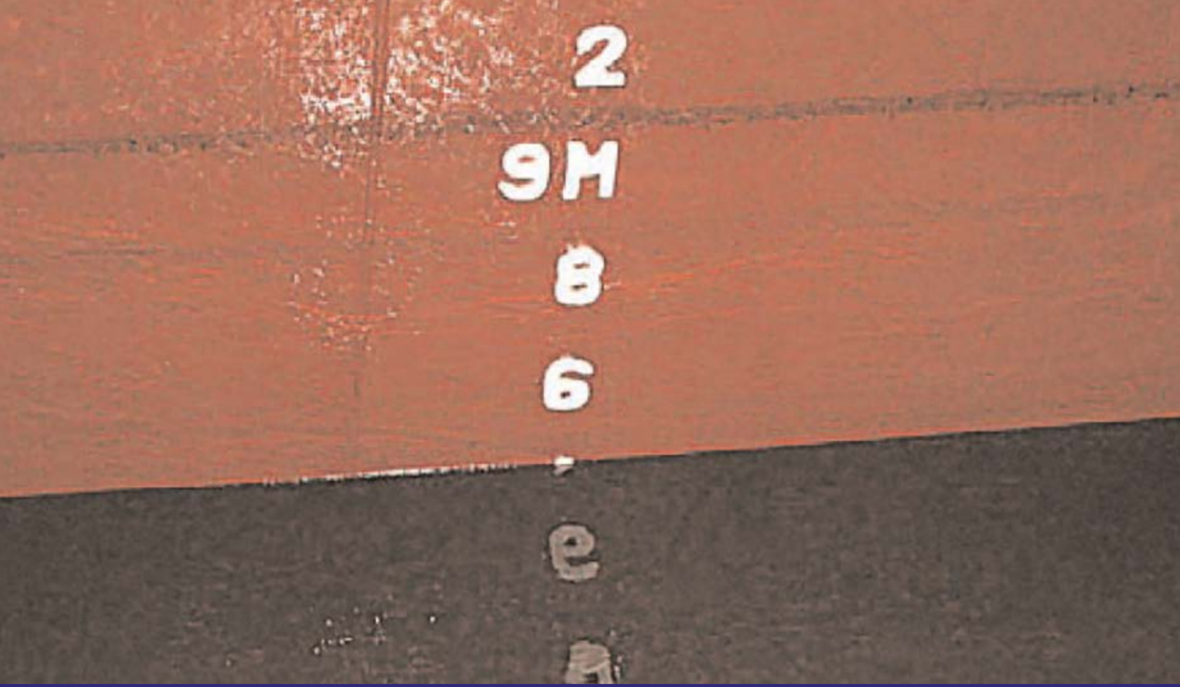

Chapter 16 – Draught Surveys

If, during loading and discharging, no shifting of weights was to take place, other than the movement of cargo, then calculating the weight of cargo by draught survey could be considered to be reasonably accurate. In practice, this seldom occurs.

The weight of the ship is determined both before and after loading and allowances made for differences in ballast water and other changeable items. The difference between these two weights is the weight of the cargo.

In order to do this, the depth that the ship is floating at is assessed from the draught marks, and the vessel's stability book is consulted to obtain the hydrostatic particulars such as the displacement and other necessary data.

Several corrections are required and the quantities of ballast and other consumable items need to be assessed so as to obtain the net weights as follows.

The weight of an empty ship consists of three elements:

1.	Empty ship	Fixed item
2.	Stores	Considered fixed
3.	Ballast, oil and fresh water	Changeable

Empty net weight = Empty ship + Stores

The weight of a loaded ship consists of four elements:

1.	Empty ship	Fixed item
2.	Stores	Considered fixed
3.	Ballast, oil and fresh water	Changeable
4.	Cargo	Fixed item

Loaded net weight = Empty ship + Stores + Cargo

Therefore, the cargo weight is the difference between the net weights.

Although a draught survey is simple in principle, in practice it is frequently a complicated and time consuming way of attempting to ascertain the weight of cargo loaded on board a ship. Many factors are involved, few of which can be established with a complete degree of accuracy.

A draught survey starts with a reading of the ship's draught, on both sides; forward, amidships and aft. There are a number of limiting factors:

- It is often difficult to accurately read the draught because of prevailing weather conditions and the presence of waves on the water surface. A vessel may have also developed a slight roll, leading to further inaccuracies
- the draught should be read from a position as close to the waterline as possible to avoid parallax, although this may not always be practicable
- a ship moored in a tidal stream or current will be affected by squat, particularly in shallow water, and this will have a further effect
- a draught can be affected when there is a large difference between the temperatures of the air and the water. This will cause a difference in the expansion of the submerged and emerged sections of the ship. There is currently no acceptable method of correcting for this
- when a ship is not on an even keel (as is always the case before loading and after discharge), the draught readings must be corrected for trim. It should be borne in mind that, at such times, the draught marks are not in line with the forward and after perpendiculars
- the draught must be corrected for the density of the water in which the vessel is floating. It is difficult to obtain a reliable average density because this will vary at different levels and locations around the ship
- the draught has to be corrected for hog and sag. This correction is generally calculated on the basis that a ship will bend parabolically, although this is not always the case.

A mean draught figure is obtained (a double mean of means) which, by comparison with the ship's displacement scale, provides the corresponding displacement. The ship's displacement table may not, however, always be completely accurate. This is usually supplied by the shipbuilder and the methods used to make up the tables may not always be totally reliable. Similarly, the trim correction may be derived by the use of various formulae, not all of which are entirely accurate.

16.1 Draught Surveys – Practice

The Master of a vessel should be advised in adequate time that a draught survey will be taking place. If it is an initial light ship survey, they should be requested, subject to the safety of the vessel, to ensure that individual ballast tanks are either fully pressed up or empty and that the vessel is upright with a trim that is within the limits of the tank calibration tables.

When draught surveys are undertaken by independent surveyors, cooperation of the ship's officers is essential. The survey sections should be undertaken with the vessel's chief officer and chief engineer or their appointed deputies.

Before undertaking the survey, it is recommended that the surveyor makes time to inspect a general arrangement plan to confirm the number and position of the various ballast, fresh water and oil bunker tanks on the vessel.

Equipment used in the survey may include:

- Strong torch
- boat/ladders
- binoculars
- patent draught mark indicator or measuring devices (draught tubes, indicators, etc)
- calibrated inclinometer or manometer
- steel tape measure with plumb bob/stainless steel sounding tape with plumb bob (preferably calibrated)
- seawater sampling bucket or can of sufficient volume
- calibrated patent draught survey hydrometer
- calibrated salinity refractometer
- ballast water sampling device
- computer/calculator.

Reading the draught marks
At the time of reading the draught marks, the vessel should be upright and on an even keel, or with a minimum of trim. The trim at survey should never exceed the maximum trim for which corrections may be included in the vessel's stability book.

To avoid errors when reading the draught marks, the vessel should, ideally, be lying in still, calm water. For example:

- For vessels lying at exposed berths or anchorages, where wave and swell surface disturbance is almost inevitable, even to the extent that the vessel may be rolling and pitching, it is usual to assess the actual mean water level over a number of readings to be at two-thirds of the distance between the lowest and highest levels of water as seen against the draught marks. Some experts advocate that, after studying wave patterns, a mean of the average highest and lowest draught readings should be used

- draught marks on vessels that are lying at a river berth or in tidal conditions when strong currents are running should, ideally, be read over periods of slack water (provided that at a low water slack there is sufficient UKC)
- currents of appreciable strengths are likely to cause the vessel to change trim or pitch slightly and/or sink bodily into the water from her static draught ('squat'). This phenomenon becomes more pronounced in shallow waters (shallow water effect)
- strong currents will result in raised water levels against the leading edge of a stationary vessel lying in flowing water. This is especially true when the flow is in the direction of a vessel's bulbous bow.

Draught marks must be read on both sides of the vessel, ie forward port and starboard, amidships port and starboard, and aft port and starboard. Alternatively, if additional marks are displayed on large vessels, they should be read at all the designated positions.

Should draught marks not be in place amidships, distances from the deck line to the waterline on both sides of the vessel must be measured. The amidships draughts can then be calculated from load line and freeboard data extracted from the vessel's stability booklet.

Draught marks should be read with the observer as close to the waterline as is safe and reasonably possible to reduce parallax error.

Although it is common practice to read the offside draught marks from a rope ladder, a launch or small boat provides a more stable environment and brings the observer to a safer position closer to the waterline.

A vessel's remote draught gauge should never be used for surveys due to lack of the necessary accuracy and the possibility of errors, which may accumulate over the working life of the instrument.

When adverse weather conditions are being experienced, access to the offside draught marks may prove difficult or impossible. At these times, the draughts on the nearside can be read and the offside draughts calculated using a manometer.

This method should never be used when the offside draughts can be safely observed and accurately read. If, as a final resort, this method cannot be undertaken, the use of a fully calibrated inclinometer, graduated to minutes of arc, is strongly recommended. The type of inclinometer fitted to vessels is not usually of sufficient accuracy to be used.

Draught marks

Draught marks (the depth at which the ship is floating) are designed to make reading simple. Metric marks are 10 cm high and are placed 10 cm apart. The steel plate they are made from is 2 cm wide. On the few vessels that still use the imperial system, the numbers are 6 inches high and located 6 inches apart, with the numbers constructed from 1 inch wide steel plate.

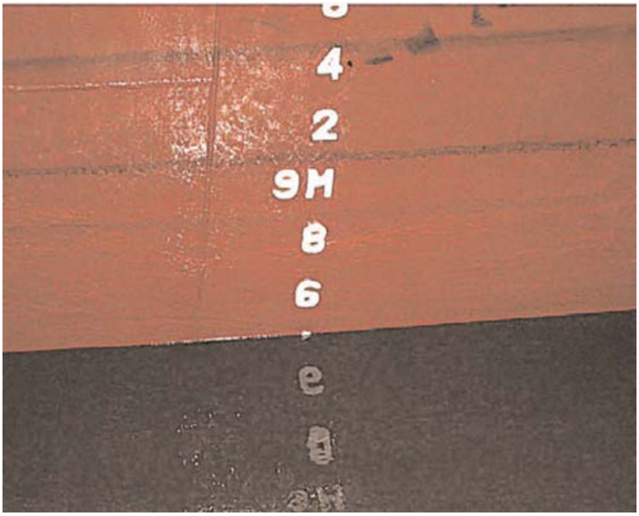

Figure 16.1: Typical draught marks.

Figure 16.1 shows depths from 8.49 to 9.64 m. The water level is at 8.49 m as half the width of the top of the '4' is visible above the water level. Some numbers are easier to assess than others. For example, in Figure 16.2, each pair of lines is 2 cm apart and it can be seen that the assessment of the depth is easy when the water level is across the '8'.

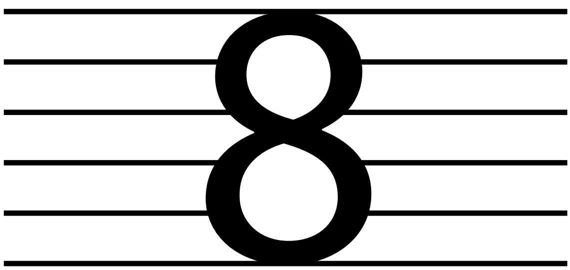

Figure 16.2: Mid number marks.

Some small coasters are only marked at the amidships point with a designated line (again 2 cm wide) called the deck line. The upper edge of this is at a known distance from the keel ('K'), which is the summation of the vessel's official summer freeboard and summer draught. Draughts are then calculated by measuring the actual freeboard (distance of the upper edge of the deck line from the water level) with a measuring tape and deducting it from 'K'.

Density of the water in which the vessel is floating

It is prudent to obtain samples of the water in which the vessel is floating at, or very close to, the time at which the draught marks are read. This is particularly relevant when the vessel is lying at an estuarial or river berth, when the density of the water may be changing due to the ebb or flow of the tide. The density should be checked quickly after obtaining the sample as there may be temperature differences between the actual sampling of the dock water and the time of determination of its density, which may lead to errors in density.

Depending on the length of the vessel under survey, a number of samples, say between one and three, should be taken. To overcome the problem of layering, the samples should be obtained using a closed sampling can at a depth of approximately half the existing draught of the vessel. Alternatively, a slow-filling container may be used to obtain an average sample from keel to waterline.

Figure 16.3: Manometer showing plastic tubing (30 to 40 m long), fitted at each end with a valve and scale. The valves are to allow the water in the tube to be retained without any air bubbles when the device is not in use.

Figure 16.4: Manometer, showing scale and water level. When a scale is fitted and used for the reading, care must be taken that the scale is fixed at the same height on each side of the vessel.

When reading the hydrometer floating in the sample of water, the eye of the observer should be as close to the water level as possible to avoid parallax errors and errors due to the meniscus. The hydrometer should also be given a 'twirl' to free it of any air bubbles.

Ballast water tanks

Ballast water tanks, including peaks and those said to be empty, must be carefully sounded or proven to be full by pressing up and overflowing from all air pipes when local regulations permit. If the ballast hold contains ballast water, this compartment must not be fully pressed up but should be sounded and the weight of the water carefully calculated.

Spaces such as the duct keel and voids, particularly those of the lower stools situated at the base of transverse bulkheads, between cargo holds, must be checked when safe to do so and proved in the same condition at initial and final surveys.

These voids often contain the manhole access covers to the adjacent double-bottom tanks. If these covers are not totally watertight, the voids will flood, or partially flood, during ballasting or pressing up of the tanks, potentially resulting in huge errors in the lightship or ballast survey. Surveyors have been known to refuse to conduct draught surveys when it has been established that there is an unknown amount of water in such void spaces.

The calculation of the weight of ballast water is undoubtedly the main source of error in a draught survey and may result in very large, and unacceptable, inaccuracies in the quantity of cargo calculated.

Density of the ballast water
It should be established where the various ballast tanks were filled. If they were from a single source, a few random samples of the water will confirm the density. If from different sources, samples must be taken from tanks containing water from each of the various sources and relevant densities of the water in individual tanks established.

The ballast tanks may contain significant amounts of muck in the form of sand, silt, shingle, rust scale, etc. The density of these deposits will differ significantly from the ballast water. Also, it may not be possible to determine the amounts of these solids that are in the tanks. The results are usually assumed in the constant, but the value may be significantly inaccurate.

The tanks should not be overflowed substantially to obtain samples unless local regulations permit. Instead, sampling equipment that is suitable for tanks that are only partially filled should be used.

When small samples are obtained, a salinity refractometer should be used to establish density. When larger samples have been obtained, a draught survey hydrometer may be used.

Establishing the correct weight of oils on board
This can be established either by sounding or ullaging of the tanks or, in the case of the engine room daily service and settling tanks, by reading the gauges.

The volume of oils in each and every tank should be measured and recorded.

The relative densities of the most recently delivered oils on board can be obtained from the bunker delivery certificates. However, bunkers are almost inevitably mixed with oils already on board, the densities of which are likely to differ. The relative density of the contents may be calculated using the following formula:

$$\text{RD of tank contents at survey} = \frac{(\text{Old oil volume} \times \text{Old RD}) + (\text{New bunker volume} \times \text{New RD})}{\text{Total volume of oil in tank}}$$

After completion of the bunker survey, the totals of each oil found must be agreed with the Chief Engineer and the Master.

Water removed from hold bilges

Certain bulk cargoes, such as ores, concentrates and some types of coal, are sprayed with water during loading to keep the dust levels down. In addition, the stockpiles of cargo at the terminal are exposed to rain and other forms of moisture. During the passage, some or all of this water content settles to the bottom of the hold and accumulates in and around the bilges. For safety reasons, this water will be pumped out. A record of bilge pumping would usually be maintained on board, but the volumes pumped out are never known exactly. This volume of water is one of the sources of variation between load port and discharge port figures.

Calculation and corrections of vessel's displacement from draught readings

Before extracting hydrostatic data from the vessel's stability book, care should be taken by surveyors to familiarise themselves with the format and methods used to display the various particulars, especially the means of depicting positions of LCF (longitudinal centre of flotation) etc, relative to amidships or to the after perpendicular.

When using a recommended draught survey computer programme or when calculating directly from data extracted from the hydrostatic particulars contained within the vessel's stability book, it is essential that the data is carefully and properly interpolated or, rarely, extrapolated.

One of the areas where significant errors often result is from the incorrect application of the sign in respect of the position of the LCF (in the first trim correction).

When undertaking initial and final displacement draught surveys to establish the weight(s) of cargo loaded, or alternatively unloaded, the difference between the net displacement weights provides the total cargo quantity. However, it is recommended for a cross check that, at the light ship/ballast survey, the vessel's light ship weight is deducted from the net displacement found. The resultant then provides the vessel's 'constant' at that time. These unknown weights might also be termed the vessel's 'stores variable'. Although variable, for a number of reasons, it should serve as a guide to the accuracy of the light ship/ballast survey.

Comparison between 'stores variable' quantities, or mean thereof, established at previous surveys should be treated with caution unless the variable is a direct comparison that can be made. For example, all surveys include a check and a record of the engine lubricating oil held in storage tank(s) etc. Occasionally, surveyors report a negative stores variable, which is theoretically impossible unless, in extremely rare instances, the vessel has been subject to modification and large quantities of structural steel removed.

Charterparties often contain reference to an approximate quantity for the vessel's constant, which may well create a discussion between the Master and the surveyor should the constant found by survey be substantially larger than that quoted by the owners. The surveyor, after relevant checks, should remain confident in the figure obtained, but always record on documents issued to the Master and clients any unusual factors or difficulties experienced during the survey. These include any differences between surveyors should owners, charterers or shippers each appoint separate survey companies to act on their behalf.

Documentation

At completion of the survey, a work sheet or computer printout should be placed on board the vessel recording the data and calculations used to obtain the cargo loaded/unloaded quantity. This document is usually produced by individual survey companies, or by shipping companies for use by their officers.

A formal survey report should be submitted to clients at a later date. Specific formal documentation has been drawn up by bodies such as the IMO and the various P&I Clubs.

The formal report document should include details of the survey as well as:

- Dates and times of surveys
- vessel particulars
- vessel location
- weather conditions (and whether these were within acceptable limits)
- sea conditions (and whether these were within acceptable limits)
- tidal/current conditions (and whether these were within acceptable limits)
- a record of any difficulties or defects in a ship's documentation or equipment that might cause the calculated weight by draught displacement survey to be outside acceptable limits of normal draught survey measurement error.

Cumulative errors

Errors can occur when reading and correcting the draughts. The final fully corrected 3/4 mean draught should be within ±10 mm of the true mean draught.

- Errors of calculation. The main error to be avoided in this section is incorrect positioning of the LCF relative to LBP/2, the amidships point
- error of the water density in which the vessel is floating. Always ensure that an average sample, or alternatively the average of a number of water samples, is obtained and that the correct type of certificated hydrometer is used to obtain the density
- sounding of tanks. Leaving aside documented tables which may not be accurate, the way of avoiding the main errors in this section of the survey is by ensuring, as best as possible, that all volumes of liquids on board, particularly ballast water, are both correctly quantified and attributed with correct densities. These factors, particularly when applied to ballast water, undoubtedly contribute to the largest number and degree of errors likely to be encountered in draught surveying.

Bearing these reservations in mind, a well-conducted draught survey under reasonable prevailing conditions is capable of achieving an absolute accuracy of ±0.5%.

Worked example

From the following information, calculate the corrections to perpendiculars and the draughts at the perpendiculars. Also calculate the true trim.

Vessel LBP = 181.8 m
Density at the time of draught reading = 1.0185 T/m³

	port side	stbd side	distance marks from perp
Forward draughts	4.61 m	4.65 m	Fd = 2.94 m aft
Midships draughts	4.93 m	5.10 m	Md = 1.44 m aft
Aft draughts	5.58 m	5.60 m	Ad = 7.30 m forward

Forward mean = (4.61 + 4.65)/2 = **4.63 m**

Midships mean = (4.93 + 5.10)/2 = **5.015 m**

Aft mean = (5.58 + 5.6)/2 = **5.59 m**

So apparent trim is: 5.59 − 4.63 = 0.96 m

And LBM is: 181.8 − 2.94 − 7.30 = 171.56 m

Forward correction $= \frac{\text{Apparent Trim} \times \text{Fd}}{\text{LBM}} = \frac{0.96 \times -2.94}{171.56}$ = **−0.0165 m**

Midships correction $= \frac{\text{Apparent Trim} \times \text{Md}}{\text{LBM}} = \frac{0.96 \times -1.44}{171.56}$ = **−0.0081 m**

Aft correction $= \frac{\text{Apparent Trim} \times \text{Ad}}{\text{LBM}} = \frac{0.96 \times 7.3}{171.56}$ = **+0.0408 m**

Now:

Forward draught = 4.63 − 0.0165 m = 4.6135 m

Midships draught = 5.015 − 0.0081 m = 5.0069 m

Aft draught = 5.59 + 0.0408 m = 5.6308 m

True trim = 5.6308 − 4.6135 m = 1.0173 m = 101.73 cm

¾ mean draught[1] $= \frac{(6 \times 5.0069) + 4.6135 + 5.6308}{8}$ = 5.0357 m

[1] This is also known as the true hydrostatic draught, which accounts for hog and sag, and indicates the value for the hydrostatic particulars tables.

From the original surveys, the following data was given in the vessel's hydrostatic particulars:

Scale density of hydrostatic particulars 1.025 T/m³

Draught	Displacement	TPC	LCF		Draught	MCTC	Draught	MCTC
5.00	19,743	42.32	–4.354		**5.50**	445.5	4.50	434.9
5.10	20,167	42.37	–4.289		**5.60**	446.6	4.60	435.9

The stability book stated that a negative (–) sign for LCF indicated forward of midships.

Interpolating the data from the table (it is easier to use centimetres in the interpolation rather than metres), the difference in the tabulated draughts is 10 cm and the draught we are looking for is 3.57 cm more than 5 m.
Therefore:

Displacement for 5.0357 m draught $= 19{,}743 + \dfrac{(20{,}167 - 19{,}743)}{10} \times 3.57$ $=$ **19,894.37**

TPC for 5.0357 m draught $= 42.32 + \dfrac{(42.37 - 42.32)}{10} \times 3.57$ $=$ **42.338**

LCF for 5.0357 m draught $= -4.354 + \dfrac{(4.354 - 4.289)}{10} \times 3.57$ $=$ **–4.331 (ford of mid)**

MCTC for 5.0357 + 50 cm $= 445.5 + \dfrac{(446.6 - 445.5)}{10} \times 3.57$ $=$ **445.89**

MCTC for 5.0357 – 50 cm $= 434.9 + \dfrac{(435.9 - 434.9)}{10} \times 3.57$ $=$ **435.26**

Therefore (dm ~ dz) = 10.63

The first trim correction is $= \dfrac{101.73 \times -4.331 \times 42.338}{181.8}$ $=$ **–102.61 T**

Second trim correction $= \dfrac{1.0173^2 \times 50 \times 10.63}{181.8}$ $=$ **+3.03 T**

Then vessel's displacement at a density of 1.025 T/m³ is calculated as follows:

Displacement for 5.0357 m	=	19,894.37 T
First trim correction	=	–102.61 T
Second trim correction	=	+3.03 T
Corrected displacement in salt water	=	**19,794.79 T**

This is the weight of the ship at the draught if it was in salt water of density 1.025 T/m³, which is the density of the ship's hydrostatic scale.

However, it is floating in water of apparent density 1.0185 T/m³.

So true displacement $= \dfrac{\mathbf{19{,}794.79 \times 1.0185}}{\mathbf{1.025}} = \mathbf{19{,}669.26\ T}$

Draught surveying is based on Archimedes' Principle, which states that anything that floats will displace an amount of the liquid it is floating in that is equal to its own weight.

16.2 Equipment

16.2.1 Manometer

In some circumstances, the wave and swell activity can be such that it is too rough to use a boat, or the wave damping tube may be difficult or even impossible to position on the hull. This situation can often be resolved by the use of a manometer to measure the list across the deck at midships, which is then added to, or subtracted from, the inboard draught reading to obtain the outboard draught.

It is not necessary for the manometer to be fitted with a scale at the ends as the height of the water in the tube is measured from the deck on each side using a tape measure. Where the list is large, the end of the manometer on the low side must be positioned higher than the end on the high side to avoid the water in the tube running out. However, when a scale is fitted and used for the reading, care must be taken that the scale is fixed at the same height on each side.

A simple manometer is constructed from a length of plastic tubing about 35 to 40 m long of 10 mm outside diameter, 6 mm inside diameter, filled with water. On each end is a valve connected to a short section of 19 mm tube. The valves allow the water in the tube to be retained without any air bubbles in it when the device is not in use. This is important, as any entrapped air will prevent the manometer working properly. The short sections of 19 mm tube provide a damping action to the movement of water in the system that is caused by ship movement.

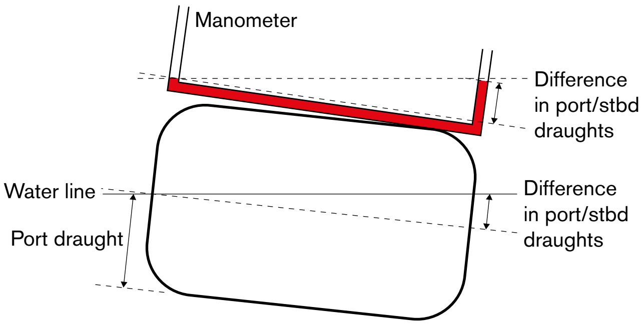

Figure 16.5: Use of a manometer to measure list.

In Figure 16.5, the starboard draught is equal to the port draught plus the difference in port and starboard draughts from the manometer.

If the manometer is not long enough to reach the vessel's sides, the true difference may be calculated from the measured difference by the use of similar triangles. In this case, the manometer is set to obtain readings at a known distance apart across the vessel.

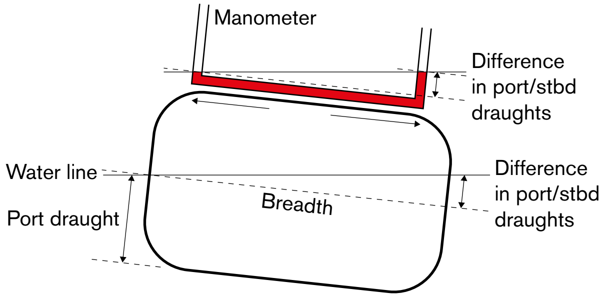

Figure 16.6: Measurement of list using a manometer and similar triangles.

In Figure 16.6:

$$\frac{\text{Difference in port/stbd draughts}}{\text{Breadth}} = \frac{\text{Difference in port/stbd readings}}{\text{d}}$$

Therefore:

$$\text{Difference in port/stbd draughts} = \frac{\text{Breadth} \times \text{Difference in readings}}{\text{d}}$$

16.2.2 Marine Hydrometers

Two types of hydrometers are commonly used in the maritime industry:

Draught survey hydrometers
These instruments are designed to measure the apparent density of water.

For the purposes of draught surveys:

Apparent density (weight in air per unit volume) (T/m^3) × Volume (m^3) = Weight (T).

Load line hydrometers
These instruments are designed to determine the relative density of water.

For the purposes of load line surveys in determination of a vessel's displacement:

Relative density (specific gravity) × Volume (m^3) = Displacement (m^3).

Marine and draught surveyors should be familiar with the correct usage of both types of instrument so that neither confusion nor errors occur during draught survey or stability calculations.

Draught survey hydrometers
Modern hydrometers of glass manufacture are calibrated at standard temperature, 15°C (60°F), and measure the apparent density of the water sample in kilograms per litre in air. They are usually marked 'for draught (or draft) survey' and 'medium ST' (medium surface tension) and graduated in the range 0.990/1.040 kg/l.

These instruments are used to determine the weight in air (apparent weight) of a vessel, from which the weight of the cargo on board may be calculated.

When manufactured of glass and calibrated at standard temperature, a small error results if the hydrometer is not used at the designed standard temperature.

However, it is accepted that no temperature correction is necessary as it is compensated at survey by the change in volume of the steel vessel itself. The corrections due to the 'coefficients of cubical expansion' of glass and steel are very approximately the same, thus they cancel out.

The older types of hydrometer used for draught surveys and manufactured from brass, or some other metal, are still found on some vessels. These instruments should be accompanied with a table of corrections and the relevant temperature correction should always be applied.

The use of a glass hydrometer is always preferable and it should be kept clean and protected.

Draught survey hydrometers should not be used for load line survey purposes.

Load line hydrometers
Load line hydrometers are used to determine the relative density (specific gravity) of a water sample at a standard temperature (T1) against a sample of distilled water at a standard temperature (T2). The standard temperature used is usually 15°C (60°F). Relative density is a ratio, a number. Load line hydrometers are usually marked 'RD' or 'Sp. Gr.', together with the standard temperatures.

When the temperatures of the water and the distilled water samples have a huge variation, a temperature correction must be applied to allow for the expansion of the hydrometer. These instruments are used to determine the displacement of a vessel at any given waterline in order to comply with the requirements of the *International Convention on Load Lines, 1966* (Reference 25).

Article 12 of the Convention permits a vessel to load to submerge the appropriate load line by an allowance made proportional to the difference between 1.025 and the actual density in which the vessel is floating. This then is relative density, ie the Convention refers to 'density in vacuo', ie mass per unit volume.

16.2.3 Differences Between Hydrometers

The displacement and apparent weight of a vessel have a relationship, as do the relative and apparent densities of the water in which the vessel is floating. The difference between the relative density (specific gravity) as determined by the load line hydrometer and the draught survey hydrometer is known as the 'air buoyancy correction', and can be accepted, at standard temperatures 15°C/15°C or 60°F/60°F, as 0.002 for marine surveys. The density of gases depends on temperature, pressure and moisture content.

The density of dry air at sea level is about 1/800th of the density of fresh water, ie 1.25 kg/m^3 when under similar conditions of temperature and pressure. It should also be noted that the actual maximum density of fresh water is 999.972 kg/m^3, which occurs at a temperature of 4.0°C. The density of fresh water at 100.0°C is 958.4 kg/m^3.

A correction should be deducted from the relative density of a load line hydrometer to compare with an actual density of a draught survey hydrometer. For example, for a sample of seawater checked by a load line hydrometer reading relative density 1.025, a draught survey hydrometer would read an actual density of 1.023 kg/l in air.

All hydrometers should be calibrated regularly.

Surveyors should only use a hydrometer manufactured for the relevant type of survey being undertaken.

16.2.4 Salinity Refractometers

Salinity refractometers are used to check the salinity of water samples.

A refractometer uses the fact that light deflects to a varying degree as it passes through different substances. When passing through water, the degree of deflection (refraction) is directly related to the quantity of mineral salts dissolved in the water.

The refractive index of a substance is a measure of how far light is bent by that substance.

For example, at 20°C, the refractive index of distilled water is 1.333 and the refractive index of seawater (relative density 1.025, salinity 35 parts per thousand) at the same temperature is 1.339.

When using a refractometer, a sample is placed on an optical prism in the sample window. As light passes through the sample, the rays are bent according to the salinity of the water, casting a shadow on the scale which is visible through the eyepiece.

A basic hand-held refractometer is used as follows:

- Ensure the refractometer is properly calibrated. If the refractometer scale reads zero, it is properly calibrated. If not, rotate the calibration screw until the shadow boundary lines up with the zero mark
- if necessary, clean the prism using a soft cloth
- rinse the equipment and the prism with part of the sample water to ensure that the sample remains unadulterated
- place several drops of the sample water on the prism, ensuring that the refractometer remains level so that none of the sample runs off the prism
- close the sample cover
- hold the instrument towards a strong light source
- adjust the focus ring until the scale is clearly visible
- read the scale at the shadow boundary
- rinse and clean the instrument before re-use.

Refractometers can be of the analogue or digital type.

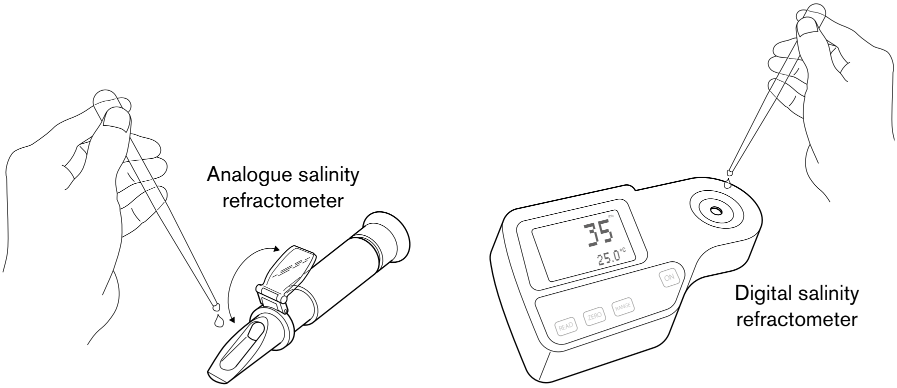

Figure 16.7: Typical basic salinity refractometer.

16.3 Draught Survey Documentation Examples

Draught survey certificate

Vessel: ______________________ B/L (M/T): ______________________

Port: ______________________ Date: ______________________

		Arrival		
	Aft	**Mid**	**Ford**	**L ship**
Port				LBP
Starboard				
Mean				Tpc
Correction to perpendicular				Lcf –(ford)
Draught				Trim
3/4 mean draught				Mct+
Disp @				McT–
Trim correction A				
Trim correction B				Oil
Corrected displacement				Fresh water
Density of dock water				Ballast
Displacement @ density				Other
Variables				Total
Net displacement				

		Departure		
	Aft	Mid	Ford	L ship
Port				LBP
Starboard				
Mean				Tpc
Correction to perpendicular				Lcf −(ford)
Draught				Trim
3/4 mean draught				Mct+
Disp @				McT−
Trim correction A				
Trim correction B				Oil
Corrected displacement				Fresh water
Density of dock water				Ballast
Displacement @ density				Other
Variables				Total
Net displacement				
Cargo				
Surveyor				

Dist of draught marks	Arrival	Departure
From aft perpendicular		
From aft perpendicular		
From aft perpendicular		

Marks forward of perpendicular +ve

Draught survey spreadsheet

File Save Ref				
Date		B/Lading	Tonnes	
Ship Name		Port		
Port of Reg			Draughts	
Flag			Arrival	Departure
Owner		Ford p		
Capt		Ford s		
Cargo Officer		Mid p		
Berth		Mid s		
Agents		Aft p		
Cargo		Aft s		
Arrived		DistFp		
Commenced		DistMidp		
Completed		DistAp		
Year of Build		App Trim	0.0000	0.0000
Gross		True Trim	Calculated	Calculated
Net		3/4 mean	Calculated	Calculated
LOA		Scale density		
LBP		Dock density		
Breadth		Disp @ 3/4 mean	Calculated	Calculated
Depth		Tpc	Calculated	Calculated
Displacement	0.00	Lcf (– if aft)	Calculated	Calculated
Deadweight		Mct+	Calculated	Calculated
Light Ship		Mct–	Calculated	Calculated
Last Port		Total Oil	0.00	0.00
Next Port		Total F.Water	0.00	0.00
Surveyor		Total Ballast	0.00	0.00
		Other		
Weather Conditions and Report		Cargo Wt		Calculated

If the hydrostatics are from the top of the keel, enter keel correction in mm			
Hydrostatic Data			
Arrival			
		Below	**Above**
Draught			
Displacement			
TPC			
LCF			
MCT+50cm			
MCT-50cm			
Departure			
Draught			
Displacement			
TPC			
LCF			
MCT+50cm			
MCT-50cm			
Constant = (Disch)			Calculated
Constant = (Load)			Calculated

Sounding record

Vessel	0				**Port**	0			**Date**	0	
Ballast			**Trim**	**Calculated**				**Trim**	**Calculated**		
			Initial Survey					**Final Survey**			
Tank	**Capacity m³**		**Sounding**	**Volume m³**	**Density**	**Tonnes**		**Sounding**	**Volume m³**	**Density**	**Tonnes**
Total	**0.00**		**Total**	**0.00**		**0.00**		**Total**	**0.00**		**0.00**

Fresh Water								**Oil**			
Tank	**Capacity m³**		**Initial Survey**		**Final Survey**			**Initial Survey**		**Final Survey**	
			Sounding	Tonnes	Sounding	Tonnes			Tonnes		Tonnes
								Heavy		Heavy	
								Diesel		Diesel	
								Lub Oil		Lub Oil	
								Slops		Slops	
								Fecal		Fecal	
Total	**0.00**		**Total**	**0.00**	**Total**	**0.00**		**Total**	**0.00**	**Total**	**0.00**

Draught survey certificate

Vessel:	0			B/L (M/T):		
Port:	0			Date:	0	
			Arrival			
		Aft	**Mid**	**Ford**	L.Ship	0.00
Port		0.0000	0.0000	0.0000	LBP	0.00
Starboard		0.0000	0.0000	0.0000		
Mean		0.0000	0.0000	0.0000	TPC	Calculated
Corr'n to Perpendicular		Calculated	Calculated	Calculated	Lcf (–Ford)	Calculated
Draught		Calculated	Calculated	Calculated	Trim	Calculated
3/4 Mean Draught		Calculated			Mct+	Calculated
Disp @	0.0000	Calculated			Mct–	Calculated
Trim Correction A		Calculated				
Trim Correction B		Calculated			Oil	0.00
Corrected Displacement		Calculated			F.Water	0.00
Density of Dock Water		0.0000			Ballast	0.00
Displacement @ Density		Calculated			Other	0.00
Variables		0.00			Total	0.00
Net Displacement		Calculated				
			Departure			
		Aft	**Mid**	**Ford**		
Port		0.0000	0.0000	0.0000		
Starboard		0.0000	0.0000	0.0000		
Mean		0.0000	0.0000	0.0000	TPC	Calculated
Corr'n to Perpendicular		Calculated	Calculated	Calculated	Lcf (–Ford)	Calculated
Draught		Calculated	Calculated	Calculated	Trim	Calculated
3/4 Mean Draught		Calculated			Mct+	Calculated
Disp @	0.0000	Calculated			Mct–	Calculated
Trim Correction A		Calculated				
Trim Correction B		Calculated			Oil	0.00
Corrected Displacement		Calculated			F. Water	0.00
Density of Dock Water		0.0000			Ballast	0.00
Displacement @ Density		Calculated			Other	0.00
Variables		0.00			Total	0.00
Net Displacement		Calculated				
Cargo		Calculated				
Surveyor		0				
Dist of Draught Marks		**Arrival**	**Departure**			
From Aft Perpendicular		0.000	0.000			
From Mid Perpendicular		0.000	0.000	Marks forward of perpendicular +ive		
From Ford Perpendicular		0.000	0.000	Marks aft of perpendicular –ive		