loaded (with free surfaces).

<u>Loadline in fully loaded departure:</u>

In conditions 100% cargo departure for pass. ships (i)) and cargo ships (ii), v)) it should be assumed that the ship is loaded to her subdivision loadline or summer loadline (or to the summer timber loadline if applicable) with water ballast tanks empty.

Water ballast:

If in any loading condition water ballast is necessary the GZ curve for that condition shall be calculated taking into account the water ballast. Its quantity and disposition should be stated.

Condition of the cargo:

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

Deck cargo:

In all cases when deck cargo is carried a realistic stowage weight should be assumed and stated, including the height of the cargo. The most unfavourable deck cargo condition which may occur during service shall be calculated.

Containers and other Large Cargo Units:

The center of gravity of a container shall be assumed to be situated in its geometrical centre. The weight of the container shall be assumed to be two thirds of its nominal maximum weight, provided that this assumption does not lead to an excessive total cargo weight.
If the ship, besides containers carries some other cargo, the remainder of the total cargo weight shall be assumed to be homogeneously distributed in the remaining cargo space.
For other large cargo units, the distribution of

cargo shall be assumed to be such that the most unfavourable loading conditions which may occur during the ship's service are produced.

Timber deck cargoes:

Where timber deck cargoes are carried, the amount of cargo and ballast shall correspond to the worst service condition in which all the relevant stability criteria are met.
In the arrival condition it shall be assumed that the weight of the deck cargo has increased by 10% due to water absorption.
If the formation of ice on the timber deck cargo may occur an allowance shall be made in the arrival condition for the additional weight due to ice accretion on the exposed surfaces.

Weight of passengers and their luggage:

A weight of 75 kg. should be assumed for each passenger except that this value may be reduced to not less than 60 kg. when this can be justified. In addition the weight and distribution of the luggage shall be determined by the Ch.M.D. ,so the professional making the calculations shall consult the Ch.M.D. in this respect.

Location and distribut. of passeng. and luggage:

Passengers and their luggage should be considered to be in the spaces normally at their disposal when assesing compliance with the criteria mentioned in paragraphs 3.3.a), b) and c).

Passenger heeling moment:

Passengers without luggage should be considered as distributed to produce the most unfavourable combination of passenger heeling moment and/or initial metacentric height which may be obtained in practice, when assesing compliance with the criteria stated in 3.3.d) and e). In this connection it is anticipated that a value higher than 4 persons per square metre will not be necessary.

Free surfaces:

For all conditions the free surfaces in tanks shall be calculated in accordance with paragraph 3.2.f).

Flooding angle:

The flooding angle for all conditions shall be determined as indicated in paragraph 3.2.e).

Icing:

An allowance for icing, where this is anticipated to occur should be made in accordance with paragraph 3.2.d). This is mandatory for ships operating in winter seasonal zones as defined in the Load-lines Convention, 1966.

3.2.c) Loading Conditions for Fishing Vessels:

i) Departure from port:

Departure condition for the fishing grounds with full crew, stores, ice, fishing gear, etc.

ii) Departure from fishing grounds full catch:

Departure from fishing grounds with full catch and 80% fuel, stores, etc.

iii) Depart. fish. grounds 50% catch (Purse Seiners):

The departure from fishing grounds with 50% catch shall be calculated for Purse Seiners.

iv) Arrival at port full catch:

Arrival at home port with 10% stores, fuel, etc. remaining and full catch.

	i)	ii)	iii)	iv)	v)	vi)
crew	100%	100%	100%	100%	100%	100%
fishing gear	100%	100%	100%	100%	100%	100%
catch	0	100%	50%	100%	50%	20%
ice	100%	80%	80%	50%	50%	50%
stores	100%	80%	80%	10%	10%	10%
fuel	100%	80%	80%	10%	10%	10%

Loading Conditions for Fishing Vessels

v) Arriv. port 50% catch 10% fuel-stores P.Seiners:

The arrival at home port with 50% catch and 10% fuel, stores, etc. shall be calculated for Purse Seiners.

vi) Arrival at port 20% catch:

Arrival in home port with 10% stores, fuel, etc. remaining and with 20% of full catch.

vii) Catching conditions for Purse Seiners:

The following additional catching conditions shall be calculated in order to analyze the effect of the net winch heeling moment according to paragraph 3.3.g).

	1	2	3	4
crew	100%	100%	100%	100%
fishing gear	100%	100%	100%	100%
catch	0	10%	30%	50%
ice	50%	50%	50%	50%
stores	50%	50%	50%	50%
fuel	50%	50%	50%	50%

Catching Conditions for Purse Seiners

Conditions iii), v) and vii) are additional ones calculated in order to perform a better control of the stability in Purse Seiner fishing vessels since they are subject to external capsizing forces superimposed on them during the normal fishing operations.

In this vessels the free surface effect produced by the fish loaded in bulk and mixed with water into the fish holds must be calculated in both departure and arrival conditions when applicable.

3.2.c)1 Assumptions for calculations fishing vessels:

The ship shall have enough structural strength for the intended loading conditions. A ship which is classed by a Classification Society recognized by the Ch.M.D. may be regarded as having enough structural strength.

The distribution of cargo need not be assumed such that the strength of the deck is exceeded or is in some other way inconsistent with the intended service of the ship.

Weight of wet nets:

The actual weight and location of the centre of gravity of the wet nets are achieved by having the net on board in a wet condition at the time of the stability test, so no special allowances are needed in this connection.

Deck cargo:

In conditions ii) and iii) above deck cargo should be included if such a practice is anticipated otherwise it will not be allowed. Above deck cargo in Purse Seiners is prohibited.

Water ballast:

Water ballast should normally only be included if carried in tanks which are specially provided for this purpose.

Condition of the cargo:

In all cases the cargo should be assumed homogeneous unless this is inconsistent with the practice.

Flooding angle:

The flooding angle for all conditions shall be determined as indicated in paragraph 3.2.e).

Icing:

An allowance for icing, where this is anticipated to occur should be made in accordance with paragraph 3.2.d). This is mandatory for ships operating in winter seasonal zones as defined in the Loadlines Convention, 1966.

Free surfaces:

For all conditions the free surfaces in tanks shall be calculated according to paragraph 3.2.f).
In Purse Seiners the free surface effect of the catch mixed with water and loaded in bulk into the

holds shall be calculated for conditions iii), v), vi) and vii).

Net winch heeling moment:

In Purse Seiners the net winch heeling moment imposed on the ship by the winch while hauling shall be calculated as indicated in paragraph 3.3.g).

Water trapped on deck:

The effect of water trapped on deck shall be calculated in accordance with paragraph 3.3.j).

3.2.d) Icing Allowance

3.2.d)1 Winter seasonal zones:

The vessel's stability shall be calculated in the worst conditions of loading, taking into account the risk of icing if the vessel operates in winter seasonal zones as defined in the Loadlines Convention, 1966.

3.2.d)2 Weight of ice on decks:

The weight of ice per square metre of all exposed weather decks and gangways shall be assumed to be not less than 30 kg/m^2 if the vessel operates to the South of latitude 60° 00'S. In other areas of the winter seasonal zones the assumed standards of icing in winter shall be 15 kg/m^2

3.2.d)3 Weight of ice in lateral areas:

The weight of ice per square metre of projected lateral area of the portion of the vessel above water plane shall be assumed to be not less than 15 kg/m^2 if the vessel operates to the South of latitude 60° 00′S. In other areas of the winter seasonal zone the assumed standards of icing in winter shall be 7.5 kg/m^2.

3.2.d)4 Centre of gravity of ice:

The height of the centre of gravity of ice accumulation shall be calculated according to the position of the corresponding parts of the decks and gangways and other continuous surfaces on which ice can accumulate.

3.2.d)5 Lateral areas of discontinuous surfaces:

The projected lateral areas of discontinuous surfaces of rails, spars (except masts) and rigging of the vessels having no sails and the projected lateral area of other small objects shall be computed by increasing the total projected lateral area of continuous surfaces by 5 per cent and the static moments of this area by 10 per cent.

3.2.e) Flooding Angle

3.2.e)1 Definition:

The flooding angle "θf" is the angle at which openings in the hull or in superstructures of deckhouses which can not be closed watertight immerse.

In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

3.2.e)2 <u>Determination of flooding angle:</u>

The flooding angle shall be determined for every loading condition in order to take it into account when analyzing the relevant intact stability criteria. A special drawing as the one shown in fig. 23 shall be made to clearly show the flooding angle and the opening affected.

3.2.e)3 <u>GZ curves:</u>

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

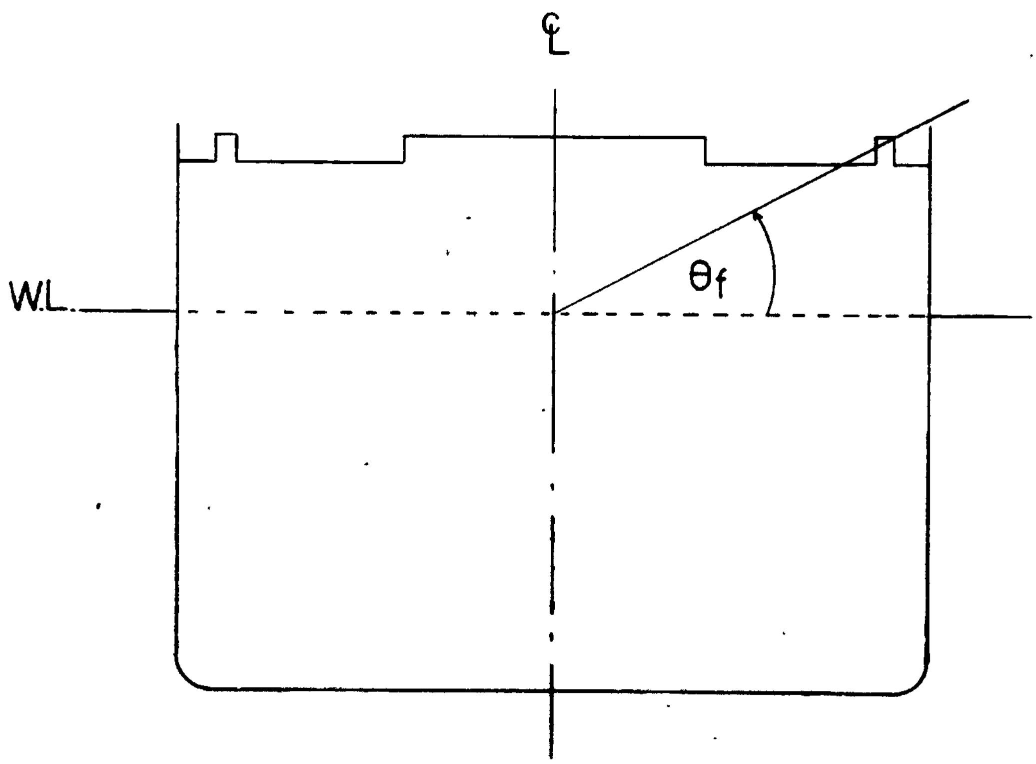


Fig. 23

3.2.e)4 Small openings:

Small openings such as those for passing wires or chains, tackle and anchors, and also holes for scuppers, discharge and sanitary pipes shall not be considered as open if they submerge at an angle of inclination of more than 30 degrees. However, if they submerge at an angle of 30 degrees or less, these openings shall be assumed open.

3.2.e)5 Purse Seiner fishing vessels:

In Purse Seiner fishing vessels the hatchways and the side pockets shall be considered as openings through which progressive flooding can take place. This is due to the fact that they are open both at the time of loading and stowing the fish at the fishing ground and at the time of unloading the fish at the harbour barges.

According to Regulation 29 of the 1977 Torremolinos Convention the flooding angle of fish holds which remain open during fishing operations must be at least 20 degrees unless the stability criteria in paragraphs 3.3.a), b) and c) can be satisfied with the fish holds partially or completely flooded.

3.2.f) Free Surfaces Correction

3.2.f)1 General:

For all conditions, the initial metacentric height and the stability curves shall be corrected for the effect of free surfaces of liquids in tanks. The most unfavourable effect of free surfaces should be used in the calculations.

The correction for free surfaces should be made taking into account the corresponding correction at all angles of inclination, in accordance with the following assumptions, extracted from IMO Resol. A.167(ES.IV).

3.2.f)2 Tanks to consider:

Tanks which are taken into account when determinig the effect of liquids on the stability at all angles of inclination shall include single tanks or a combination of tanks for each kind of liquid (including those for water ballast) which according to the service conditions can simultaneously have free surfaces.

For the purpose of determining this free surface correction, the tanks assumed slack should be those which develop the greatest free surface moment Mfs at a 30 degrees inclination, when in the 50% full condition.

3.2.f)3 Free Surface Moment:

The value of Mfs for each tank may be derived from the formula:

$$Mfs = V \cdot b \cdot g \cdot k \sqrt{\frac{V}{b \cdot l \cdot h}}$$

where:

Mfs = Free surface moment at a certain inclination in ton-m.

V = Tank total capacity in m^3.

b = Tank maximum breadth in m.

g = Specific weight of the liquid in ton/m^3.

$d = \frac{V}{b \cdot l \cdot h}$ tank block coefficient.

h = Tank maximum height in m.

l = Tank maximum length in m.

k = From table b/h vs. Θ, in next page. Intermedium values of "k" shall be interpolated.

3.2.f)4 Tanks to neglect:

Small tanks which satisfy the following condition when using the value of "k" corresponding to the angle of inclination of 30 degrees, need not be included in computation:

$$V \cdot b \cdot g \cdot k \sqrt{\frac{V}{b \cdot l \cdot h}} < 0.01 \cdot \Delta min$$

where:

Δmin = minimum ship displacement in metric tons.

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

3.2.f)5 Purse Seiners:

In Purse Seiner fishing vessels the free surface effect

TABLE OF COEFFICIENT "K" FOR FREE SURFACES CORRECTION

b/h \ θ	5°	10°	15°	20°	30°	40°	45°	50°	60°	70°	75°	80°	90°
20	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
10	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
5	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
3	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
2	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
1.5	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	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
0.75	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
0.5	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
0.3	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
0.2	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
0.1	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

* Intermediate values shall be interpolated.

of the catch in bulk and mixed with water into the holds shall be calculated for conditions indicated in paragraph 3.2.c) iii), v), vi) and vii), in accordance with Regulation 33 (3) (f) of the 1977 Torremolinos Convention.

3.3 INTACT STABILITY CRITERIA

The following criteria based mainly in IMO Resolution A.167(ES.IV) and IMO Resolution A.168(ES.IV) shall be complied with by passenger ships, cargo ships and fishing vessels of 24 m. in length and over.

The intact stability criteria stated in this section and in paragraph 3.4.c) 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 cargo.

3.3.a) Dynamic Stability

The table below represents the requirements for the area "A" under the GZ curve in m-rad, between specified angles of inclination.

	0° to 30°	0° to 40° or θf*	30° to 40° or θf*
passenger, cargo, fishing.	0.055	0.090	0.030
purse seiners	0.066	0.108	0.036

* The angle θf is the flooding angle as defined in paragraph 3.2.e).

3.3.b) Righting Lever:

Passenger, cargo, fishing vessels.	Purse Seiners
$GZ \geqslant 0.2m.$ at $\theta \geqslant 30^\circ$	$GZ \geqslant 0.24m.$ at $\theta \geqslant 30^\circ$
GZmax at $\theta \geqslant 25^\circ$	GZmax at $\theta \geqslant 25^\circ$

3.3.c) Initial Metacentric Height:

Passenger and Cargo ships	Fishing vesels	Purse Seiners
$GM_o \geqslant 0.15m.$	$GM \geqslant 0.35m.$	$GM \geqslant 0.50m.$

The following additional criteria need to be complied with only by passenger ships:

3.3.d) Crowding Heeling Angle:

Angle of heel due to crowding of passengers to one side. $< 10^\circ$

3.3.e) Turning Heeling Angle:

Angle of heel due to Turning $\leqslant 10^{\circ}$

when calculated with the formula:

$$M_r = 0.02 \frac{V_o^2}{L} \cdot \Delta \left(KG - \frac{d}{2} \right)$$

where:

M_r = Turning heeling moment in Ton-m.

V_o = Service speed in m/s

L = Length of ship at waterline in m.

Δ = Displacement in metric tons.

d = Mean draft in m.

KG = Height of centre of gravity above keel in m.

The table in the next page resumes the intact stability criteria stated in this chapter. It can be appreciated that the criteria regarding the area under the GZ curve and righting lever are exactly the same for passenger, cargo and fishing vessels over 24 m. in length. However, the criterion regarding initial metacentric height is higher for fishing vessels.

The criteria 3.3.a), b) and c) for fishing vessels are stated in IMO Resolution A.168(ES.IV), in the Code of

INTACT STABILITY CRITERIA

		Purse Seiner	Fishing Vessel	Passeng. Ship	Cargo Ship	Alternat. Cargo ship	Timber on deck
Dynamic Stability	GZ Curve Area: (m-rad)						
	0° to 30°,	0.066	0.055	0.055	0.055	0.012/c	
	0° to θ_f or 40°,	0.108	0.090	0.090	0.090	0.020/c	0.080
	30° to θ_f or 40°,	0.036	0.030	0.030	0.030	0.007/c	
	0° to θ_v ,					0.035/c	
Righting Arm	GZ at $\theta \geqslant 30^\circ$ (m)	0.24	0.20	0.20	0.20	0.04/c	
	GZ maximum	at $\theta \geqslant 25^\circ$	at $\theta \geqslant 25^\circ$	at $\theta \geqslant 25^\circ$	at $\theta \geqslant 25^\circ$	0.05/c	$\geqslant$.25m
Metacentric Height	GMo (m)	0.500	0.350	0.150	0.150	0.150	0.1 depar ture
					0.3 (grain)	0.3 (grain)	0.3 grai
	Crowding Heel. Angle			$\leqslant 10^\circ$			
	Turnig Heeling angle			$\leqslant 10^\circ$			
Net Winch	Net winch heel. ang.	$\leqslant 10^\circ$ or θ_d					
	Net winch heel. arm	$l_n \leqslant GZ_{(10^\circ \text{or} \theta_d)}$					
Water on deck	Resid. Dynam. Stab.	$A_b \geqslant A_a$	$A_b \geqslant A_a$				
Rolling and wind	Steady wind angle θ_o	$\leqslant 16^\circ$ or $0.8\theta_d$	$\leqslant 16^\circ$ or $0.8\theta_d$	$\leqslant 16^\circ$ or $0.8\theta_d$	$\leqslant 16^\circ$ or $0.8\theta_d$	$\leqslant 16^\circ$ or $0.8\theta_d$	$\leqslant 16^\circ$ or .8θ
	Resid. Dynam. Stab.	$A_b \geqslant A_a$	$A_b \geqslant A_a$	$A_b \geqslant A_a$	$A_b \geqslant A_a$	$A_b \geqslant A_a$	$A_b \geqslant A_a$
Grain	Grain shift angle θ_g				$\leqslant 12^\circ$	$\leqslant 12^\circ$	$\leqslant 12$
	Resid. Dynam. Stab.				$A_b \geqslant 0.075$ m-r	$A_b \geqslant 0.075$ m-r	$A_b \geqslant$ .07 m-r

θ_f = Flooding Angle. θ_v = Angle of vanishing stability. θ_d = Angle of deck immersion.

Safety for Fishermen Part B and in the 1977 Torremolinos Convention which has already been ratified by Chile.

The criteria for Purse Seiners has been increased due to the need to improve their stability since additional capsizing forces are imposed on them under catching operations (see paragraph 3.3.g)).

3.3.f) Alternative Criteria for Dry Cargo Ships

The following criteria included in Annex 4 of SLF 31/22, ref. 12), were proposed by the Federal Republic of Germany to the IMO Subcommittee on Stability, Loadlines and on Fishing Vessels Safety. They are alternative criteria to the ones for cargo vessels stated in paragraphs 3.3.a) and b) and will enter into force after adoption by the IMO Assembly.

The criteria introduce a form factor "c" which allows the assessment of stability taking into account the ship individually and in line with their significance the parameters determined by tank tests, such as principal dimentions, KG and the ship's form. Thus, the criteria considers the dramatic change which has taken place in the design of dry cargo ships, such as the effect of containerisation which has caused a continuous increase in the value of the ratio B/D and a continuous decrease in the value of the ratio L/B since 1960.

Hormann and Wagner, ref. 13), mention that the traditional criteria of IMO Resol. A.167(ES.IV) and IMO Resol. A.562(14) do not consider the existing differences in stability characteristics and, as proved during tank tests, the resultant different stability requirements. In spite of this those criteria are being applied worldwide up to the present day to all sizes, shapes and types of ships.

Blume, ref. 15, also questions whether the traditional criteria of IMO Resol. A.167(ES.IV) can still be used for ships of modern design, since they do not consider the hull form characteristics.

The German criteria introduces the hull form factor "c" which has been conceived in such a way that its value becomes higher for hull forms which are favourable as to safety against capsizing and lower for hull forms which are unfavourable as to safety against capsizing.

3.3.f)1 <u>Conditions for applying the criteria:</u>

The criteria are applicable to ships of 24 m. in length and over complying with the following conditions:

- B/D ratio between 1.5 and 2.5

- Ordinary midship section shape (vertical side walls).

- Superstructure or deckhouse aft or almost aft.

- Continuous deck with hatches and normal type forecastle.

- Hatches between forecastle and deckhouse.

The next page shows the relevant parameters to consider for the calculation of the hull form factor "c".

3.3.f)2 <u>Calculation of the hull form factor "c":</u>

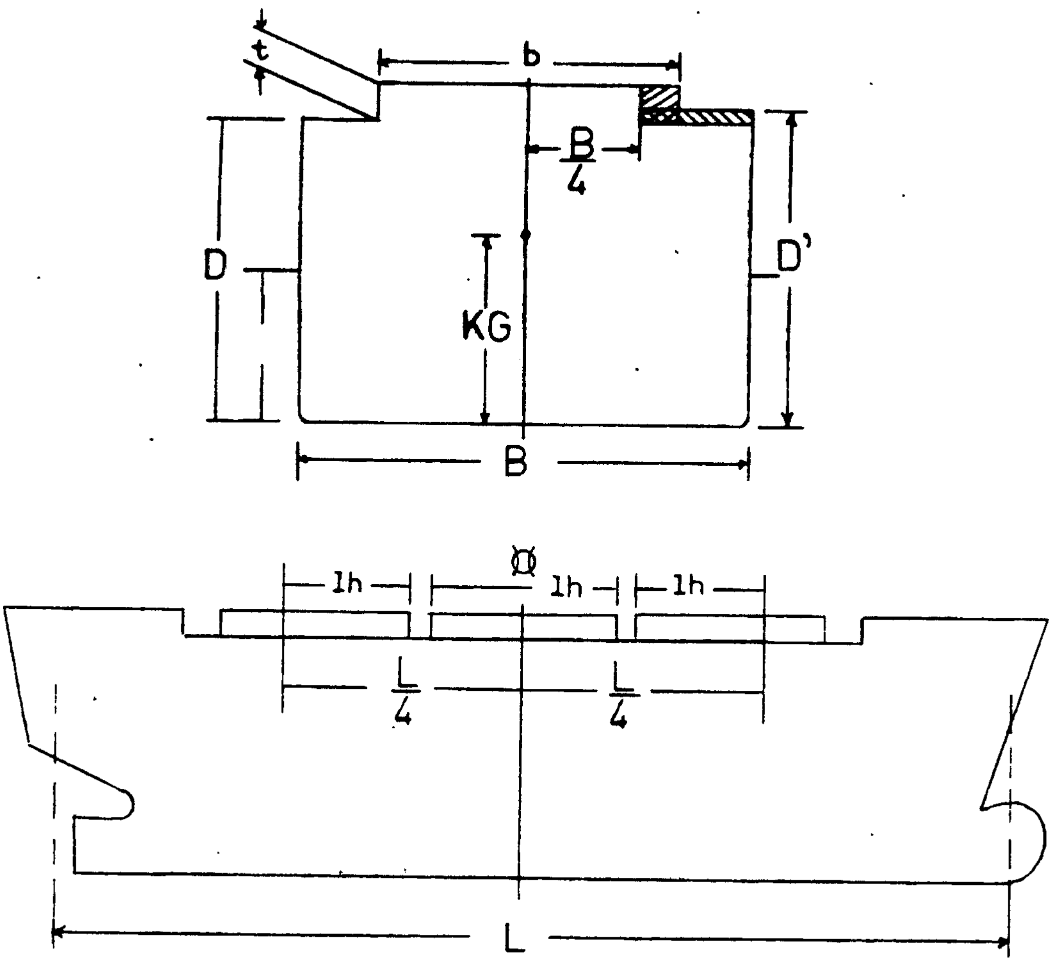


Fig. 24

$$c = \frac{d \cdot D'}{B^2} \cdot \sqrt{\frac{d}{KG}} \cdot \frac{C_B}{C_W} \cdot \sqrt{\frac{100}{L}}$$

If L is less than 100 m., L=100 to be inserted.

If L is less than d, KG=d to be inserted.

$$D' = D + t\left[\frac{2b\ B}{B}\right] \cdot 2\frac{\sum lh}{L}$$

If b is less than B/2, b=B/2 to be inserted.

c = Hull form factor.

d = Draught.

B = Moulded draught.

KG = Centre of gravity above base line.

C_β = Block coefficient.

C_W = Water line coefficient.

L = Length of the ship, according to paragraph 3.1.b).

D' = Depth corrected for the influences of hatches.

D = Depth.

b = Breadth of hatches.

lh = Sum of lengths of hatches within L/4 from either side of the midship section.

3.3.f)3 Criteria:

The following criteria are an alternative to the ones in paragraphs 3.3.a) and b).

i) Dynamic stability

The table below represents the requirements regarding the minimum value of the area "A" under the GZ curve between specified angles of inclination.

	0° to 30°	0° to 40°	30° to 40°	0° to θ_V *
"A"	0.012/c	0.020/c	0.007/c	0.035/c

* θ_V = Angle of vanishing stability (range of stability).

ii) Righting lever

$$GZ_{30^\circ} \geqslant 0.04/c$$

$$GZ_{max} \geqslant 0.05/c$$

It can be seen in the table above that this criteria introduces a requirement as to the minimum value for the total area under the GZ curve, in other words a requirement for the total righting energy available to stand the action of capsizing moments affecting the ship.

3.3.g) Fish Heeling Moment

3.3.g)1 General:

Several casualties have occurred to Purse Seiner fishing vessels while operating in fishing grounds in the Chilean Economic Exclusive Zone and the study of these casualties has revealed the action of a very strong capsizing moment (due to the fish caught in the net) which the ships have not been able to withstand.

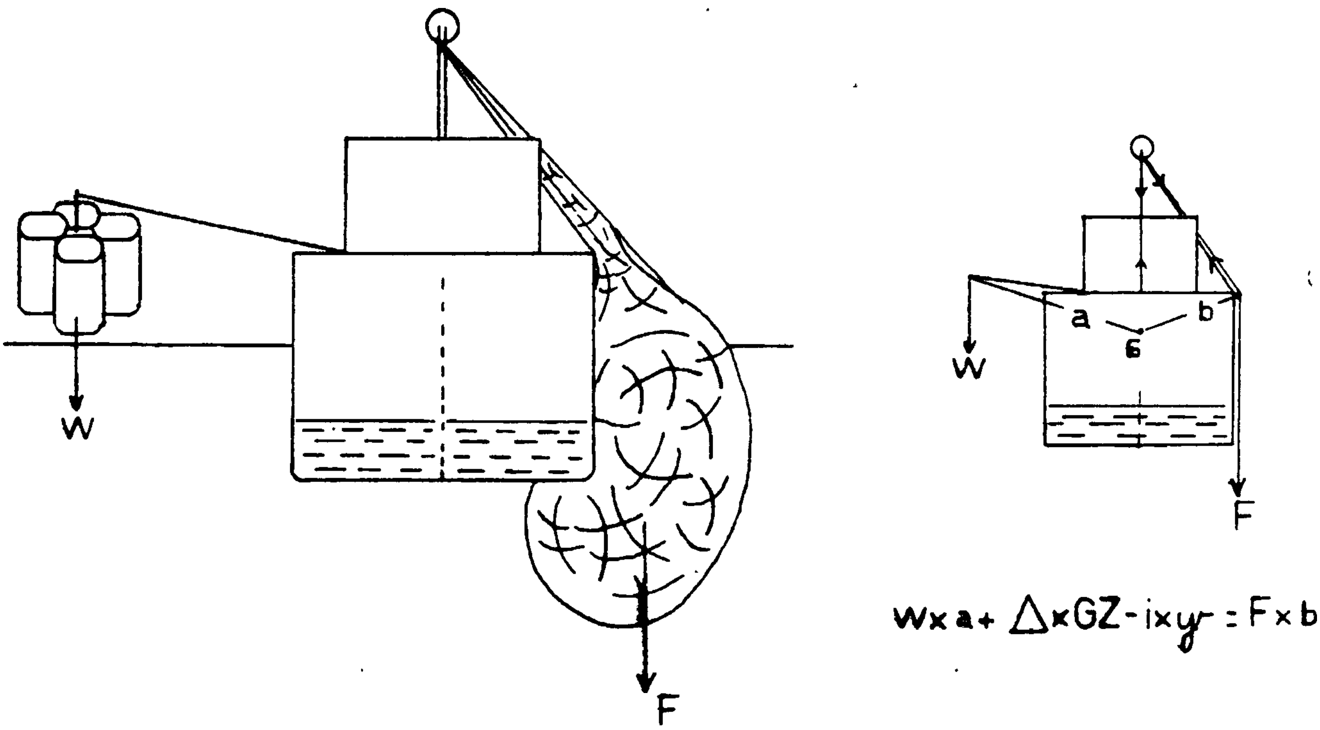


Fig. 24

Existing Purse Seiners up to 300 Tons. deadweight have installed a so-called "righting drums" device in order to be able to perform their normal fishing operations. This device has been a rudimentary solution for coping with the problem and it is easily understood that there is a need to replace it with a vessel design that improves the stability parameters in the future.

The righting drums device is shown in Fig. 25. The drums are under the sea water surface from the beginning and when force F increases so that the ship heels, the drums filled with water go up counteracting the heeling moment and uprighting the ship.

Unfortunately force F caused by the fish caught into the net is unpredictable and there is no way to calculate it. Moreover, it varies depending on unknown factors.
The casualties investigations have revealed that force F increases dangerously when the fish sqeezed into the net die and apparently stop buoying.
Higher forces have also been reported as occurring at the time when the fish are breeding. This has been described by witnesses as though the whole mass of sometimes two or three hundred tons of fish tried to swim downwards at the same time in order to escape from the net.

The problem is sometimes increased by the fact that the force F acts in the net winch which is usually located above the centre of gravity of the ship and the presence of free surfaces in the fish holds which contain a certain amount of fish and water already loaded.

In paragraph 3.3.g)3 special criteria based on document PFV/276 of the IMCO Subcommittee of Fishing Vessels, ref. 16, are stated. The criteria does not really tackle the problem described above since it is based on the heeling moment caused by the winch power while hauling, so what it evaluates is the heeling moment acting on the vessel by virtue of the power of the net winch.

Special rules for the calculations and stability criteria applicable to Purse Seiners have been stated in paragraphs 3.3.a), b) and c) taking into account the provisions of Regulations 30 and 33 of the 1977 Torremolinos Convention. They must be understood as being an attempt to improve the safety on board Purse Seiners, taking due account of the additional external forces imposed on the vessels under all actual operating conditions.

3.3.g)2 <u>Net Winch Heeling Moment</u>

The equations for the net winch heeling moment "M", and the net winch heeling arm "ln", are given below.

$$Mn = Pn \cdot y \qquad ln = \frac{Mn}{\Delta}$$

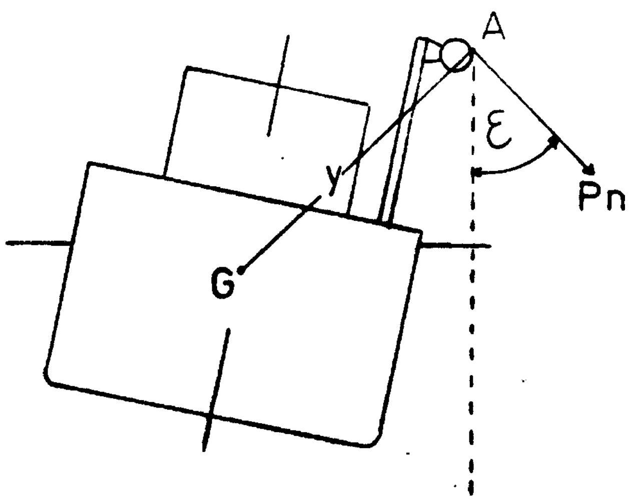


Fig. 26

Pn = Maximum nominal pull transmitted to the fishing gear from the fishing hauling machinery.

Δ = The vessel's displacement at the specified loading condition.

y = Distance $\overline{GA}$ from centre of gravity to point A.

The only difference which has been introduced to the assumptions considered in document IMCO PFV/276 is with regard to the lever "y", which in that document is calculated by means of the equation below and represents the distance between the point O (intersection between centre plane and the initial water plane) and point A.

$$y = \sqrt{y_a^2 + (z_a - d^2)}$$

where:

y_a = Distance between centre plane and point A.

z_a = Distance between base line and point A.

d = Mean draught of the vessel at the loading condition.

3.3.g)3 Criteria

The criteria control the maximum value of the heeling angle "θn" produced by the net winch when hauling and the value of the net winch heeling arm "ln".

i) <u>Net winch heeling angle:</u>

$$\theta n \leqslant 10^{\circ} \text{ or } \theta d, \text{ whichever is less.}$$

ii) <u>Net winch heeling arm:</u>

$$GZ_{10^{\circ}} \geqslant ln$$

In the case of Θd being less than 10 degrees the following condition shall be fulfilled:

$$GZ_{\theta d} \geqslant ln$$

GZ shall be corrected by free surfaces and by the effect of force F acting upon the ship at a point higher than the vessel's centre of gravity.

The selection of a heeling angle equal to 10 degrees or Θd whichever is less, is absolutely reasonable since all the fish holds are usually open during the fishing operation and it is obviously dangerous to get angles of heel greater than 10 degrees or Θd. Moreover the whole fishing operation performed by the crew on deck becomes dangerous and difficult on the slippery deck surface at greater angles of heel.

3.3.h) Timber on deck criteria

According to Regulation 42 of the 1966 Loadlines Convention a timber deck cargo may be regarded as giving the ship a certain additional buoyancy and a greater degree of protection against the sea.

Thus, for ships carrying timber on deck the following criteria of IMO Resolution A.206(VIII) may apply in substitution for criteria given in paragraphs 3.3.a), b) and c), provided that the cargo extends longitudinally between superstructures transversely for the full beam of ship after due allowance for a rounded gunwale not exceeding 4 per cent of the breadth of the ship and/or securing the supporting uprights and which remains securely fixed at large angles of heel. Where there is no limiting superstructure at the after end, the timber deck cargo shall extend at least to the after end of the aftermost hatchway.

3.3.h)1 Dynamic stability

The area "A" under GZ curve between the angles of inclination indicated below shall not be less than 0.08 m-rad.

	0° to 40° or θf*
"A"	0.08

* θf=Flooding angle as defined in paragraph 3.2.e).

3.3.h)2 Righting lever

GZmax. $\geqslant$ 0.25m.

3.3.h)3 Initial metacentric height

GM departure $\geqslant$ 0.1m.

GM must be always positive after corrections for:

free surfaces
absorption of water by deck cargo
ice accretion

The criteria mentioned above may only apply if the ship complies with the special requirements for ships assigned timber freeboards, Chapter IV of the 1966 Loadlines Convention and the Code of Safe Practice for Ships carrying Timber Deck Cargoes adopted by IMO Resolution A.287(VIII).

3.3.i) Wind and Beam Seas Rolling Criteria

These wind and rolling criteria (weather criterion) are intended to consider the effect of external forces on the ship's stability. They applies to passengers and cargo ships of 24 m. in length and over and to fishing vessels of 45 m. in length and over. It's based on IMO Resolution A.562(14) and must be complied with by ships at any loading condition.

The ship is first assumed to be affected by a steady wind pressure which heels the ship to θ_0. She then rolls windwards due to wave action to an angle θ_1. Finally the ship is subjected to a gust wind pressure.

The angle θ_0 shall not exceed 16° or 80% of the angle of deck edge immersion "θd", whichever is less.

3.3.i)1 Steady Wind Moment:

The steady wind moment "Mw_1" and the steady wind heeling lever "lw_1" are calculated by means of the equations below.

$$Mw_1 = P \cdot A \cdot Z \quad \text{ton-m.}$$

$$lw_1 = \frac{P \cdot A \cdot Z}{\Delta} \quad \text{m.}$$

where:

$P = 0.0514$ ton/m^2.

A = Projected lateral area of the portion of ship and deck cargo above the waterline, m .

Z = Vertical distance from the centre of A to the centre of the under water lateral area or approximately to a point at one half of the draught. m.

Mw_1 = Steady wind moment.

lw_1 = Steady wind heeling lever.

3.3.i)2 Gust wind moment:

The gust wind moment and the gust wind heeling lever are calculated by means of the equations below.

$$Mw_2 = 1.5\ Mw_1 \left[ton\text{-}m\right]$$

$$lw_2 = \frac{Mw_2}{\Delta} \left[m\right]$$

3.3.i)3 Wave Rolling Angle:

The wave rolling angle θ_1 is calculated using the following equation:

$$\theta_1 = 109\ k \cdot X_1 \cdot X_2 \cdot \sqrt{r \cdot s} \quad \text{degrees}$$

where:

X_1 = Factor as shown in table 1.

X_2 = Factor as shown in table 2.

k =
- 1.0 for round bilged ships having no bilges or bar keels.
- 0.7 for a ship having sharp bilges.
- As shown in table 3 for a ship having bilge keels, a bar keel or both.

$r = 0.73 \pm 0.6\ \overline{OG}/d$

where: $\overline{OG}$ = Distance between the centre of gravity and the waterline in m. (+ if the centre of gravity is above the waterline, - if it is below).

d = Mean moulded draught of the ship in m.

s = Factor as shown in table 4.

θ_1 for vessels provided with antirolling devices should be determined without taking into account the operation of these devices.

B/D	X	C_B	X	$\frac{Ak \cdot 100}{L \cdot B}$	k	T	s
≤2.4	1.0	≤0.45	0.75	0	1.0	≤6	0.100
2.5	0.98	0.50	0.82	1.0	0.98	7	0.098
2.6	0.96	0.55	0.89	1.5	0.95	8	0.093
2.7	0.95	0.60	0.95	2.0	0.88	12	0.065
2.8	0.93	0.65	0.97	2.5	0.79	14	0.053
2.9	0.91	≥0.70	1.00	3.0	0.74	16	0.044
3.0	0.90			3.5	0.72	18	0.038
3.1	0.88			≥4.0	0.70	≥20	0.035
3.2	0.86						
3.3	0.84						
3.4	0.82						
≥3.5	0.80						

Table 1 Table 2 Table 3 Table 4

* Intermediate values shall be interpolated.

L = Waterline length in m.

B = Moulded breadth in m.

d = Mean moulded draught in m.

C_B = Block coefficient.

Ak = Total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of them.

GM = Metacentric height corrected for free surfaces, in m.

$$T = \frac{2\ c \cdot B}{\sqrt{GM}} \quad \text{Rolling Period}$$

where:

$$c = 0.373 + 0.023\ (B/d) - 0.043\ (L/100)$$

3.3.i)4 Criteria:

The steady wind heeling lever "lw_1" and the gust wind heeling lever "lw_2" are constant values at all angles of inclination.

After drawing the GZ curve corrected for free surfaces, ice accretion if applicable and the effect of Mw_1, θ_1, and Mw_2, as shown in Fig. 27, the following criteria shall be satisfied.

i) Steady wind heeling angle

$\theta_0 \leqslant 16^\circ$ or 80% θd*, whichever is less.

* θd = Angle of deck immersion.

ii) Residual dynamic stability

Area b ⩾ Area a

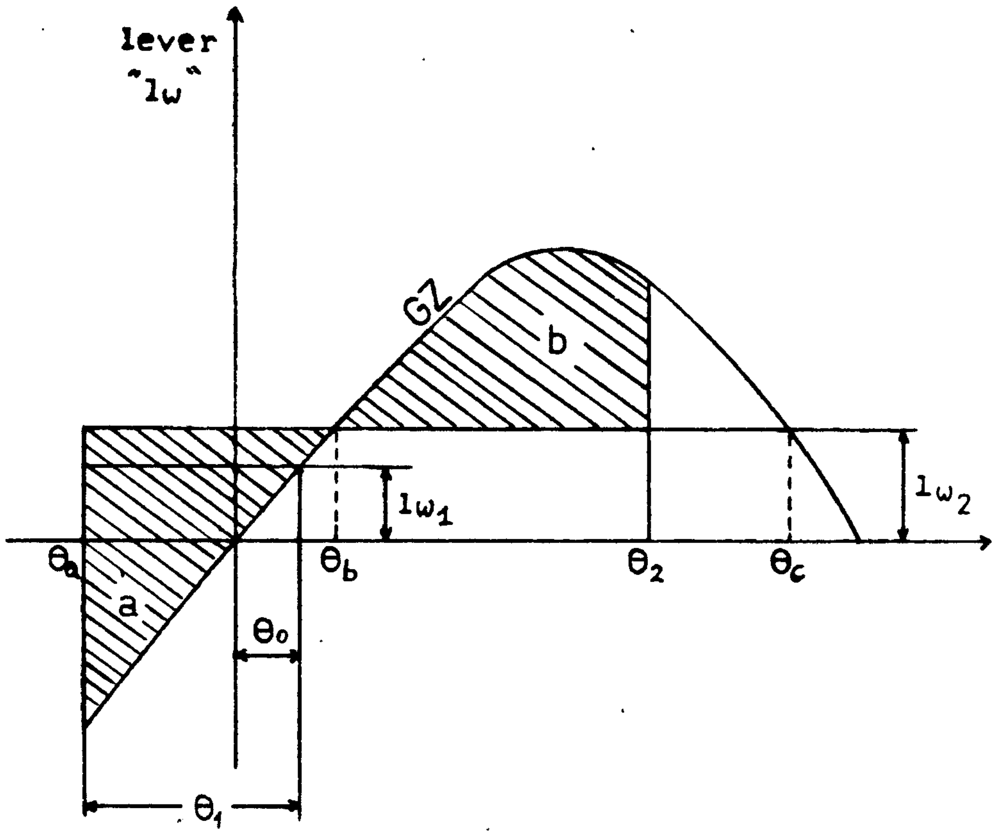


Fig. 27

θ_o = Angle of heel due to steady wind moment Mw_1.

θ_1 = Angle of roll windwards due to wave action.

$\theta_a = \theta_1 - \theta_o$

θ_2 = Angle of flooding θf* or 50 or θc, whichever is less.

θ_b = Angle of first intercept between lever lw_2 and GZ curve.

O_c = Angle of second intercept between lever lw_2 and GZ curve.

* θf = Flooding angle as defined in paragraph 3.2.e).

3.3.i)5 <u>Fishing vessels less than 45 m. in length:</u>

The following interim criteria apply to fishing vessels between 24 m. and 45 m. in length. They are based on the method proposed by the IMO Subcommittee on Stability, Loadlines and on Fishing Vessels Safety in report SLF 33/12, ref. 29, and are subject to changes after further investigation by the IMO SLF Subcommittee.

The method is basically the same as the one applicable to passenger and cargo vessels of 24 m. in length and over and fishing vessels of 45 m. in length and over. Only 2 modifications are introduced.

The first modification deals with the value to consider for the steady wind pressure P, which is decreased according to the table on the next page.

The second modification deals with the rolling coefficient "c", which can be taken from Annex III of the Code of Safety for Fishermen and Fishing Vessels, Part B as:

c = 0.95, for double boom shrimp fishing boats.

$h=Z-(d/2)$ [m]	P [N/m^2]	V [m/s]
1	303.7	20.1
2	374.4	22
3	419.0	23.6
4	452.0	24.5
5	480.2	25.3
6	502.7	25.9

c = 0.80, for deep sea fishing boats.

c = 0.60, for boats with a live fish well.

The Code proposes the above-mentioned values for "c" when calculating GM by means of the equation:

$$GM = \left(\frac{c \cdot B}{T}\right)^2$$

and states that they are mean values. The observed values according to the Code were between 0.05 of those given above. Since the referred values were based upon a series of limited tests, the Ch.M.D. may allow values established in a rolling test witnessed by a Ch.M.D.'s surveyor for a particular ship.

Moreover, if no "c" data are available or they are considered inappropriate, then the equation:

$$c = 0.373 + 0.023\ (B/D) - 0.043\ (L/100)$$

can be employed.

3.3.j) Water Trapped on Deck Criteria

The following criteria is based on Recommendation 2 adopted by the 1977 Torremolinos Convention and is applicable to fishing vessels over 24 m. in length.

3.3.j)1 Water on deck heeling moment

The water on deck heeling moment "Mwod" shall be calculated assuming that the deck well is filled to the top of the bulwark at its lowest point and the vessel heeled up to the angle at which this point is immersed.

The equations for the calculation of the water on deck heeling moment "Mwod", and the water on deck heeling arm "lwod", are given below.

$$Mwod = k \cdot Mw$$

$$lwod = \frac{Mwod}{\Delta}$$

where:

Mw = Static heeling moment due to water on deck.

k = coefficient.

i) Assumptions for calculating Mw:

At the beginning the vesel is in the upright position.

During heeling, trim and displacement are constant and equal to the values for the vessel without water on deck.

The effect of freeing ports should be ignored.

ii) <u>Determination of k:</u>

-static approach, $k = 1$

-quasi static approach,

if $\theta d < 10^\circ$ or $\theta b < 20^\circ$, $k > 1$

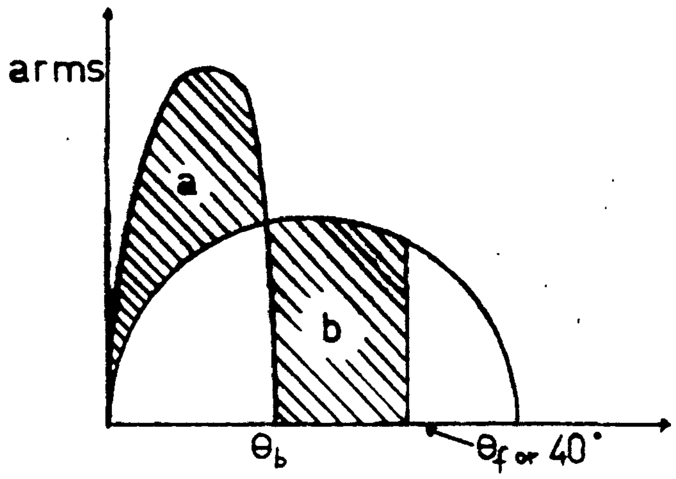
if $\theta d > 20^\circ$ or $\theta b > 30^\circ$, $k < 1$

θd = Angle of deck immersion.
θb = Angle of bulwark immersion.

3.3.j)2 Criterion:

The following criteria shall be fulfilled as far as the residual dynamic stability of the ship is concerned.

Area b $\geqslant$ Area a



3.4 GRAIN LOADING STABILITY BOOKLET

3.4.a) General

All ships intended to carry grain in bulk shall comply with the special provisions of the 1974 Solas Convention Chapter VI and/or IMO Resolution A.264(VIII) "IMO Grain Rules".

A ship without the Grain Stability Booklet duly approved by the Ch.M.D. shall not be allowed to load grain.

The Grain Stability Booklet shall contain all the information indicated for the Stability Booklet in section 3.1 and the following additional information calculated according to Chapter VI of the 1974 Solas Convention.

1) Curves or tables of Grain Heeling Moments for every compartment, filled or partly filled, or combination thereof, feeders and trunks, including the effects of temporary fittings.

2) Tables of maximum permissible grain heeling moments or other information sufficient to prove compliance with the criteria mentioned in paragraph 3.4.c) at all stages of any voyage.

3) Details of scantlings of any temporary fittings and where applicable the provisions necessary to meet the requirements of section I (E) of Part C of Chapter VI of the 1974 Solas Convention.

4) Checking of compliances with the criteria in paragraph 3.4.c) for each calculated loading condition.

5) A detailed working example for the guidance of the Master on how to calculate stability for any different loading condition and the checking of compliances with the criteria in paragraph 3.4.c).

6) Loading instructions in the form of notes summarizing the provisions of Chapter VI of the 1974 Solas Convention.

7) The stability levers (cross curves) shall include the calculation for 12 degrees and 40 degrees.

3.4.b) Grain Shift Heeling Moment

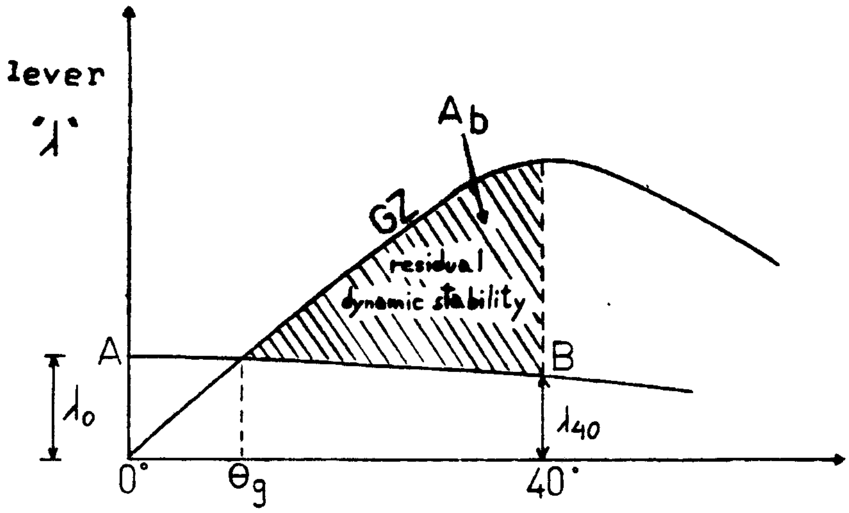
The grain shift heeling moment "Mg", shall be calculated as stated in Chapter VI of Solas 74 in order to depict the grain shift heeling lever curve as shown in Fig. 29.

$$Mg = \frac{\text{Volumetric grain heeling moment}}{\text{stowage factor}}$$

$$\lambda_0 = \frac{Mg}{\Delta}$$

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

The straight line AB in fig. 29 is defined by λ_0 and λ_{40} and represents the heeling lever curve due to transverse grain shift.



θ_g = Angle of heel due to grain shift

Fig.29

3.4.c) <u>Grain Shift Criteria:</u>

3.4.c)1 <u>Grain shift heeling angle</u>

$$\theta g \leqslant 12^\circ$$

3.4.c)2 <u>Residual dynamic stability</u>

Area b, enclosed by GZ curve and AB between θg and θf* or 40°, must not be less than 0.075 m-rad.

3.4.c)3 **<u>Initial metacentric height</u>**

$$GM \geqslant 0.3m.$$

* See section 3.2.e).

3.5 DAMAGE STABILITY BOOKLET

The ships indicated in the following paragraphs shall include as a second part of the Stability Booklet the subdivision and damage stability calculations approved by a Classification Society recognized by the Ch.M.D.

This means that the Classification Society has checked and approved the subdivision and damage stability calculations as far as the compliances with the criteria contained in the applicable international rules are concerned.

The calculations of damage stability shall clearly specify:

Damage assumptions,
Flooding assumptions,
Standards of damage,
Survival requirements or Criteria.

3.5.a) Loadlines Assignment

The 1966 Loadlines Convention establishes the minimum freeboard permitted for a ship. However the draught associated with the loadline assigned shall not be greater than the maximum draught otherwise permitted by the relevant damage stability provisions applicable to the ship.

3.5.b) Ship Type B with Reduced Freeboard

A ship type B according to the 1966 Loadlines Convention is one which is not designed to carry only liquid cargoes in bulk. Such a ship, if over 100 m. in length, may be assigned a freeboard less than those required by table B of Regulation 28 of the 66 LL Convention, provided that she complies with the provisions of Regulation 27 of that convention.

The applicable considerations for calculation of the subdivision and damage stability are stated in Regulation 27(7) paragraphs d), e) and Regulations 27(8) and 27(9) of the aforesaid convention.

3.5.c) Ship Type A

A ship type A according to the 1966 Loadlines Convention is one which is designed to carry only liquid cargoes in bulk and fulfils the definition given in Regulation 27(2) of the 66 LL Convention. Such a ship, if over 150 m. in length and designed to have empty compartments when loaded to its summer load waterline, shall be able to withstand flooding under the conditions established in Regulation 27(3) of the aforesaid convention.

3.5.d) Passenger Ships

The Subdivision and Damage Stability Calculations for passenger ships shall be performed according to the provisions of Chapter II-1 of the 1974 Solas Convention. Alternately the aforesaid calculations may be performed according to the provisions of IMO Resolutions A.265(VII) and A.266(VIII), refs. 21 and 22 respectively.

3.5.d)1 Subdivision loadlines:

The subdivision loadlines shall be assigned, marked and recorded according to the Regulations applicable (Solas

Chapter II-1 or IMO Resol. A.265(VIII).

In no case shall any subdivision loadline mark be placed above the deepest loadline in salt water as determined by the strength of the ship or the 66 LL Convention.

The freeboard corresponding to each approved subdivision loadline and the conditions of service for which they are approved, shall be clearly indicated on the International Passenger Ship Safety Certificate.

3.5.d)2 Damage Control Plan:

A Damage Control Plan or Damage Contingency Plan approved by the Ch.M.D. shall be made available on board, as indicated in Regulation 23, Chapter II-1 of the 74 Solas Convention.

There shall be permanently exhibited, for the guidance of the officer in charge of the ship, plans showing clearly for each deck and hold the boundaries of the watertight compartments, the openings therein with the means of closure and positions of any controls thereof, and the correction of any list due to flooding.

In addition, Damage Control Booklets approved by the Ch.M.D., containing the aforementioned information shall be made available to the officers of the ship.

The existence on board of the Damage Control Plan as indicated above is a requirement for the issuance and validity of the International Passenger Ship Safety Certificate.

3.5.e) Dry Cargo Ships

Until now the 1974 Solas Convention has not included specific regulations dealing with damage stability and subdivision for dry cargo ships. Nevertheless the Convention does include in Chapter II-1 provisions as to the Damage Control Plan and construction and testing of peak bulkheads, stern tubes, watertight bulkheads, watertight doors, sidescuttles, watertight decks, trunks, bilge pumping arrangement and so on for cargo ships.

The IMO Subcommittee on Stability, Loadlines and on Fishing Vessels Safety has already considered the issue of establishing an acceptable level of safety as far as the Subdivision and Damage Stability Standards for Dry Cargo Vessels and Ro-Ro Ships are concerned. As a result of these studies regulations based on the probabilistic approach of IMO Resolution A.265(VIII) have been developed and adapted to suit the design characteristics of Dry Cargo and Ro-Ro ships.

Circular 484 of the Maritime Safety Committee, ref. 22, contains the provisions for Subdivision and Damage Stability for Dry Cargo Ships including Ro-Ro Ships and it will enter into force in Chile after adoption by Resolution of the IMO Assembly.

3.5.e)1 Damage Control Plan

A Damage Control Plan or Damage Contingency Plan approved by the Ch.M.D. shall be made available on board, as indicated in Regulation 23-1 Chapter II-1 of the Solas 74 Convention. There shall be permanently exhibited, for the guidance of the officer in charge of the ship, a plan showing clearly for each deck and hold the boundaries of the watertight compartments, the openings therein with the means of closure and positions of any controls thereof, and the arrangements for the correction of any list due to flooding. In addition, Damage Control Booklets approved by the Ch.M.D. containing the aforesaid information shall be made available to the officers of the ship.

The damage control plan shall contain as general precautions a listing of equipment, conditions and operational procedures necessary to maintain watertight integrity under ship operations. As specific precautions a listing of elements (i.e. closures, security of cargo, sounding of alarms etc) being vital to the survival of the ship and its crew shall be included.

Information on Indicators according to the provisions of Regulation 23-1 2) shall be made available in the vicinity of the plan and in the damage control booklets including :

- Sliding doors,
- Hinged doors in watertight bulkheads,
- Open and closed condition indicators,
- Shell doors,
- Other openings which could lead to major flooding if left open or not properly secured.

3.5.f) <u>Oil Tankers</u>

Oil Tanker means a ship constructed or adapted primarily to carry oil in bulk in its cargo spaces and includes Combination Carriers (a ship which carries either oil or solid cargoes in bulk) and any Chemical Tanker as defined in paragraph 3.5.g) when it is carrying a cargo or part cargo of oil in bulk.

The Subdivision and Damage Stability Calculations for Oil Tankers shall be performed in accordance with the provisions of the Marpol 73/78 Convention, Regulation 25. The damage assumptions, hypotethical outflow of oil calculations and cargo tanks limitation and arrangement shall be taken into account as stated in Regulations 22, 23 and 24 of the afore saidconvention.

The Unified Interpretation of the Provisions of Annex I of Marpol 73/78, included in the IMO publication "Regulations for the Prevention of Pollution by Oil", ref. 23, shall be considered.

The Damage Stability Booklet shall include all information related to loading and distribution of cargo necessary to ensure compliance with the regulations above mentioned. This information shall also be made available on board non self propelled tankers to which Annex 1 of Marpol 73/78 applies.

3.5.g) Chemical Tankers

"Chemical Tanker" means a ship constructed or adapted primarily to carry a cargo of Noxious Liquid Substances in Bulk and includes an Oil Tanker as defined in paragraph 3.5.f) when carrying a cargo or part cargo of Noxious Liquid Substances in Bulk.

Chemical Tankers built before 1 July 1986 shall comply with the damage stability provisions of chapter II of the BCH Code, ref. 24. (Reference shall be made to the

Guidelines for the Uniform Application of the Survival Requirements of the Bulk Chemical Code and the Gas Carrier Code, ref. 26).

The Stability Booklet approved by the Ch.M.D. shall contain loading information with details concerning:

- The loaded conditions of full and empty or partially empty tanks.
- The position of those tanks in the ship.
- The specific gravities of the various parcels of cargoes carried.
- Ballast arrangements in critical conditions of loading.

Provisions for evaluating other conditions of loading should also be contained in the booklet.

Chemical Tankers built on or after 1 July 1986 shall comply with the damage stability provisions of chapter II of the IBC Code, ref. 25. (The Guidelines of ref. 26 shall be taken into account).

When calculating Intact Stability the effect of free surfaces of consumable liquids shall be considered. Thus, it should be assumed that for each type of liquid at least one transverse pair or a single centre tank has a free surface and the tank or combination of tanks to be taken into account should be those where the effect of free surfaces is the greatest.

The Stability Booklet shall contain loading information with details of typical service and ballast conditions, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities.

In addition, the booklet should contain sufficient information to enable the Master to load and operate the ship in a safe and seaworthy manner.

3.5.h) <u>Gas Carriers</u>

Gas Carrier is a ship constructed or adapted primarily to carry a cargo of Liquefied Gases in Bulk which are within the scope or application of:

i) Regul. 1.2 of the Gas Carrier Code, ref. 27.

ii) Regul. 1.1 of the IGC Code, ref. 28.

Both Codes above mentioned apply to Liquefied Gases having a vapour pressure exceeding 2.8 kp/cm^2 absolute at a temperature of 37.8° C, and certain other substances which the Gas Carrier and IGC Codes show in their chapters 19 and XIX respectively.

The damage stability calculations shall be made in accordance with Chapter II of the Gas Carrier Code for ships built before 1 July 1986.

Reference shall be made to the Guidelines for the Uniform Application of the Survival Requirements of the BCH and Gas Carrier Code, ref. 26.

For ships built on or after 1 July 1986 the damage stability calculations shall be performed in accordance with Chapter II of the IGC Code, ref. 28.

The Stability Booklet shall contain:

- Loading information with details of typical service conditions.
- Loading and unloading and ballasting operations.
- A summary of the ship's survival capabilities.
- Provisions for evaluating other conditions of loading.

In addition, the booklet should contain sufficient information regarding the ship and its cargo to enable the Master to load and operate the ship in a safe and seaworthy manner.

BIBLIOGRAPHY

1) International Convention for the Safety of Life at Sea 1974 as amended, IMO Publication London 1986. IMO Sales Number 110 86.02. E .

2) International Convention on Loadlines, 1966 as amended, IMO Publication London 1981. IMO Sales Number 701 81.01.E .

3) Torremolinos International Convention for the Safety of Fishing Vessels, 1977. IMO Publication London 1977. IMO Sales Number 741 77.10.E .

4) International Convention for the Prevention of Pollution from Ships, 1973. IMO Publication London 1977. IMO Sales Number 520 77.14.E .

5) Protocol of 1978 to the 1974 Solas Convention and Protocol of 1978 relating to the 1973 Marpol Convention, IMO Publication London 1978. IMO Sales Number 088 78.09.E .

6) IMO Resolution A.267(VIII) adopted 20 November 1973 "Code of Practice concerning the Accuracy of Stability Information for Fishing Vessels".

7) IMO Resolution A.167(ES.IV) adopted in November 1968 "Recommendation on Intact Stability for Passenger and Cargo Ships under 100 m. in length". IMO Sales Number 832 87.13.E .

8) IMO Resolution A.168(ES.IV) adopted in November 1968

"Recommendation on Intact Stability of Fishing Vessels".

9) U.S. Coast Guard, Navigation and Vessel Inspection Circular 15-81 "Guidelines for Conducting Stability Tests", published 16 December 1981.

10) International Convention on Tonnage Measurement of Ships, 1969. IMO Publication London 1970. IMO Sales Number 713 70.01.E .

11) Code of Safety for Fishermen and Fishing Vessels, Part B. IMO Publication London 1975. IMO Sales Number 75.05.E .

12) IMO Document SLF 31/22 published by the IMO Subcommittee on Stability, Loadlines and on Fishing Vesels Safety on June 23 1986. "Report to the Maritime Safety Committee".

13) Third International Conference on Stability of Ships and Ocean Vehicles, Gdansk, September 1986. Paper 3.2 presented by H. Hormann and D. Wagner "Stability Criteria for Present Day Ships Design".

14) IMO Resolution A.562(14) adopted in November 1985 "Recommendation on a Severe Wind and Rolling Criterion (Weather Criterion) for the Intact Stability of Passenger and Cargo Ships of 24 m. in length and over", included in IMO Sales Number 832 87.13. E.

15) "Development of New Stability Criteria for Modern Dry Cargo Vessels", Article by P. Blume, Hamburg Ship Model Basin, Federal Republic of Germany, 1987.

16) IMO DocumenT PFV/276 of the IMO Subcommitee on Safety of Fishing Vessels, published April 1980. "Effect of Fishing Gear on Stability of Fishing Vessels".

17) IMO Resolution A.206(VII) adopted in October 1971 "Amendments to IMO Resolution A.167(ES.IV) with respect to ships carrying Timber Deck Cargoes". Included in IMO Sales Number 832 87.13.E .

18) IMO Resolution A.287(VIII) adopted 20 November 1973 "Code of Safe Practice for Ships carrying Timber Deck Cargoes". IMO Sales Number 275 81.05.E .

19) IMO Resolution A.264(VIII) adopted 20 November 1973 "IMO Grain Rules". IMO Sales Number 263 82.14.E .

20) IMO Resolution A.265(VIII) adopted in November 1973 "Regulations on Subdivision and Stability of Passenger Ships as an equivalent to Part B of chapter II of the 1960 Solas Convention". IMO Sales Number 74.09.E.

21) IMO Resolution A.266(VIII) adopted in November 1973 "Recommendation on a Standard Method for Establishing Compliance with the Requirements for Cross Flooding Arrangements in Passenger Ships". Included in IMO Sales Number 74.09.E .

22) Circular 484 of the IMO Maritime Safety Committee, published on May 6 1988 "Subdivision and Damage Stability of Dry Cargo Ships, including Ro-Ro Ships".

23) IMO Regulations for the Prevention of Pollution by Oil, IMO Publication London 1986. IMO Sales Number 525 86.01.E .

24) Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk, "BCH Code". IMO Publication London 1986. IMO Sales Number 772 86.12.E .

25) International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk, "IBC Code". IMO Publication London 1986. IMO Sales Number 100 86.11.E .

26) IMO Guidelines for the Uniform Application of the Survival Requirements of the Bulk Chemical Code (BCH Code) and the Gas Carrier Code, Included in IMO Sales Number 782 83.16.E (Gas Carrier Code).

27) Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk "Gas Carrier Code" adopted by IMO Resolution A.329(IX). IMO Sales Number 782 83.16.E .

28) 1983 Amendments to the Solas 74 Convention. Volume III: "International Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk" (IGC Code) adopted by Resolution MSC 5(48). IMO Sales Number 104 83.12.E .

29) IMO Document SLF 33/12 published by the IMO Subcommittee on Stability and Loadlines and on Fishing Vessels Safety "Report to the Maritime Safety Committee", 25 July 1988.