

DOCUMENT 1



SUB-COMMITTEE ON STABILITY AND
LOAD LINES AND ON FISHING VESSELS
SAFETY
48th session
Agenda item 4

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REVIEW OF THE INTACT STABILITY CODE

Report of the Intersessional Correspondence Group (part 3)

Submitted by Germany

SUMMARY

Executive summary: This document contains the report of the intersessional Correspondence Group on Intact Stability

Action to be taken: Paragraph 2

Related documents: SLF 48/4, SLF 48/4/1, SLF 48/4/2, SLF 47/6/3, SLF 47/6/4, SLF 47/6/8, SLF 47/6/10, SLF 47/6/12, SLF 47/6/15, SLF 47/6/18, SLF 47/6/19, SLF 47/6/20, SLF 47/6/22, SLF 47/6/23, SLF 47/6/25, SLF 47/WP.2 and SLF 47/WP.3

1 Parts of the draft revised text of the IMO resolution A.749(18) (IS Code) is attached at annex (only Annexes are included. Part A is attached to document SLF 48/4/1 and Parts B and C are attached to document SLF 48/4/2).

Action requested of the Sub-Committee

2 The Sub-Committee is invited to consider the information provided and to take action as appropriate.

<i>Annex 2 – Detailed guidance for the conduct of an inclining test</i>	
1	Introduction
	<p>This annex supplements the inclining standards put forth in chapter 7 of this Code. This annex contains important detailed procedures for conducting an inclining test in order to ensure that valid results are obtained with maximum precision at a minimal cost to owners, shipyards and the Administration. A complete understanding of the correct procedures used to perform an inclining test is imperative in order to ensure that the test is conducted properly and so that results can be examined for accuracy as the inclining experiment is conducted.</p>
2	Preparations for the inclining test
2.1	Free surface and tankage
2.1.1	<p>If there are liquids on board the ship when it is inclined, whether in the bilges or in the tanks, they will shift to the low side when the ship heels. This shift of liquids will exaggerate the heel of the ship. Unless the exact weight and distance of liquid shifted can be precisely calculated, the metacentric height (GM) calculated from the inclining test will be in error. Free surface should be minimized by emptying the tanks completely and making sure all bilges are dry; or by completely filling the tanks so that no shift of liquid is possible. The latter method is not the optimum because air pockets are difficult to remove from between structural members of a tank, and the weight and centre of the liquid in a full tank should be accurately determined in order to adjust the light-ship values accordingly. When tanks must be left slack, it is desirable that the sides of the tanks be parallel vertical planes and the tanks be regular in shape (i.e. rectangular, trapezoidal, etc.) when viewed from above, so that the free surface moment of the liquid can be accurately determined.</p> <p>For example, the free surface moment of the liquid in a tank with parallel vertical sides can be readily calculated by the formula:</p>

$$M_{fs} = lb^3/12Q \quad (\text{mt})$$

where:

l = length of tank (m)

b = breadth of tank (m)

Q = specific volume of liquid in tank (m³/t)

(Measure Q directly with a hydrometer).

$$\text{Free surface correction} = \frac{\sum M_{fs} (1) + M_{fs} (2) + \dots + M_{fs} (x)}{\text{displ.}} \quad (m)$$

where:

M_{fs} = free surface moment (mt)

displ = displacement (t)

Free surface correction is independent of the height of the tank in the ship, location of the tank, and direction of heel. As the width of the tank increases, the value of free surface moment increases by the third power. The distance available for the liquid to shift is the predominant factor. This is why even the smallest amount of liquid in the bottom of a wide tank or bilge is normally unacceptable and should be removed prior to the inclining experiment. Insignificant amounts of liquids in V-shaped tanks or voids (e.g. a chain locker in the bow), where the potential shift is negligible, may remain if removal of the liquid would be difficult or would cause extensive delays.

When ballast water is used as inclining weight, the actual transverse and vertical movements of the liquid should be calculated taking into account the change of heel of the ship. Free surface corrections as defined in this paragraph should not apply to the inclining tanks.

2.1.2 Free surface and slack tanks - The number of slack tanks should normally be limited to one port/ starboard pair or one centreline tank of the following:

2.1.2.1 fresh water reserve feed tanks;

2.1.2.2 fuel/diesel oil storage tanks;

2.1.2.3 fuel/diesel oil day tanks;

2.1.2.4 lube oil tanks;

2.1.2.5 sanitary tanks; or

2.1.2.6 potable water tanks.

To avoid pocketing, slack tanks should normally be of regular (i.e. rectangular, trapezoidal, etc.) cross section and be 20% to 80% full if they are deep tanks and 40% to 60% full if they are double-bottom tanks. These levels ensure that the rate of shifting of liquid remains constant throughout the heel angles of the inclining test. If the trim changes as the ship is inclined, then consideration should also be given to longitudinal pocketing. Slack tanks containing liquids of sufficient viscosity to prevent free movement of the liquids, as the ship is inclined (such as bunker at low temperature), should be avoided since the free surface cannot be calculated accurately. A free surface correction for such tanks should not be used unless the tanks are heated to reduce viscosity. Communication between tanks should never be allowed. Cross-connections, including those via manifolds, should be closed. Equal liquid levels in slack tank pairs can be a warning sign of open cross connections. A bilge, ballast, and fuel oil piping plan can be referred to, when checking for cross connection closures.

2.1.3 Pressed-up tanks - "Pressed up" means completely full with no voids caused by trim or inadequate venting. Anything less than 100% full, for example the 98% condition regarded as full for operational purposes, is not acceptable. Preferably, the ship should be rolled from side to side to eliminate entrapped air before taking the final sounding. Special care should be taken when pressing fuel oil tanks to prevent

accidental pollution. An example of a tank that would appear "pressed up", but actually contains entrapped air, is shown in figure A2-2.1.3.

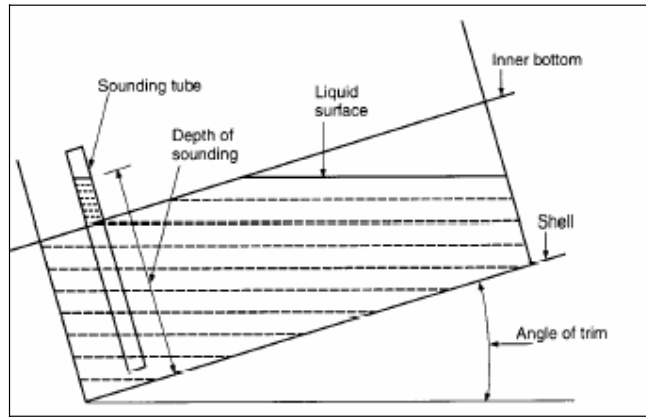


Figure A2-2.1.3

2.1.4 Empty tanks – It is generally not sufficient to simply pump tanks until suction is lost. Enter the tank after pumping to determine if final stripping with portable pumps or by hand is necessary. The exceptions are very narrow tanks or tanks where there is a sharp deadrise, since free surface would be negligible. Since all empty tanks should be inspected, all manholes should be open and the tanks well ventilated and certified as safe for entry. A safe testing device should be on hand to test for sufficient oxygen and minimum toxic levels. A certified marine chemist's certificate certifying that all fuel oil and chemical tanks are safe for human entry should be available, if necessary.

2.2 Mooring arrangements

The importance of good mooring arrangements cannot be overemphasized. The arrangement selections will be dependent upon many factors. Among the most important are depth of water, wind and current effects. Whenever possible, the ship should be moored in a quiet, sheltered area free from extraneous forces such as propeller wash from passing ships, or sudden discharges from shore side pumps. The depth

of water under the hull should be sufficient to ensure that the hull will be entirely free of the bottom. The tide conditions and the trim of the ship during the test should be considered. Prior to the test, the depth of water should be measured and recorded in as many locations as necessary to ensure the ship will not contact the bottom. If marginal, the test should be conducted during high tide or the ship moved to deeper water.

2.2.1 The mooring arrangement should ensure that the ship will be free to list without restraint for a sufficient period of time to allow a satisfactory reading of the heeling angle, due to each weight shift, to be recorded.

2.2.2 The ship should be held by lines at the bow and the stern, attached to bollards and/or cleats on the deck. If suitable restraint of the ship cannot be achieved using deck fittings, then temporary padeyes should be attached as close as possible to the centreline of the ship and as near the waterline as practical. Where the ship can be moored to one side only, it is good practice to supplement the bow and stern lines with two spring lines in order to maintain positive control of the ship, as shown in figure A2.2.2.1. The leads of the spring lines should be as long as practicable. Cylindrical camels should be provided between the ship and the dock. All lines should be slack, with the ship free of the pier and camels, when taking readings.

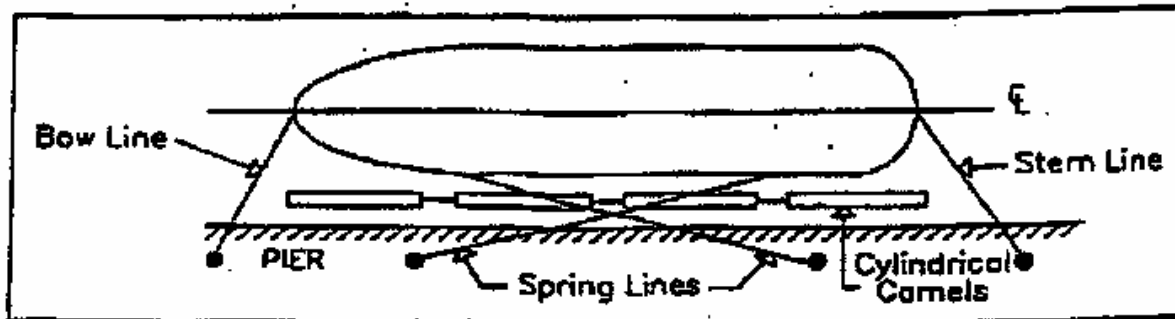


Figure A2-2.2.1

2.2.2.1 If the ship is held off the pier by the combined effect of the wind and current, a superimposed heeling moment will act on the ship throughout the test. For steady conditions this will not affect the results.

<p>Gusty winds or uniformly varying wind and/or current will cause these superimposed heeling moments to change, which may require additional test points to obtain a valid test. The need for additional test points can be determined by plotting test points as they are obtained.</p> <p>2.2.2.2 If the ship is pressed against the fenders by wind and/or current, all lines should be slack. The cylindrical camels will prevent binding but there will be an additional superimposed heeling moment due to the ship bearing against the camels. This condition should be avoided where possible but, when used, consideration should be given to pulling the ship free of the dock and camels and letting the ship drift as readings are taken.</p> <p>2.2.2.3 Another acceptable arrangement is where the combined wind and current are such that the ship may be controlled by only one line at either the bow or the stern. In this case, the control line should be led from on or near the centre line of the ship with all lines but the control line slack, the ship is free to veer with the wind and/or current as readings are taken. This can sometimes be troublesome because varying wind and/or current can cause distortion of the plot.</p> <p>2.2.3 The mooring arrangement should be submitted to the approval authority for review prior to the test.</p> <p>2.2.4 If a floating crane is used for handling inclining weights, it should not be moored to the ship.</p>	
<p>2.3 Test weights</p> <p>2.3.1 Weights, such as porous concrete, that can absorb significant amounts of moisture should only be used if they are weighed just prior to the inclining test or if recent weight certificates are presented. Each weight should be marked with an identification number and its weight. For small ships, drums completely filled with water may be used. Drums should normally be full and capped to allow accurate weight control. In such cases, the weight of the drums should be verified in the presence of the Administration representative using a recently calibrated scale.</p> <p>2.3.2 Precautions should be taken to ensure that the decks are not overloaded during weight movements. If deck strength is questionable then a structural analysis should be performed to determine if existing framing can support the weight.</p>	

<p>2.3.3 Generally, the test weights should be positioned as far outboard as possible on the upper deck. The test weights should be on board and in place prior to the scheduled time of the inclining test.</p> <p>2.3.4 Where the use of solid weights to produce the inclining moment is demonstrated to be impracticable, the movement of ballast water may be permitted as an alternative method. This acceptance would be granted for a specific test only, and approval of the test procedure by the Administration is required. As a minimal prerequisite for acceptability, the following conditions should be required:</p> <p>2.3.4.1 inclining tanks should be wall-sided and free of large stringers or other internal members that create air pockets. Other tank geometries may be accepted at the discretion of the Administration;</p> <p>2.3.4.2 tanks should be directly opposite to maintain ship's trim;</p> <p>2.3.4.3 specific gravity of ballast water should be measured and recorded;</p> <p>2.3.4.4 pipelines to inclining tanks should be full. If the ship's piping layout is unsuitable for internal transfer, portable pumps and pipes/hoses may be used;</p> <p>2.3.4.5 blanks must be inserted in transfer manifolds to prevent the possibility of liquids being "leaked" during transfer. Continuous valve control must be maintained during the test;</p> <p>2.3.4.6 all inclining tanks must be manually sounded before and after each shift;</p> <p>2.3.4.7 vertical, longitudinal and transverse centres should be calculated for each movement;</p> <p>2.3.4.8 accurate sounding/ullage tables must be provided. The ship's initial heel angle should be established prior to the incline in order to produce accurate values for volumes and transverse and vertical centres of gravity for the inclining tanks at every angle of heel. The draught marks amidships (port and starboard) should be used when establishing the initial heel angle;</p> <p>2.3.4.9 verification of the quantity shifted may be achieved by a flow meter or similar device; and</p>	
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<p>2.3.4.10 the time to conduct the inclining must be evaluated. If time requirements for transfer of liquids are considered too long, water may be unacceptable because of the possibility of wind shifts over long periods of time.</p>	
<p>2.4 Pendulums</p> <p>2.4.1 The pendulums should be long enough to give a measured deflection, to each side of upright, of a least 15 cm. Generally, this will require a pendulum length of at least 3 m. It is recommended that pendulum lengths of 4-6 m be used. Usually, the longer the pendulum the greater the accuracy of the test; however, excessively long pendulums are used on a tender ship the pendulums may not settle down and the accuracy of the pendulums would then be questionable. On large ships with high GM, pendulum lengths in excess of the length recommended above may be required to obtain the minimum deflection. In such cases, the trough, as shown in figure A2-2.4.6, should be filled with high-viscosity oil. If the pendulums are of different lengths, the possibility of collusion between station recorders is avoided.</p> <p>2.4.2 On smaller ships, where there is insufficient headroom to hang long pendulums, the 15 cm deflection should be obtained by increasing the test weight so as to increase the heel. On most ships the typical inclination is between one and four degrees.</p> <p>2.4.3 The pendulum wire should be piano wire or other monofilament material. The top connection of the pendulum should afford unrestricted rotation of the pivot point. An example is that of a washer with the pendulum wire attached suspended from a nail.</p> <p>2.4.4 A trough filled with a liquid should be provided to dampen oscillations of the pendulum after each weight movement. It should be deep enough to prevent the pendulum weight from touching the bottom. The use of a winged plumb bob at the end of the pendulum wire can also help to dampen the pendulum oscillations in the liquid.</p> <p>2.4.5 The battens should be smooth, light-coloured wood, 1 to 2 cm thick, and should be securely fixed in position so that an inadvertent contact will not cause them to shift. The batten should be aligned close to the pendulum wire but not in contact with it.</p>	

2.4.6 A typical satisfactory arrangement is shown in figure A2-2.4.6. The pendulums may be placed in any location on the ship, longitudinally and transversely. The pendulums should be in place prior to the scheduled time of the inclining test.

2.4.7 It is recommended that inclinometers or other measuring devices only be used in conjunction with at least one pendulum. The Administration may approve an alternative arrangement when this is found impractical.

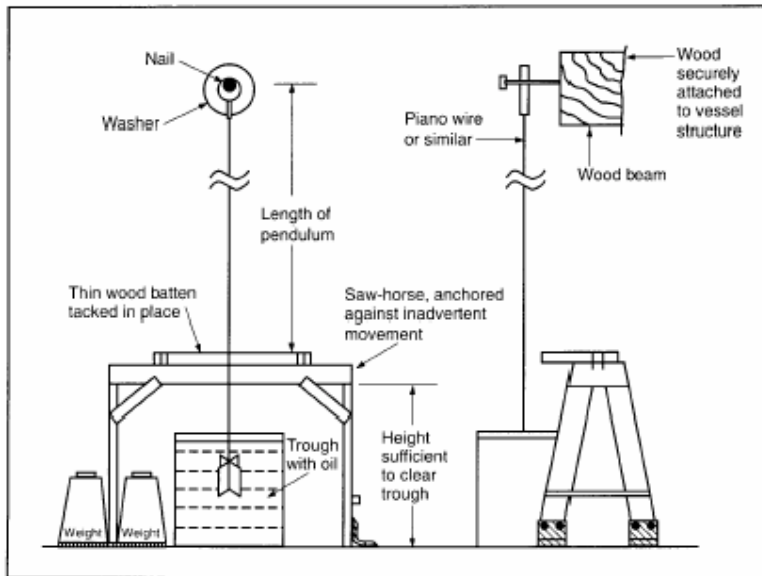


Figure: A2-2.4.6

2.5 U-tubes

2.5.1 The legs of the device should be securely positioned as far as outboard as possible and should be parallel to the centreline plane of the ship. The distance between the legs should be measured perpendicular to the centreline plane. The legs should be vertical, as far as practical.

<p>2.5.2 Arrangements should be made for recording all readings at both legs. For easy reading and checking for air pockets, clear plastic tube or hose should be used throughout. The U-tube should be pressure-tested prior to the inclining test to ensure watertightness.</p> <p>2.5.3 The horizontal distance between the legs of the U-tube should be sufficient to obtain a level difference of at least 15 cm between the upright and the maximum inclination to each side.</p> <p>2.5.4 Normally, water would be used as the liquid in the U-tube. Other low-viscosity liquids may also be considered.</p> <p>2.5.5 The tube should be free of air pockets. Arrangements should be made to ensure that the free flow of the liquid in the tube is not obstructed.</p> <p>2.5.6 Where a U-tube is used as a measuring device, due consideration should be given to the prevailing weather conditions (see 4.1.1.3):</p> <p>2.5.6.1 if the U-tube is exposed to direct sunlight, arrangements should be made to avoid temperature differences along the length of the tube;</p> <p>2.5.6.2 if temperatures below 0°C are expected, the liquid should be a mixture of water and an anti-freeze additive; and</p> <p>2.5.6.3 where heavy rain squalls can be expected, arrangements should be made to avoid additional water entering the U-tube.</p>	
<p>2.6 Inclometers</p> <p>The use of inclinometers should be subject to at least the following recommendations:</p> <p>2.6.1 the accuracy should be equivalent to that of the pendulum;</p> <p>2.6.2 the sensitivity of the inclinometer should be such that the non-steady heeling angle of the ship can be recorded throughout the measurement;</p>	

<p>2.6.3 the recording period should be sufficient to accurately measure the inclination. The recording capacity should be generally sufficient for the whole test;</p> <p>2.6.4 the instrument should be able to plot or print the recorded inclination angles on paper;</p> <p>2.6.5 the instrument should have linear performance over the expected range of inclination angles;</p> <p>2.6.6 the instrument should be supplied with the manufacturer's instructions giving details of calibration, operating instructions, etc.; and</p> <p>2.6.7 it should be possible to demonstrate the required performance to the satisfaction of the Administration during the inclining test.</p>	
<p>3 Equipment required</p> <p>Besides the physical equipment necessary such as the inclining weights, pendulums, small boat, etc., the following are necessary and should be provided by or made available to the person in charge of the inclining:</p> <p>3.1 engineering scales for measuring pendulum deflections (rules should be subdivided sufficiently to achieve the desired accuracy);</p> <p>3.2 sharp pencils for marking pendulum deflections;</p> <p>3.3 chalk for marking the various positions of the inclining weights;</p> <p>3.4 a sufficiently long measuring tape for measuring the movement of the weights and locating different items on board;</p> <p>3.5 a sufficiently long sounding tape for sounding tanks and taking freeboard readings;</p>	

<p>3.6 one or more well maintained specific gravity hydrometers with range sufficient to cover 0.999 to 1.030, to measure the specific gravity of the water in which the ship is floating (a hydrometer for measuring specific gravity of less than 1.000 may be needed in some locations);</p> <p>3.7 other hydrometers as necessary to measure the specific gravity of any liquids on board;</p> <p>3.8 graph paper to plot inclining moments versus tangents;</p> <p>3.9 a straight edge to draw the measured waterline on the lines drawing;</p> <p>3.10 a pad of paper to record data;</p> <p>3.11 an explosion-proof testing device to check for sufficient oxygen and absence of lethal gases in tanks and other closed spaces such as voids and cofferdams;</p> <p>3.12 a thermometer; and</p> <p>3.13 draught tubes (if necessary).</p>	
<p>4 Test procedure</p> <p>The inclining experiment, the freeboard/draught readings and the survey may be conducted in any order and still achieve the same results. If the person conducting the inclining test is confident that the survey will show that the ship is in an acceptable condition and there is the possibility of the weather becoming unfavourable, then it is suggested that the inclining be performed first and the survey last. If the person conducting the test is doubtful that the ship is complete enough for the test, it is recommended that the survey be performed first since this could invalidate the entire test, regardless of the weather conditions. It is very important that all weights, the number of people on board, etc., remain constant throughout the test.</p>	
<p>4.1 Initial walk through and survey</p> <p>The person responsible for conducting the inclining test should arrive on board the ship well in advance of the scheduled time of the test to ensure that the ship is properly prepared for the test. If the ship to be inclined is large, a preliminary walk through may need to be done the day preceding the actual incline.</p>	

To ensure the safety of personnel conducting the walk through, and to improve the documentation of surveyed weights and deficiencies, at least two persons should make the initial walk through. Things to check include: all compartments are open, clean, and dry, tanks are well ventilated and gas-free, movable or suspended items are secured and their position documented, pendulums are in place, weights are on board and in place, a crane or other method for moving weights is available, and the necessary plans and equipment are available. Before beginning the inclining test, the person conducting the test should:

4.1.1 consider the weather conditions. The combined adverse effect of wind, current and sea may result in difficulties or even an invalid test due to the following:

4.1.1.1 inability to accurately record freeboards and draughts;

4.1.1.2 excessive or irregular oscillations of the pendulums;

4.1.1.3 variations in unavoidable superimposed heeling moments.

In some instances, unless conditions can be sufficiently improved by moving the ship to a better location, it may be necessary to delay or postpone the test. Any significant quantities of rain, snow, or ice should be removed from the ship before the test. If bad weather conditions are detected early enough and the weather forecast does not call for improving conditions, the Administration representative should be advised prior to departure from the office and an alternative date scheduled;

4.1.2 make a quick overall survey of the ship to make sure the ship is complete enough to conduct the test and to ensure that all equipment is in place. An estimate of items which will be outstanding at the time of the inclining test should be included as part of any test procedure submitted to the Administration. This is required so that the Administration representative can advise the shipyard/ naval architect if in their opinion the ship will not be sufficiently complete to conduct the incline and that it should be rescheduled. If the condition of the ship is not accurately depicted in the test procedure and at the time of the inclining test the Administration representative considers that the ship is in such condition that an accurate incline cannot be conducted, the representative may refuse to accept the incline and require that the incline be conducted at a later date;

4.1.3	enter all empty tanks after it is determined that they are well ventilated and gas-free to ensure that they are dry and free of debris. Ensure that any pressed-up tanks are indeed full and free of air pockets. The anticipated liquid loading for the incline should be included in the procedure required to be submitted to the Administration;	
4.1.4	survey the entire ship to identify all items which need to be added to the ship, removed from the ship, or relocated on the ship to bring the ship to the light-ship condition. Each item should be clearly identified by weight and vertical and longitudinal location. If necessary, the transverse location should also be recorded. The inclining weights, the pendulums, any temporary equipment and dunnage, and the people on board during the inclining test are all among the weights to be removed to obtain the light-ship condition. The person calculating the light-ship characteristics from the data gathered during the incline and survey and/or the person reviewing the inclining test may not have been present during the test and should be able to determine the exact location of the items from the data recorded and the ship's drawings. Any tanks containing liquids should be accurately sounded and the soundings recorded;	
4.1.4.1	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 safe side when estimating, so the following rules of thumb should be followed:	
4.1.4.1.1	when estimating weights to be added: <ul style="list-style-type: none">- estimate high for items to be added high in the ship.- estimate low for items to be added low in the ship.	
4.1.4.1.2	when estimating weights to be removed: <ul style="list-style-type: none">- estimate low for items to be removed from high in the ship.- estimate high for items to be removed from low in the ship.	
4.1.4.1.3	when estimating weights to be relocated: <ul style="list-style-type: none">- estimate high for items to be relocated to a higher point in the ship.- estimate low for items to be relocated to a lower point in the ship.	

4.2 Freeboard/draught readings

- 4.2.1 Freeboard/draught readings should be taken to establish the position of the waterline in order to determine the displacement of the ship at the time of the inclining test. It is recommended that at least five freeboard readings, approximately equally spaced, be taken on each side of the ship or that all draught marks (forward, midship, and aft) be read on each side of the ship. Draught mark readings should be taken to assist in determining the waterline defined by freeboard readings, or to verify the vertical location of draught marks on ships where their location has not been confirmed. The locations for each freeboard reading should be clearly marked. The longitudinal location along the ship should be accurately determined and recorded since the (moulded) depth at each point will be obtained from the ship's lines. All freeboard measurements should include a reference note clarifying the inclusion of the coaming in the measurement and the coaming height.
- 4.2.2 Draught and freeboard readings should be read immediately before or immediately after the inclining test. Weights should be on board and in place and all personnel who will be on board during the test, including those who will be stationed to read the pendulums, should be on board and in location during these readings. This is particularly important on small ships. If readings are made after the test, the ship should be maintained in the same condition as during the test. For small ships, it may be necessary to counterbalance the list and trim effects of the freeboard measuring party. When possible, readings should be taken from a small boat.
- 4.2.3 A small boat should be available to aid in the taking of freeboard and draught mark readings. It should have low freeboard to permit accurate observation of the readings.
- 4.2.4 The specific gravity of the flotation water should be determined at this time. Samples should be taken from a sufficient depth of the water to ensure a true representation of the flotation water and not merely surface water, which could contain fresh water from run-off of rain. A hydrometer should be placed in a water sample and the specific gravity read and recorded. For large ships, it is recommended that samples of the flotation water be taken forward, midship, and aft and the readings averaged. For small ships, one sample taken from midships should be sufficient. The temperature of the water should be taken and the measured specific gravity corrected for deviation from the standard, if necessary. A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site.

<p>Correction is necessary if specific gravity is measured when sample temperature differs from the temperature at the time of the inclining (e.g., if check of specific gravity is done at the office).</p> <p>4.2.5 A draught mark reading may be substituted for a given freeboard reading at that longitudinal location if the height and location of the mark have been verified to be accurate by a keel survey while the ship was in dry-dock.</p> <p>4.2.6 A device, such as a draught tube, can be used to improve the accuracy of freeboard/draught readings by damping out wave action.</p> <p>4.2.7 The dimensions given on a ship's lines drawing are normally moulded dimensions. In the case of depth, this means the distance from the inside of the bottom shell to the inside of the deck plate. In order to plot the ship's waterline on the lines drawing, the freeboard readings should be converted to moulded draughts. Similarly, the draught mark readings should be corrected from extreme (bottom of keel) to moulded (top of keel) before plotting. Any discrepancy between the freeboard/draught readings should be resolved.</p> <p>4.2.8 The mean draught (average of port and starboard readings) should be calculated for each of the locations where freeboard/draught readings are taken and plotted on the ship's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot should yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/draughts should be retaken.</p>	
<p>4.3 The incline</p> <p>4.3.1 Prior to any weight movements the following should be checked:</p> <p>4.3.1.1 the mooring arrangement should be checked to ensure that the ship is floating freely. (This should be done just prior to each reading of the pendulums.)</p> <p>4.3.1.2 the pendulums should be measured and their lengths recorded. The pendulums should be aligned so that when the ship heels, the wire will be close enough to the batten to ensure an accurate reading but will not come into contact with the batten. The typical satisfactory arrangement is shown in figure A2-2.4.6.</p>	

- 4.3.1.3 the initial position of the weights is marked on the deck. This can be done by tracing the outline of the weights on the deck.
- 4.3.1.4 the communications arrangement is adequate.
- 4.3.1.5 all personnel are in place.
- 4.3.2 A plot should be run during the test to ensure that acceptable data are being obtained. Typically, the abscissa of the plot will be heeling moment (weight times distance) and the ordinate will be the tangent of the heel angle (deflection of the pendulum divided by the length of the pendulum). This plotted line does not necessarily pass through the origin or any other particular point for no single point is more significant than any other point. A linear regression analysis is often used to fit the straight line. The weight movements shown in figure A2-4.3.2-1 give a good spread of points on the test plot.

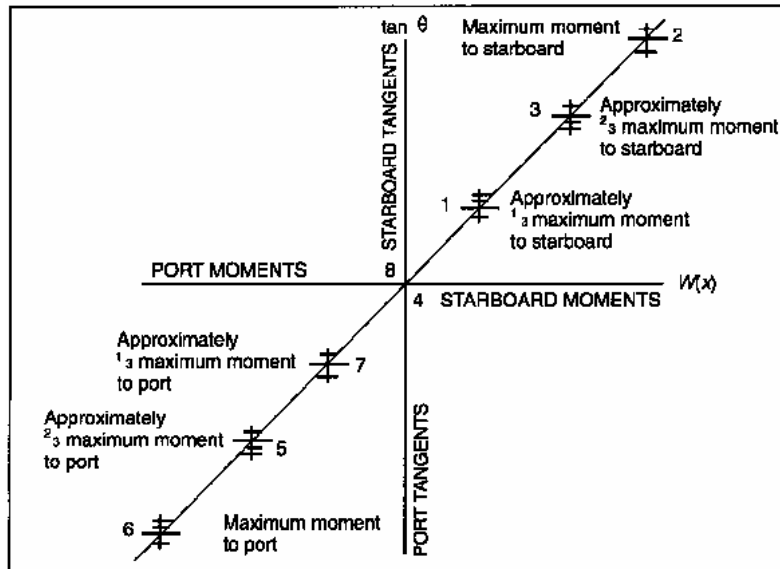


Figure: A2-4.3.2.1

Plotting all of the readings for each of the pendulums during the inclining experiment aids in the discovery of bad readings. Since $W(x)/\tan \theta$ should be constant, the plotted line should be straight. Deviations from a straight line are an indication that there were other moments acting on the ship during the inclining. These other moments should be identified, the cause corrected, and the weight movements repeated until a straight line is achieved. Figures A2-4.3.2-2 through A2-4.3.2-5 illustrate examples of how to detect some of these other moments during the inclining, and a recommended solution for each case. For simplicity, only the average of the readings is shown on the inclining plots.

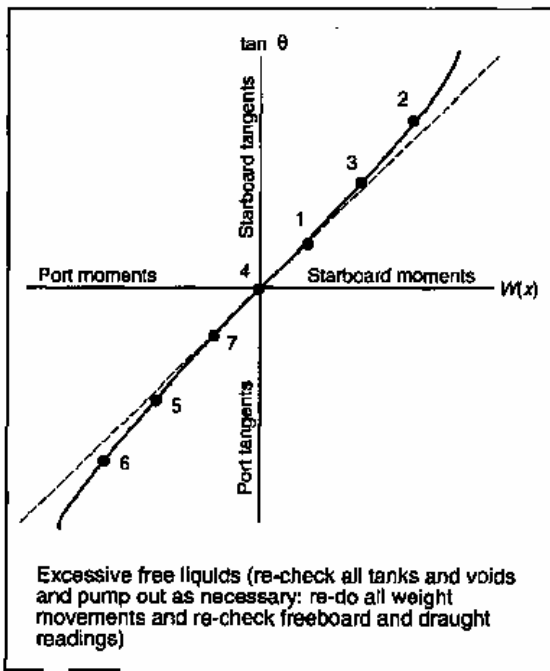


Figure: A2-4.3.2.2

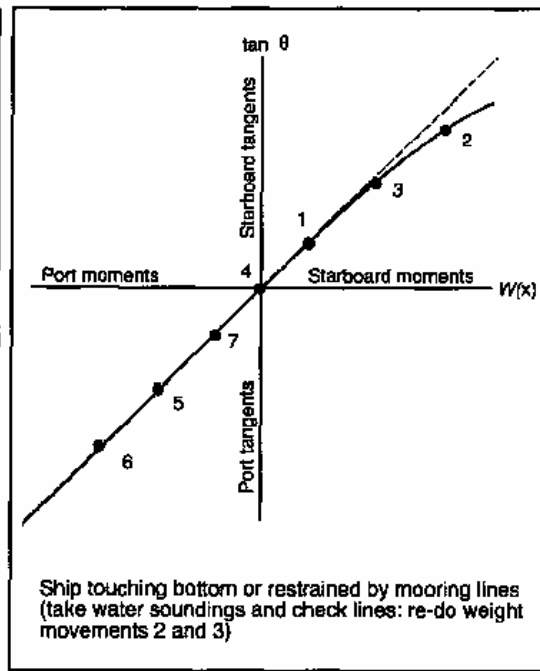


Figure: A2-4.3.2.3

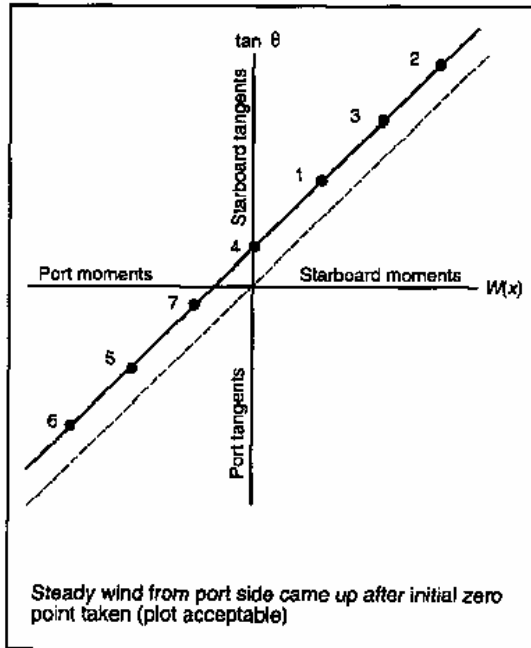


Figure: A2-4.3.2.4

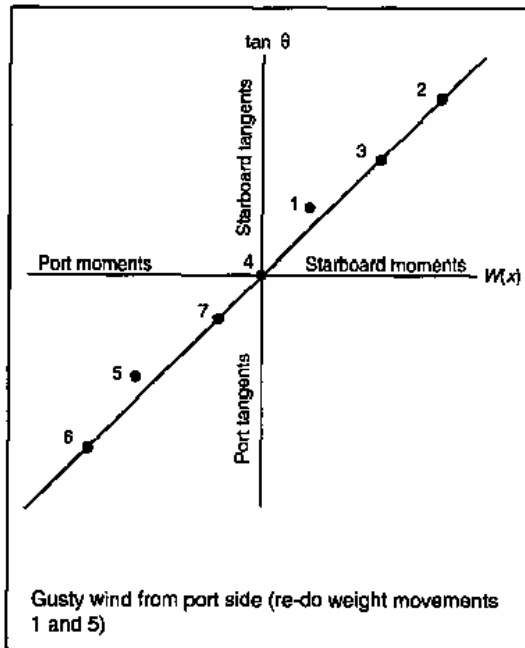


Figure: A2-4.3.2.5

- 4.3.3 Once everything and everyone is in place, the zero position should be obtained and the remainder of the experiment conducted as quickly as possible, while maintaining accuracy and proper procedures, in order to minimize the possibility of a change in environmental conditions during the test.
- 4.3.4 Prior to each pendulum reading, each pendulum station should report to the control station when the pendulum has stopped swinging. Then, the control station will give a "standby" warning and then a "mark" command. When "mark" is given, the batten at each position should be marked at the location of the pendulum wire. If the wire was oscillating slightly, the centre of the oscillations should be taken as the mark. If any of the pendulum readers does not think the reading was a good one, the reader should

advise the control station and the point should be retaken for all pendulum stations. Likewise, if the control station suspects the accuracy of a reading, it should be repeated for all the pendulum stations. Next to the mark on the batten should be written the number of the weight movement, such as zero for the initial position and one through seven for the weight movements.

4.3.5 Each weight movement should be made in the same direction, normally transversely, so as not to change the trim of the ship. After each weight movement, the distance the weight was moved (centre to centre) should be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant tangents are plotted on the graph. Provided there is good agreement among the pendulums with regard to the tan 'theta' value, the average of the pendulum readings may be graphed instead of plotting each of the readings.

4.3.6 Inclining data sheets should be used so that no data are forgotten and so that the data are clear, concise, and consistent in form and format. Prior to departing the ship, the person conducting the test and the Administration representative should initial each data sheet as an indication of their concurrence with the recorded data.

<i>Annex 4 – Determination of ship's stability by means of rolling Period tests (for ships up to 70 m in length)</i>	
1	Recognizing the desirability of supplying to masters of small ships instructions for a simplified determination of initial stability, attention was given to the rolling period tests. Studies on this matter showed that the rolling period test may be recommended as a useful means of approximately determining the initial stability of small ships when it is not practicable to give approved loading conditions or other stability information, or as a supplement to such information.
2	<p>Investigations comprising the evaluation of a number of inclining and rolling tests according to various formulae showed that the following formula gave the best results and it has the advantage of being the simplest:</p> $GM_0 = \left(\frac{fB}{T_r}\right)^2$ <p>where:</p> <p>f = factor for the rolling period (rolling coefficient) as given in 1.6.4;</p> <p>B = breadth of the ship in metres;</p> <p>T_r = time for a full rolling period in seconds (i.e. for one oscillation "to and fro" port - starboard - port, or <i>vice versa</i>).</p>
3	The factor "f" is of the greatest importance and the data from the above tests were used for assessing the influence of the distribution of the various masses in the whole body of the loaded ship.
4	For coasters of normal size (excluding tankers) and fishing vessels, the following average values were observed:

	f values
Empty ship or ship carrying ballast	f ~ 0.88
Ship fully loaded and with liquids in tanks comprising the following percentage of the total load on board (i.e. cargo, liquids, stores, etc.)	
20% of total load	f ~ 0.78
10% of total load	f ~ 0.75
5% of total load	f ~ 0.73
Double boom shrimp fishing boats	f ~ 0.95
Deep sea fishing boats	f ~ 0.80
Boats with live fish well	f ~ 0.60

The stated values are mean values. Generally, observed f values were within ± 0.05 of those given above.

- 5 The above f-values were based upon a series of limited tests and, therefore, Administrations should re-examine these in the light of any different circumstances applying to their own ships.
- 6 It should be noted that the greater the distance of masses from the rolling axis, the greater the rolling coefficient will be. Therefore it can be expected that:
- 6.1 the rolling coefficient for an unloaded ship, i.e. for a hollow body, will be higher than that for a loaded ship; and
- 6.2 the rolling coefficient for a ship carrying a great amount of bunkers and ballast - both groups are usually located in the double bottom, i.e. far away from the rolling axis - will be higher than that of the same ship having an empty double bottom.
- 7 The above recommended rolling coefficients were determined by tests with ships in port and with their consumable liquids at normal working levels; thus, the influences exerted by the vicinity of the quay, the limited depth of water and the free surfaces of liquids in service tanks are covered.

8 Experiments have shown that the results of the rolling test method get increasingly less reliable the nearer they approach GM-values of 0.20 m and below.

9 For the following reasons, it is not generally recommended that results be obtained from rolling oscillations taken in a seaway:

9.1 exact coefficients for tests in open waters are not available;

9.2 the rolling periods observed may not be free oscillations but forced oscillations due to seaway;

9.3 frequently, oscillations are either irregular or only regular for too short an interval of time to allow accurate measurements to be observed; and

9.4 specialized recording equipment is necessary.

10 However, sometimes it may be desirable to use the ship's period of roll as a means of approximately judging the stability at sea. If this is done, care should be taken to discard readings which depart appreciably from the majority of other observations. Forced oscillations corresponding to the sea period and differing from the natural period at which the ship seems to move should be disregarded. In order to obtain satisfactory results, it may be necessary to select intervals when the sea action is least violent and it may be necessary to discard a considerable number of observations.

11 In view of the foregoing circumstances, it needs to be recognized that the determination of the stability by means of the rolling test in disturbed waters should only be regarded as a very approximate estimation.

12 The formula given in paragraph 2 above can be reduced to:

$$GM_0 = \frac{F}{T_r^2}$$

and the Administration should determine the F-value(s) for each ship.

13	The determination of the stability can be simplified by giving the master permissible rolling periods, in relation to the draughts, for the appropriate value(s) of F considered necessary.	
14	The initial stability may also be more easily determined graphically by using the attached sample nomogram (figure A3-14) as described below:	
14.1	The values for B and f are marked in the relevant scales and connected by a straight line (1). This straight line intersects the vertical line (mm) at the point M.	
14.2	A second straight line (2) which connects this point M and the point on the T_r scale corresponding with the determined rolling period, intersects the GM scale at the requested value.	
15	Section 16 shows an example of a recommended form in which these instructions might be presented by each Administration to the masters. It is considered that each Administration should recommend the F -value or values to be used.	
16	Test procedure	
16.1	The rolling period required is the time for one complete oscillation of the ship and to ensure the most accurate results in obtaining this value the following precautions should be observed:	
16.1.1	The test should be conducted with the ship in harbour, in smooth water with the minimum interference from the wind and tide.	
16.1.2	Starting with the ship at the extreme end of a roll to one side (say port) and the ship about to move towards the upright, one complete oscillation will have been made when the ship has moved right across to the other extreme side (i.e. starboard) and returned to the original starting point and is about to commence the next roll.	
16.1.3	By means of a stop-watch, the time should be taken for not less than about 5 of these complete oscillations; the counting of these oscillations should begin when the ship is at the extreme end of a roll.	

	<p>After allowing the roll to completely fade away, this operation should be repeated at least twice more. If possible, in every case the same number of complete oscillations should be timed to establish that the readings are consistent, i.e. repeating themselves within reasonable limits. Knowing the total time for the total number of oscillations made, the mean time for one complete oscillation can be calculated.</p>	
16.1.4	<p>The ship can be made to roll by rhythmically lifting up and putting down a weight as far off middle-line as possible; by pulling on the mast with a rope; by people running athwartships in unison; or by any other means. However, and this is most important, as soon as this forced rolling has commenced the means by which it has been induced should be stopped and the ship allowed to roll freely and naturally. If rolling has been induced by lowering or raising a weight it is preferable that the weight is moved by a dockside crane. If the ship's own derrick is used, the weight should be placed on the deck, at the middle-line, as soon as the rolling is established.</p>	
16.1.5	<p>The timing and counting of the oscillations should only begin when it is judged that the ship is rolling freely and naturally and only as much as is necessary to accurately count these oscillations.</p>	
16.1.6	<p>The mooring should be slack and the ship "breasted off" to avoid making any contact during its rolling. To check this, and also to get some idea of the number of oscillations that can be reasonably counted and timed, a preliminary rolling test should be made before starting to record actual times.</p>	
16.1.7	<p>Care should be taken to ensure that there is a reasonable clearance of water under the keel and at the sides of the ship.</p>	
16.1.8	<p>Weights of reasonable size which are liable to swing (e.g. a lifeboat), or liable to move (e.g. a drum), should be secured against such movement. The free surface effects of slack tanks should be kept as small as is practicable during the test and the voyage.</p>	
16.2	<p>Limitations to the use of this method</p>	
16.2.1	<p>A long period of roll corresponding to a GM_O of 0.20 m or below indicates a condition of low stability. However, under such circumstances, accuracy in determination of the actual value of GM_O is reduced.</p>	

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| <p>16.2.2 If, for some reason, these rolling tests are carried out in open, deep but smooth waters, inducing the roll, for example, by putting over the helm, then the GM_0 calculated by using the method and coefficient of paragraph 1.6.16.1 above should be reduced by (figure to be estimated by the Administration) to obtain the final answer.</p> | |
| <p>16.2.3 The determination of stability by means of the rolling test in disturbed waters should only be regarded as a very approximate estimation. If such test is performed, care should be taken to discard readings which depart appreciably from the majority of other observations. Forced oscillations corresponding to the sea period and differing from the natural period at which the vessel seems to move should be disregarded. In order to obtain satisfactory results, it may be necessary to select intervals when the sea action is least violent and it may be necessary to discard a considerable number of observations.</p> | |

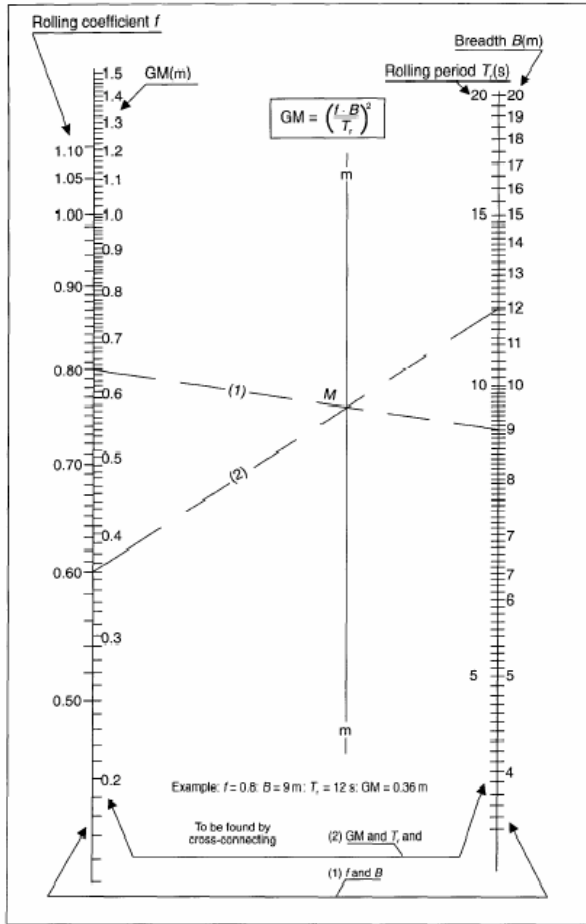


DIAGRAM Figure 14