

NORTH 

LOSS PREVENTION  
GUIDES



# DRAUGHT SURVEYS

A GUIDE TO GOOD PRACTICE

Second Edition

JIM DIBBLE,  
PETER MITCHELL  
and North of England  
P&I Association

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This publication is intended for general guidance only to assist in the conduct of a draught survey but it cannot apply to every situation. Readers should take care to ensure that the recommendations contained in this publication are appropriate for a particular situation before implementing them. Whereas every effort has been made to ensure that recommendations are comprehensive, North of England P&I Association and the authors do not under any circumstances whatsoever accept responsibility for any errors, omissions and mis-statements or for the consequences of implementing or attempting to implement the recommendations.

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## Chapter 1

# INTRODUCTION

The purpose of a draught survey is to determine the amount of cargo loaded or discharged for the benefit of all the interested parties. A well-conducted draught survey of a large vessel should achieve accuracy to within 0.5%.

The survey must be conducted meticulously, taking into account all the prevailing circumstances. The final report should incorporate every aspect and difficulty which has been encountered in order to convey all aspects of the survey.

While draught surveys may be carried out by professional surveyors, the ship's officers should also perform a draught survey to the same degree of accuracy. It is hoped that this guide will assist in achieving the required standards.

### *Draught survey*

The draught survey is the 'before and after' survey, which determines, by measurement, the vessel's displacement before and after loading or discharging. The difference between these two displacements is the weight of cargo loaded or discharged.

### *Deadweight survey*

Under certain circumstances, the surveyor or ship's officer may have no choice and be restricted to carrying out a deadweight survey. The weights of all measurable non-cargo elements on the vessel are determined – bunkers, fresh water, ballast, stores and so on. These are then added to the light displacement (including any lightship constant). This total is then deducted from the present displacement to produce the approximate weight of cargo on board.

See Appendix I for a glossary of terms used in this guide.

### *UN ECE draught survey code forms*

The UN ECE draught survey code forms have been included in Appendix II. They are the work of the United Nations Economic Commission for Europe, Committee on Energy, Coal Working Party, which produced the Code of Uniform Standards and Procedures for the Performance of Draught Surveys of Coal Cargoes. The working party recommends the use of the forms to achieve uniformity and consistency in draught surveys, so avoiding the discrepancies which give rise to commercial disputes.

The code and its forms can be freely downloaded from the UN ECE website at <http://www.unece.org/energy/sc/coal/code.html>.

## Chapter 2

# PRACTICAL PROCEDURE

It is impossible to cover every conceivable problem likely to be encountered when carrying out a draught survey. Ships and ports vary so much that there will always be the unforeseen circumstances which will require an on-the-spot decision. These notes and steps to be taken give only a broad approach to the subject. There is however no substitute for experience.

An inaccurate survey may result in considerable expense to several parties, therefore it should be conducted carefully and accurately. Being well prepared and having sufficient time will allow the survey to be conducted correctly. It may not appear expedient to delay the ship to complete the draught survey properly, but it could save money in the long term. This decision must lie with the master. However careful preparation could reduce delays to a minimum.

All parties should work together for a unanimous result. The facts should be established by inspection and not by verbal agreement.

### STEPS TO BE TAKEN

***1. The ship and ship's staff must be prepared for the survey. Shore surveyors must be ready for the ship's arrival.***

The ship should be asked to prepare for the draught survey.

The ballast tanks should be adjusted to a level covered by the sounding tables. It should be remembered that full tanks can be pressed up but still retain air pockets and also it can be difficult to establish that a tank is completely empty without visual inspection.

Ballast holds (main cargo holds used for ballast) should be empty of ballast on arrival at the loading port, if possible.

The vessel should arrive with a safe trim, suitable for navigation to enter port and within the limits of trim covered by the trim corrections of the sounding tables. The vessel should arrive in an upright condition.

Staff, documentation and equipment should be ready on the arrival of the ship.

There should be no movement of ballast, fresh water, bunkers or cargo and hatches, cranes and moorings until all measurements are taken and agreed by surveyors and ship's officers. The prudent surveyor will have observed the shore-side draughts before boarding as these can be used to indicate any changes.

Typical tools of a draught surveyor are shown in Figure 1 and an equipment checklist is provided in Appendix III.



Figure 1. Typical tools of a draught surveyor (Paul Combs)

## 2. Examine the ship's documentation and discuss the ship's present condition

Surveyors and ship's officers should discuss documentation details and the location and state of all compartments. The instruction pages of the stability information book and calibration tables should be studied and a check made of the tank capacities with the capacity plan. It should be remembered that the port and starboard tanks may not be the same and consequently have separate calibration tables.

The base for measurement of vertical heights, the reference point for longitudinal measurements, the units and the sign conventions used in the tables must all be verified. The units used in the correction tables should also be carefully noted because there is sometimes a mixture of units and sign conventions contained within the same documentation. The calculations and corrections in this guide are all based on the metric units of metres and tonnes.

The full sounding depths of tanks, the summer draught and freeboard and the record of recent tank soundings should be noted.

If a bunker survey is not to be carried out, the chief engineer's bunker figures (fuel oil, diesel oil and lubrication oil) are required, also the daily port consumption quantities. Should any bunkers or stores be delivered during the stay then the delivery notes must be sighted for the additional quantities to be included in the final survey. The draught survey only takes account of changes to the bunkers on board, that is consumption and deliveries.

The position of the anchors should be checked. Should any alterations be proposed during the stay then the weight of the anchors and cables should be determined.

The ship's staff and surveyors should work together throughout. An information checklist is provided in Appendix IV.

## 3. Take accurate overboard water samples and draughts

### Density

Using a sample bucket take samples from half draught depths from at least two positions on the offshore and the onshore side, avoiding discharges, stagnant water between ship and jetty and outfall areas. Take samples of about one litre and do not mix the samples.

Rinse out the bucket and the sample jar with the first sample of water. Take the density readings promptly, protecting the sample jar from the wind and direct sunlight. Hold the hydrometer vertically by the top of the stem and gently lower into the sample until it floats freely. Take the hydrometer reading where the overall level liquid surface meets the graduated stem, not the top of the meniscus. Avoid parallax by filling to near the top of the sample jar and placing the eye in line with the liquid level (see Figure 2).

The bottom of the sample jar should have 25 mm clearance below the base of the hydrometer and have a minimum internal diameter of 50 mm.

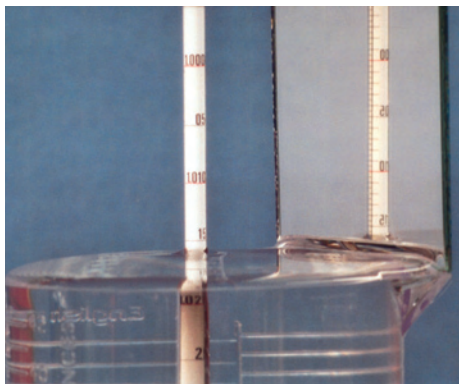


Figure 2. Hydrometer showing meniscus and using a mirror for a rear view, reading is 1.0165



If densities obtained show no major variation then calculate the average value, however if there are suspicious variations in the readings then additional samples should be taken and this factor included in the report. Measure the apparent density with a suitable glass draught survey hydrometer, such as manufactured by Zeal, and be aware of any tidal changes which may affect the sample density (see density section in Chapter 4).

### *Draughts*

The draughts and densities should be obtained at nearly the same time if possible. Draughts and densities taken at slack water are the most accurate but this may not be practicable.

All the draughts should be read with great care and every effort made to read directly from ship's side using a boat, ladder or other available means. The figures should be written down as they are obtained to avoid mistakes of memory.

If required, the midships draughts can be obtained by measuring the freeboard from the waterline to the top of the deckline or to a convenient point above the deckline, when a correction must be applied. A tape with a float plate at the zero mark can be usefully employed to achieve this measurement (see draught measurement section in Chapter 4).

## ***4. Calculate the ship's underwater volume and displacement***

- a) Correct the observed draughts to the centreline, that is the mean of the port and starboard draughts.
- b) Correct the centreline draughts to their value at the correct position of the perpendiculars.
- c) Allow for hog or sag and obtain the correct draught midships.
- d) Enter the corrected draught into the hydrostatic tables to obtain the uncorrected displacement.
- e) Correct this value of displacement for
  - first trim correction
  - second trim correction
  - list (if necessary)
  - density.

See Chapter 4 for details of these calculations.

## ***5. Determine the quantity of deductibles***

### *Ballast and fresh water soundings*

Every compartment capable of carrying water should be carefully inspected and sounded, allowing sufficient time for fluctuations in levels due to the removal of the sounding caps (see Figure 3). When at an exposed berth the movement of the vessel may create errors. To overcome this problem several soundings should be taken and the average value assumed to be the correct one.

The sounding tape must be checked to ensure that it reaches the bottom of the tank. If the tape is marked at the ship's full depth it can act as a useful guide and the consistency of the depth of the different tanks can be checked. It should be remembered that the vertical tank height and the length of sounding pipe may be different.

Full tanks may have air pockets, especially when the ship is trimmed. Topside tanks can be overflowed from forward and aft air pipes until a steady flow through both is unmistakable – the sounding pipe extension may prove useful for this operation.

It is very important that all regulations relating to the discharge of ballast water are complied with and that care should be taken to ensure that overflowing ballast water causes no other problems, such as wetting of cargo waiting to be loaded, soaking the electric power boxes on the quayside or washing debris or other pollutants over the side.

For a stern trim the position of the forward air pipe relative to the forward tank bulkhead should be checked to determine any possible remaining void spaces and where necessary this factor should be allowed for. Other full tanks should be sounded and the trim corrections made.

The ballast discharged from tanks may leave residual liquid in pipes and in areas of poor drainage. This water is difficult to detect and time should be allowed for drainage purposes before taking soundings.

Empty tanks will probably have residual water even at zero soundings. These indeterminable quantities can be ignored at both before and after surveys, provided that all parties are satisfied that no changes have taken place during the interval between surveys. In other circumstances it may be necessary to assume a small percentage (1% or 2%) of the tanks' total capacity as additional weight to cover all remaining drainings.

If the ballast soundings are outside the maximum range of the calibration tables then ballast should be run out until the level is suitable.

The duct keel, pipe tunnels, peak tanks and swimming pool should not be forgotten and soundings taken as usual. The bilges should be checked and any pumped out during the ship's stay must be recorded. When a vessel loads a dry bulk cargo which has been wetted, a record of bilges pumped during the whole voyage could prove very useful as evidence, to explain any apparent loss of cargo between successive surveys.

Ballast holds often cause problems due to poor tank calibrations and hull deformation. These should be empty of ballast prior to arrival at the loading port and visually inspected if possible.

Bunker tanks need not be inspected and sounded during a draught survey, unless a bunker survey is also required.



Figure 3. Using a sounding tape

See soundings and ullages section in Chapter 5.

### *Ballast samples*

The water within the sounding pipe may not be properly mixed and therefore not be representative of the liquid in the whole tank. If in doubt the sample should be taken at the bottom of the pipe using a suitable sampling can which be opened at the appropriate depth.

Sufficient sample densities can be obtained from the tanks down one side of the ship only, unless major variations occur. Variations could be caused by the ballasting taking place at different times and locations. The ballast tank dipper or hand pump down the sounding pipe may be used to obtain a sample where the water is well mixed, as shown in Figure 4. The sample jar should be rinsed out with the first sample and then the hydrometer used to obtain the apparent density of the water, as with the sea water density, a temperature correction is not necessary. A ballast hold should be sampled at different levels with the water sample bucket and checked for any major variations.



Figure 4. Taking a ballast sample

The measurement of density, the hydrometer to use and the reading obtained can cause problems – the density section in Chapter 4 should be read carefully to avoid these problems.

## ***6. After completion of loading or discharging, repeat sections 3, 4 and 5 above, for the final survey***

Adequate preparation is required again for the final survey. The intended quantities of cargo, bunkers, fresh water and stores and the proposed finishing draught should be determined in advance of completion of cargo. If there is to be a final trim by the head then an intermediate survey of the ballast remaining on board should be carried out while the trim is still by the stern. Accurate determination of the ballast on board remains a major issue and ensuring that the empty tanks are actually clear of ballast is a major cause of errors in the final calculations.

Invoice figures for the weights of all bunkers, spares and stores taken on board during the stay should be verified and a check made that nothing has been landed. Changes in the bilges, swimming pool and other regions not directly associated with the working of the vessel should be determined.

## **ACCURACY AND CONSISTENCY**

All calculations contained in this guide should be carefully executed and agreed between parties. The same survey methods should be used at the loading and the discharging ports to achieve consistency of results.

The calculations should deal only with the acquired facts and not introduce any unsubstantiated constants. The constant often referred to with draught surveys is dealt with in the lightship constant section in Chapter 3 and its significance should be understood.

All circumstances that may influence the accuracy of the surveys should be recorded on the survey report – see checklist in Appendix V.

Shortage claims on bulk cargoes are a major concern to the shipowner and their P&I clubs. They result in claims involving significant sums of money. Well maintained records when used as evidence, including accurate and comprehensively documented draught surveys from both the load and discharge ports, may enable these claims to be successfully defended.

## Chapter 3

# INFORMATION REQUIRED

It is the master's responsibility to ensure that the draught marks are clearly visible at a minimum of six positions on the hull, that is at **the forward end, the aft end and midships, on both sides.**

It is also the responsibility of the ship's master to provide the surveyor with up-to-date and accurate information which has been certified by the ship's flag state. This information should contain details of the ship and its present condition.

For details of what should be included refer to the information checklist in Appendix IV. The presentation and precision of the information will vary widely from ship to ship and the language may not be that of the surveyor.

Take great care when using the data. Read the stability information book introduction pages to determine the contents of each of the tables, and how they should be applied. Not all the information will be required for every draught survey.

The United Nations recommends that every ship carrying bulk cargoes should be provided with a data manual for draught surveys, which should be certified by the ship's flag-state administration or its classification society.

### UN recommendations for data manual for draught surveys

The language of the manual should be English or have English translations. The metric system of units should be used throughout.

Longitudinal measurements should be based upon midships.

Sign convention: measurements forward are negative (–), measurements aft are positive (+).

Vertical measurements are to be taken from the bottom of the keel plate.

It is recommended that vessels in excess of 200 m length overall (LOA) should be marked at five points on each side: forward, midships and aft as usual and also at the mid points between these positions. This allows a more accurate assessment of any hogging or sagging effects.

The positions of the draught marks relative to the appropriate perpendicular should be included in the data manual.

Unfortunately such as data manual is often not available.

## HYDROSTATIC PARTICULARS

Information is calibrated against draught, usually for the even-keel condition.

**The displacement is the weight of the ship, derived from volume of water displaced by the ship × apparent density.**

In the metric system, the displacement is often given in tonnes of salt water at an apparent density (weight in air) of 1.025 t/m<sup>3</sup>.

It is important to establish the exact weight-to-volume relationship.

## ***Draught and freeboard***

### *Forward draught*

The forward draught is the distance from the bottom of the keel to the waterline on the forward perpendicular when the ship is upright.

### *Aft draught*

The aft draught is the distance from the bottom of the keel to the waterline on the aft perpendicular when the ship is upright.

### *Freeboard*

Freeboard is the distance from the waterline to the deckline, normally measured midships.

### *Depth of ship*

The depth of the ship is the distance from the bottom of the keel to the deckline. That is

$$\text{Depth} = \text{draught} + \text{freeboard}$$

### *Arithmetical mean draught*

The arithmetical mean of the forward draught and the aft draught will equal the draught midships if there is no hog or sag. This is called the arithmetical mean draught (AMD).

### *True mean draught*

A ship trims about the longitudinal centre of flotation (LCF). When a ship trims due to shifting a weight, that is no change of displacement, the only draught which does not change is the draught at the longitudinal centre of flotation. It is this draught which will give the appropriate displacement on the hydrostatic tables, and it is called the true mean draught (TMD). The position of the LCF is therefore critical to a draught survey.

### *Layer correction*

The difference between the true mean draught and the arithmetical mean draught is known as the layer correction.

### *Trim factors*

Some stability information books tabulate trim factors, forward and aft, but no position for the longitudinal centre of flotation (LCF) forward of the aft perpendicular (AP).

The LCF can be found from the trim factors by the following formula

$$\text{LCF from AP} = \frac{\text{length between perpendiculars} \times \text{aft trim factor}}{\text{forward trim factor} + \text{aft trim factor}}$$

### *Trimmed hydrostatics*

Some ships are supplied with ‘trimmed hydrostatics’. These normally consist of several sets of hydrostatic data each one calculated for a particular trim. They may be in 0.2 m steps covering the range of trims over which the vessel is expected to operate. Each set of hydrostatic data consists of displacements tabulated against draught for a particular density. The densities may be in increments of 0.005 from 1.000 to 1.025 and the draughts in 0.05 m

steps. Such tables avoid the need for both the first and second trim corrections and also the density correction described in Chapter 4.

Trimmed hydrostatic tables need to be interpolated for draught, density and trim to find the correct displacement. This interpolation is fairly difficult and needs careful thought to achieve an accurate result.

Check the use of trimmed hydrostatics in the introduction to the stability information book.

## DEADWEIGHT OR DISPLACEMENT SCALE

The displacement, deadweight, tonnes per centimetre immersion (TPC) and moment to change trim per centimetre (MCTC) for salt water are shown against the true mean draught (TMD) in the deadweight or displacement scale. It may also show the same for fresh water.

If only salt water values are given then the scale should be entered with the TMD in actual observed density. Calculations should be carried out with these figures as the density correction will take care of the adjustments at a later stage.

The scale will also show summer load draught and the lightship draught. It will relate the final TMD to the final displacement. Study it carefully to make certain of the weight-to-volume relationship.

## PLANS

### *Capacity plan*

The capacity plan shows all the cargo compartments, ballast spaces and bunker tanks on the ship.

Capacity tables list every space in the ship which may be used for cargo, ballast, stores, fuel, lubricating oil and fresh water.

The position of each space is indicated by the number of the ship's frames at each extremity of the space.

The volume of each space, in cubic metres, is listed for

- grain space – the gross volume measure to the ship's side plating
- bale space – the nett volume measured to the inside of the frames or spare ceiling (cargo battens).

Spaces for liquid only are tabulated in either cubic metres or the number of tonnes of the liquid which the tank normally holds, specifying the density used to calculate those tonnes. If the tables give cubic metres then these must be multiplied by the observed density to find tonnes. If the tables give tonnes then they must be divided by the density of the table and multiplied by the observed density.

### *General arrangement plan*

The general arrangement plan shows the layout of the ship and indicates all the spaces within it. It gives the position of all the spaces, their use and capacity.

### *Other plans*

More detailed plans of ballast tanks and bunker tanks may be necessary.

If the vessel is trimmed it may be important to know the horizontal surface area of liquid in the tank and the relative position of the sounding pipe to assess the quantity of liquid in the tank accurately.

## **SOUNDING TABLES**

Sounding tables are separate tables, often found in the care of the chief officer and/or the chief engineer.

The tables may be calibrated with either soundings or ullages.

The calibrations may use cubic metres (i.e. tonnes of fresh water) or the average density of the liquid which is normally carried in the tank and give tonnes of that liquid.

For accurate assessment of the quantity of liquid in any tank, the actual density of the liquid should be determined and the quantity re-calculated.

## **CORRECTION TABLES AND DIAGRAMS**

### *Sounding correction tables*

The sounding tables will have been calculated for the ship on an even keel.

Correction tables should accompany any sounding table of a tank for which the sounding pipe is not at the longitudinal centre of the tank.

The table should give the correction for any sounding and for each metre of trim of the ship over the normal operating range of trims and require interpolation for the actual trim. In the absence of such tables, calculations will have to be made from the original plans.

### *Trim correction*

The stability information book may include a table to apply the corrections for trim. Investigate carefully whether this includes both the first and second trim corrections (see Chapter 4).

### *Position of marks*

The stability information book may provide a correction to apply to the appropriate draught readings to correct the reading to the value it would have had at the correct position (see Chapter 4).

### *Hull deflection*

The stability information book may provide a special means of calculating the vessel's hull distortion correction when calculating an accurate underwater volume (see Chapter 4).

### *Hydrometer certificate*

Certificates of calibration issued by BSI British Standards, International Organization for Standardization (ISO) or manufacturers such as Zeal provide the appropriate correction to apply to the hydrometer (see Figure 5).

## **LIGHTSHIP**

The lightship weight is that which has been determined during an inclining experiment.

It includes: the ship and its full equipment, engine room spares, water in the boilers to



working level and lubricating oil in the engines.

It does not include: personnel, cargo, fuel, stores and water.

### *Growth of lightship*

The inclining experiment may have been performed a considerable time ago but, over a period of years, the lightship weight will increase. This is due to the changes in the equipment, the build up of paint over the ship, the storage of old equipment, mud in the ballast tanks, the accumulation of dunnage and so on. This phenomenon is known as the growth of lightship and is thought to amount to about 0.2% of the light displacement per annum. This growth is accounted for in the lightship constant.

### *Lightship constant*

Vessels which regularly assess their lightship weight find that the weight from their calculations differs from the tabulated value in the stability information book. This difference is named the lightship constant at that particular draught survey.

A record should be kept of the lightship constant at each draught survey. It may not be a constant value since it is the result of inaccuracies of calibrations, accumulations of sludge, asymmetrical hull distortion and many other factors. It can only be used for a guide to the consistency of results and the variations experienced on previous surveys.

When carrying out a deadweight survey, the value of the lightship constant may become more significant and a record of previous values is then important.

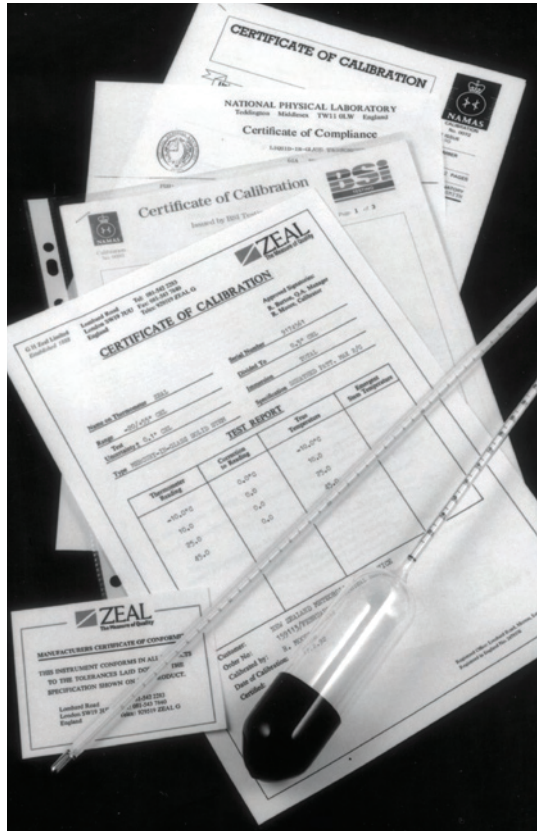


Figure 5. Hydrometer and certificates (by kind permission of G H Zeal Ltd)

## *Chapter 4*

# ASSESSMENT OF UNDERWATER VOLUME

The underwater volume of the ship, and ultimately its displacement, is normally found by carefully reading and analysing the draught marks and by carefully establishing the density of water in which the vessel is floating.

The corrected mean draught is entered in the hydrostatic tables in the stability information book to find the appropriate displacement equivalent to this draught and density. The value must then be corrected to determine the precise weight of the ship in its present circumstances.

### GENERAL DRAUGHT MEASUREMENT

The draught survey is based upon the accurate reading of the draught marks, therefore no effort should be spared to achieve accuracy. Draughts should be measured in metres to two decimal places, that is to the nearest centimetre.

Before cargo operations commence, the water density and all six draught marks should be read, recorded and comments made on the prevailing conditions. During the time that the readings are being made, no transfer or discharge of liquid of any sort, or movement of any weight within the ship, should be allowed.

The draughts and density should be taken again on completion of the loading or discharging operation.

#### *Measuring draughts in a swell*

In turbulent conditions there may be waves, swell, pitching and rolling to take into account. In these conditions, the wave pattern should be studied to establish the wave cycle. During a series of average waves the mean of the highest and lowest draught readings should be recorded.

A total of 12 mean readings should be obtained. The highest and lowest means should be rejected and then the average of the remaining ten will give the most accurate reading possible under the circumstances.

The forward, aft and midships draught measurements should all be found in a similar fashion.

#### **Worked example: measuring draught in a swell**

The following are mean draught readings (in metres) over an observed cycle of waves: 11.25, 9.80, 11.40, 9.70, 11.35, 9.75, 11.30, 9.60, 11.00, 9.90, 11.25, 9.70.

Calculate the appropriate draught.

#### *Answer*

Reject 11.40 and 9.60 m. Add remainder = 105.

Estimated draught reading =  $105 / 10 = 10.50$  m.

## DRAUGHT MEASURING EQUIPMENT

A measuring device may be used to improve the accuracy of the draught measurement (see Figure 6).

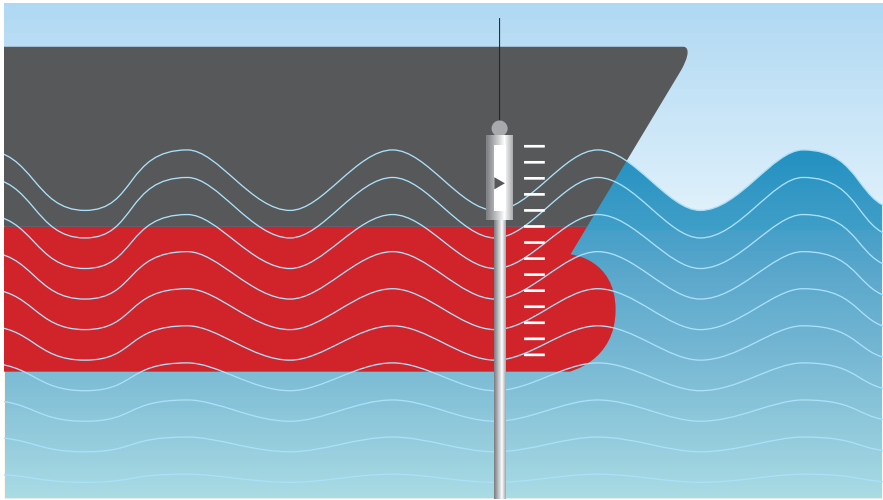


Figure 6. Using a draught measuring device to improve accuracy

Such devices are based on the principle that the turbulence on the surface of the water does not extend down to any great depth. They use a long, flexible, open-ended, weighted hose projecting downwards to below the turbulence.

The device is held directly in front of the draught marks and, after allowing a few seconds for the tubes to fill with water, the mean water level is indicated by the float.

The float may have a small rise and fall, but this will be minimal compared with the wave motion (see Figure 7).

The device is difficult to use at the bow and the stern. It should be held close enough to the draught marks under the overhang of the bow and the stern to avoid parallax. The device may be attached to the hull by a strong magnet.

A statement describing the prevailing sea conditions should be included in the survey report to avoid a dispute later.

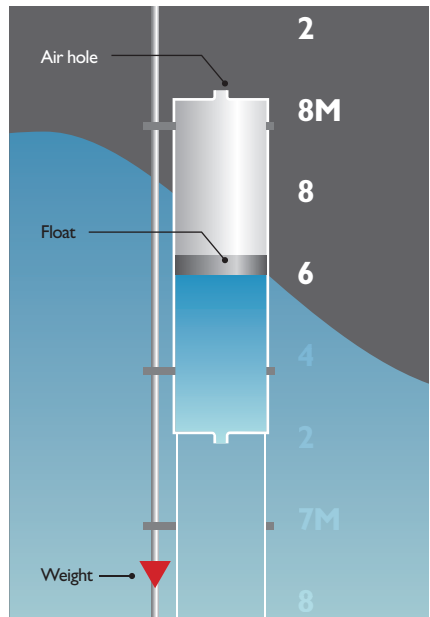


Figure 7. The float movement will be minimal

## DRAUGHT READING ON OUTBOARD SIDE

Every attempt should be made to read the draughts on the offshore side of the vessel although, in some situations, this may prove to be impractical or even dangerous. In such an event, the onshore marks should be read and the other side calculated with the help of a manometer (see Figure 8).

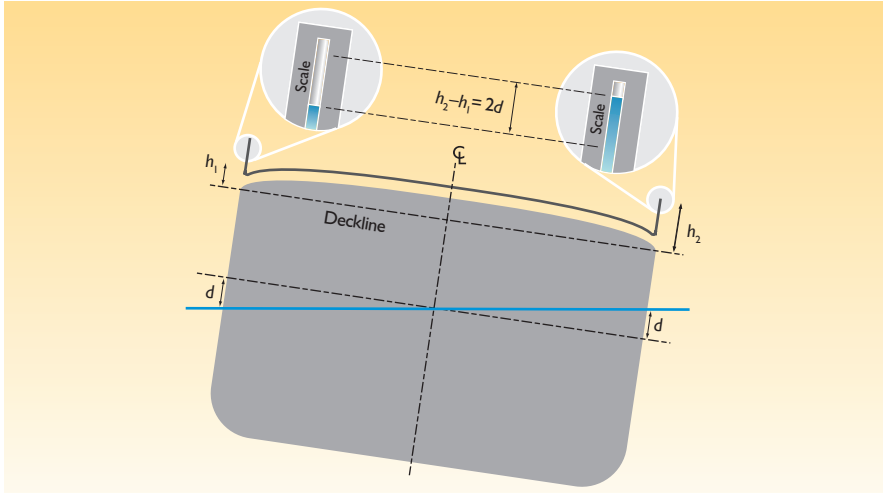


Figure 8. Using a manometer to calculate offshore side draughts

The manometer should comprise of a short length of clear, rigid, plastic tube fitted to each end of a hose to facilitate measuring water levels. If possible the hose should stretch the full beam of the vessel and the measurements should be taken at the extreme breadth. The outboard reading is found by adding or subtracting the manometer reading ( $2d$ ) to the inboard draught.

When using the full beam proves impossible, then the outboard draught may be calculated using similar triangles (see Figure 9).

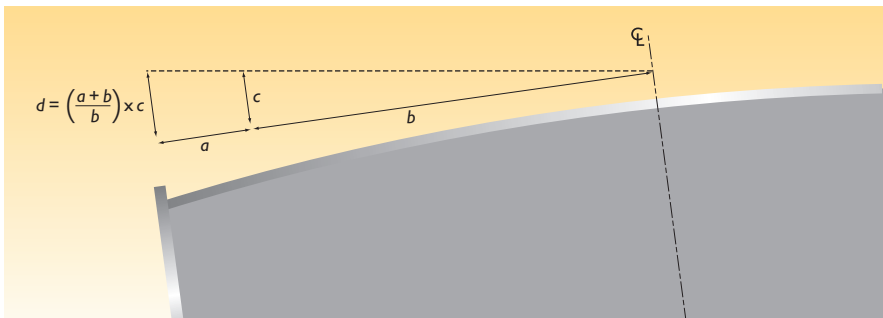


Figure 9. Similar triangles can be used if the manometer hose does not reach the edge of the ship

The levels must be measured from the same base line, and taken at equal distances from the centreline on both sides of the vessel.

All air must be excluded from the hose and the water levels in both tubes kept at a height which is higher than the deck at the centreline.

The heights of water levels, on both sides of the ship, are measured above the deckline (*h*) or some other fixed level. The difference between the two heights is then halved and the result (*d*) is added to, or subtracted from, the one draught reading to obtain the mean draught at the centreline.

#### Worked example: measuring draught with a manometer

The port draught midships = 8.00 m.

The starboard side is to be found by manometer, where the readings are taken at 8.50 m on either side of the centre line.

The vessel's full beam = 20.85 m.

Calculate the midships mean draught (i.e. centreline draught) if there is a difference of 0.25 m between the two readings of the manometer and the starboard reading is the higher.

#### Answer

Effective manometer beam =  $8.50 \times 2 = 17.00$  m.

By similar triangles  $0.25 / 17 = d / 20.85$

$d = 20.85 \times 0.25 / 17 = 0.31$  full beam difference.

Half beam difference =  $0.31 / 2 = 0.15$  m.

Centreline draught =  $0.15 + 8.00 = 8.15$  m.

It may be more practical in some situations to measure the midships freeboard and from this calculate the midships draught.

## DRAUGHT GAUGES

Draught gauges may be very helpful as a check, but should never replace the reading of draughts using the fixed draught marks on the ship's hull.

## SQUAT

When there is a strong current running and there is water depths of less than twice the draught of the vessel, the draught readings may be misleading due to the effects of squat.

The survey report should include reference to possible squat effects, even if a suitable correction to the draught readings cannot be determined. See checklist of factors which may influence survey accuracy in Appendix V.

## CORRECTION OF DRAUGHTS TO PERPENDICULARS AND MIDSHIPS

Firstly, correct observed draughts, forward, aft and midships, for the effect of any list or heel by calculating the mean of port and starboard in each case.

There may also be a list correction (in tonnes) to apply to the displacement (see page 22).



Figure 10. (Above left) Misplacement of marks forward (Paul Coombs)

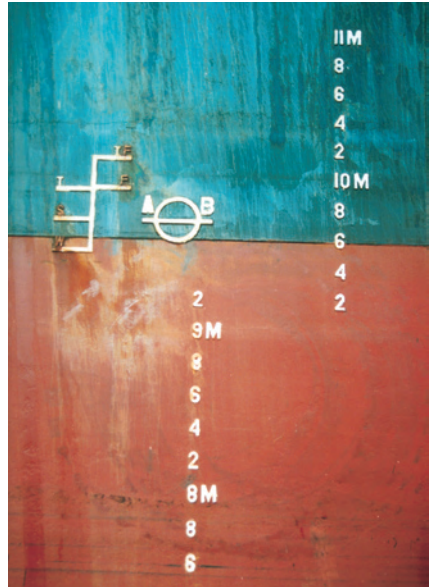


Figure 11. (Above right) Misplacement of marks midships

Figure 12. (Below) Misplacement of marks aft (Paul Coombs)



Secondly, when the vessel is trimmed and the vessel's draught marks are not sited at the correct position on the perpendiculars – termed as 'misplacement' of marks' (see Figures 10–12), corrections to the observed draughts must be applied (see Figure 13).

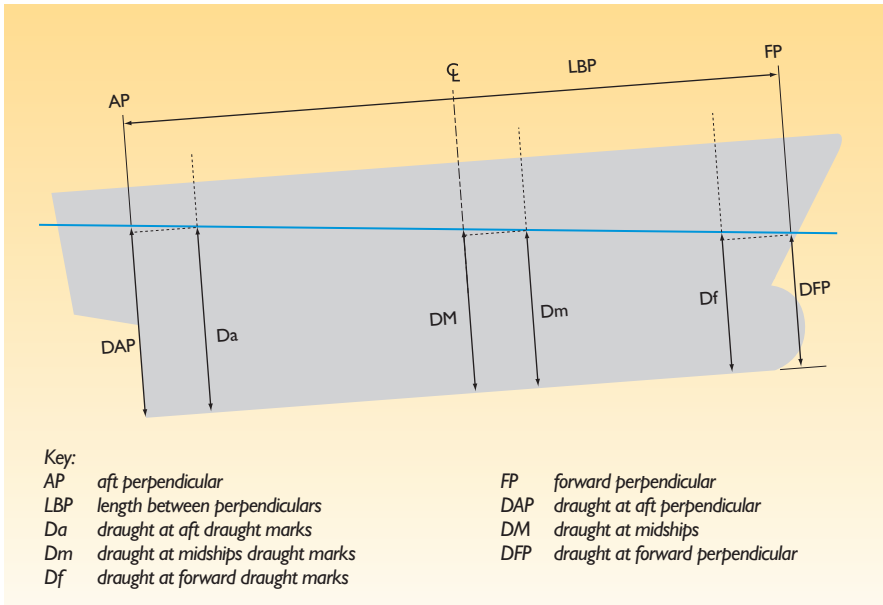


Figure 13. Correction for misplacement of draught marks

$$\text{Forward correction} = \frac{\text{apparent trim} \times \text{distance DFP to Df}}{\text{distance Da to Df}}$$

$$\text{Aft correction} = \frac{\text{apparent trim} \times \text{distance DAP to Da}}{\text{distance Da to Df}}$$

$$\text{Midships correction} = \frac{\text{apparent trim} \times \text{distance DM to Dm}}{\text{distance Da to Df}}$$

Where

apparent trim = the difference between Da and Df

### Sign convention

If the direction of misplacement of the draught mark from the perpendicular (or midships position) is the same as the direction of the trim, then the correction is negative (–) when applied to the observed draught.

An even keel would not require the above corrections to be applied.

### Worked example: correction of draught mark observations

With reference to the following particulars, calculate the correct forward and aft draughts, if the observed draughts are: forward 6.35 m, aft 7.88 m.

Position of draught marks: forward 1.82 m aft of FP, aft 6.00 m forward of AP. LBP = 170 m.

#### *Answer*

Apparent trim =  $7.88 - 6.35 = 1.53$  m

Length between marks =  $170 - (6.0 + 1.82) = 162.18$  m

Correction forward =  $1.53 \times 1.82 / 162.18 = -0.02$  m

Draught forward =  $6.35 - 0.02 = \mathbf{6.33}$  m

Correction aft =  $1.53 \times 6.00 / 162.18 = +0.06$  m

Draught aft =  $7.88 + 0.06 = \mathbf{7.94}$  m

### *Misplacement corrections with hull deflection*

The corrections to the perpendiculars and midships assume that the keel of the vessel is straight. When the vessel is hogged or sagged (see page 22), these corrections may no longer be correct. The tabulated corrections in the stability information book, or the formulae on the previous page, must be corrected to the particular circumstances.

The easiest method is to use the trim between the midships mark and the particular end draught then calculate using this half length trim, the half-length and the distance of the misplacement.

Repeat the procedure at the other end draught mark with the similarly modified trim, the half length and the distance of misplacement.

### Worked example: correction of draught mark observations with hull deflection

Observed draughts: forward 6.00 m, midships 6.40 m, aft 7.40 m.

Distance of forward mark from FP = 2.00 m aft, distance of aft mark from AP = 5.00 m forward. LBP = 100 m.

#### *Answer*

Total trim = 1.40 m, AMD = 6.70 m, therefore the vessel is hogged.

Trim forward midships = 0.40 m

Forward correction =  $2 \times 0.40 / (50 - 2) = -0.02$  m

Forward draught =  $\mathbf{5.98}$  m

Trim aft to midships = 1.00 m

Aft correction  $5.00 \times 1.00 / (50 - 5) = +0.11$  m

Aft draught =  $\mathbf{7.51}$  m



## CORRECTION FOR LIST

When a vessel lists, it often rises in the water. This means that the mean of the side draughts is a centreline draught, which is less than the actual draught that would have been observed had the vessel been upright. This may be ignored for small angles of list. However, if the draught survey is to be carried out on a vessel which has suffered a cargo shift or is lying at a large angle of list, then it should be calculated.

The correction, in tonnes, to be applied to the displacement is by the formula

$$\text{Correction for list (tonnes)} = 6 (\text{TPC}_2 - \text{TPC}_1) \times (d_2 - d_1)$$

Where

$d_2$  and  $d_1$  = midships draughts on each side

$\text{TPC}_1$  = the TPC equivalent to the draught  $d_1$

$\text{TPC}_2$  = the TPC equivalent to the draught  $d_2$ .

### *Sign convention*

Always positive (+).

#### Worked example: displacement correction for list

Vessel is listed 5°. The draughts midships are: port 6.00 m (equivalent TPC = 32), starboard 8.00 m (equivalent TPC = 34).

#### *Answer*

$$\text{Correction} = 6 (34 - 32) (8.00 - 6.00) = \mathbf{24 \text{ t positive (+)}}$$

(It will normally be a small correction.)

## CORRECTION FOR HULL DEFLECTION (HOG AND SAG)

When the observed draughts have been corrected for list and displacement of marks, an arithmetical mean of the forward and aft draughts must be calculated, that is the arithmetical mean draught (AMD).

Compare the AMD with the corrected midships draught to establish whether the hull is distorted. The AMD should equal the draught midships if the ship is neither hogged or sagged.

If the actual draught is less than AMD then the vessel is hogged. If the actual draught is greater than AMD then the vessel is sagged (see Figure 14).

Every effort should be made, taking into account the information available, to determine the appropriate correction for hull deflection. The ultimate accuracy of the survey results are normally dependant on this correction.

It is difficult to establish the ship's distorted shape precisely but the following factors should be taken into account

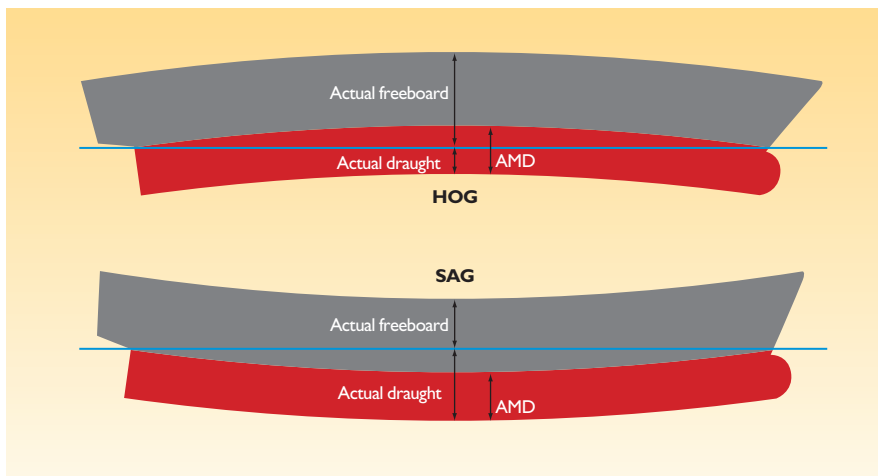


Figure 14. Identifying hog or sag using the arithmetical mean draught (AMD)

- residual deformation
- cargo distribution
- bunkers / ballast distribution
- daily variation.

Larger vessels can be liable to daily variations in the amount of hull deflection. By day, the sun heats the upper parts of the vessel, resulting in a hogged condition. The same vessel may suffer sagging when the upper portion loses its heat at night.

The assessment of the vessel's shape will establish the appropriate draught to enter in the hydrostatic data in the stability information book. This will determine the displacement for that particular instant.

### *Methods of calculating hull-deflection correction*

There are several methods of calculating the correction for hog or sag. Agreement on the use of one of these alternatives must be made before the proposed voyage begins and adhered to until the voyage ends. These methods only take into account hull deformation or deflection.

#### *Method 1*

Some ship's stability information books have a table of corrections to apply to the extracted displacement. When the table or graph is used, then this fact should be stated on the report so that it can be used throughout.

#### *Method 2 (the most common and simplest method)*

Assume that the deformed shape of the vessel follows a regular mathematical curve.

The correction is dependant on the block coefficient.

(i) For finer-lined vessels

$$\text{Mean adjusted draught} = \frac{(6 \times \text{DM}) + \text{DFP} + \text{DAP}}{8}$$

This is often referred to as ‘the mean of mean of means’.

(ii) For fuller-form vessels, and box-shaped vessels

$$\text{Mean adjusted draught} = \frac{(4 \times \text{DM}) + \text{DFP} + \text{DAP}}{6}$$

Where

mean adjusted draught = draught midships corrected for hog and sag

DM = draught midships

DFP = draught at forward perpendicular

DAP = draught at aft perpendicular.

### Worked example: method 2 for calculating mean draught with hull deflection

The vessel has a sleek form for a fast passage, but is suffering from hull deflection.

The draughts at the perpendiculars are: forward 5.64 m, aft 6.42 m. The draught midships is 6.11 m.

What is the mean adjusted draught, taking into account the distortion of the hull.

*Answer*

$$\text{Mean adjusted draught} = \frac{(6 \times 6.11) + 5.64 + 6.42}{8} = \mathbf{6.09 \text{ m}}$$

### Method 3

The correction is dependant on the coefficient of fineness (waterplane coefficient).

The coefficient is used entered on a graph (included in some stability information books) to obtain a ‘factor’ (see Figure 15).

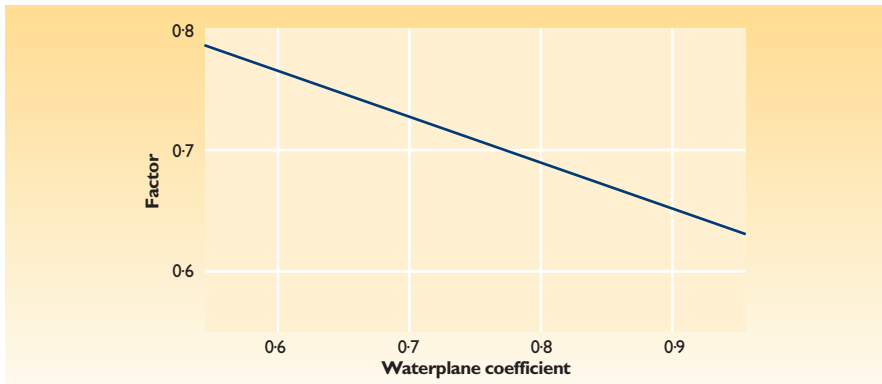


Figure 15. Example of graph used to obtain adjustment factor for waterplane coefficient

Then

$$\text{Mean adjusted draught} = \text{AMD} + \text{factor} (\text{DM} - \text{AMD})$$

### Worked example: method 3 for calculating mean draught with hull deflection

A vessel is floating at the following draughts: forward 5.80 m, aft 6.20 m, midships 6.18 m. These draughts have been corrected to the perpendiculars and midships marks. Calculate the mean adjusted draught taking into account the distortion of the hull using the waterplane coefficient table. The waterplane coefficient tabulated in the stability information book = 0.60.

#### Answer

Extracted factor 0.76

$$\text{AMD} = (5.80 + 6.20) / 2 = 6.00 \text{ m}$$

$$\text{Mean adjusted draught} = 6.00 + 0.76 (6.18 - 6.00) = \mathbf{6.14 \text{ m}}$$

#### Method 3 alternative 1

The extracted factor can be used directly to determine a correction in tonnes to apply to the final displacement.

$$\text{Correction (tonnes)} = \text{factor} \times \text{TPC} \times 100 \times \text{hog or sag}$$

Where

$$\text{hog or sag} = (\text{difference between DM and AMD})$$

#### Method 3 alternative 2

The graph or table itself may be adapted to give a correction table directly in tonnes (i.e. factor  $\times$  TPC  $\times$  100) for each metre of hog or sag. This would give a correction to apply to the final displacement by entering the table with the AMD and the hog or sag in metres.

#### Other methods

Alternative methods require additional draught/freeboard measurements at points other than perpendiculars and midships, along the vessel's length. This is very difficult to establish (see data manual for draught surveys in Chapter 3).

## CORRECTIONS FOR TRIM

There may be a total trim correction table included in the stability information book. This will normally combine the following first and second corrections. Find out what it includes, and examine the ship's stability data carefully before conducting a survey.

### First trim correction (correction for layer)

The displacement scale is normally calculated on the assumption that the vessel is lying on an even keel. The first trim correction is to correct the draught midships to the true mean draught, at the centre of flotation.

This correction is also known as the correction for layer or layer correction (see Figure 16).

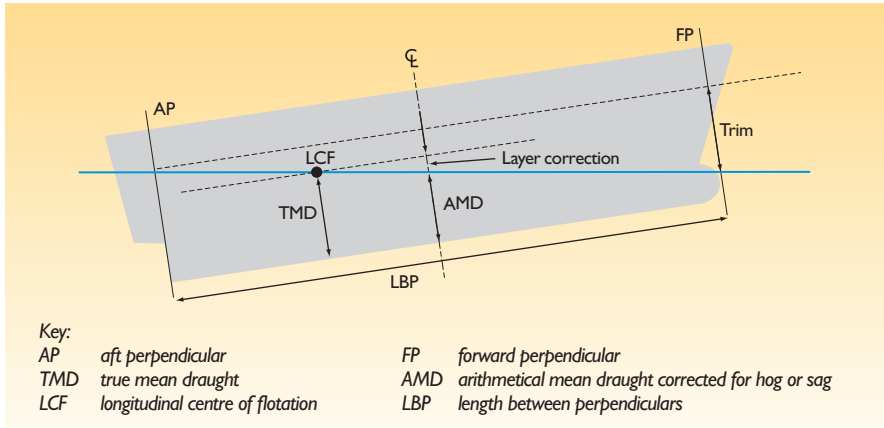


Figure 16. Correction for layer

$$\text{Layer correction (metres)} = \frac{(\text{distance LCF to midships}) \times \text{trim}}{\text{LBP}}$$

then  $\text{TMD} = \text{AMD} \pm \text{layer correction}$ .

$$\text{First trim correction (tonnes)} = \text{layer correction} \times \text{TPC} \times 100$$

$$= \frac{(\text{distance LCF to midships}) \times \text{trim} \times \text{TPC} \times 100}{\text{LBP}}$$

Actual displacement (tonnes) = tabulated displacement  $\pm$  first trim correction

*Sign convention*

Trim	LCF forward of midships	LCF aft of midships
Aft	negative (-)	positive (+)
Forward	positive (+)	negative (-)

**Worked example: first displacement correction for trim**

A vessel of LBP 150 m has the following draughts: forward 6.85 m, aft 7.25 m. The LCF is situated at a position 70 m forward of the AP. TPC = 40. Calculate the first trim correction in tonnes.

*Answer*

$$\text{Trim} = 7.25 - 6.85 = 0.40 \text{ m}$$

$$\text{Distance LCF to midships} = 150/2 - 70 = 5 \text{ m}$$

$$\text{First trim correction} = \frac{5 \times 0.40 \times 40 \times 100}{150} = +53 \text{ t}$$

### Second trim correction

The second trim correction is for the shift of the centre of flotation (LCF) which occurs as the vessel changes its trim. The position of the LCF, as specified in the hydrostatic particulars, is normally for the even-keel condition.

The draught at the *final* position of LCF is required.

$$\text{Second trim correction (metres)} = \frac{\text{trim} \times (\text{MCTC}_2 - \text{MCTC}_1)}{2 \times \text{TPC} \times \text{LBP}}$$

Where

$\text{MCTC}_2$  = MCTC for the draught at the AP

$\text{MCTC}_1$  = MCTC for the draught at the FP

or vice versa when trimmed by the head.

However the second trim correction is normally calculated in tonnes as follows:

$$\text{Second trim correction (tonnes)} = \frac{50 \times \text{trim}^2 \times (\text{MCTC}_2 - \text{MCTC}_1)}{\text{LBP}}$$

Where

$\text{MCTC}_2$  = MCTC for mean adjusted draught + 0.5 m

$\text{MCTC}_1$  = MCTC for mean adjusted draught – 0.5 m

Actual displacement (tonnes) = tabulated displacement  $\pm$  second trim correction

#### Sign convention

Always positive (+).

#### Worked example: second displacement correction for trim

A vessel is floating in salt water with an AMD of 6.10 m corrected for deflection and a trim of 1.40 m by the stern.

Extracted values from hydrostatics:

MCTC for 5.60 m = 310.0, MCTC for 6.60 m = 322.90, LBP = 170 m.

Calculate the second trim correction in tonnes for the vessel in this condition.

#### Answer

Trim = 1.40 m

$$\text{Second trim correction} = \frac{50 \times 1.40^2 \times (322.90 - 310.0)}{170} = +7.4 \text{ t}$$

## DENSITY

Determine the water density at the time of taking the draughts using a glass hydrometer, which is designed for draught surveys and marked

1. medium surface tension
2. apparent density in kg / l scale range between 0.990 to 1.040 (1.000 kg/l = 1.000 t/m<sup>3</sup>)
3. instrumental standard 15° C.

The instrument should be provided with a certificate of calibration with a maximum error not exceeding 'x' kg/l tested against a national standard (see Figure 5).

If the hydrometer used is graduated with a different scale then it is not the standard type so additional corrections may be required – see details for alternative hydrometers in Appendix VI.

### *Correction for density*

$$\text{Actual displacement (tonnes)} = \text{tabulated displacement} \times \frac{\text{density 1}}{\text{density 2}}$$

Where

density 1 = average density of water sampled

density 2 = density specified in the hydrostatic information.

#### *Notes*

1. *Do* apply the hydrometer index error, if any. It is quoted on the certificate.
2. *Do not* apply any correction for temperature.
3. *Do not* adjust the draught for the density, but *do* correct the displacement instead.
4. *Do* enter in the hydrostatic tables the actual TMD, irrespective of density, and then convert the extracted value to the correct density at the final calculation. It is wrong to convert the TMD to a salt water TMD and then enter it in the hydrostatics.
5. *Do* extract MCTC, LCF and so on for the actual TMD and use these extracted values to calculate the first and second trim corrections.
6. The stability information book should quote some form of relationship between weight and volume:

1 cubic metre of fresh water 1 tonne

1 cubic metre of salt water 1.025 tonnes

or similar figures.

The following example gives apparent density in the same units used by a standard draught survey hydrometer.

#### **Worked example: displacement correction for density**

The extracted hydrographic displacement equivalent to the observed draught of 5.30 m = 15,250 t for salt water where 1 m<sup>3</sup> of salt water = 1.025 t.

Find: true displacement if the average observed apparent density = 1.015 t/m<sup>3</sup>

#### *Answer*

$$\text{Actual displacement} = 15,250 \times 1.015 / 1.025 = \mathbf{15,101 \text{ t}}$$

## ASSESSMENT SUMMARY

The corrections in this chapter may be applied to the observed draughts to convert them to a draught that can be used to enter in the ship's hydrostatic particulars to determine the correct displacement.

Some of the corrections may be calculated in tonnes or in metres. Experience and speed of calculation has shown that these corrections should be calculated in tonnes (instead of metres), and used to correct a value of displacement extracted from the hydrostatic particulars in the stability information book.

The observed draughts are corrected to the perpendiculars and midships, the hull deflection found and the hydrostatics entered with the corrected arithmetical mean draught (AMD). The displacement extracted is then adjusted with the first and second trim corrections and the correction for density, all in tonnes.

A corrections checklist is provided in Appendix VII.



## *Chapter 5*

# **DEDUCTIBLES**

The deductibles are the components of the ship's total weight, which must be deducted from the calculated displacement to determine the weight of cargo on board.

The total weight of the ship will be made up of

- light displacement (remember components may be missing e.g. anchors out)
- cargo
- ballast
- fuel and fresh water
- swimming pool water and other easily forgotten weights on board
- stores and provisions
- crew and effects.

Stores, provisions, crew and their effects are likely to be constant during a draught survey, and could be added on to the light displacement.

### ***Preparations***

Examine the relevant basic ship's plans showing the layout of pipes and tanks, including the location of their sounding pipes.

Make a note of the tank dimensions, reference heights and obtain the authorised calibration tables for these tanks.

Remember that automatic gauge readings (if fitted), should be noted for comparison against the manual readings.

## **SOUNDINGS AND ULLAGES**

The liquid quantities of ballast, fuel and fresh water must be carefully measured as soon as possible after the draughts have been read.

A sounding is the measurement from the striker plate on the base of the tank below the sounding pipe to the top of the liquid (see Figure 3).

When taking a sounding, always check the tape is at the bottom of the tank, by checking the full measurement from the striker plate to the top of the sounding pipe.

An ullage is the measurement from the surface of the liquid to a fixed datum point, usually the top of the sounding pipe.

Measure and record soundings (or ullages) for every tank in the ship.

Check the bilges for any liquid.

Some tanks may have two sounding pipes, check both, particularly if the ship is trimmed.

The sounding tables should be part of the ship's approved documentation, they are produced when the vessel is built and therefore may have become less accurate with the passage of time.

## SAMPLING

By sounding a tank and using the sounding tables, the volume of liquid is found. With the apparent density of the liquid, its mass can be determined.

$$\text{Mass} = \text{volume} \times \text{apparent density}$$

It is most important that each tank should be sampled for density as well as being sounded for volume (see Figure 4).

Apply the temperature correction to the density reading before using it to calculate the quantity of bunkers in a tank when doing a bunker tank survey. It is *not* normal to apply a temperature correction when determining ballast quantities.

## TRIM CORRECTIONS

The sounding pipe should be positioned at a point within the tank where it will always provide the correct sounding applicable to the sounding tables, regardless of the ship's trim. However, this position is not always possible to achieve and correction tables for trim should then be available to use with the sounding tables. These corrections should be calibrated for every half metre of trim, by the head and by the stern, over the operational range of trims. Alternatively, sounding tables for different trims may be provided.

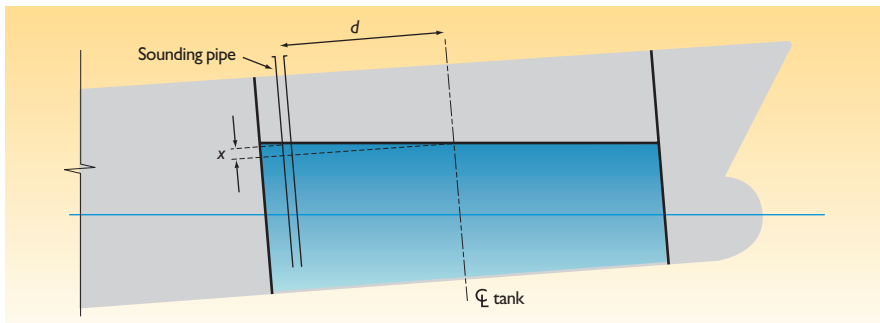


Figure 17. Trim correction for tank sounding

If no corrections are available, it may be necessary to calculate them. Appropriate measurements can be taken from the plans of the tank.

$$\text{Correction to sounding } (x) = \frac{d \times \text{trim}}{\text{LBP}}$$

Where

$d$  is the distance from the sounding pipe to the tank centre.

### Sign convention

Trim	Sounding forward of tank centre	Sounding aft of centre
Forward	Negative (-)	Positive (+)
Aft	Positive (+)	Negative (-)

The accuracy of the correction formula is acceptable, provided the bottom of the tank is covered with liquid and the tank is approximately rectangular.

### Worked example: calculating liquid rectangular volume with trim correction

A ship, LBP 120 m, has a trim of 2.00 m by the stern. A sounding was taken in a rectangular double bottom tank, and found to be 1.05 m. If the tank measured length 24.0 m, breadth 8.2 m, and the sounding pipe was 3.0 m forward of the aft bulkhead, find the volume of liquid in the tank.

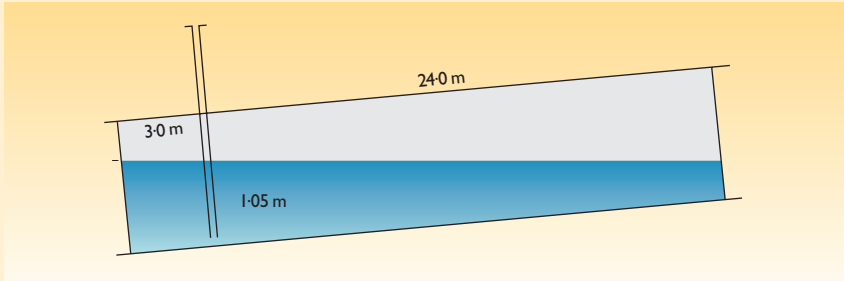


Figure 18.

#### Answer

Correction to sounding =  $d \times \text{trim} / \text{LBP} = 9.0 \times 2.0 / 120 = 0.15 \text{ m}$   
 Observed sounding = 1.05 m  
 Even keel sounding = 0.90 m  
 Volume of liquid =  $24.0 \times 8.2 \times 0.90 = 177.1 \text{ m}^3$

When a vessel is trimmed a tank may appear full but have a large void space immediately forward of the sounding or ullage point.

Alternatively, a tank may have no soundings and appear empty, but still have a considerable quantity of liquid remaining in it.

## LIQUID SLOP TANKS

Where small quantities of ballast water remain in a ballast hold, on a trimmed ship, this quantity must be included in the assessment.

It is possible to calculate the volume of the wedge of liquid, from one sounding, using the wedge formula.

The wedge formula was developed to determine small volumes of cargo 'remaining on board'.

The formula assumes a free-flowing liquid on an upright, but trimmed vessel, and also it assumes a rectangular tank where the sounding is not constrained by a sounding pipe.

The wedge formula is

$$\text{Wedge volume} = \frac{\text{LBP} \times \text{breadth of tank} \times (\text{corrected sounding})^2}{2 \times \text{vessel's trim}}$$

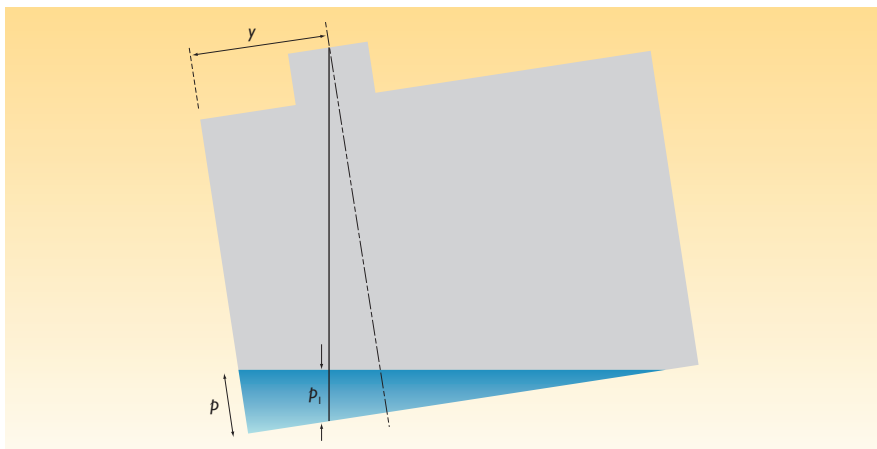


Figure 18.

The corrected sounding can be calculated by the following approximate formula

Corrected sounding ( $p$ ) = observed sounding ( $p_1$ ) + distance ( $y$ )  $\times$  trim / LBP

Where  $y$  is the distance from the sounding position to the end bulkhead.

#### Worked example: calculating liquid wedge volume with trim correction

From the following information, find the volume of oil remaining in a tank where the sounding was 0.20 m.

LBP 150 m, trim 2.00 m by the stern, breadth of tank 12.5 m, sounding position 6.0 m forward of aft bulkhead.

#### Answer

$$\begin{aligned} \text{Corrected sounding} &= \text{sounding} + \text{distance} \times \text{trim} / \text{LBP} \\ &= 0.20 + 6 \times 2.00 / 150 = 0.2 + 0.08 = 0.28 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Wedge volume} &= \frac{\text{LBP} \times \text{breadth} \times \text{corrected sounding}^2}{\text{trim} \times 2} \\ &= \frac{150 \times 12.5 \times 0.28^2}{2.00 \times 2} \\ &= 36.75 \text{ m}^3 \end{aligned}$$

## MIXTURES

When conducting a bunker survey and the vessel loads bunkers, this could be mixed with bunkers already on board. The relative density (RD), or density, of the mixture must be used to calculate the total quantity of the oil in the tank.

The final RD of the mixture can be found by the following formula

$$\text{RD of mixture} = \frac{(\text{original volume} \times \text{original RD}) + (\text{loaded volume} \times \text{loaded RD})}{\text{original volume} + \text{loaded volume}}$$

## RESIDUE IN COMPARTMENTS

Tanks for liquids, particularly ballast tanks, are subject to the build up of residues and scale. The quantity of sediment is difficult to assess without entering the tank.

The effect on the ballast calculations can be minimised by leaving a measurable quantity of water in the tank instead of pumping it completely dry. The calculations then use a known amount of water which can be deducted from the displacement. The error due to the unknown weight of sediment is reduced to the difference between the density of water and the density of the sediment. The accumulation of sediment will reduce the deadweight capacity of the vessel and therefore should not be allowed to accrue indefinitely.

Inspect ballast tanks if in any doubt about the quantity of sediments. There are patent chemicals available to put the mud into suspension so that it may be disposed of with the water in an appropriate and safe manner when a suitable opportunity allows. However, these may not always be effective; when a hard crust has developed on the top of the mud, it can sometimes only be removed by hand.

## ANCHORS AND CABLES

The anchors may be in the housed position, where they contribute to the lightship, or they may have been used in the mooring of the ship. Then the anchors will be on the sea bed along with a given length of cable. The loss of weight due to their removal is weight taken from the light displacement – this amount should therefore be added to the quantity of cargo. There should be information available on board to enable the surveyor to establish or calculate the weight of the missing anchor and cable.

In the case of the chain cable, it can be calculated with reasonable accuracy by the following formula

$$\text{Weight per shackle (27.43 m) (tonnes)} = 0.0005805 \times (\text{link diameter in mm})^2$$

The link diameter is the diameter of the steel rod which makes up each individual link. In the case of the anchor itself, this will vary from ship to ship, but the information should be available on board. The anchor weight should be rounded to the nearest half tonne.

## ADDITIONAL FACTORS

It should be appreciated that the cargo may change its characteristics over a period of time. The moisture content varies with the atmospheric conditions, and liquid drains into the bilges. The removal of bilge water between the two surveys should be noted. This is also important during a voyage when a wetted cargo may lose its moisture content and later cause a dispute over cargo quantities.

The changes in the condition of the vessel such as the accumulation of rain water, ice or snow, could be significant and should be accounted for in the calculations.

The swimming pool can hold considerable quantities of water, which could cause a discrepancy if the pool is emptied, or filled, during the period between the before and after draught surveys. In this case a correction must be applied to the results.

All spaces should be inspected to ensure they are the same at both the initial and final surveys, not forgetting spaces such as the duct keel, peaks, cofferdams and so on.

**Remember: the accuracy of the survey depends on diligence!**

# APPENDIX I

## GLOSSARY

- Aft draught** The distance from the bottom of the keel to the waterline on the aft perpendicular when the ship is upright.
- Aft perpendicular (AP)** A perpendicular drawn to the waterline at the point where the aft side of the rudder post meets the summer load line. Where no rudder post is fitted it is taken as the centre line of the rudder stock.
- Apparent density** The weight in air of a unit volume.
- Apparent trim** The difference between the draughts observed at the forward and aft draught marks.
- Arithmetical mean draught (AMD)** The arithmetical mean of the forward draught and the aft draught.
- Assigned summer freeboard** The distance from the upper edge of the summer load line to the upper edge of the deck line.
- Block coefficient (Cb)** The ratio of the underwater volume of the vessel to the volume of a rectangular block of the same overall dimensions.
- Breadth (beam)** Maximum width of the ship.
- Centre of flotation (CF)** The centroid of the waterplane area. It is the point about which the ship trims, heels and lists.
- Deadweight** The difference between the light displacement and the loaded displacement. It is the carrying capacity of the ship and includes the weight of cargo, ballast, fuel, water, stores, crew and effects.
- Density** The mass per unit volume.
- Depth** Distance from the top of the deck plating at the side of the ship to the bottom of the keel.
- Displacement** The mass of water displaced by the ship. It represents the total weight of the ship and is calculated by: volume of displacement  $\times$  density of water.
- Draught** The distance from the bottom of the keel to the waterline. Sometimes spelled *draft*.
- Even keel** When the forward and aft draughts are the same, the ship is said to be on an even keel. The ship's hydrostatic data is calculated for this condition.
- Forward draught** The distance from the bottom of the keel to the waterline on the forward perpendicular when the ship is upright.
- Forward perpendicular (FP)** A perpendicular drawn to the waterline at the point where the fore side of the stem meets the summer load line (or load waterline LWL).
- Freeboard** The distance from the waterline to the upper surface of the freeboard deck at the ship's side.
- Fresh water allowance (FWA)** The amount by which the summer load line may be submerged in fresh water.
- Heel** The ship is heeled when inclined by an external force .
- Hog** The condition of a ship when it is deformed so that the forward and aft draughts are deeper than the midships draught. It is referred to as a hull deflection.

**Length between perpendiculars (LBP)** Distance from the forward perpendicular to the aft perpendicular.

**Length overall (L or LOA)** Maximum length of the ship.

**Light displacement** The displacement of the ship and superstructure with all fixed equipment plus engine room spares and with water in the boilers to working level. Also referred to as lightship or lightweight.

**List** The ship is listed when inclined by weights within the ship.

**Longitudinal centre of flotation (LCF)** The distance of the centre of flotation from midships or the aft perpendicular.

**Mass** The mass of an object is the quantity of matter it contains and is calculated by: volume  $\times$  density

**Midships** The point midway between the forward and aft perpendiculars. The centre of the load line circle should indicate this position.

**Midships draught** The distance from the bottom of the keel to the waterline at a position midway between the perpendiculars.

**Moment to change trim per centimetre (MCTC or MCT1cm)** The moment of the weight (i.e. weight  $\times$  distance) required to change the trim of the ship by 0.01 m.

**Moulded breadth** Width of the ship amidships, measured inside the shell plating.

**Moulded depth** Distance from the keel to the deck the ship's side, measured inside of the shell plating.

**Relative density (RD)** The ratio of the weight of a substance to the weight of an equal volume of fresh water. RD of fresh water: 1.000 at 4°C. RD of salt water: 1.025 at 4°C. The term specific gravity, previously used in place of RD, is no longer used with SI units.

**Sag** The condition of a ship when it is deformed so that the midships draught is deeper than the forward and aft draughts. It is referred to as a hull deflection.

**Sounding** The distance from the bottom of a tank to the top of the liquid within it.

**Summer load displacement** The displacement of the ship when loaded to its summer load line.

**Tonnes per centimetre immersion (TPC)** The weight which must be loaded or discharged to change the ship's mean draught by 0.01 m.

**Trim** The difference between the forward and aft draughts.

**True density** The weight in a vacuum of a unit volume.

**True mean draught (TMD)** The draught at the centre of flotation.

**True trim** The difference between the draughts at the forward and aft perpendiculars.

**Ullage** The distance above a liquid, within a tank, to the measuring point at the top of the tank.

**Volume of displacement** The volume of water displaced by a ship and is calculated by: length  $\times$  breadth  $\times$  draught  $\times$  block coefficient (Cb).

**Waterplane coefficient (Cw)** The ratio of the area of the ship's waterplane to a rectangle of the same extreme dimensions. Also known as the coefficient of fineness.

**Weight** The weight of an object is the force it exerts on anything which freely supports it.

## APPENDIX II

### UN ECE DRAUGHT SURVEY CODE FORMS

These forms were downloaded from <http://unece-draughtsurvey.ath.cx> on 21 July 2009.

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059		<input type="checkbox"/> UNLOADED	
060	Corporate Identification:		
061			
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063	Vessel No.:	Survey No.:	
064			
065	General remarks by the surveyor/s		
066			
067	Correction for stem and stern obtained by:	<input type="checkbox"/> calculation	<input type="checkbox"/> tables
068	Correction for trim (1) obtained by:	<input type="checkbox"/> calculation	<input type="checkbox"/> tables
069	Correction for trim (2) obtained by:	<input type="checkbox"/> calculation	<input type="checkbox"/> tables
070	Correction due to trim for liquid applied at:	<input type="checkbox"/> soundings	<input type="checkbox"/> volumes
071	Correction due to trim for liquid obtained by:	<input type="checkbox"/> calculation	<input type="checkbox"/> tables
072			
073	Ship's approved hydrostatic tables and lightship information issued by and dated:		
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075			
076			
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080	Degree of tank calibration complies with code:	<input type="checkbox"/> Yes	<input type="checkbox"/> No
081			
082	Range of trim correction tables available		
083			
084	Shipyard no.:	Hull no.:	Dated at:
085			
086	Surveyor remarks on ship's documents:		
087			
088		meters	metric tonnes
089	Length overall		Constant declared
090	Length between p.p.		Constant calculated
091	Extreme breadth		Light displacement
092	Moulded breadth		Light shipweight (plan)
093	Depth overall incl. keel plate		Summer displacement
094	Moulded depth		Summer deadweight
095	Summer draught		Net register tons
096	Summer freeboard		Gross register Tons
097			
098		STARTING SURVEY	FINISHING SURVEY
099	Tonnes per Centimetre Immersion	_____	_____
100	Longitudinal Centre of Flotation	_____	_____
101	Distance marks forward pp. (forward - aft+)	_____	_____
102	Distance marks after pp. (forward - aft+)	_____	_____
103	Distance marks midship pp. (forward - aft+)	_____	_____
104	Moment to Trim One Centimetre +50	_____	_____
105	Moment to Trim One Centimetre -50	_____	_____
106	Yessel list	_____	_____
107	Accessibility of sounding pipes	_____	_____
108	Working order of gauges	_____	_____
109	Legibility of draught marks	_____	_____
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115	This form should be filled with pertinent shipyard-registry data by the Master in advance of survey start to reduce time/inconvenience.		
116			

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Displacement corrected for deductibles																																																																																																																	
Draughts, densities, fresh water and ballast soundings witnessed and agreed to by the Chief Officer. Fuel oil soundings witnessed and agreed to by the Chief Engineer unless otherwise stated in form "A"																																																																																																																	

**U.N. - ECE - DRAUGHT SURVEY CODE**

178	<b>DRAUGHT SURVEY REPORT OF CARGO IN BULK</b>				<input type="checkbox"/> LOADED	<b>FORM "D1"</b>	
179					<input type="checkbox"/> UNLOADED		
180	Corporate Identification:						
181	Vessel Name: _____ Survey No: _____						
182	Starting Sounding: _____ From Hours: _____ To Hours: _____ Date: _____ Time: _____						
183							
184							
185							
186							
187							
188	<b>Compartment Title:</b>	<b>Maximum height</b>	<b>Sounding</b>	<b>Sounding</b>	<b>Volume</b>	<b>Density of</b>	<b>Total</b>
189	• Tank no.	measured (°)	tillage	tillage	corrected	water	weight
190	• Bilges	meters	meters	corrected for	for trim /lis1	in air	Metric
191	• Duct keel	meters	meters	trim /lis1	m <sup>3</sup>	Kgm <sup>3</sup>	tonnes
192							
193	<b>A -BALLAST</b>						
194							
195							
196							
197							
198							
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212							
213							
214							
215							
216							
217							
218							
219							Total A
220							
221	<b>B -FRESH WATER</b>						
222							
223							
224							
225							
226							
227							
228							
229							
230							
231							
232							Total B
233							
234	(*) Statement of obstructions in sounding tube A:						
##							

U.N. • ECE • DRAUGHT SURVEY CODE						
235	<b>DRAUGHT SURVEY REPORT OF CARGO IN BULK</b>				<input type="checkbox"/> LOADED	<b>FORM "D2"</b>
236					<input type="checkbox"/> UNLOADED	
237	Corporate Identification:					
238	Vessel Name:					
239	Survey no.:					
240	From Hours:		To Hours:		Date:	Time:
241	FINISHING SOUNDING:					
242						
243						
244						
245	<b>Compartment Title:</b>	<b>Maximum height</b>	<b>Sounding</b>	<b>Sounding</b>	<b>Volume</b>	<b>Density of</b>
246	• Tank no.	measured (°)	/ullage	/ullage	corrected	water
247	• Bilges	metres	metres	corrected for	for trim /lit	in air
248	• Duct keel			trim /lit	m <sup>3</sup>	Kg/m <sup>3</sup>
249				metres		tonnes
250	<b>A - BALLAST</b>					
251						
252						
253						
254						
255						
256						
257						
258						
259						
260						
261						
262						
263						
264						
265						
266						
267						
268						
269						
270						
271						
272						
273						
274						
275						
276						Total A
277						
278	<b>B - FRESH WATER</b>					
279						
280						
281						
282						
283						
284						
285						
286						
287						
288						
289						
290						Total B
291						
292	(*) Statement of obstructions in sounding tube A:					
293						

U.N. • ECE • DRAUGHT SURVEY CODE										
304	<b>DRAUGHT SURVEY REPORT OF CARGO IN BULK</b>							<input type="checkbox"/> LOADED <input type="checkbox"/> UNLOADED		<b>FORM "D3"</b>
305										
306										
307	Corporate Identification:									
308										
309	Vessel M/V:					Survey no.:				
310										
311	SOUNDINGS									
312										
313	STARTING SURVEY					FINISHING SURVEY				
314	Compartment									
315	Title:	Total	Sounding	Actual	Actual	Weight	Sounding	Actual	Actual	Weight
316	Tank no.	sounded	Ullage	Density	Volume	Metric	Ullage	Density	Volume	Metric
317	Slop t.	depth m.	meters	Kgm3	m3	Tonnes	meters	Kgm3	m3	Tonnes
318										
319	C - FUEL OIL									
320										
321										
322										
323										
324										
325										
326										
327										
328										
329										
330										
331										
332										
333	Total C					Total C				
334										
335	D - DIESEL OIL									
336										
337										
338										
339										
340										
341										
342										
343	Total D					Total D				
344										
345										
346	SUMMARY OF DEDUCTIBLES									
347										
348	STARTING SURVEY					FINISHING SURVEY				
349	metric tonnes					metric tonnes				
350	Ballast water									
351	Fresh water									
352	Fuel oil									
353	Diesel oil									
354	Slops									
355	Lubricating oil									
356	Swimming pool water									
357	Anchor & Chain									
358	Others									
359										
360	Total Deductibles									
361										
##										

<b>U.N. • ECE • DRAUGHT SURVEY CODE</b>										
364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422	<p><b>DRAUGHT SURVEY REPORT OF CARGO IN BULK</b></p> <div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;"> <input type="checkbox"/> LOADED  <input type="checkbox"/> UNLOADED                 </div> <div style="text-align: right; padding-right: 20px;"><b>FORM "E"</b></div> </div> <p><b>Corporate Identification:</b> _____</p> <p><b>Vessel Name:</b> _____ <b>Survey No.:</b> _____</p> <p style="text-align: center;"><b>CARGO STATEMENT</b></p> <table style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <tr> <td style="width: 80%;"></td> <td style="width: 20%; text-align: center; border: 1px solid black; padding: 2px;">Metric Tonnes</td> </tr> <tr> <td style="padding-left: 40px;">Starting Displacement Corrected</td> <td style="border: 1px solid black; height: 20px;"></td> </tr> <tr> <td style="padding-left: 40px;">Finishing Displacement Corrected</td> <td style="border: 1px solid black; height: 20px;"></td> </tr> <tr> <td style="padding-left: 40px;">Difference in Displacement = TOTAL CARGO IN BULK IS:</td> <td style="border: 1px solid black; height: 20px;"></td> </tr> </table> <p><b>OBSERVATIONS:</b> Shore scale quantity (if available) M.T. _____</p> <p>Note on any unusual situation/s, exceptions from required Uniform Code standard, specific identification (source, drawing no., date, title, certifying authority) of each ship's document used in translating recorded measurements into weights and, when applicable, reasons for surveyor's refusal or impossibility to perform the survey: _____</p>		Metric Tonnes	Starting Displacement Corrected		Finishing Displacement Corrected		Difference in Displacement = TOTAL CARGO IN BULK IS:		
	Metric Tonnes									
Starting Displacement Corrected										
Finishing Displacement Corrected										
Difference in Displacement = TOTAL CARGO IN BULK IS:										
	<p style="text-align: center;"><b>Metric Tonnes</b></p> <p>Corrected light displacement = _____</p> <p>Deductables = _____</p> <p>Lightship = _____</p> <p>Constant = _____</p> <p>Mean of previous constants = _____</p> <p>I certify that the constant calculated from this draught survey has been entered into the ship's "Constant Certificate"</p>									
	<p>In my judgement the weather conditions, the sea conditions, and the conditions of the ship at the times the draught surveys were conducted, were within acceptable limits and did not adversely affect the accuracy of this survey. This Bona Fide report consisting of _____ pages, including this page, all duly initialled or signed is issued without prejudice and is for the benefit of whom it may concern.</p> <p><b>Name of surveying firm</b> _____ <span style="float: right;">(corporate identification)</span></p> <p><b>By:</b> _____</p> <p style="text-align: center; font-size: small;">(Signature of Surveyor)</p> <p><b>Name/s in print</b> _____</p> <p>I have participated in all stages of this draught survey and agree with the results obtained. I acknowledge receipt of the ship's copy.</p> <table style="width: 100%; border: 1px solid black; margin-top: 10px;"> <tr> <td style="width: 33%; padding: 2px;"><b>Signed:</b></td> <td style="width: 33%; padding: 2px;"><b>Rank:</b></td> <td style="width: 33%; padding: 2px;"><b>Name in print:</b></td> </tr> <tr> <td style="height: 30px;"></td> <td></td> <td></td> </tr> </table>	<b>Signed:</b>	<b>Rank:</b>	<b>Name in print:</b>						
<b>Signed:</b>	<b>Rank:</b>	<b>Name in print:</b>								
	<p>Filesaker Pro 3.0 • Edition July 1997</p>	7-7								

## APPENDIX III

### EQUIPMENT CHECKLIST

Sample jar and water sample bucket with line	
Ballast tank dipper with line	
Small hand pump with hose for taking samples	
Draught survey hydrometer with certificate	
Steel sounding pipe with graduations in metres	
Water-finding paste	
Draught / freeboard measuring device	
Manometer if some draughts are impossible to read, plus a long measuring tape	
Plastic tube with plug, to act as sounding pipe extension	
Boat available to read inaccessible draughts	
Pilot ladder on board ready for obtaining draughts	
Documentation	
Pocket computer with draught survey program or calculator	





## APPENDIX V

### CHECKLIST OF FACTORS THAT MAY INFLUENCE SURVEY ACCURACY

Height of waves/swell	
State of tide – under-keel clearance	
Variations in density	
Anchors moved, in or out	
Quantity of bilges pumped	
Suspect calibrations	
Clarity of draught marks	
Squat effects	
Daytime/night-time	
Ice/snow on deck	
Residue in tanks	
Ship movements	

*(Not an exhaustive list)*

## APPENDIX VI

### ALTERNATIVE HYDROMETERS CORRECTIONS

To correct to apparent density (density in air) from a hydrometer calibrated in	
true density (density in vacuo)	minus (-) 0.0011 g/ml
relative density (15°C / 4°C)	minus (-) 0.0011
relative density (15°C / 15°C)	minus (-) 0.002
(g/ml = kg/l = t/m <sup>3</sup> )	

## APPENDIX VII

### CORRECTIONS CHECKLIST

<b>Observed draughts</b> – port and starboard at forward, aft and midships	
Mean values, i.e. of centreline draughts at forward, aft and midships	
Correction from marks to perpendicular and midships positions misplacement opposite to trim, then positive (+) misplacement same as trim, then negative (-)	
Hog/sag correction (mean of mean of means, or similar) negative (-) for hog positive (+) for sag	
<b>Corrected mean draught</b> – to enter in hydrostatic tables	
Displacement from displacement table	
First trim correction or correction for layer (in tonnes) LCF same as trim, then positive (+) LCF opposite to trim, then negative (-)	
Second trim correction (in tonnes) always positive (+)	
List correction (in tonnes) always positive (+)	
Correction for density less than salt water density, then negative (-)	
<b>Corrected displacement</b>	

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# DRAUGHT SURVEYS

A GUIDE TO GOOD PRACTICE  
Second Edition

by JIM DIBBLE, PETER MITCHELL and  
North of England P&I Association

The accurate measurement of dry bulk cargoes by a vessel can minimise considerably the risk of shortage claims and disputes. This guide outlines the methods and corrections for a draught survey to be carried out to the required accuracy. It is designed to help surveyors and recommends procedures and formulas for every circumstance likely to be encountered during the conduct of draught surveys. The UN ECE draught survey forms have been included in an effort to achieve standardisation throughout the industry.

**Jim Dibble** is a master mariner with 50 years experience in the shipping industry. He spent 12 years at sea as a deck officer and 31 years in the marine education department at South Tyneside College, where he led the development of the Marine Simulation Centre. He has since worked as a marine consultant and is currently UK managing director of Seagull Maritime Information Technologies Ltd.

**Peter Mitchell** is a master mariner with 40 years experience in the shipping industry, firstly as a deck officer and then as a senior lecturer in the marine department at South Tyneside College, UK. He is now retired.

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