



*Leaflet for*

***Inclining test and Lightweight Survey***

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## Version information

Version	Date	Editor	Items treated	Approved
1.0	2005-05	Fim, TBo, Pei	initial version	HB
2.0	2011-04	Pei, GLe, SKI, MBst	draft readings, status of vessel, FSM, tank fillings	AFI
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## Objective

Requirements for the conduction of inclining experiments and lightweight surveys are given by the International Maritime Organisation (IMO) and the International Association of Classification Societies (IACS) (ref. to § 4 *related regulations*).

This document deals with relevant aspects included in the documents issued by the above mentioned organisations and shall give further explanations and assistance.

This leaflet does not substitute the careful and detailed study of the relevant regulations as it does not contain all relevant aspects of the latter.

## 1 Inclining Test

### 1.1 Purpose and objective

An inclining test has to be carried out for all passenger vessels and every cargo ship having a length of 24 m and upwards (acc. to ICLL and SOLAS) upon its completion or after a major conversion.

If approved lightship data from a sister vessel are available the Administration may allow to carry out a lightweight survey only. Hence in most cases only one inclining test will be carried out for a series of vessels.

An inclining test is carried out to determine the ship's lightship weight and the position of the centre of gravity (longitudinal, vertical and transversal). Lightship condition is a vessel complete in all aspects, without consumables, stores, cargo, crew and effects and without any liquids on board except machinery and piping fluids. Due to this all additional, missing and weights to be repositioned have to be recorded accurately.

During the inclining test as a minimum eight distinct weight movements have to be conducted.

A lightweight check is usually carried out for sister ships in a series of vessels to show that the weight and longitudinal centre of gravity have not changed significantly compared to the first vessel of the series. If the lightweight survey shows good correspondence with the lightship data of the sister vessel, the transversal and vertical centre of gravity can be derived from the sister vessel.

In case sister vessels are constructed on different shipyards, at least for the first ship on every shipyard an inclining test is to be carried out.

A precise procedure and accuracy for all measurements during the inclining test and lightweight survey is from highest importance as such data are relevant for the whole life span of the vessels, any inaccuracy must be avoided.

Related Regulation: ILLC, Reg. 10; SOLAS, Chapter II-1, Reg. 22; IS Code 2008, Chapter 8

### 1.2 Acceptance of the test

Any inclining test or lightweight survey is only acceptable when all relevant requirements from IMO/IACS are strictly followed and observed. A test could be rejected if

- The test conditions are not acceptable. In this case the local surveyor reserves the right not to witness the test.
- The further processing of the test results is doubtful. In this case the evaluation of the test could be rejected by GL leading to a revision by the yard/consultant.

### 1.3 Procedure of the inclining test

#### 1.3.1 Notification of the inclining test/lightweight survey

A written notification is to be submitted by the shipyard/consultant to GL in due time before the test, stating the intended procedures. This gives the opportunity for all involved parties that the test later on can be carried out under best possible conditions.

Related Regulation: IS Code 2008, Chap. 8.2.1

#### 1.3.2 Condition of the vessel

At the time of the inclining test the vessel should be as **complete as possible**.

The amount and type of work that is left to be completed (mass to be added) affects the accuracy of the lightship characteristics. If the mass or centre of gravity of an item to be added can not be determined with confidence, it is best to conduct the inclining test after the item is added.

In case the vessel is equipped with cranes, such cranes shall be installed prior to the test. **In case cranes are not yet fitted to the vessel a respective permission to carry out the inclining test is to be obtained in due time before the test.**

Before the inclining test is carried out all temporary material (e.g., tool boxes, staging etc.) and personal not directly involved in the inclining test have to be removed from the ship.

The decks of the inclined vessel have to be free of water, as the liquid may shift and pocket in a fashion similar to liquids in tanks. Any rain, snow or ice should be removed before the test.

**Slack tanks should be kept to an absolute minimum.**

Before the inclining test the vessel should be as upright as possible. With inclining weights in the initial position, up to half degree of list is acceptable. The actual trim and deflection of keel, if practical, should be considered in the hydrostatic data. In order to avoid excessive errors caused by significant changes in the water plane area during heeling, hydrostatic data for the actual trim and the maximum anticipated heeling angles should be checked beforehand (such information is to be included in the notification of the inclining test)

**A maximum initial heeling angle of 0.5deg is acceptable.**

The total mass used for inclination should be sufficient to provide a minimum inclination of one degree and an absolute maximum of four degrees of heel to each side.

Related Regulation: IS Code 2008, Chap. 8.2.2

#### 1.3.3 Mooring Arrangement

As the mooring arrangement strongly affects the results of an inclining experiment, great importance has to be attached to this matter.

| While the draft and pendulum readings are taken during the inclining test, it has to be ensured that the vessel can move freely.

The ship has to be moored in a calm area, with sufficient water depth and no passing ships during the test. A mooring place with current (from river or tide) or waves should be avoided.

In general the ship should be moored with lines at both end of ship and the ropes shall be fixed as close to the ships centreline as possible. When the ship is moored only to one side long spring lines should be added.

If case of unstable weather conditions during the test (e.g. gusty wind from varying directions) the impact on the heeling moments may be strong. In this case additional test points have to be included.

During an inclining test, after every shift of weight, and before taking the measurement of inclination, it is to be checked that the mooring lines are slack.

Related Regulations: IS Code 2008, Annex 1 2.2

### 1.3.4 Draft Readings

To obtain exact results the draft readings should be taken immediately before or after the inclining test on each side of the vessel at all draught marks (at least aft, midship and forward). If no midship draft mark is available, the distance from waterline to Plimsoll mark shall be taken.

**The accuracy of draft readings shall be within  $\pm 1$  cm.** To achieve such accuracy it is recommended performing draft readings by use of a transparent flexible draft tube, tagged with a scale that can be held directly to the draft marks. By this equipment the influence of waves can be eliminated.

*Sample pictures of draft tube:*



It is recommend to carry out a second draft measurement (after the inclining test/lightweight survey) to verify the data again.

Provisions are to be taken to allow easy draft readings also at that side of the vessel which faces the pier; commonly the vessel shall be towed away from pier to have some clearance.

While the draft readings are taken **all weights should be onboard and in place.**

Normally the water around a vessel is not that calm to allow an exact draft reading. If the water is moving more readings should be taken and the average value used.

Experience shows that the accuracy of draft readings is of utmost importance. Any deviation could have a negative influence on the correctness of results as a direct influence on the lightship mass and also on VCG (by KM) is apparent.

Related Regulation: IS Code 2008, Annex 1.4.2.2 and 1.4.2.6

### 1.3.5 Measurement of sea water density and temperature

Shortly after the draught readings are taken the density and temperature of the sea water should be taken. For reasons of accuracy the sample should be taken from a sufficient depth to ensure a true representation of the flotation water.

It is recommended determining the specific density of seawater shortly after the sample is taken to ensure that the sample temperature can not change significantly. Otherwise a correction of the specific gravity would be necessary.

For large vessels, it is recommended to take samples of the flotation water forward, midship and aft. The average value should be taken for the calculation.

Related Regulation: IS Code 2008, Annex 1.4.2.4

### 1.3.6 Measurement devices for inclination

In general the use of three pendulums is recommended but a minimum of two pendulums should be used to allow identification of bad readings at any one pendulum stations.

**The pendulums have to be located in a wind protected area.**

The use of an inclinometer or a U-Tube should be considered in each separate case. It is recommended that inclinometers or other measuring devices should only be used in conjunction with at least one pendulum.

The pendulums should be long enough to give a measured deflection, to each side of upright, of at least 15 cm. Generally, this will require a pendulum length of at least 3 m. It is recommended that pendulum length should be as long as possible, due to the fact that the longer the pendulum the greater the accuracy of the test.

Related Regulation: IS Code 2008, Chap. 8.2.4

### 1.3.7 Tanks

**During an inclining test slack tanks should be reduced to an absolute minimum.**

Due to the fact that the determination of free surfaces of partially filled tanks may be doubtful, and furthermore an exact mass measurement and determination of the centres of gravity for a trimmed vessel is very difficult, it is recommended that all tanks should be empty and clean, or completely filled.



Empty tanks are to be visually inspected and are to be totally dry, full tanks are to be pressed up to the air pipe.

The density of liquid in tanks is to be measured (e.g. for BW tanks the density might be different to the surrounding sea water).

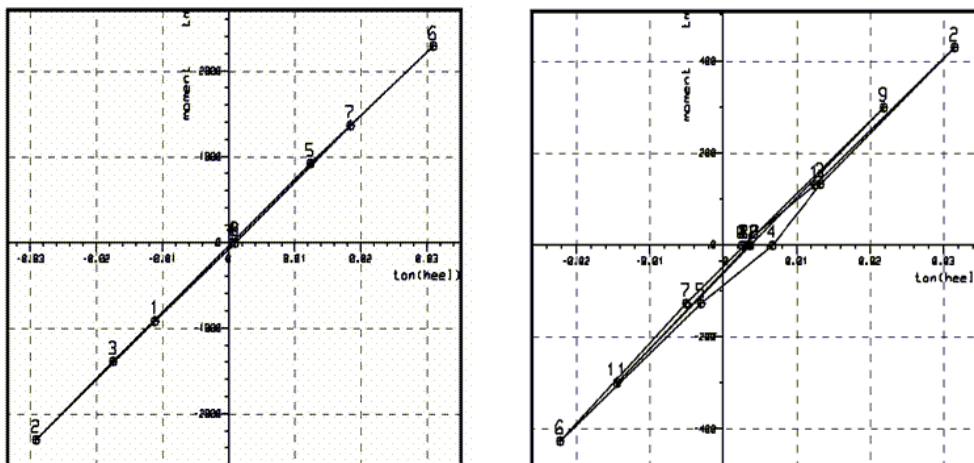
In particular ballast water tanks shall be completely full (100% / pressed up) or completely empty (0%). Any residual fillings in BW tanks are not acceptable. - Only one BW tank (respectively the Anti-Heeling tanks) may have a partial filling level to compensate the initial heeling angle of the vessel during the test. - For the evaluation/calculation of the test a free surface correction for BW will not be accepted.

For HFO tanks it is to be recorded whether the tank is heated (incl. temperature measurement) or not; i.e. it is to be clarified if the fuel oil is liquid or not.

If tanks are partially filled, the viscosity of the fluid, the depth of the fluid and the shape of the tank should be such that the free surface can be accurately determined. In this case the shipyard has to provide GL with sounding or ullage tables and their input valves. If necessary, trim values should be considered for these sounding or ullage table.

To ensure that no pocketing occurs the partially filled tanks should have a regular cross section. For deep tanks the filling level should be between 20% and 80% and for double-bottom tanks between 40% and 60%.

**In general communication between tanks can not be accepted**, moreover, cross-connections, including those via manifolds, shall be closed during the test. The following plot of two different inclining tests should demonstrate the strong impact of free surfaces during inclining tests:



The left tangent plot shows an optimal inclining test without influence of free surface moments, while the right tangent plot shows a test with a huge amount of free surfaces during the test (deviation of the tangent line).

If ballast water tanks are used instead of inclining weights the filling level must be such that during the inclining test no changes of the free surface area occur. Due to this care should be taken that the filling level at the observation angles is as far as possible away from steps in the structure of the tanks.

Related Regulation: IS Code 2008, Chap. 8.2.1 and Annex 1.2.1

### 1.3.8 Additional weights / Missing weights / Weights to be repositioned

The total volume of missing weights should not exceed 2%, of the lightship displacement. The sum of additional masses onboard during the test (excluding ballast water) should not exceed 4%.



When recording additional or missing items or items to be relocated their weights and positions have to be considered accurately.

Each item should be clearly identified by mass and position (all three dimensions).

If the mass of items onboard during the test, or to be added afterwards, has to be estimated, the following rules regarding the centre of gravity have to be observed.

- When estimating mass to be added:  
Estimate high for items to be added high in the ship  
Estimate low for items to be added low in the ship
- When estimating mass to be removed:  
Estimate low for items to be removed from high in the ship  
Estimate high for items to be removed from low in the ship
- When estimating mass to be relocated:  
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

The inclining weights, pendulums (incl. equipment), any temporary equipment and the persons onboard during the inclining test are among the mass to be removed to obtain the light ship condition.

Related Regulation: IS Code 2008, Annex 1.4.1, IACS Rec. 31

### 1.3.9 Shifting of weights / Pumping of water ballast

The ship can be inclined by shifting solid weight blocks or by pumping water ballast from side to side.

If solid inclining weights are used, it is to be checked that the used weights are marked with an identification number and weight. In general the mass of shifting weights shall be officially confirmed prior to the inclining test. The accurate position (longitudinal vertical and transversal) has to be recorded after each shift. During the shifting of weight blocks it is recommended marking the position on the deck by tape or paint for easy relocation after each shift.

In case solid weight blocks are not available, the use of **water buckets** as shifting weights is possible. **A respective permission to make use of water buckets instead of solid weights is to be obtained in due time before the test** (see also notification to the inclining test). Any change of the water level inside the buckets or pumping of water between the buckets is not acceptable respectively a special permission is needed.

Generally the test weights should be positioned as far outboard as possible on the upper deck.

For large vessels it may be impractical to use solid weight blocks. In this case the use of **ballast water** may be permitted by the Administration as an alternative method. **A respective permission to make use of water ballast instead of solid weights is to be obtained in due time before the test** (see also notification to the inclining test). As an exemption is granted for a specific test only, the surveyor has to verify that for the actual test a procedure, stamped by the concerned Administration is available.

If water ballast is used for inclining the vessel, at least the following conditions are preserved:

- The inclining tanks should be wall-sided to avoid air pockets. If other tank geometries have to be used care should be taken that the filling level at the observation angles is as far as possible away from steps in the structure of the tanks.
- The used tanks should be directly opposite to maintain ships trim.
- The specific gravity of the ballast water has to be measured and recorded.

- All inclining tanks must be manually sounded before and after each shift.
- At each shift the total volume of both tanks shall be calculated based on the sounding data. In case the volume differs to the previous shift, this would be an indication of wrong sounding measurements.
- Before the test starts (i.e. before the initial sounding of the BW tanks are taken) the BW pump shall be used for a short time to ensure that no air pockets are within the pipes which connect the BW shifting tanks.
- Accurate sounding/ullage tables must be provided by the shipyard (including their input valves).

#### 1.4 Calculation and potential sources of error

A lot of influences could increase the potential of errors during the conduction and the evaluation of an inclining test. In the following the most common mistakes and problems are described.

- Experience shows that non-sufficient correctness during the draft measurement is a large source of potential errors. Therefore exact draft readings are of highest importance.
- Visual drafts reading from the pier are to be avoided as the accuracy is not sufficient. In principle reliable equipment is to be used, e.g. draft tubes.
- The measured heeling angle during the test shall be between 1° and 4°. Smaller heeling angles than 1° are generally not acceptable as the accuracy of the evaluation/calculation is jeopardized. For heeling angles exceeding 4° it is likely that the righting lever curve (GZ curve) leaves its linear section.
- Partly filled tanks should be limited.  
In particular partly filled *ballast water tanks* should be avoided as the exact determination of the free surface correction and the exact determination of the mass and centre of gravity for a trimmed vessel is doubtful and could lead to vague results.
- The amount of additional weights should be limited.
- All "movable weights" belonging to the vessel should be in normal "operation position". Up-folded hatch covers are to be avoided. Crane beams shall be in the normal storage position. Tween deck covers and grain bulkheads should preferably be not onboard as they are not part of the lightship.  
If applicable stern ramps, side shell doors and liftable tween deck ramps are also to be in the storage respectively normal operation position.
- Free hanging items, such as crane hooks, are to be fixed and secured in order to avoid swinging when the vessel is inclined.
- The trim level of the vessel during test can be freely chosen.  
It is not necessary to obtain level trim due to the availability of hydrostatic data for the trimmed vessel with today's computer programs. Filling of ballast water tanks in order to obtain level trim of the vessel bears a possible inaccuracy when determining the exact mass.
- The permission for a lightweight survey is to be obtained prior to the test.  
For example, if a ship of the same type is build by two different shipyards it is not acceptable to use the lightship data of a vessel build on a different shipyard. The same problem occurs when parts of the hull structure are built on two different shipyards.

The above mentioned sources of potential errors belong to the test conditions and conduction itself. In addition potential errors in the further processing of the test results could impede the examination process.

- It is essential that the shipyard/consultant forwards all necessary information to GL. Missing information in the submitted documents cause delays that would be easily avoidable.
- Sometimes also the calculation sheets are not complete or the shown calculation contains mistakes. To name a few, sometimes the deflection is not considered correctly or the shellfactor is not included.

## 2 Lightweight survey

**If a lightweight survey will be carried out for sister vessel a respective permission is to be obtained in due time before the test.** Commonly the request to carry out lightweight survey for further vessels of a series should be included in the notification of inclining test that is submitted for the first vessel.

A lightweight survey shall be carried out with the same procedure and accuracy as an inclining test but the shifting of weights (inclination) can be omitted.

The acceptable deviations in lightship data for sister vessels acc. to IS Code 2008, Reg. 8.1.2 are to be observed. In case the stipulated deviations are exceeded an additional inclining test is to be carried for such vessel.

## 3 Duties and responsibilities

### 3.1 Shipyard

The shipyard is responsible that all tasks during an inclining test or lightweight survey are carried out according the respective Regulations and above stated explanations.

During the inclining test the shipyard should provide the persons in charge with hydrostatic data, a general arrangement plan, a capacity plan, tank sounding tables and a draught mark location plan. Furthermore all relevant equipment is to be provided by shipyard (e.g. sampan, densimeter, scale, boat to go alongside the vessel, pendulums incl. measurement scale, sounding tape, etc. ).

Afterwards the shipyard prepares the calculation of the lightship data. A copy shall be presented to the surveyor of the Classification Society.

The final report is to be submitted to GL for examination/approval.

### 3.2 Classification Society

During each inclining test or lightweight survey a GL-Surveyor has to be present during the test. After the inclining test or lightweight survey report is prepared by the shipyard, the surveyor has to verify the correctness of stated measurements (e.g. draft readings, sea water density, additional/missing weights, shiftings, pendulum readings...) and to stamp and sign the documents.

The approval/examination is done by GL on behalf of the relevant Flag State Administration.

For German flagged vessels the documents have also to be approved by the German Flag State Administration (See-Berufsgenossenschaft BGV).

## 4 Related Regulations

Code on Intact Stability, 2008 (IS Code 2008)

Safety of Life at Sea 1974, as amended (SOLAS)

International Convention on Load Line, 1966 (ICLL)

IACS Recommendation 31: Inclining Test Unified Procedure (Rec. 31)

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