

## **PART 6**

### **NOTES FOR GUIDANCE FOR CARRYING OUT AN INCLINING TEST**

#### **6.1 Introduction**

**6.1.1** These notes are intended to provide practical guidance in order to minimise inaccuracies and ensure that the information derived from the inclining test provides a satisfactory basis, acceptable to the MCA or delegated Authority, for the determination of the ship's stability characteristics.

**6.1.2** It is appreciated that the following recommended procedures for inclining tests cannot always be achieved and equally efficient alternative procedures may have to be adopted to suit particular circumstances.

**6.1.3** For small ships where it is considered impracticable to adopt procedures as given in these notes, advice may be sought from Headquarters.

**6.1.4** The inclining test must be witnessed by a Surveyor of the MCA or delegated Authority.

**6.1.5** Advice on the procedure when an inclining test may be dispensed with in certain circumstances is contained at paragraph 6.4 below.

#### **6.2 Preparations for Test**

##### **6.2.1 Preliminary meeting with builders/owners**

**6.2.1.1** The Surveyor should inspect the ship shortly before the test to satisfy himself that the ship will be in an acceptable condition. If this is not so the Surveyor may require that the test be postponed.

**6.2.1.2** An opportunity should be taken to discuss and confirm arrangements for the test with the Builder/Owner with particular regard to the following:

(a) Inclining weight data:

(i) type, amount and position on board; (ii) method of handling weights; and

(iii) anticipated maximum angle of heel to each side from upright.

(b) Pendulums; approximate location and length.

(c) Stabilograph or similar instrument; calibration and position.

(d) Condition of tanks and approximate trim; consideration being given to practical measures to minimise the free surface of liquids, excessive trim or initial heel.

(e) Draught marks:

(i) should have been checked on the building berth or in dry dock by the Surveyor from the MCA or delegated Authority as appropriate;

(ii) keel sight readings indicating the baseline from which the draught marks have been measured should be available for reference;

(iii) whether a plastic damping tube with engraved scale would be of assistance in reading marks if the water surface is likely to be disturbed;

(iv) whether suitable datum marks required to be established should the draught marks be inaccessible e.g. when there is a flat overhang at the stern;

(v) that a recently calibrated hydrometer with suitable density bucket is available; and

(vi) that a suitable small boat is available.

(f) Degree of completion:

(i) items to be added;

(ii) items to be deducted;

(iii) items to be relocated; and e

(iv) removal of debris and overall cleanliness.:

(g) Location and timing:

(i) the test should be carried out where possible in a wet dock basin to provide stable conditions and minimise disturbance from passing craft;

(ii) where the test may be affected by a tidal stream or current it may require to be timed with a slack water period; and

(iii) there should be no risk of grounding during the test.

(h) Specialised ship types:

(i) hopper and suction dredgers; where underwater hopper doors, dump or suction valves are fitted, their closed or open position should be established;

(ii) oil rig drill ships; the relatively large windage may cause errors in observed deflections. (At an early stage, consideration should have been given in inclining the ship without the tower and correcting results by calculation); and

(iii) vehicle carriers with removable or hinged decks; the centre of gravity of the ship will require to be determined for two lightship conditions, and such decks will require to be adequately secured to prevent movement during the test.

## **6.2.2 Data required**

**6.2.2.1** Trimmed hydrostatic data should be available over an adequate range of draughts.

**6.2.2.2** Tank layout plan, showing the locations of the sounding pipes, air pipes and access manholes.

**6.2.2.3** Tank calibrations and capacities.

**6.2.2.4** Length of sounding pipes, from striker to deck plate. This can provide a useful indication in event of a sounding pipe being blocked.

## **6.2.3 General condition of the ship**

**6.2.3.1** The ship should be complete or virtually so. An accurate list of items to be added, deducted, or relocated after the test should be prepared by the Builder/Owner and their weights and positions as recorded agreed by the Surveyor. Such items, however, should be reduced in number to the absolute minimum.

**6.2.3.2** In conjunction with the person conducting the test, the Surveyor should inspect the ship to ensure that all items on the list at paragraph 6.2.3.1 above are accurately assessed and check that any omissions are taken into account.

**6.2.3.3** The ship should be generally clean. Shipyard equipment, staging and debris should be removed as far as practicable.

**6.2.3.4** Suspended weights including boats, anchors, derricks, vehicle ramps and decks etc. should be secured in their seagoing positions.

**6.2.3.5** Tank top, open floored spaces and bilges in the machinery space and elsewhere should be clean and dry. Loose water and oil should be removed.

**6.2.3.6** In general, machinery, refrigerated cargo and domestic piping systems, boilers and associated equipment should be at operating levels. In tankers the cargo deck lines should be drained off.

**6.2.3.7** Keys to all locked compartments should be available.

**6.2.3.8** In the inclining condition, it should be ensured that the ship has adequate positive stability.

## **6.2.4 Tanks**

### **6.2.4.1 General**

(a) The number of tanks containing liquids during the test should be kept to a minimum. As a guide the total weight of liquids should not exceed 25% of the lightweight. This may be exceeded where it is desirable to reduce the trim of the vessel.

(b) As indicated in paragraph 6.2.1.2(d) the disposition of all liquids required to be on board should be agreed by the Surveyor, prior to the test.

(c) Where it is agreed that particular tanks may contain liquid, these must either be pressed full or the level must be such that the free surface effect can be accurately determined. Slack tanks where permitted should comply with the 'slack' tank instructions given in paragraph 6.2.4.2 below. In passenger vessels the number of slack tanks is restricted to one pair for either oil or fresh water.

(d) All tanks not permitted to contain liquids during the test should be dry. (See also paragraph 6.2.4.4).

(e) Cross connections between port and starboard tanks containing liquids should be checked to ensure that the control valves are closed.

### **6.2.4.2 Slack tanks**

(a) The free surface for slack tanks should be subject to agreement of the Surveyor. When these are not agreed and they are slack a free surface correction should not be allowed for in determining the lightship KG.

(b) Slack tanks should be limited to tanks with essentially rectangular form. Double bottom tanks should generally not be slack during the experiment.

(c) As a guide where tanks are permitted to contain liquids in accordance with sub-paragraph .2(a), above, deep tanks should be 20% to 80% full and double bottom tanks 40% to 60% full to ensure that a significant change in the dimensions of the free surface does not occur during inclining. The effect of trim should be taken into account when considering the configuration of the liquid surface.

(d) Tanks containing liquids of high viscosity should not be permitted to be slack since the free surface effect is impossible to determine. However, if such liquids can be heated to reduce viscosity then a free surface correction can be accepted at the Surveyor's discretion.

#### 6.2.4.3 Pressed-up tanks

Such tanks are assumed to be completely full with no pockets or voids. In practice it is difficult to obtain a completely filled tank even assuming normal venting and air hole provision and free surface of unknown extent may occur in an apparently filled tank, see Figure 14. For this reason tanks required to be pressed up should be filled in advance of the test until the tank is completely full. Each tank should subsequently be topped up, the final topping up being carried out slowly and the tank ullage checked at intervals.

#### 6.2.4.4 Empty tanks

(a) Where tanks are required to be empty, it is not sufficient to pump tanks until suction is lost. The manholes should be opened and empty tanks should be inspected. Final stripping should be performed with portable pumps where this is necessary. Narrow tanks such as peaks having sharp deadrise and negligible free surface may be exceptions to this.

(b) Proper safety precautions should be adopted before entering the tanks-See Merchant Shipping Notice No.M.1345 Re 'MS (Entry into Dangerous Spaces) Regulations 1988' and Code of Practice.

#### 6.2.4.5 Identification of liquids

Liquids retained in tanks should be identified and their specific gravities determined.

### 6.2.5 Trim

**6.2.5.1** Trim by the head or excessive trim by the stern should be avoided.

**6.2.5.2** If tanks are to be pressed up, some trim by the stern will aid in venting and elimination of air pockets. A small trim will also facilitate

emptying tanks required to be empty. Where a number of tanks are permitted to be full, aftermost tanks should be pressed up first.

**6.2.5.3** Any marked change in the shape of the waterplane when the ship is heeled during inclining such as may occur with a chine form or where the ship has 'flat' sections aft, should be avoided e.g. by modifying the trim so that the chine is immersed both when upright and heeled.

**6.2.5.4** Hydrostatic particulars for the ship 'as inclined' should be calculated for the actual trimmed waterline unless the trim is not significant, when the particulars can be accurately obtained from the level keel hydrostatic information. A correction should be made for hog or stag as applicable.

#### **6.2.6** List

**6.2.6.1** As far as practicable the ship should be upright with the inclining weights in initial position.

**6.2.6.2** A small initial list is acceptable but ideally this should not exceed one-half degree. Weights to correct list should be used where necessary.

#### **6.2.7** Mooring arrangements

The ship should be moored so that it is floating freely during heeling in an adequate depth of water. The mooring ropes should be arranged so as not to restrict heeling. Ideally the ship should be moored bow and stern only, by as few lines as possible led parallel to the fore and aft axis.

#### **6.2.8** Weather

**6.2.8.1** It is desirable that the weather should be fine with little or no wind and with calm water conditions.

**6.2.8.2** The effect of wind, current, wavelets, or difficult mooring conditions may affect results adversely due to:

- (a) inability to measure draught and freeboards accurately;
- (b) excessive or irregular oscillations of the pendulums; and
- (c) variations in superimposed heeling moments. In poor or deteriorating weather conditions, the Surveyor will require to assess the situation and indicate whether he considers it necessary to discontinue the test.

## **6.3 Conduct of the Test**

### **6.3.1 Supervision**

**6.3.1.1** Routine preparation, organisation and direction of the test is the Builder's/Owner's responsibility.

**6.3.1.2** The Builder's/Owner's representative in charge should:

- (a) make sure that the ship is completely prepared for the test in compliance with paragraph 6.2 above;
- (b) have authority over all personnel participating in the test; and
- (c) maintain close liaison with the Surveyor;

**6.3.1.3** The Surveyor will personally verify:

- (a) the adequacy of the ship's preparation and condition;
- (b) that the mooring arrangements are satisfactory having regard to the weather conditions; and
- (c) the accuracy of the test data accumulated and confirm its proper recording in the test report.

### **6.3.2 General**

**6.3.2.1** The minimum number of personnel should be on board during the test, and their same position maintained during the recording of the pendulum readings.

**6.3.2.2** Shore gangways should be lifted during the test to minimise restriction of ship's movement and maintain control on the number of personnel on board during test. Power lines, hoses etc. connected to the shore should be kept to a minimum and those that are essential kept slack at all times.

**6.3.2.3** Any appreciable quantities of snow or ice must be removed from the ship before the test.

**6.3.2.4** If the inclining test is carried out at low water, checks should be made to ensure that the ship is not aground.

### **6.3.3 Test weights**

**6.3.3.1** The total weight used should be sufficient to produce an inclination of about 1 to 2 degrees to each side. Larger inclinations of up to 3 degrees may be necessary to provide measurable deflections of the pendulum on smaller ships. This will depend upon the hull form

and whether the waterplane shape changes during heeling. See also paragraph 6.2.5.3. The inclination should not exceed 4 degrees from the upright zero position.

**6.3.3.2** Generally, it will be most convenient to use 4 weight or sets of weights. These should be as near equal as practicable and be positioned symmetrically 2 each port and starboard.

**6.3.3.3** The weights should be compact and of such configuration that the vertical centre of gravity may be accurately determined. Personnel are not an acceptable alternative to weights.

**6.3.3.4** Each weight should be marked with an identification number and its weights. The Surveyor should confirm that the test weights have been verified by means of weighbridge or equivalent immediately prior to the test. Weight test certificates should be inspected and the Surveyor should be satisfied that the certificates remain applicable.

**6.3.3.5** The weights should be positioned as far outboard as possible on the upper deck. The positions of the weights should be marked and arrangements made to ensure that they can be placed back in their exact original positions as the test progresses.

**6.3.3.6** The transverse movement of the weights should be arranged so that there is no longitudinal change in the position of each weight which would affect the ship's trim.

**6.3.3.7** The lifting arrangements should be such that the weights can be transferred rapidly once the test has started, to minimise delay and reduce the likelihood of encountering changing tide, current or weather conditions.

**6.3.3.8** In general the use of water transfer between wing tanks is not acceptable. Exceptionally this method may be accepted in the case of large ships (e.g. VLCCs) where normal means of inclining are clearly inappropriate and in which a large reserve of stability is clearly anticipated in the vessel's derived intact, damage and grain conditions.

**6.3.3.9** Where water transfer is approved:

(a) the tanks used should have vertical boundaries well beyond the range of water surface movement during the test;

(b) the transfer should take place between tanks directly opposite one another to maintain the ship's trim;

(c) where gravity transfer is adopted, two tanks each port and starboard should be used with adequate head between each pair of tanks port and starboard to provide several movements;



- (d) the specific gravity of the water transferred should be checked;
- (e) the pipe lines used for shifting the water should be full on commencement. The isolating valves should be checked for tightness and strict valve control maintained during test;
- (f) ullage boards should be fitted to enable the level of water in each tank involved to be measured before and after each shift and recorded in test report; and
- (g) final calculation should take account of the reduction in KG during the test due to the transferred layers of water.

#### **6.3.4 Pendulums**

**6.3.4.1** At least two pendulums should be used except as noted in paragraph 6.3.4.5 below. These should be located in separate positions in areas protected from the wind.

**6.3.4.2** The pendulums should be as long as practicable. See typical arrangements in Figure 15. They should comprise good quality wire such as piano wire.

**6.3.4.3** The deflections of the pendulum giving the reading for each individual shift of inclining weight should be sufficient to provide accurate results. A deflection for each shift of not less than 35mm would be expected.

**6.3.4.4** Care should be taken that the trough is of adequate size to give ample margin beyond the maximum anticipated deflection and that the pendulum weight does not touch the bottom of the trough. The trough should be secured against accidental movement. Improved damping can be achieved by filling with oil rather than water.

**6.3.4.5** In lieu of one of the pendulums referred to in paragraph 6.3.4.1 above:

- (a) a stabilograph may be used. The Surveyor should ensure that the stabilograph has been regularly tested and require reports of such tests to be provided; or
- (b) a u tube water level may be used. The ends of the level should be positioned as far outboard as possible. Arrangements should be made for a record of all readings (from both ends of the tube) to be obtained. Clear plastic tube should be used. and care should be taken to exclude all air bubbles and avoid topping up after commencement of test.

### **6.3.5 Draughts and Freeboards**

**6.3.5.1** Using the boat provided, draughts should be read immediately - before the test, with the gangway raised, and with the ship in the same condition as during the test.

**6.3.5.2** Draughts should be read port and starboard at the forward and aft draught marks and freeboard or datum mark measurements obtained amidships to determine hog and sag. In cases where the ship's form makes the draught marks inaccessible or difficult to read, adjacent check measurements of freeboard to a suitable datum should be taken.

**6.3.5.3** The longitudinal positions at which the draught readings are obtained should be recorded so that the necessary corrections can be applied in the inclining report.

**6.3.5.4** For small vessels:

(a) freeboard may be utilised in lieu of draught measurements 8 after establishing the sheer profile relative to the keel. In addition to measurements at bow and stern, measurements should be obtained at convenient locations near the fore and fore and aft and port and starboard should be taken simultaneously; and

(b) when recording measurements, particular care should be taken that all persons who will be on board during the test, are disposed in the positions allocated.

**6.3.5.5** The specific gravity of water in which the ship is floating should be checked using a hydrometer at the same time as the draughts are measured. Where necessary, readings at various depths should be obtained to ensure accurate assessment of the mean specific gravity. The hydrometer should be checked in fresh water before use.

### **6.3.6 Communications and Control**

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

**6.3.6.2** There should be efficient two-way communications between the person in control and:

(a) the weight handlers;

(b) each pendulum or deflection recording station; and

(c) the mooring attendants.

### 6.3.7 Weight movements

**6.3.7.1** Following the initial zero reading, the standard test should preferably involve at least 8 weight movements, and in no case less than 6 weight movements. Thus, where  $W$  is the total weight on each side of the ship:

Shift	Movement
	Zero reading
1	$W/2$ tonnes P to S
2	$W/2$ tonnes P to S
3	$W/2$ tonnes S to P
4	$W/2$ tonnes S to P (zero check)
5	$W/2$ tonnes S to P
6	$W/2$ tonnes S to P
7	$W/2$ tonnes P to S
8	$W/2$ tonnes P to S (zero check)

**6.3.7.2** At each weight shift, the pendulum readings should be marked on a wood batten, the deflection being measured from the previous shift mark.

**6.3.7.3** As the test proceeds the standard of the results may conveniently be verified by plotting the shift moments against the deflection tangents or equivalents as indicated in Figure 16. The weight movements proposed should give a good spread of points but additional shifts should be carried out if necessary to minimise any error resulting from an appreciable 'Stagger'. All readings without omission should be shown in the test report. This recorded plot is to be included in the final inclining experiment report.

**6.3.7.4** Weight movements should be made directly athwartships so as to avoid a change in the ship's trim and should be maintained in the same horizontal plane above the keel, except where water transfer is permitted.

**6.3.7.5** Checks should be made during the test to see that all personnel are in their agreed locations and that all mooring lines which should be slack, are in fact slack.

### 6.3.8 Test results

**6.3.8.1** The Builder/Owner should provide the Surveyor with a detailed inclining test report which should include:

- (a) a complete record of all test information, including the trace from the stabilograph if used and including movement shift plot of inclinations recorded;

(b) a statement providing a clear account of the condition of the ship as inclined. This should include all weights, with their centres of gravity, required to be added, deducted or relocated for derivation of the lightship condition; and

(c) calculations using the test data to determine the characteristics of the ship in the inclined and lightship condition.

**6.3.8.2** The Surveyor should examine the test report for accuracy and completeness and immediately advise the Builder/Owner concerning any comments or disagreement with the report.

**6.3.8.3** When the Surveyor has confirmed his satisfaction with the results of the inclining test and the accuracy of the report, the report should be used as a basis for the production of the stability information booklet (marked 'provisional') to be placed on board prior to the ship's departure on the maiden voyage.

**6.3.8.4** A copy of the inclining test report should be included in the approved stability information booklet.

## **6.4 Dispensation from the Inclining Test Requirement**

On receipt of a written request from the Builders/Owners, the Department or delegated Authority may agree to dispense with the inclining test for ships other than passenger ships, under provisions of Regulation 32(4)(a) and (b) of the Merchant Shipping (Load Lines) Regulations 1998, in the case of:

### **6.4.1 Sisterships**

subject to:

**6.4.1.1** the ships being under construction in the same shipyard;

**6.4.1.2** the Surveyor being satisfied that the ships are similar in all respects (except as referred to in sub-paragraph (e) below);

**6.4.1.3** the Surveyor being satisfied with the accuracy of the inclining test carried out on the first ship;

**6.4.1.4** a lightweight check being carried out on each subsequent ship after the first ship;

**6.4.1.5** small modifications capable of accurate assessment being taken into account by calculation; and

**6.4.1.6** in the case of a series of sister ships (e.g. 3 or more), the Surveyor may subsequently require further inclining tests additional to that carried out on the first ship as checks on the effect of cumulative unspecified changes.

## **6.4.2 Large tankers or bulk ore carriers**

Subject to:

**6.4.2.1** the lightship being based on that of a ship of similar design for which reliable information is available;

**6.4.2.2** the ship's proportions and arrangements being such that a large amount of stability reserve is available above statutory minima in all probable intact, damage and grain loading conditions;

**6.4.2.3** supporting calculations of the estimated lightweight and position of centre of gravity being provided;

**6.4.2.4** a lightweight check being carried out on the subject ship; and

**6.4.2.5** in the case of subsequent sister ships, the requirement for a lightweight check being at the discretion of the Surveyor. Small modifications capable of accurate assessment can be taken into account of by calculation.

## **6.4.3 Local agreement to dispensation**

In the case of ships falling under paragraphs 6.4.1 or 6.4.2 inclusive being dealt with by the MCA, dispensation from inclining may be agreed locally by Marine Office subject to any case in doubt being submitted for the consideration of Headquarters.

## **6.5 Ships Transferring from Foreign to United Kingdom Registry**

**6.5.1** An inclining test should be carried out before the ship re-enters service, unless:

**6.5.1.1** the report of the previous inclining test carried out before transfer is available and has been witnessed by a recognised Classification Society, flag administration or a senior naval architect employed by a Builder or Owner.

**6.5.1.2** after examination the Surveyor considers the inclining test report is sufficiently detailed and acceptable in other respects and the Surveyor is satisfied that the report is applicable to the ship at the time of survey being in mind the type and age of the vessel.

**6.5.1.3** a responsible representative of the Owner provides written confirmation that he has satisfied himself that the results of the last test are still valid for the ship in its present condition.

**6.5.2** If an inclining test is necessary the draught marks need not be checked (as required by 6.2.1.2(e)) if documented confirmation of their accuracy is available.

## **6.6 Lightweight Check**

**6.6.1.**The lightweight check should be carried out by the Builder's/Owner's representatives. The Surveyor may require to attend at his discretion.

**6.6.2.**Where applicable, the Surveyor should confirm with the builders that the ship is similar in all respects to the first sister ship for which a satisfactory inclining test or lightweight check report is available.

**6.6.3.**The same care should be exercised in carrying out the lightweight check, as applies to the inclining test. The relevant parts of the Notes for guidance apply.

**6.6.4.**After the lightweight check has been completed the builders should furnish the Surveyor with a report which includes details of the conditions of the ship, calculation of lightship displacement and longitudinal centre of gravity.

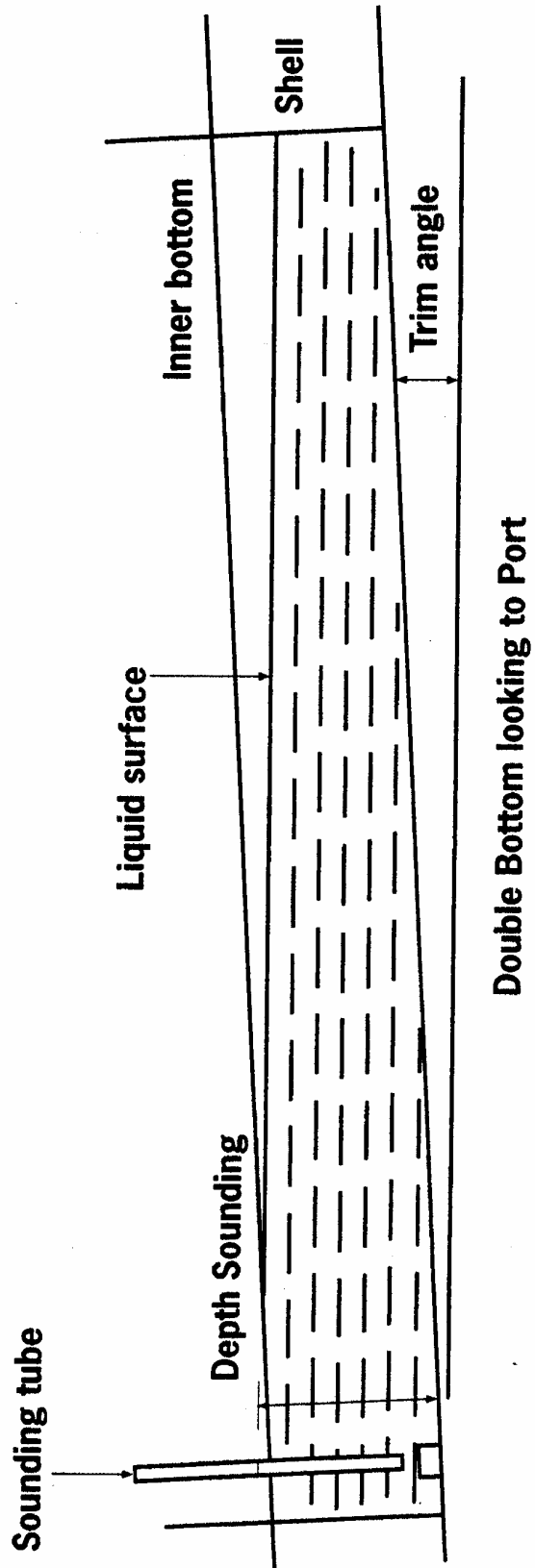
**6.6.5.**If the lightship particulars obtained from the lightweight check do not agree closely with the test results for the first ship, the subject ship should be inclined ie;

(a) weight within + or -2%; and

(b) LCG position within + or -1 % (measured from AP).

**6.6.6** Where the lightship comparison is satisfactory, the lightship particulars from the inclining test or lightweight check report for the first ship may be applied to the subject ship and a copy of the report should be included in the stability information suitably endorsed to indicate an identical sister. Small modifications capable of accurate assessment may be taken account of by calculation. A copy of the lightweight check report should be kept in the file record

**Sketch showing how Double Bottom Tanks may be slack due to trim when sounding shows full tank**



**Figure 14**

# Typical inclining pendulum arrangement

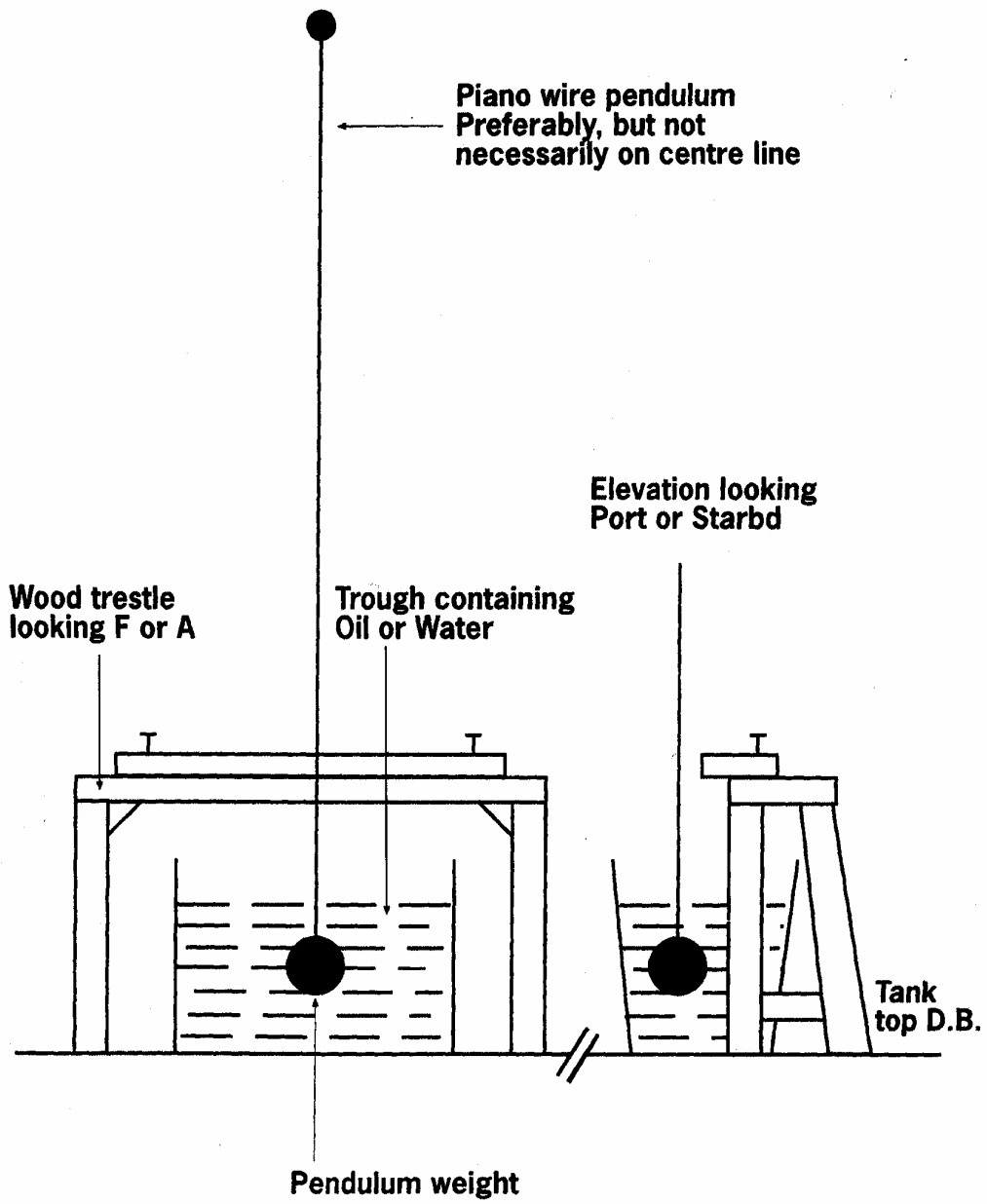


Figure 15



# Graphical Presentation of Inclining Results

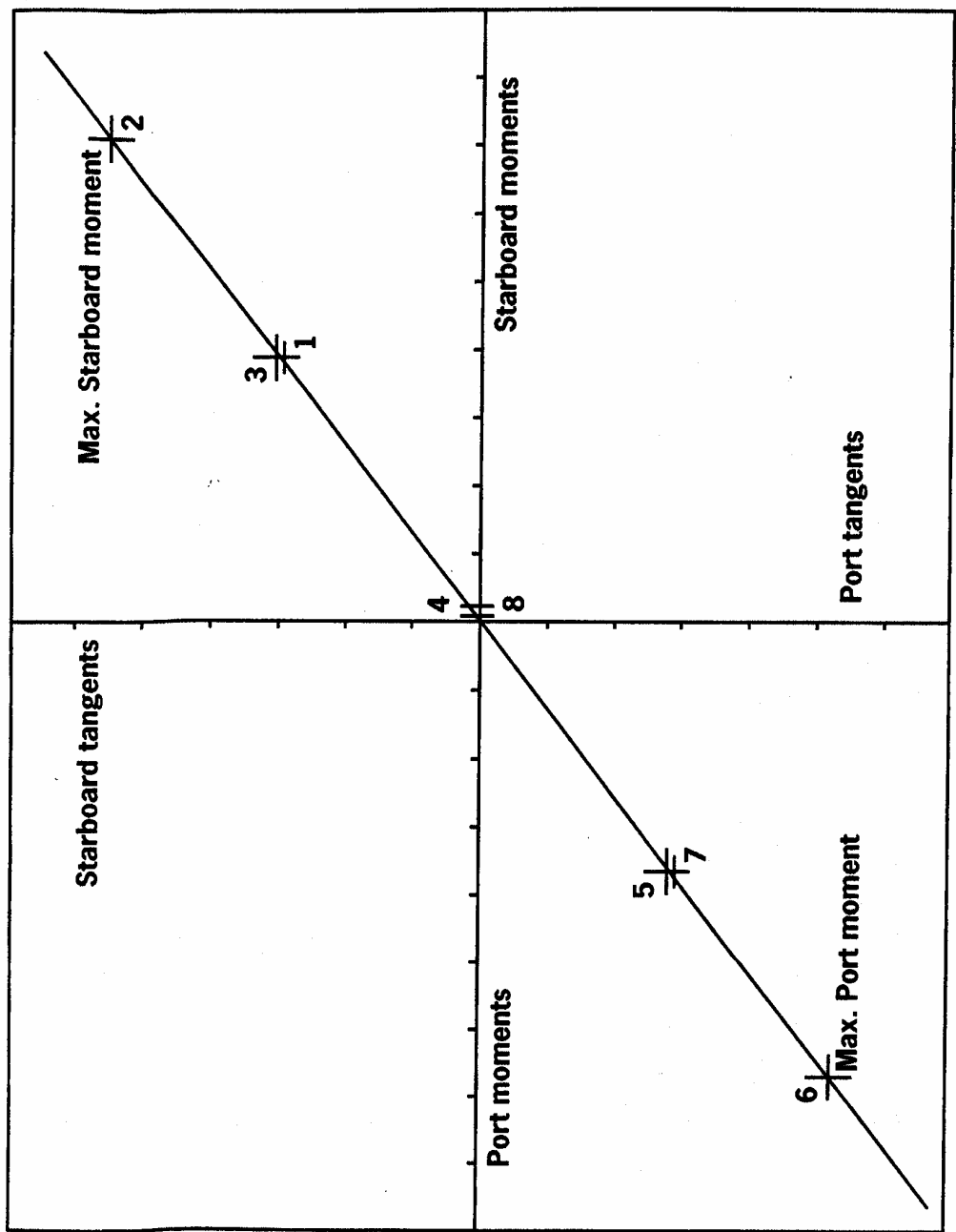


Figure 16