1

INTRODUCTION TO DRAFT SURVEY AND GENERAL PRINCIPLES

"SGS"

Draft surveys will involve the surveyor in the measurement of a wide variety of vessels of different types and nationalities – each with its own characteristics. The high level of accuracy required depends on careful attention to detail and the proper handling of unusual circumstances which may arise from time to time. Here, there is no substitute for proper practical training and experience – the mere study of this manual is not enough.

It seems probable that in the years to come various additional corrections and new forms of measurement apparatus may be developed and this manual will therefore need to be revised from time to time in order to keep abreast of modern practice. Suggestions for improving the manual will be more than welcome and should be addressed to:

The Draft Survey Technical Centre
SGS – Van Bree N.V. – MINDIV
Doornzelestraat 88
B – 9000 Gent
Belgium

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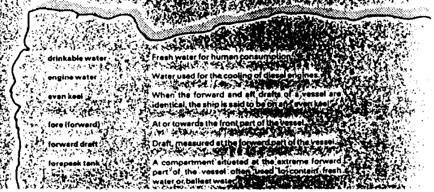
3. The vessel's documents which are required to carryout a draft survey are based on:

   - the vessel floating in water of a certain density
   - the vessel being on even keel. That is with the same draft reading forward and aft.
   - the vessel being upright. That is without list and with the same midships draft on port and starboard sides.

Unfortunately, such ideal conditions are rarely encountered and in practice, certain corrections have to be applied. These will be explained in the following sections of the manual.

2
GLOSSARY



SECTION 2

GLOSSARY OF TERMS

ENGLISH VERSION

Term or abbreviation	Definition and explanation
aft	At or towards the rear part of the vessel.
aft draft	Draft, measured at the aft part of the vessel.
aft perpendicular	An imaginary vertical line, at right angles to the keel, passing through the first frame and therefore located on or nearby the ship's rudder post.
AP	Aft perpendicular.
after peak tank	A compartment situated at the extreme rear of the vessel often used to contain fresh water or ballast water.
ballast	Water pumped into or out of the vessel in order to maintain stability.
ballast tanks	Tanks aboard the vessel specially designed to receive ballast water or, in the case of tank vessels, cargo tanks used to contain ballast.
breadth	Maximum width of the ship.
boiler feedwater tanks	Tanks provided aboard the vessel to contain water used for the production of steam.
bilges	Spaces at the bottom of the engine room or pump-rooms where water is allowed to accumulate. As the bilges usually also contain waste oil, they may not be discharged within the port limits. For draft survey purposes the quantity of liquid in the bilges should be controlled before and after loading or discharge, so that any change in quantity can be detected.
bunker tanks	Tanks intended to contain fuel oil either for steam raising purposes or for the provision of power to the main engines and auxiliaries.
calibration tables	See tank sounding tables

centre of flotation — The point around which a ship tips often called the "tipping centre".

cofferdams fwd and aft — These terms apply more particularly to ocean tankers, coastal tankers and tank barges. They are empty spaces provided in order to separate the cargo tanks from the machinery space aft and from the forward peak and other forward parts of the ship. Cofferdams frequently contain water, either intentionally or accidentally, and should therefore always be sounded both before and after cargo is measured by draft survey.

constant — The difference between the light ship weight according to ship's documents and the net empty survey displacement after deducting all measurable weights.

deadweight — This is the weight of a vessel's cargo, fuel, water and stores

deckline — A line clearly marked on the port and starboard sides of the vessel, amidships as required by International Loadline Regulations.

deeptanks — Tanks situated near to the bottom of the vessel.

density (true) — The mass of a volume unit of a liquid. It may be expressed in terms of grammes per millilitre, kilogrammes per cubic meter, pounds per cubic foot, etc.

density (apparent) — Density, as defined above, but without allowing for the buoyancy effect of the atmosphere. The apparent density of sea water, fresh water, ballast water, etc. is measured by the SGS draft survey hydrometer. This gives weights comparable to those which would be obtained by weighing a carefully calibrated container on an accurate weighbridge, so as to obtain commercial weights.

diesel oil — Fuel oil used to feed diesel engines. There are various grades of diesel oil including light diesel oil for auxiliary engines and heavier diesel oil for main engines.

displacement — The total weight of water displaced by the vessel. Displacement includes the light ship weight plus all other weights on board including cargo, ballast bunkers, etc.

displacement table/scale — A table, specially prepared for each vessel, giving the displacement corresponding to various drafts.

double bottom tanks — Tanks situated in the vessel's double bottom and used either for bunkers or ballast water.

draft (draught) — Depth of water from the water surface down to the bottom of the ship's keel.

draft marks — A series of figures painted or welded on the vessel's hull, usually forward, midships and aft, on both port and starboard sides and indicating the draft of the vessel at the points where the draft marks are situated.

draft survey — A system of cargo measurement based on measuring the draft of the vessel before and after loading or discharge, taking into account any changes in weight other than cargo, which may have taken place during cargo handling operation, i.e. changes in the weight of water ballast, bunkers, stores, etc.

drinkable water — Fresh water for human consumption.

engine water — Water used for the cooling of diesel engines.

even keel — When the forward and aft drafts of a vessel are identical, the ship is said to be on an "even keel".

fore (forward) — At or towards the front part of the vessel.

forward draft — Draft, measured at the forward part of the vessel.

forepeak tank — A compartment situated at the extreme forward part of the vessel often used to contain ballast water.

forward perpendicular — An imaginary vertical line, at right angles to the keel and passing through the point where the summer loadline intersects the vessel's stem.

freeboard (assigned or statutory)	The distance from the upper part of the deckline to the summer loadline as "assigned" or stated in the Freeboard Certificate relating to the vessel concerned.
fresh water	Not salt water (sea water). This is the water on board a vessel for drinking, washing etc.
fuel oil (heavy)	High density fuel oil used either as boiler fuel or as fuel for main diesel engines suitably adapted for the purpose.
hogging	The deflection of a vessel loaded in such manner that the draft amidships is less than the mean of the forward and aft drafts.
hydrostatic curves	A document specially prepared for each vessel indicating, among other things, the centre of flotation or "tipping centre" at various drafts.
keel	The part of a ship extending along the bottom from stem to stern.
LCF	Longitudinal centre of flotation.
length between perpendiculars (LBP)	Distance between the forward and aft perpendiculars measured parallel to the keel.
list	Inclination of the vessel from the vertical position measured at the longitudinal midships axis. It is usually measured by means of an inclinometer giving results in degrees of angle. List can also be calculated, if necessary, from the difference between the port and starboard midships drafts.
light ship weight	The weight of the vessel after completion of construction but without fuel bunkers, stores, etc. The light ship weight is usually mentioned on the vessel's displacement scales and represents the difference between the displacement scale and the deadweight scale.
lubricants	Oils for lubricating the main engine, auxiliary engines and other moving equipment aboard the vessel.
mean aft draft	Average of the aft drafts on port and starboard side.
mean forward draft	Average of the midships drafts on port and starboard side.
mean midships draft	Average of the midships drafts on port and starboard side.
midships	Longitudinal centre of the vessel as indicated on the hull by the Port and Starboard loadline marks.
moment	The moment of a force is a measure of the rotating effect of the force about a given point. The rotating effect will depend upon the magnitude of the force and the length of the lever upon which the force acts, i.e. the perpendicular distance between the line of action of the force and the point around which the moment is being exerted.
Moment to change trim 1 cm (MTC)	The force required to change the trim of a vessel by 1 cm. This is defined as the weight – in metric tons, multiplied the distance it is moved from the centre of flotation – in metres.
Moment to change trim 1 inch (MTI)	The force required to change the trim of a vessel by 1 inch. This is defined as the weight – in long tons, multiplied the distance it is moved from the centre of flotation – in feet.
Plimsoll line	Another name for summer load mark.
port side	The left-hand side of the vessel as seen by an observer facing forward.
rudder post	The vertical axis around which the rudder turns.
sagging	The deflection of a vessel loaded in such manner that the draft amidships is greater that the mean of the forward and aft drafts.
scale drawings	Vessel's plans prepared so that each centimetre of distance on the scale corresponds to a known distance on the vessel. For example a scale marked 1/100 means that 1 cm on the drawing corresponds to 1 m on the ship itself.
sounding	Distance between the bottom of a tank and the surface of the liquid which it contains.
	A fixed pipe through which soundings are taken.

specific gravity — Ratio between the mass or weight in air of a given volume of liquid and the mass or weight in air of the same volume of distilled water. Both the temperature of the liquid and the temperature of the water must be defined. There are thus various forms of specific gravity which can lead to considerable confusion. It is for this reason that the term apparent density is preferred, as this corresponds to weights obtained by weighing on a weighbridge.

starboard side — The right-hand side of the vessel as seen by an observer facing forward.

stem correction — Correction applied to the mean forward draft when the forward draft marks are not situated at the forward perpendicular.

stern correction — Correction applied to the mean aft draft when the aft draft marks are not situated at the aft perpendicular.

summer loadline — An imaginery line, parallel to the keel passing through the upper edge of the summer mark which corresponds to the maximum draft permitted in the summer zone in sea water.

summer mark — The line, surrounded by a circle, permanently marked by centre punch, or by welding, on the port and starboard sides of the vessel amidships as prescribed by the ship's Loadline Certificate.

t per cm immersion (TPC) — The number of metric tonnes required to change the mean draft of the vessel by 1 cm.

t per inch immersion (TPI) — The number of long tons required to change the mean draft of the vessel by 1 inch.

trim — Difference between the mean draft forward and the mean draft aft, both measurements having been corrected to the forward and aft perpendiculars where necessary.

trim corrections — Corrections applied to the displacement of the vessel when the vessel is not floating on an even keel.

ullage — Distance between the surface of the liquid in a tank and the top of the tank or corresponding sounding pipe.

3
INTRODUCTION TO THE MV "MINDIV"

SECTION 3

INTRODUCTION TO THE M/V "MINDIV"

The M/V "MINDIV" is a hypothetical vessel with clearly specified dimensions as given below. This vessel will be used in the subsequent sections of the manual to illustrate the various techniques and calculations involved with a draft survey.

GENERAL PARTICULARS

Type of ship	:	bulk carrier, single deck type
Keel laid	:	November 1, 1980
Gross tonnage	:	16,400 t
Net tonnage	:	11,500 t
Deadweight	:	26,000 t
Light weight	:	5,000 t
Length overall	:	180.00 m
Length between perpendiculars	:	170.00 m
Breadth moulded	:	20.00 m
Summer freeboard	:	3.00 m
Summer load draft	:	10.00 m

The general layout of the MINDIV and its hold and tank arrangements are shown in figure 1. opposite.

NOTE

In line with international standards (IS), the following abbreviations are used in this manual:

t : metric tonnes
tons : long tons – sometimes written LT.

Note that 1 LT = 1.016047 t

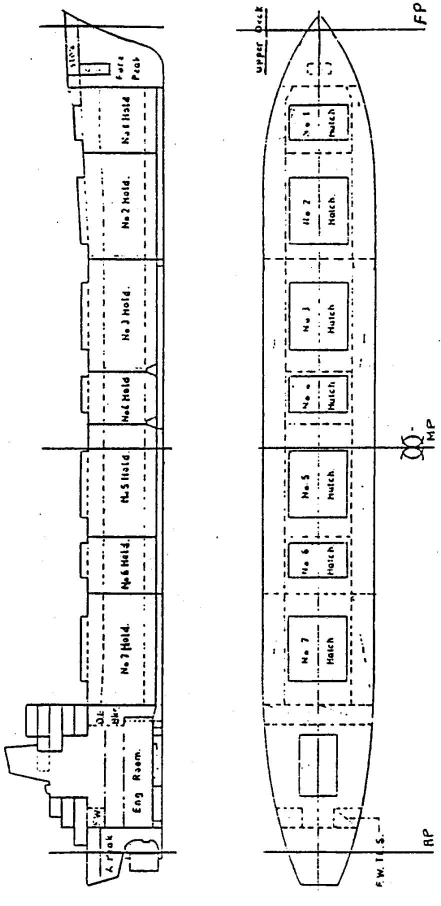
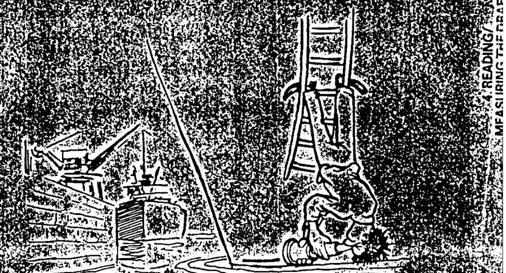


Figure 1 MV "MINDIV"
HOLD AND TANK ARRANGEMENT

4
READING OR MEASURING THE DRAFT



4. READING/
MEASURING THE DRAFT

SECTION 4

READING OR MEASURING THE DRAFT

4.1 Introduction

In this section of the manual we are going to consider the procedures for reading and measuring a vessel's draft – that is the depth of its keel in the water. These procedures rely upon marks which appear on every vessel and which are of known height above the keel.

Definitions

Draft reading : **reading the draft from draft marks marked on the hull of the vessel**

Draft measurement : **measuring the draft from certain fixed reference points and the waterline.**

Before reading or measuring the draft of the vessel the following actions must be folowed:

(i) Request the Chief Officer to halt all operations that may cause the position of the waterline to change relative to the marks on the vessel, namely:–

- the transfer of ballast or other liquids
- the loading and/or discharge of cargo
- the movement of booms and deck cranes or the opening or closing of hatch covers.

(ii) Check the ballast tanks (refer Section 11)

(iii) Note the position of the anchors.

Whenever possible, draft readings or measurements should be effected jointly with the Chief Officer or his representative.

4.2 Reading the Draft

Sea going vessels will have a scale of draft marks in up to six positions on the hull – forward, aft and midships on both port and starboard sides of the vessel. The scales indicate the depth of the keel in the water.

The scales will either be:

In the metric system See fig. 2	–	metres (m) and centimetres (cm)
In the imperial system See figs 3 and 4.	–	feet (ft) and inches

In some cases both systems will be used.

Taking a draft reading is simply a matter of noting the water level on the scale. Often this is not as easy as it sounds. The draft marks could be difficult to read – due to rust or poor painting, the sea could be choppy or there could be a swell. Where the vessel is in a state of excessive trim, the stern or bow scales could even be clear of the water.

To ensure the highest level of accuracy, readings should be taken close to the water line – from a launch if possible to reduce the problems of parallax.

Examples of the metric and imperial systems are given overleaf.

Figure 2a METRIC SYSTEM

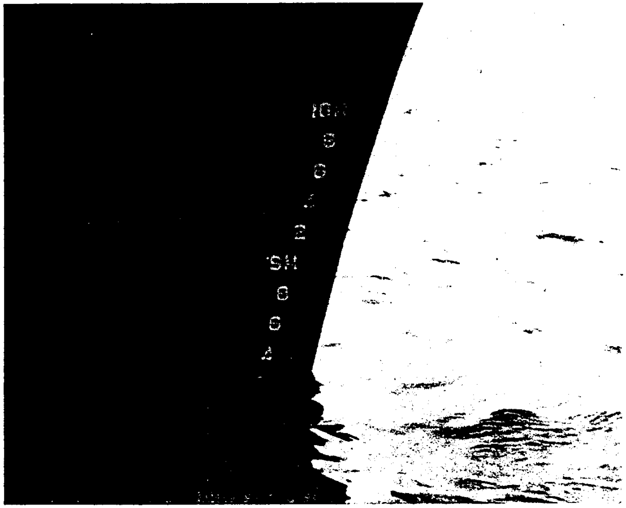


Figure 2b METRIC SYSTEM

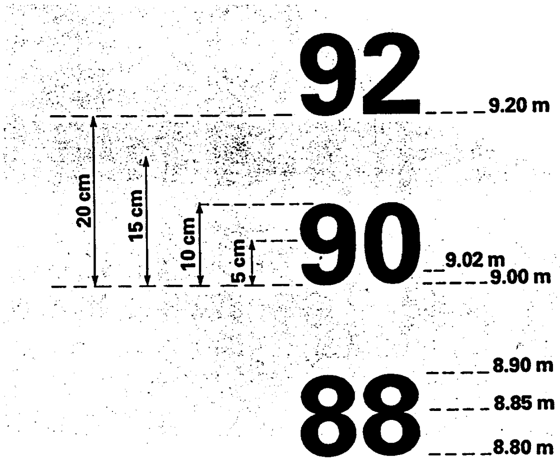


Figure 3a IMPERIAL FEET AND INCHES SYSTEM

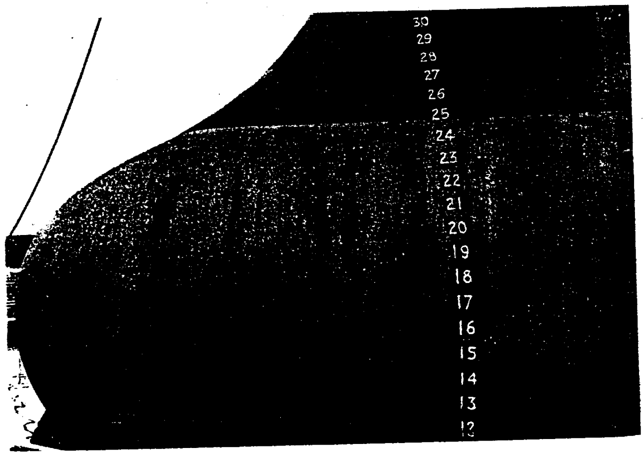


Figure 3b IMPERIAL FEET AND INCHES SYSTEM

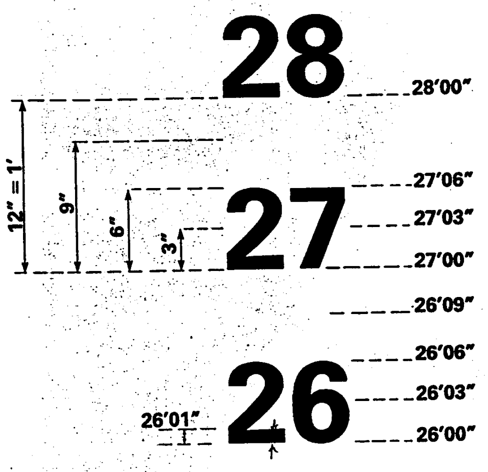


Figure 4a IMPERIAL FEET AND INCHES SYSTEM

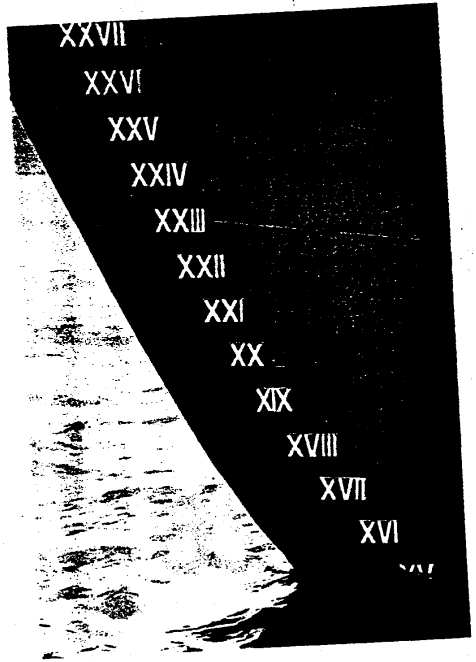
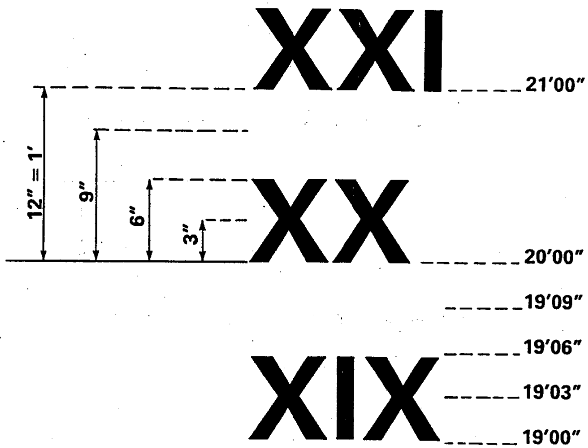


Figure 4b IMPERIAL FEET AND INCHES SYSTEM



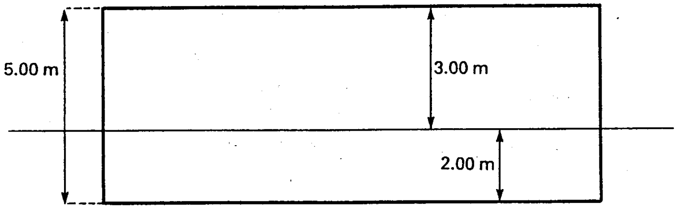
4.3 Measuring the Draft

When the midships draft scale is not marked or cannot be clearly read, the draft must be measured indirectly.

This is done by measuring the distance between the surface of the water and any point on the vessel's hull that is of known height above the keel. The measured distance is then subtracted from the height of the reference point above the keel.

To illustrate this, let's consider a rectangular box 5.00 metres high (fig. 5). To determine its draft, the distance between the top of the box and the water is measured and this distance subtracted from the total height of the box.

Fig. 5



Total height of the box	5.00 m
Distance between the top of the box and the water line	3.00 m
Draft	2.00 m

As you can see, this gives the same result as measuring the distance from the bottom of the box to the surface of the water.

In the following sections of the manual, we will show that a vessel is merely a more complicated shape of box and that the same principles apply, provided that corrections are made to account for the profile of the vessel's hull.

Let us now apply this principle to the MV "MINDIV".

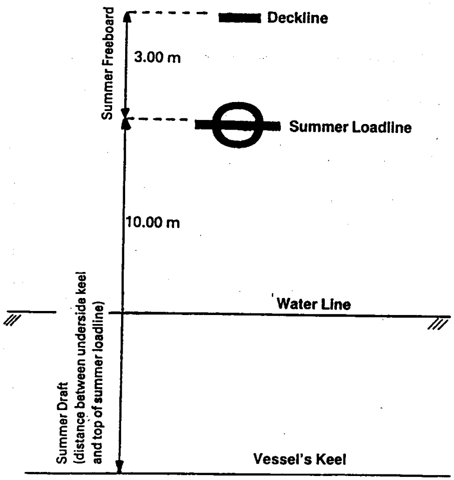
On all vessels there are two official fixed reference points. These are the:

deckline
and
summer loadline (or summer draft)

which appear on both the port and starboard at the midships.

(Further details of the deckline and summer loadline arrangements are given in Appendix I).

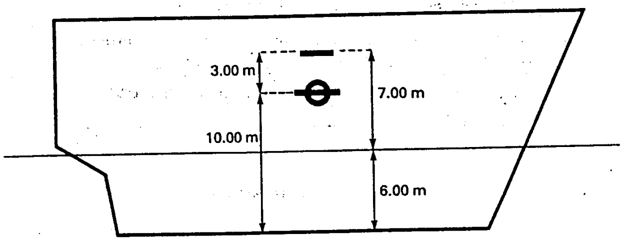
Fig. 6 below shows the loadline arrangement for the MV "MINDIV".



Because the height of the marks above the keel are always given in the vessel's general particulars, the midships draft is easily determined. This can be done in two ways. Let's consider the case of our hypothetical vessel, the MV "MINDIV".

The first method is to measure the distance between the deckline and the surface of the water and to subtract this from the known height of the deckline above the keel (fig. 7).

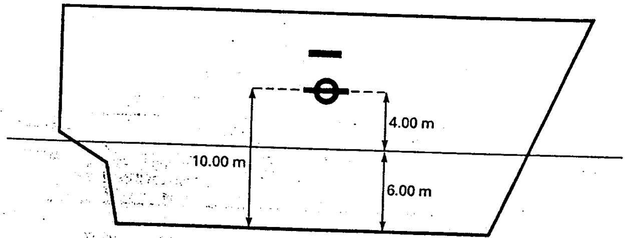
Fig. 7



Height of the deckline above the keel	13.00 m
Measured distance between the deckline and the water	7.00 m
Draft of the vessel	6.00 m

Alternatively, the draft could be found by measuring the distance between the top of the summer loadline and the surface of the water and subtracting this from the known height of the summer loadline above the keel (fig. 8).

Fig. 8



Height of the summer loadline above the keel — **10.00 m**

Measured distance between the summer loadline and the water — **4.00 m**

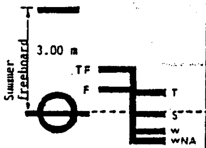
Draft of the vessel — **6.00 m**

As you can see, both methods give the same result. In fact any mark on a vessel's hull – of known height above the keel, can be used to determine the draft.

For example, where draft marks are illegible or corroded, or when the vessel is close to the quay and the marks cannot be read, the distance of the water line could be measured from a legible draft mark, or even from a port hole providing its distance above the keel is marked on the vessel's plans.

In practice the position of a vessel's summer loadline and deckline can be obtained from the vessel's hydrostatic documents (these will be explained in detail in subsequent sections). Examples of these for the MV "MINDIV" and two other vessels are shown in figs. 9, 10 and 11, overleaf.

Figure 9: MV "MINDIV" Hydrostatic Table

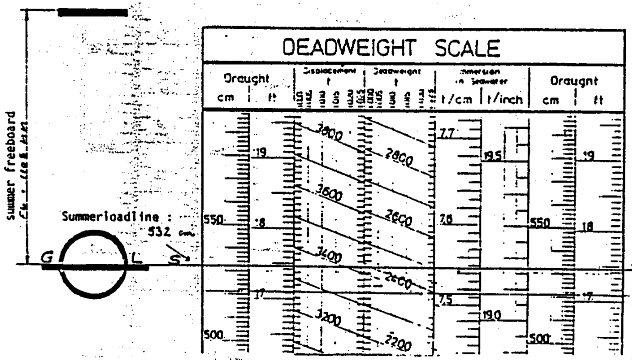


DRAFT IN METRES	SEAWATER 1.025				DRAFT IN METERS
	DISPLAC. IN t (t=1000kg)	DEAD-WEIGHT t	MOMENT CHANGE TRIM 1CM t x m	TONNES PER CM IMMERSION (TPC)	
10.20	31.700	26.700	416	35,06	10.20
10.10	31.350	26.350	413	35,03	10.10
10.00	31.000	26.000	410	35.00	10.00
9.90	30.650	25.650	407	34,97	9.90
9.80	30.301	25.301	404	34,86	9.80
9.70	29.953	24.953	401	34,75	9.70
9.60	29.606	24.606	396	34,64	9.60
9.50	29.260	24.260	392	34,52	9.50
9.40	28.915	23.925	389	34,40	9.40
9.30	28.572	23.572	384	34,28	9.30
9.20	28.230	23.230	380	34,15	9.20

SUMMERLOADLINE : 10.000 m

FREEBOARD : 3.000 m

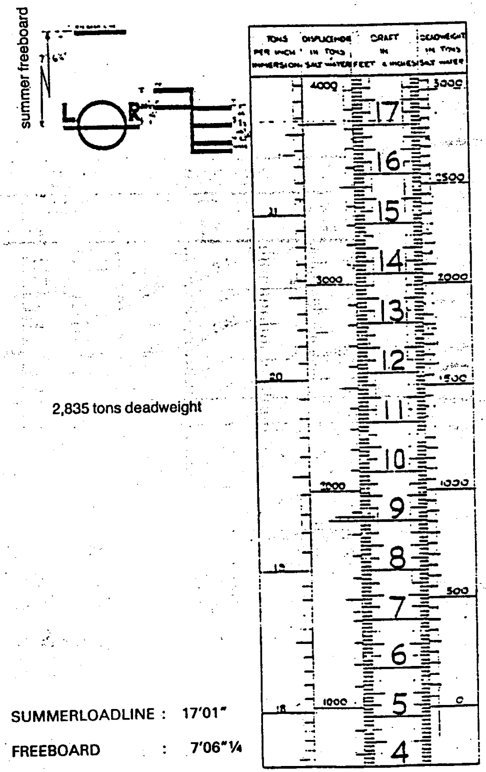
Figure 10: MV "DOLOMIT" Hydrostatic Scale



SUMMERLOADLINE : 5.320 m

FREEBOARD : 1.105 m

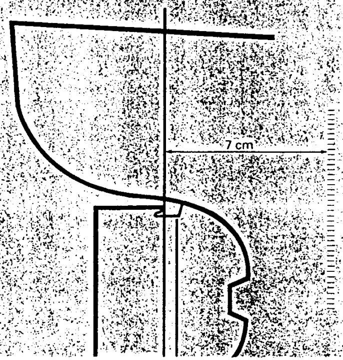
Figure 11: MV "PELEGOS" Hydrostatic Scale



SUMMERLOADLINE : 17'01"

FREEBOARD : 7'06"¼

5
CORRECTING DRAFT READINGS TO PERPENDICULARS



SECTION 5

CORRECTING DRAFT READINGS TO PERPENDICULARS

5.1 Introduction

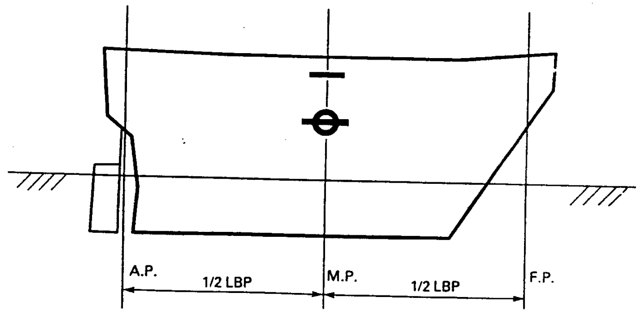
The "Perpendiculars" are imaginary vertical lines, dividing the length of the vessel into two equal parts, in order to simplify various calculations such as trim, stability, etc.

Ships documents are always based on the draft reading at the perpendiculars. Since draft marks are not always situated at their perpendiculars, then the observed draft readings need to be corrected to the perpendicular.

Definitions

- The forward perpendicular (**F.P.**) is an imaginary line at right angles to the keel situated at the point where the summer loadline intersects the vessel's stem.
- The aft perpendicular (**A.P.**) is an imaginary vertical line at right angle to the keel, passing through the first frame and therefore located on or nearby the ship's rudderpost (see note p. 51).
- The midships perpendicular (**M.P.**) is situated midway between the F.P. and the A.P.
- The distance between F.P. and A.P. is called Length Between Perpendiculars (**LBP**).

Fig. 12



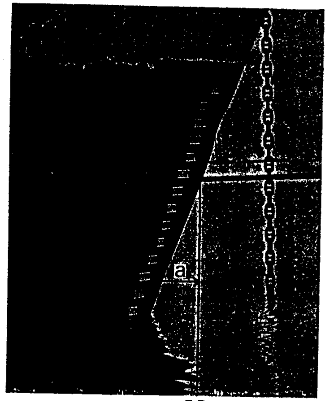
NOTE:

It is useful to note that the numbering of the frames starts from the A.P. and that the A.P. is the position of the first frame, usually marked "O" on the plans, although on USA built vessels and some other ones, frame numbering starts from the F.P.

The following pages illustrate how draft marks may be situated away from the perpendiculars, Fig. 13.

Position of Draft Marks to the Forward Perpendicular (FP)

Figure 13a



F.P.

Figure 13b

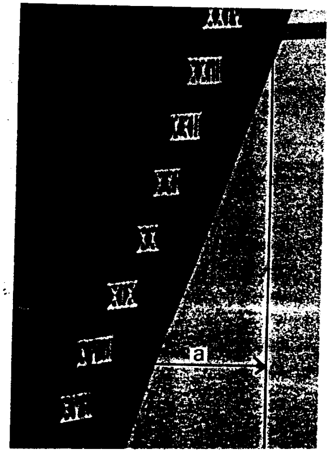
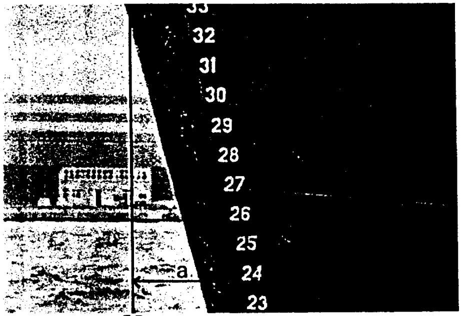
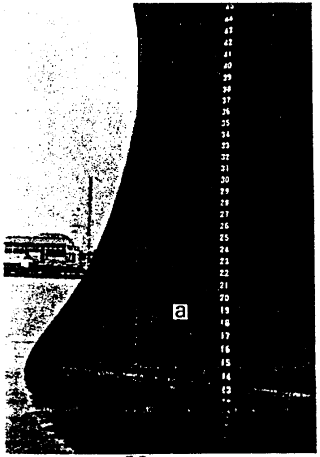


Figure 13c



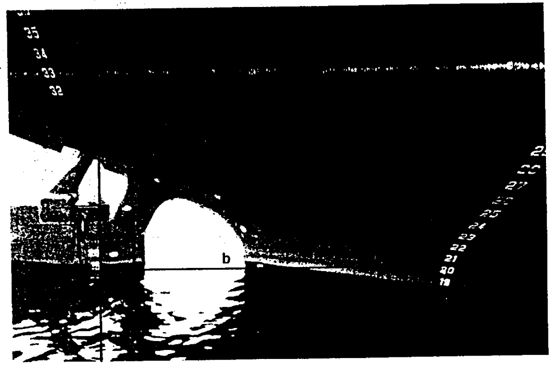
F.P.

Figure 13d



F.P.

Figure 14 Position of the Draft Marks to the Aft Perpendicular (AP)



A.P.

Position of the Draft Marks to the Mid-ships Perpendicular (MP)

Figure 15a

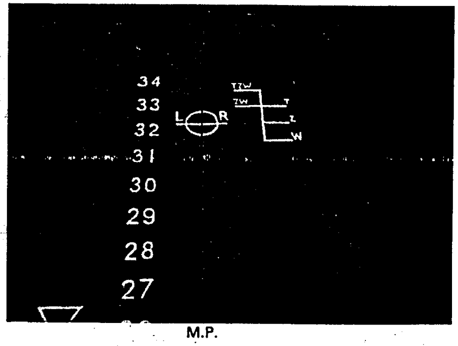
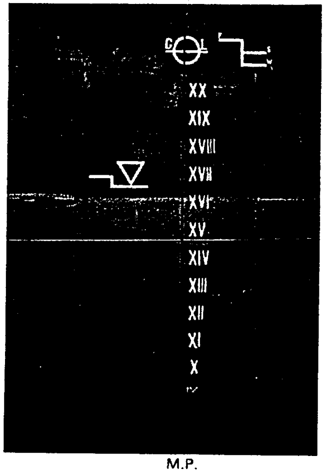


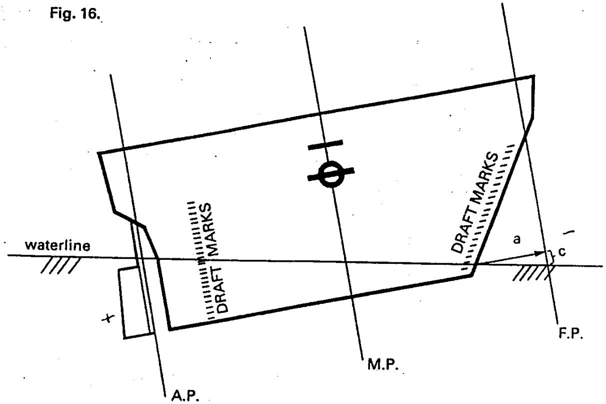
Figure 15b



5.2 Forward draft (stem correction)

Consider a vessel trimmed by the stern as shown in Fig. 16, i.e. with a deeper draft aft than forward.

Fig. 16.



a = distance between the forward perpendicular and the forward draft mark.

c = the perpendicular correction.

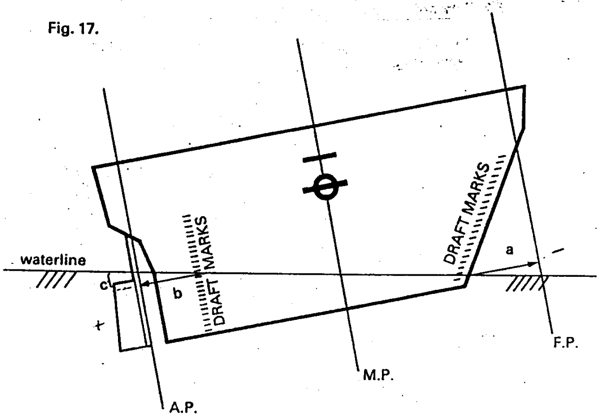
The observed forward draft when projected to the forward perpendicular (F.P.), cuts the perpendicular at a point above the water level. Consequently, less draft would be obtained if read on the F.P.

Therefore, when the draft mark is located aft of the perpendicular and the vessel is trimmed by the stern, the correction (c) will be negative, resulting in a smaller reading on the forward perpendicular (F.P.).

5.3 Aft draft (stern correction)

Again consider a vessel trimmed by the stern as shown in Fig. 17 below.

Fig. 17.



b = distance between the aft perpendicular and the aft perpendicular.

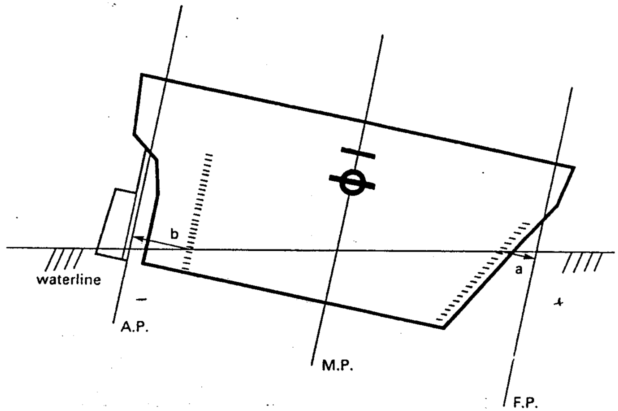
c = the perpendicular correction.

The observed draft when projected to the aft perpendicular (A.P.), cuts the perpendicular at a point deeper in the water. Consequently, more draft would be obtained if read on the A.P.

Therefore, when the draft mark is located forward of the perpendicular and the vessel is trimmed by the stern, the correction (c) will be positive, resulting in a greater reading on the perpendicular.

Opposite signs will be applied when the vessel is trimmed by the head, (Fig 18), i.e. when the forward draft is deeper than the aft draft.

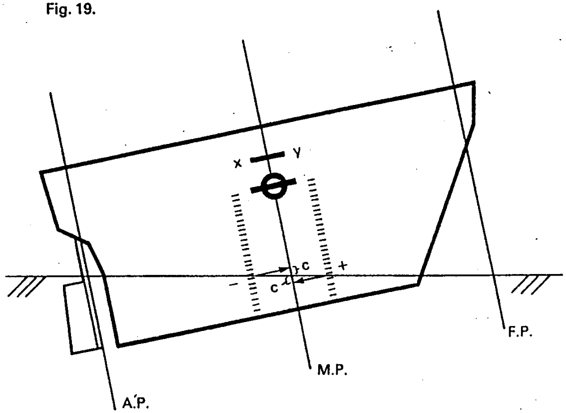
Fig. 18.



5.4 Midship's draft (midship's correction)

Applying the same principle as explained in 5.2 and 5.3.

Fig. 19.



- When the vessel trims by the stern and the observed midships draft is aft of the midships perpendicular, the sign will be negative. (case x: compare with the stem correction in fig. 16).
- When the vessel trims by the stern and the observed midships draft is forward of the midships perpendicular, the sign will be positive. (case y: compare with the stern correction in fig. 17).
- Opposite signs will apply when the vessel trims by the head, i.e. with a deeper draft forward than aft.

5.5 Calculation of the Perpendicular Corrections

The perpendicular correction is calculated with the formula:–

$$\frac{\text{Observed Trim (m)} \times \text{Distance between Observed Draft Mark and Perpendicular (m)}}{\text{Length between the Draft Marks (m)}}$$

SUMMERLOADLINE.

Where observed trim is: the difference between the observed aft and forward draft.

Rules

Trim by stern – Draftmark aft of the perpendicular Trim by head – Draftmark forward of the perpendicular	Correction – ve
Trim by stern – Draftmark forward of the perpendicular Trim by head – Draftmark aft of the perpendicular	Correction + ve

No perpendicular correctons are required when the vessel is on an even keel or when the draft marks are situated on the perpendicular.

$$\Delta F = \frac{f \cdot dif}{LBP}; \quad \Delta A = \frac{a \cdot dif}{LBP};$$

5.6 Determination of the distance between the Observed Draft and the Perpendicular

When correcting the draft readings to the perpendicular, the first step is to find the distance the draft marks are away from the perpendicular. These distances are sometimes shown in the vessel's documents. If they are not, they may be estimated by marking the position of the observed draft and the perpendicular on the quay and then measuring the distance between them.

At the midships, the distance between the observed draft and the perpendicular can be measured directly from the quay or a launch.

Reference to ship's documents

The distance between the observed draft and the perpendicular can be calculated from the vessel's documents, as follows:–

Firstly the scale of the drawing has to be found.

Where the scale is not marked on the plans, it can be determined by comparing any of the vessel's known dimensions with the corresponding distance on the drawing.

For example, we know that the summer draft of the M/V MINDIV is 10.00 m. If we measure the corresponding distance on the drawing – that is the distance AB, between the summer loadline and the keel, we find this to be 10 cm (fig. 21).

From this, the scale of the drawing can be found. This is simply the dimension measured on the drawing, 10 cm, divided by actual dimension, 10 m – that is 1000 cm.

$$= 10/1000$$

$$= 1/100$$

In other words, 1 cm on the drawing represents 100 cm on the vessel.

This can be checked by measuring any other known distance, however, greater accuracy will be achieved using the large dimensions such as the length between perpendiculars (LBP).

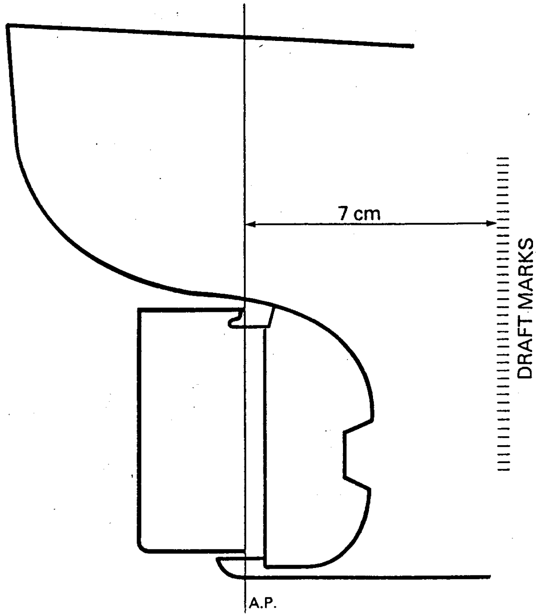
5.6.1 Distance between the aft draft and the A.P.

In the case of the M/V MINDIV, the aft draft marks are 7 cm away from the aft perpendicular (fig. 20). This means that the actual distance on the vessel will be:

$$= 7 \times 100 \text{ cm}$$

$$= 7 \text{ m}$$

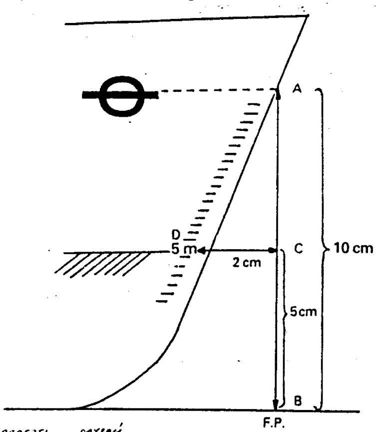
Figure 20



5.6.2 Distance between the forward draft and the F.P.

In the case of the MV "MINDIV" and many other vessels the draft marks at the stem of the vessel follow the profile of the hull, therefore the distance between the draft marks and the F.P. will vary depending on the draft of the vessel.

For example, the MV "MINDIV" fig. 21 below



Let's consider the case of an observed forward draft of 5.00 m.

The first step is to multiply this distance by the scale. This gives us the corresponding distance on the drawing:

= 500 cm x 1/100
= 5 cm

In other words, the position where the forward draft was read – point "S", is 5 cm above the keel.

The next step is to measure line CD. This is the distance parallel to the keel between point "D" – where the draft was read, and point "C" – on the forward perpendicular.

This is found to be 2 cm.

By dividing this distance by the scale of the drawing, the distance it represents is found.

= 2 cm – 1/100
= 2 cm x 100
= 2 m

5.6.3 Distance between midships draft and the M.P.

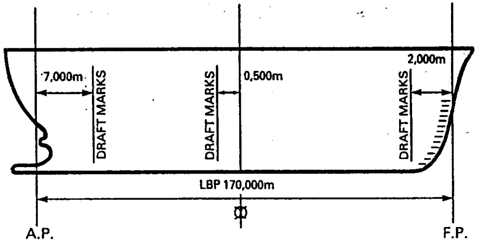
It is therefore obvious that when the draft marks are situated forward or aft of midships, the distance between the middle of the draft marks and the middle of the circle of the Plimsoll mark can be measured on the hull.

EXAMPLE:

MV "MINDIV"

POSITION OF THE DRAFT MARKS

Fig. 22



Observed forward draft	5.000 m.
Observed midships draft	6.020 m.
Observed aft draft	7.000 m.
LBP	170.000 m.

Observed trim: 7.000 m – 5.000 m = 2.000 m (by the stern)

Length between the marks:
170.000 m – (2.000 m + 7.000 m) = 161.000 m. = LBM

To correct the forward, midships and aft draft to the perpendiculars.

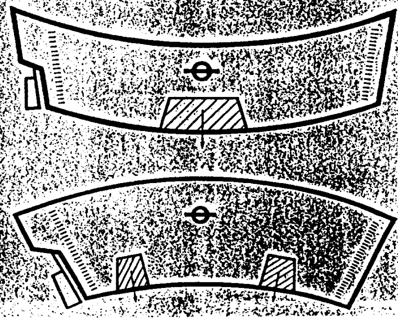
Stem correction = $\frac{2.000\ m \times 2.000\ m}{161.000\ m}$ = 0.025m

Stern correction = $\frac{2.000\ m \times 7.000\ m}{161.000\ m}$ = 0.087 m

Midships correction $\frac{2.000\ m \times 0.500\ m}{161.000\ m}$ = 0.006 m

Observed forward draft correction is minus (vessel trims by the stern and observed draft marks are aft of F.P.)	5.000 m –0.025 m
Corrected forward draft (Hypothetical draft at F.P.)	4.975 m
Observed aft draft correction is plus (vessel trims by the stern and observed draft marks are forward of A.P.)	7.000 m + 0.087 m
Corrected aft draft (Hypothetical draft at A.P.)	7.087 m
Observed midships draft correction is minus (vessel trims by the stern and observed draft marks are aft of M.P. same condition as stem correction)	6.020 m –0.006 m
Corrected midships draft (Hypothetical draft at M.P.)	6.014 m

6
CALCULATION OF THE MEAN DRAFT, CORRECTED FOR HULL DEFORMATION



SECTION 6

CALCULATION OF THE MEAN DRAFT CORRECTED FOR HULL DEFORMATION

6.1 Introduction

When a large vessel is subjected to an uneven distribution of weight, hull deformation can occur. This leads to different draft readings forward, midships and aft – even when the vessel is 'upright' and on 'even keel'. Where hull deformation has occurred, the midships, forward and aft drafts must all be taken into account when determining the vessel's final draft.

In this section of the manual, we are going to consider the types of deformation that occur and the corrections that are made to achieve the mean draft corrected for hull deformation.

The types of deformation that are likely to occur are known as "hogging" and "sagging".

6.2 Hogging

Hogging is best illustrated by a beam which has a weight at each end and is supported at its mid-point. The result is that the beam bends in a concave manner (fig. 23).

The same thing occurs when a vessel's hull is loaded either side of midships (fig. 24).

Fig. 23

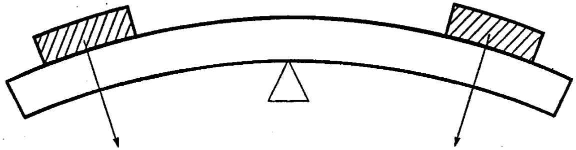
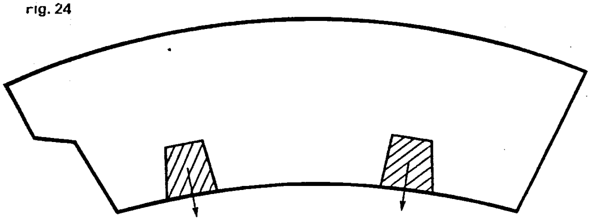


Fig. 24



6.3 Sagging

Sagging is illustrated by a beam which has a weight at the centre. The result is that the beam is deformed in a convex manner (fig. 25).

The same thing occurs when the hull of a vessel is loaded with all the weight midships. The sagging stress forces the midships downwards (fig. 31).

Fig. 25

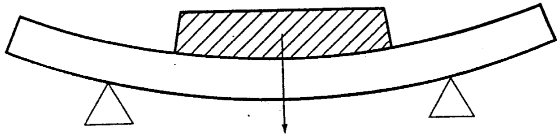
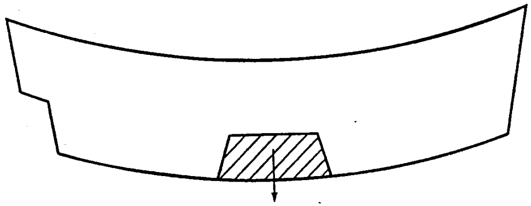


Fig. 26

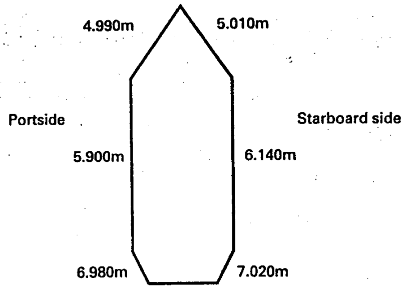


In general, a vessel tends to hog in the empty condition and to sag when loaded. Of course, this is not a universal rule and does not apply to all vessels nor all conditions of loading.

Hogging or sagging can also be influenced by the position of the vessel's castle and engines.

Having seen the types of deformation and how they occur, the example below explains how to determine whether there is any deformation.

Fig. 27



$$\text{Mean forward draft} = \frac{\text{port + starboard}}{2} = \frac{4.990 + 5.010\text{ m}}{2} = 5.000\text{ m}$$

$$\text{Mean midships draft} = \frac{\text{port + starboard}}{2} = \frac{5.900 + 6.140\text{ m}}{2} = 6.020\text{ m}$$

$$\text{Mean aft draft} = \frac{\text{port + starboard}}{2} = \frac{6.980 + 7.020\text{ m}}{2} = 7.000\text{ m}$$

To determine whether the vessel is sagging or hogging, the mean of the mean forward and mean aft drafts must be calculated, to compare this result with the mean midships draft:

$$\text{Mean forward and aft draft} = \frac{5.000 + 7.000\text{ m}}{2} = 6.000\text{ m}$$

This demonstrates that the vessel's hull is sagging by 2 cm.

6.4 Calculation of the mean draft corrected for hull deformation

When correcting for hull deformation, the first step is to calculate:

- the mean forward draft
- the mean aft draft
- the mean midships draft

– and from these, to calculate three further means:

- the mean forward and aft draft
- the mean of means draft
- the mean of means corrected draft

Using the following formulae:–

Note: The drafts used in these formulae are the draft readings corrected to the perpendicular.

$$\text{Mean forward draft (FWD)} = \frac{\text{forward port + forward starboard}}{2}$$

$$\text{Mean midships draft (MID)} = \frac{\text{midships port + midships starboard}}{2}$$

$$\text{Mean aft draft (AFT)} = \frac{\text{aft port + aft starboard}}{2}$$

$$\text{Mean forward and aft draft (M)} = \frac{\text{FWD + AFT}}{2}$$

$$\text{Mean of means draft (MM)} = \frac{\text{M + MID}}{2}$$

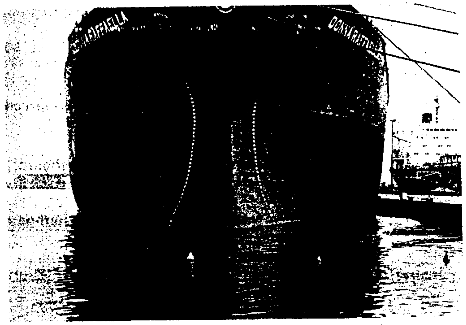
$$\text{Mean of means corrected draft (MMC)} = \frac{\text{MM + MID}}{2}$$

It is the mean of means corrected draft, MMC, which will be used for further calculations.
Although this system for hull deformation applies to most cargo vessels, other types of vessels, such as fast passenger ships and warships, use a slightly different system.

Because the midships is the widest part of a vessel, the midships draft has the greatest effect on the vessel's final mean draft.

This is illustrated in fig. 28 below.

Figure 28



This is also demonstrated by the MMC formula as follows:

$$MMC = \frac{MM + MID}{2}$$

as $$MM = \frac{M + MID}{2}$$

$$MMC = \frac{M + MID}{4} + \frac{MID}{2} = \frac{M + 3\,MID}{4}$$; $MMC = \frac{T_F + 6MID + T_A}{8}$;

It can be seen that a 75% weighting is given to the mean midships draft (MID), and 25% weighting to the mean forward and aft draft (M). This reflects the relative greater width of the midships to the forward and aft width of the vessel, and the greater significance of the midships draft to the forward and aft drafts.

$$MMC = \frac{2M + 6MID}{8}$$

Example MV "MINDIV"

To end this section let us return to the MV "MINDIV".

From Section 5 we calculated the forward, midships and aft drafts corrected to their respective perpendiculars.

Assuming the drafts are the same port and starboard we have:–

Mean forward draft (FWD)	=	4.975 m
Mean midships draft (MID)	=	6.014 m
Mean aft draft (AFT)	=	7.087 m

These mean draft values can now be used to calculate the mean draft corrected for hull deformation (MMC):

Mean forward and aft draft (M) $= \frac{FWD + AFT}{2} = \frac{4.975 + 7.087\text{ m}}{2}$

$= 6.031$ m

Mean of means draft (MM) $= \frac{M + MID}{2} = \frac{6.031 + 6.014\text{ m}}{2}$

$= 6.0225$ m

Mean of means corrected draft (MMC) $= \frac{MM + MID}{2} = \frac{6.0225 + 6.014\text{ m}}{2}$

$= 6.01825$ m

and:

– mean draft for + aft	=	6.031 m
– mean draft midships	=	6.014 m
difference	=	0.017 m

This shows that the vessel's hull is hogging by 0.017 m or 1.7 cm.

7
CALCULATION OF THE CORRESPONDING DISPLACEMENT

SECTION 7

CALCULATION OF THE CORRESPONDING DISPLACEMENT

7.1 Introduction

From the mean draft corrected for hull deformation or means of means corrected draft (MMC) we will now in this section calculate the corresponding displacement.

This is done by use of the vessel's hydrostatic particulars. These hydrostatic particulars express the relationship between draft in metres (or feet) to a weight or volume displacement, and can take the form of:–

– hydrostatic tables (figure 29, 30)
– hydrostatic scales (figure 31, 32)
– hydrostatic curves (figure 33, 34, 35)

The form used will vary from shipyard to shipyard and from country to country.

7.2 Hydrostatic Tables

From the hydrostatic tables it is possible to read the displacement corresponding to a certain draft.

To explain this let us return to the MV "MINDIV" where we calculated the MMC to be 6.01825 m.

Referring to the hydrostatic table, fig. 29 we note that the tables do not list all possible drafts, therefore it is necessary to interpolate between 6.00 m and 6.10 m, as shown below:

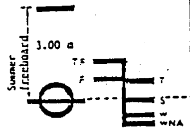
Draft	**Displacement**
6.10 m	= 18,282 t
6.00 m	= 17,981 t
Difference: ~~10~~ 0,1m m or 10 cm	= 301 t
Therefore 1 cm	= 30.1 t
0.01825 m = 1.825 cm	= 30.1 t x 1.825 = 54.933 t

Therefore

6.000 m + 0.01825 m A Draft of 6.0182 m	= 17,981 t + 54.933 t = 18,035.933 t.

A further example of a hydrostatic table is shown in Fig. 30.

Figure 29 MV "MINDIV" Hydrostatic Table



DRAFT IN METRES	SEAWATER 1.025				DRAFT IN METRES
	DISPLAC. IN t	DEAD-WEIGHT t	MOMENT CHANGE TRIM 1CM t x m	TONNES PER CM IMMERSION (TPC)	
10.20	31.700	26.700	416	35.06	10.20
10.10	31.350	26.350	413	35.03	10.10
10.00	31.000	26.000	410	35.00	10.00
9.90	30.650	25.650	407	34.97	9.90
9.80	30.301	25.301	404	34.86	9.80
9.70	29.953	24.953	401	34.75	9.70
9.60	29.606	24.606	396	34.64	9.60
9.50	29.260	24.250	392	34.52	9.50
9.40	28.915	23.925	389	34.40	9.40
9.30	28.572	23.572	384	34.28	9.30
9.20	28.230	23.230	380	34.15	9.20
9.10	27.889	22.889	375	34.01	9.10
9.00	27.550	22.550	372	33.87	9.00
8.90	27.212	22.212	367	33.73	8.90
8.80	26.875	21.875	362	33.58	8.80
8.70	26.540	21.540	357	33.43	8.70
8.60	26.206	21.206	352	33.27	8.60
8.50	25.874	20.874	347	33.12	8.50
8.40	25.544	20.544	338	32.97	8.40
8.30	25.215	20.215	333	32.82	8.30
8.20	24.888	19.888	329	32.67	8.20
8.10	24.562	19.562	325	32.54	8.10
8.00	24.237	19.237	323	32.41	8.00
7.90	23.913	18.913	319	32.29	7.90
7.80	23.591	18.591	316	32.19	7.80
7.70	23.270	18.270	313	32.07	7.70
7.60	22.950	17.950	310	31.96	7.60
7.50	22.631	17.631	307	31.85	7.50
7.40	22.313	17.313	304	31.74	7.40
7.30	21.996	16.996	301	31.63	7.30
7.20	21.680	16.680	298	31.52	7.20
7.10	21.365	16.365	295	31.41	7.10
7.00	21.053	16.053	292	31.30	7.00
6.90	20.741	15.741	289	31.19	6.90
6.80	20.430	15.430	286	31.08	6.80
6.70	20.120	15.120	283	30.97	6.70
6.60	19.810	14.810	280	30.86	6.60
6.50	19.502	14.502	277	30.75	6.50
6.40	19.195	14.195	274	30.64	6.40
6.30	18.888	13.888	271	30.53	6.30
6.20	18.584	13.584	268	30.42	6.20
6.10	18.282	13.282	265	30.31	6.10
6.00	17.981	12.981	262	30.20	6.00
5.90	17.681	12.681	259	30.09	5.90
5.80	17.381	12.381	256	29.98	5.80
5.70	17.082	12.082	253	29.87	5.70
5.60			250		
5.50			247		

Figure 30 Hydrostatic Table

HYDROSTATIC TABLE (WITH SHELL AND ALL APPENDAGES)

DRAUGHT	DISPLA-CEMENT	DIFF.	TPC	MTC	LCB	LCF	KB	TKM	LKM	DISPT. IN FW
(M)	(T)		(T)	(T-M)	(M)	(M)	(M)	(M)	(M)	(T)
6.00	39432	0	69.6	961.8	F 9.56	F 7.85	3.07	19.82	554.3	38471
5.99	39363	69	69.5	961.7	F 9.56	F 7.86	3.06	19.84	555.2	38403
5.98	39293	70	69.5	961.5	F 9.56	F 7.86	3.06	19.86	556.1	38335
5.97	39224	69	69.5	961.3	F 9.57	F 7.87	3.05	19.89	556.9	38267
5.96	39154	70	69.5	961.1	F 9.57	F 7.88	3.05	19.91	557.8	38199
5.95	39084	70	69.5	960.9	F 9.57	F 7.88	3.04	19.93	558.6	38131
5.94	39015	69	69.5	960.7	F 9.58	F 7.89	3.04	19.96	559.5	38063
5.93	38945	70	69.5	960.5	F 9.58	F 7.89	3.03	19.98	560.4	37995
5.92	38876	69	69.5	960.3	F 9.58	F 7.90	3.03	20.00	561.3	37928
5.91	38806	70	69.5	960.1	F 9.59	F 7.91	3.03	20.02	562.2	37860
5.90	38737	69	69.5	959.9	F 9.59	F 7.91	3.02	20.05	563.0	37792
5.89	38667	70	69.5	959.7	F 9.59	F 7.92	3.02	20.07	563.9	37724
5.88	38597	70	69.5	959.5	F 9.59	F 7.93	3.01	20.10	564.8	37656
5.87	38528	69	69.5	959.3	F 9.60	F 7.93	3.01	20.12	565.7	37588
5.86	38458	70	69.5	959.1	F 9.60	F 7.94	3.00	20.14	566.6	37520
5.85	38389	69	69.5	958.9	F 9.60	F 7.94	3.00	20.17	567.5	37453
5.84	38319	70	69.5	958.7	F 9.61	F 7.95	2.99	20.19	568.4	37385
5.83	38250	69	69.5	958.5	F 9.61	F 7.96	2.99	20.21	569.3	37317
5.82	38180	70	69.4	958.3	F 9.61	F 7.96	2.98	20.24	570.2	37249
5.81	38111	69	69.4	958.1	F 9.62	F 7.97	2.98	20.26	571.1	37181
5.80	38041	70	69.4	957.9	F 9.62	F 7.97	2.97	20.29	572.0	37114
5.79	37972	69	69.4	957.7	F 9.62	F 7.98	2.97	20.31	572.9	37046
5.78	37902	70	69.4	957.5	F 9.63	F 7.99	2.96	20.34	573.9	36978
5.77	37833	69	69.4	957.2	F 9.63	F 7.99	2.96	20.36	574.8	36910
5.76	37764	69	69.4	957.0	F 9.63	F 8.00	2.95	20.39	575.7	36843
5.75	37694	70	69.4	956.8	F 9.63	F 8.01	2.95	20.41	576.6	36775
5.74	37625	69	69.4	956.6	F 9.64	F 8.01	2.94	20.43	577.6	36707
5.73	37555	70	69.4	956.4	F 9.64	F 8.02	2.94	20.46	578.5	36639
5.72	37486	69	69.4	956.2	F 9.64	F 8.02	2.93	20.48	579.4	36572
5.71	37416	70	69.4	956.0	F 9.65	F 8.03	2.93	20.51	580.4	36504
5.70	37347	69	69.4	955.8	F 9.65	F 8.04	2.92	20.54	581.3	36436
5.69	37278	69	69.4	955.6	F 9.65	F 8.04	2.92	20.56	582.3	36368
5.68	37208	70	69.4	955.4	F 9.66	F 8.05	2.91	20.59	583.2	36301
5.67	37139	69	69.4	955.2	F 9.66	F 8.05	2.91	20.61	584.2	36233
5.66	37069	70	69.3	955.0	F 9.66	F 8.06	2.91	20.64	585.1	36165
5.65	37000	69	69.3	954.8	F 9.67	F 8.07	2.90	20.66	586.1	36098
5.64	36931	69	69.3	954.6	F 9.67	F 8.07	2.90	20.69	587.1	36030
5.63	36861	70	69.3	954.4	F 9.67	F 8.08	2.89	20.71	588.0	35962
5.62	36792	69	69.3	954.2	F 9.68	F 8.08	2.89	20.74	589.0	35895
5.61	36723	69	69.3	953.9	F 9.68	F 8.09	2.88	20.77	590.0	35827
5.60	36653	70	69.3	953.7	F 9.68	F 8.10	2.88	20.79	590.9	35759
5.59	36584	69	69.3	953.5	F 9.68	F 8.10	2.87	20.82	591.9	35692
5.58	36515	69	69.3	953.3	F 9.69	F 8.11	2.87	20.84	592.9	35624
5.57	36445	70	69.3	953.1	F 9.69	F 8.12	2.86	20.87	593.9	35556
5.56	36376	69	69.3	952.9	F 9.69	F 8.12	2.86	20.90	594.9	35489
5.55	36307	69	69.3	952.7	F 9.70	F 8.13	2.85	20.92	595.9	35421
5.54	36237	70	69.3	952.5	F 9.70	F 8.13	2.84	20.95	596.9	35353
5.53	36168	69	69.3	952.3	F 9.70	F 8.14	2.84	20.98	597.9	35286
5.52	36099	69	69.3	952.0	F 9.71	F 8.15	2.83	21.00	598.9	35218
5.51	36029	70	69.3	951.8	F 9.71	F 8.15	2.83	21.03	599.9	35151
5.50	35960	69	69.2	951.6	F 9.71	F 8.16	2.82	21.06	600.9	35083

7.3 Hydrostatic Scales

These are usually available on a vessel, sometimes as part of the general arrangement plan. Often they are small and difficult to read therefore it is preferable to use the hydrostatic tables or curves if available, for greater accuracy.

However, when a hydrostatic scale is used and the final MMC does not correspond with an indicated draft, it will be most difficult to read directly the corresponding displacement.

Therefore an interpollation would be more accurate.

for example, refer to Fig 31 opposite.

If MMC = 15'09" 25
it is impossible to read directly an accurate displacement corresponding to this MMC.
Therefore it is necessary to interpolate between the nearest indicated draft which reads directly corresponding displacement on the scale.

Draft		Displacement
16'11"00	=	3,800.000 L.T. (long tons)
15'09"00	=	3,500.00 L.T.
Difference		
1'02"00 (or 14 inches)	=	300.000 L.T.
1"	=	21.429 L.T.
0.25"	=	5.357 L.T.
Therefore		
15'09"00 + 0.25"	=	3,500.000 L.T. + 5.357 L.T.
15'09"25	=	3,505.357 L.T.

An interpollation or a combination of an indicated draft with the TPC or TPI would be more accurate, where

TPC = **Tonnes per cem (metric)**
(the additional displacement for a change in the draft by 1 cm)

TPI = **Tons per inch (imperial)**
(the additional displacement for a change in the draft by 1 inch)

Refer again to Fig 31 to find the displacement for 15'09"25

	Draft		**Displacement**
	15'09"00	=	3,500.000 L.T.
TPI at	15'09"00	=	21.170 L.T.
Then	0.25"	=	21,170 L.T. x 0.25
		=	5.293 L.T.
Therefore	15'09"00 + 0.25"	=	3,500.000 + 5.293
	15'09"25	=	3,505.293 L.T.

Fig 32 shows a different layout of a Hydrostatic Scale.

Figure 31 MV 'PELEGOS" Hydrostatic Scale

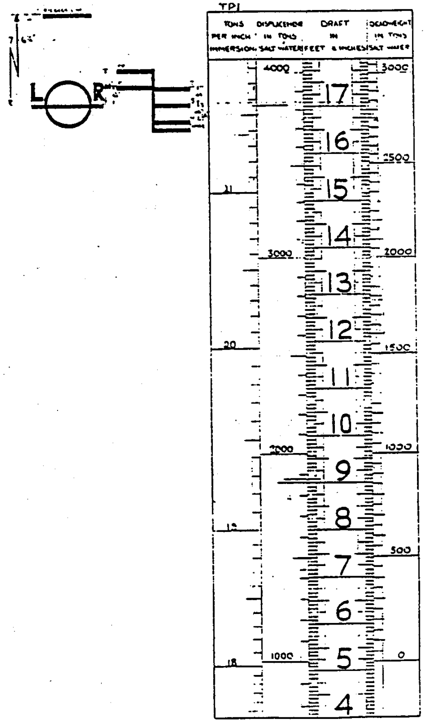
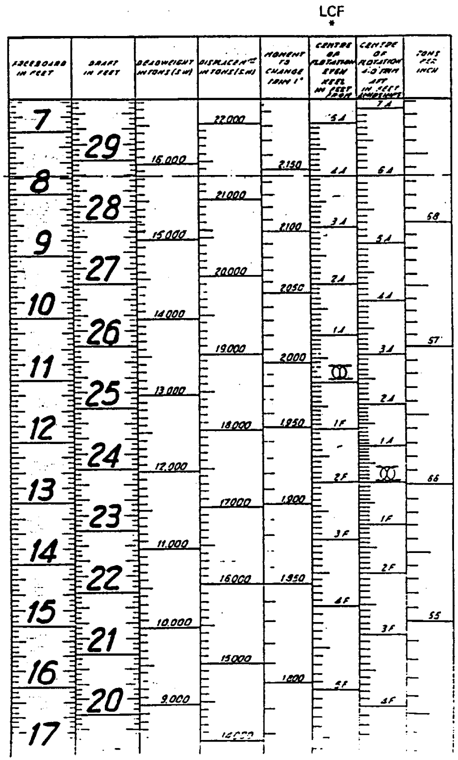


Figure 32 Hydrostatic Scale



*Occasionally the distance between the centre of flotation and midships is given on the displacement scale, but this is not common.

7.4 Hydrostatic Curves

Hydrostatic curves can give accurate readings of the corresponding displacement so long as extreme care is taken to read the values on the curves. A small error in alignment can result in a large difference in the displacement value.

Examples of typical hydrostatic curves are shown in Figs. 33, 34, 35.

NOTE:
Care must also be taken for the different ways in which the displacement can be expressed, such as:

- Metric (t = metric tonnes) or imperial (LT = long tons) units and 1 LT = 1,016047 t.

- Displacement in salt (SW) or fresh water (FW).
  For the same quantity loaded on board, a vessel will have more draft in fresh water than in salt water (see Section 9).

- Moulded or Extreme displacement.

  Moulded displacement: the displacement is based from the upper part of the keel plate (thickness about 2 or 3 cm),

  Extreme displacement: the displacement is calculated from the underside of the keel plate.

As the draft marks painted on the hull of the vessel refer always to the underside of the ship, the extreme displacement should be used at all times.

- Deadweight or Displacement:

  Displacement: the total weight of water displaced by the vessel. This displacement includes the light ship weight plus all the other weights on board such as cargo, ballast water, bunkers, etc.

  Deadweight: displacement excluding the light ship weight.
  or
  Displacement = deadweight + light ship weight.

If the hydrostatic particulars show only deadweight, the light ship weight has to be added to obtain the corresponding displacement. This is a procedure which should always be followed, to avoid errors, with the further applied density correction.

Figure 33 Hydrostatic Curve

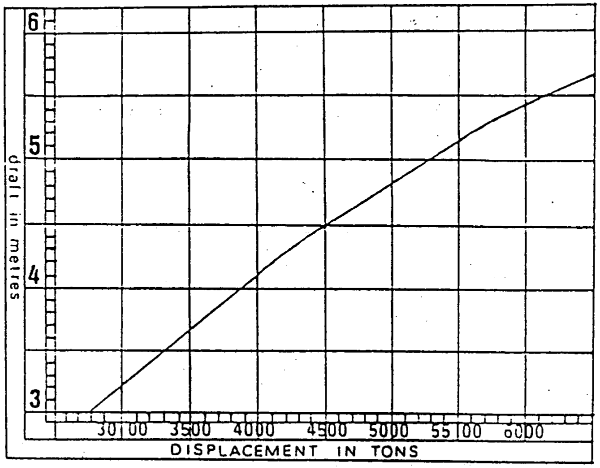
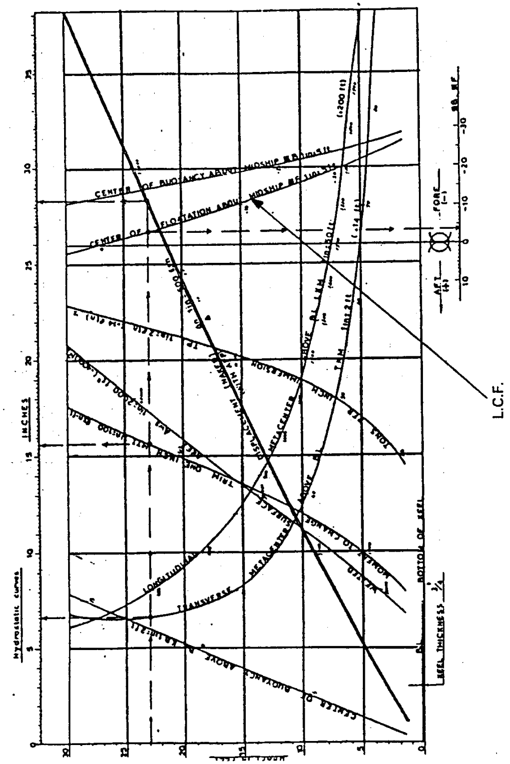


Figure 34 Hydrostatic Curves



SECTION 8

CORRECTING DISPLACEMENT FOR THE EFFECT OF TRIM AND LIST.

8.1 Introduction

In the previous sections of the manual, we have seen how a vessel's mean draft is calculated and how the vessel's documents are used to determine the corresponding displacement.

We have also seen that a vessel's displacement tables refer to the vessel in an even keel and upright condition. This means that when carrying out a draft survey, if the vessel is found to be trimmed or to have list, corrections to the displacement corresponding to the vessel's mean corrected draft (MMC) may be necessary.

In this section of the manual we are going to look at why these corrections are necessary and how they are made.

Definitions

The **trim** is the difference between the corrected forward and aft draft (resulting from the rotation of the vessel around its transversal axis).

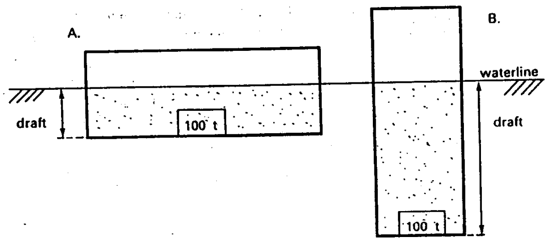
The **apparent trim** is the difference between forward and aft draft, read on the marks of the ship.

The **list** is the inclination of the vessel from its vertical position measured at the logitudinal midships axis. It is usually measured by means of an inclinometer giving results in degrees of angle. List can also be calculated from the difference between the port and starboard midships drafts.

8.2 Why Corrections for Trim are Necessary

To understand why a correction for trim is necessary consider 2 boxes, A and B, floating in water as shown in figure 36 below.

Figure 36



Although the boxes have the same volume and weight (and therefore displace the same weight of water) their drafts are different. Box B has a deeper draft than Box A, which proves that draft depends on the underwater shape of the box. The same principle applies to a vessel where the shape and dimensions of the hull are different forward and aft. The aft structure is usually wider and displaces therefore more volume than the forward part.

Since the underwater shape of a vessel differs from that of a box, a vessel does not trim or rotate around the midships but about its longitudinal centre of flotation (LCF) or tipping centre.

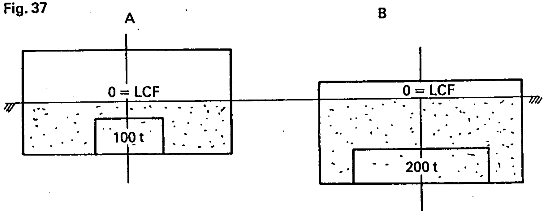
The LCF is located somewhere on the vessel's waterplane area and varies according to the vessels draft.

Consider the examples as shown in Figs. 37 and 38.

Example
Consider two equal boxes, A and B as shown in Fig. 37

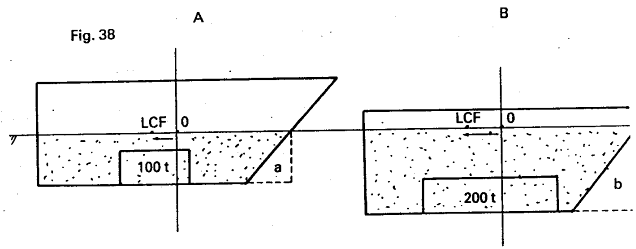
Box A contains a 100t weight
Box B contains a 200t weight

Fig. 37



In this case the forward underwater part equals the aft underwater part of the box,hence the position of the LCF does not vary with the draft and remains on the midship perpendicular.

Fig. 38



In the case of boxes with different shaped ends, asymmetrical shapes, the LCF varies with the draft and is not at the midships position. The LCF moves to a position along the waterplane to a position of equlibrium where the volume aft is equal to the volume displaced at the forward part of the vessel.

As the difference between the immersed forward and aft part increases with the draft (box B) the LCF moves further back from the midships.

Conclusion

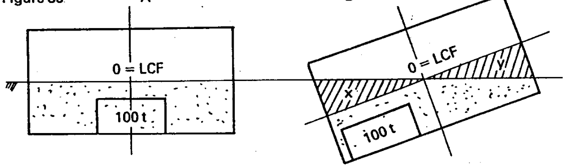
Concerning a vessel, the position of the LCF varies with the draft and is very rarely at the midships position. Therefore, when a vessel trims, a correction is required.

This is referred to as the **first trim correction.**

The position of the LCF according to the draft is given in the ship's hydrostatic particulars for the vessel on even keel.

Example: Consider again 2 similar boxes, A and B, each containing a 100 MT weight (Figure 39).

Figure 39

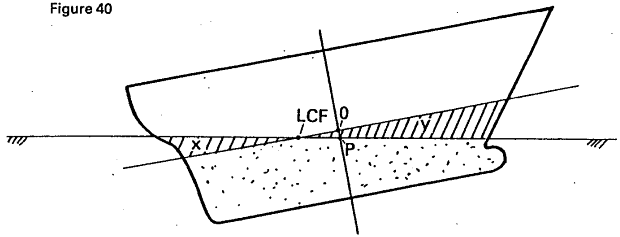


The LCF, is, in box A, at the midships perpendicular. Moving the weight away from midships will cause the box to trim (box B).
Because the shape of the box is the same forward and aft the LCF does not move and the MMC draft does not change.
This can be clarified as follows:
Since the weight in the boxes does not change, the displacement remains constant or the volume lifted out of the water (area Y) equals the volume which is additionally immersed (area X).

The breadth of the box is constant therefore the area of triangle X is equal to triangle Y.

Example: Consider the vessel as shown in Fig. 40 below.
The movement of a weight on board to the aft part of the ship will cause a trim to the stern.

Figure 40



Again the volume lifted out of the water must equal the volume additionally immersed. Taking into account that the shape of the vessel forward is narrower than the shape of the section aft, triangle Y is longer than triangle X. This implies that the LCF moves backward and that the MMC draft decreases with the distance O-P.

Conclusion

The movement of the LCF with the trim will lead to the **second trim correction.**

The calculation of O-P gives the total trim correction in distance, to be applied on the MMC draft.
Multiplication of the O-P with the corresponding TPC results in the trim correction expressed in tons.

8.3 Calculation of the First Trim Correction (FTC)

The First Trim Correction is calculated with the following formula:–

$$FTC\,(t) = \frac{TRIM\,(m) \times LCF\,(m) \times TPC\,(t/cm) \times 100}{LBP\,(m)}$$

where TRIM (m) : corrected trim or the difference between the corrected forward and aft draft.

LCF (m) : the distance between the midships perpendicular and the longitudinal centre of flotation at the MMC draft.

TPC (t/cm) : tonnes per centimetre immersion at the MMC draft.

LBP (m) : length between the forward and the aft perpendicular.

The values of LCF, TPC and LBP can be obtained from the hydrostatic particulars of the ship.
The value of the TPC is multiplied by 100 to convert from t/cm to t/m.

When working in the imperial system:

$$FTC\,(L.T.) = \frac{TRIM\,(feet) \times LCF\,(feet) \times TPI\,(LT/inch) \times 12}{LBP\,(feet)}$$

The value of TPI is multiplied by 12 to convert from LT/inch into LT/feet.

How to apply this correction?

- when the LCF (from midships) is on the same side of the deepest draft, the correction has to be added.
- when the LCF is on the opposite side of the deepest draft, the correction has to be subtracted.

Rules:

Trim by the stern – LCF aft of midships		
Trim by head – LCF forward of midships	**Correction +**	
Trim by stern – LCF forward of midships		
Trim by head – LCF aft of midships	**Correction –**	

N.B. Trim by stern also referred to as:
trim aft or trim + ve
Trim by head also referred to as:
trim forward or trim – ve.

A negative result signifies that the LCF has moved forward of the midperpendicular.
A positive result means that the LCF has moved backward of the midperpendicular.

Figure 41

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H Y D R O S T A T I S C H E   F O R M D A T E N

DEPLACEMENT FUER DICHTE (T/M3) 1.00	1.015	1.025	TUKK	KM	ETM	VERDRAENGUNGS-SCHWP. VON HL	ZUNAHME	TRIMMFAKTOR + HINTEN	- VORNE
(T)	(T)	(T)	(M)	(M)	(MT/M)	(M)	(T/CM)		
1144.	1162.	1173.	2.00	5.54	2543.	35.50	6.3	.237	-.224
1157.	1174.	1186.	2.02	5.51	2548.	36.50	6.3	.239	-.226
1169.	1186.	1198.	2.04	5.49	2554.	36.50	6.3	.241	-.228
1181.	1199.	1211.	2.06	5.45	2560.	36.50	6.3	.243	-.230
1193.	1211.	1223.	2.08	5.42	2566.	36.50	6.3	.245	-.232
1206.	1224.	1236.	2.10	5.39	2572.	36.50	6.3	.247	-.234
1218.	1236.	1248.	2.12	5.37	2578.	36.50	6.3	.249	-.236
1230.	1249.	1261.	2.14	5.34	2584.	36.50	6.3	.251	-.238
1243.	1261.	1274.	2.16	5.31	2590.	36.50	6.3	.252	-.239
1255.	1274.	1286.	2.18	5.29	2596.	36.50	6.4	.254	-.241
1267.	1286.	1299.	2.20	5.26	2602.	36.50	6.4	.256	-.243
1280.	1299.	1312.	2.22	5.24	2608.	36.50	6.4	.258	-.245
1292.	1311.	1324.	2.24	5.22	2614.	36.50	6.4	.260	-.247
1304.	1324.	1337.	2.26	5.19	2621.	36.50	6.4	.262	-.249
1317.	1337.	1350.	2.28	5.17	2627.	36.50	6.4	.263	-.250
1329.	1349.	1363.	2.30	5.15	2633.	36.50	6.4	.265	-.252
1342.	1362.	1375.	2.32	5.13	2640.	36.49	6.4	.267	-.254
1354.	1374.	1388.	2.34	5.11	2647.	36.49	6.4	.269	-.256
1367.	1387.	1401.	2.36	5.09	2653.	36.49	6.4	.270	-.258
1379.	1400.	1414.	2.38	5.07	2660.	36.49	6.4	.272	-.259
1392.	1412.	1426.	2.40	5.05	2667.	36.49	6.4	.274	-.261
1404.	1425.	1439.	2.42	5.03	2674.	36.49	6.4	.275	-.263
1417.	1438.	1452.	2.44	5.01	2681.	36.49	6.4	.277	-.265
1429.	1450.	1465.	2.46	5.00	2688.	36.48	6.4	.279	-.266
1442.	1463.	1478.	2.48	4.98	2696.	36.48	6.4	.280	-.268
1454.	1476.	1490.	2.50	4.96	2703.	36.48	6.4	.282	-.270
1467.	1489.	1503.	2.52	4.95	2710.	36.48	6.5	.283	-.271
1479.	1501.	1516.	2.54	4.93	2718.	36.48	6.5	.285	-.273
1492.	1514.	1529.	2.56	4.92	2726.	36.48	6.5	.286	-.275
1504.	1527.	1542.	2.58	4.90	2734.	36.47	6.5	.288	-.276
1517.	1540.	1555.	2.60	4.89	2741.	36.47	6.5	.289	-.278
1530.	1552.	1568.	2.62	4.88	2749.	36.47	6.5	.291	-.280
1542.	1565.	1581.	2.64	4.86	2757.	36.47	6.5	.292	-.281
1555.	1578.	1594.	2.66	4.85	2765.	36.46	6.5	.294	-.283
1567.	1591.	1607.	2.68	4.84	2773.	36.46	6.5	.295	-.284
1580.	1604.	1620.	2.70	4.83	2781.	36.46	6.5	.296	-.286
1593.	1617.	1633.	2.72	4.81	2789.	36.46	6.5	.298	-.288
1606.	1630.	1646.	2.74	4.80	2797.	36.45	6.5	.299	-.289
1618.	1643.	1659.	2.76	4.79	2805.	36.45	6.5	.301	-.291
1631.	1655.	1672.	2.78	4.78	2813.	36.45	6.5	.302	-.292
1644.	1668.	1685.	2.80	4.77	2822.	36.45	6.6	.303	-.294
1656.	1681.	1698.	2.82	4.76	2830.	36.44	6.6	.305	-.295
1669.	1694.	1711.	2.84	4.75	2839.	36.44	6.6	.306	-.297
1682.	1707.	1724.	2.86	4.74	2848.	36.44	6.6	.307	-.299
1695.	1720.	1737.	2.88	4.73	2858.	36.43	6.6	.309	-.300
1708.	1733.	1750.	2.90	4.72	2868.	36.43	6.6	.309	-.301
1720.	1746.	1763.	2.92	4.72	2878.	36.43	6.6	.310	-.303

Example A

Given that:

Mean corrected forward draft	:	1.000m
Mean corrected aft draft	:	3.000m
The MMC draft	:	2.000m
TPC at 1.500 m	=	9.8 t/cm
2.000 m	=	10.0 t/cm
2.500 m	=	10.2 t/cm
LBP	=	70.000 m
Breadth of the ship	=	15.000 m

1st Trim Correction or FTC (m) = $\dfrac{\textbf{Trim x LCF x TPC x 100}}{\textbf{LBP}}$

Trim : 3.000 m – 1.000 m = 2.000 m (by the stern)

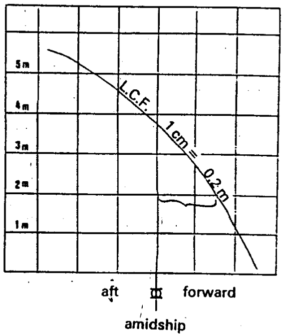
hydrostatic curves:

LCF can be obtained from the hydrostatic curve in Fig. 42.

At the mean draft of 2.00m the LCF is situated at a distance of 1.5 cm forward of the midships perpendicular

The scale on the LCF curve states 1cm = 0.2m

Therefore the real distance between the LCF and the midships perpendicular is 1.5 x 0.2m = 0.3m (forward)



Horizontal distance:
1 cm = 0.2 m

FTC (t) = $\dfrac{2.000\text{ m x } 0.3\text{ m x } 10\text{ t/cm x } 100}{70.000\text{ m}} = -8.571\text{ t}$

The sign of the correction is negative as the LCF, forward of the midperpendicular (thus –), is on the opposite side as the deepest draft (trim by the stern or +)

The example below shows the calculation of the first trim correction in the imperial system.

Example B.

Given that:

Mean corrected fore draft	: 26'00"
Mean corrected aft draft	: 30'00"
The MMC draft	: 28'00"
TPI at 28'00".	: 68 LT/inch
LCF at 28'00"	: + 3.1 feet aft of the midperpendicular
LBP	: 520 feet
MTI at 27'06"	: 2080
MTI at 28'06"	: 2130

first trim correction

FTC (L.T.) = $\dfrac{\textbf{trim x LCF x TPI x 12}}{\textbf{LBP}}$

Trim : 30'00" – 26'00" = 4'00" (by the stern)

FTC (L.T.) = $\dfrac{4' \text{ x } 3.1' \text{ x } 68 \text{ L.T./inch x } 12}{520'} = +19.458$ L.T.

The sign of the correction is positive as the LCF is on the same side as the deepest draft.

8.4 Calculation of the Second Trim Correction (STC)

The position of the LCF, according to the hydrostatic particulars, is based on the even keel condition. Since the position of the LCF varies also with the vessel's trim a second trim correction has to be applied to compensate for this additional LCF movement.

$$\text{STC (t)} = \frac{\text{Trim}^2\text{ (m)} \times 50 \times dm/dz}{\text{LBP (m)}}$$

Where : Trim (m) : corrected trim
50 : constant (metric system)
LBP (m) : length between perpendiculars
$\frac{dm}{dz}$(m) : the change of MTC for a draft interval of 1 meter at the MMC draft or

Referring to Fig. 43 below.

$$\frac{dm}{dz} = \frac{\text{MTC (at MMC draft + 0.5 m)} - \text{MTC (at MMC draft} - \text{0.5 m)}}{\text{1.000 m}}$$

$$= \text{MTC (at MMC draft + 0.5 m)} - \text{MTC (at MMC draft} - \text{0.5 m)}$$

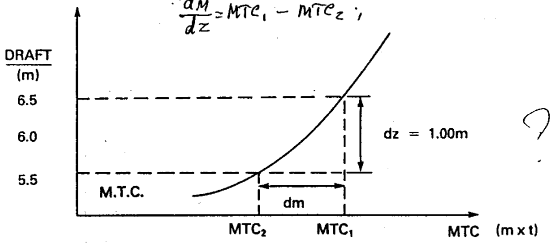


Figure 43

The MTC (moment to change trim 1 centimetre in seawater) is the moment, expressed in metres x tonnes calculated from the LCF position required to change a ship's trim by 1 centimetre in seawater.
For example: MTC = 20 m x t means that a weight of 20 tonnes, moved over a distance of 1 metre forward or aft of the LCF position causes a change in trim of 1 centimetre.
This change of trim can also be caused by 5 tonnes moved over a distance of 4 metres.

The MTC varies with the draft of the ship and its value is usually mentioned in the hydrostatic particulars of the vessel.
When the MTC is expressed in m x t to change trim 1 metre, the value has to be divided by 100 to obtain m x t to change trim 1 centimetre.

When the MTC is not available in the ship's particulars, dm/dz can be estimated as follows :

$$\frac{dm}{dz} = \frac{7.2\text{ (TPC}^2\text{ (at the MMC +0.5 m)} - \text{TPC}^2\text{ (at the MMC} - \text{0.5 m)}}{\text{breadth of the vessel (m)}}$$

For the imperial system :

$$\text{STC (L.T.)} = \frac{\text{Trim}^2\text{ (feet)} \times 6 \times dm/dz}{\text{LBP (feet)}}$$

$$\text{Where } \frac{dm}{dz} = \frac{\text{MTI (at MMCdraft + 6 inch)} - \text{MTI (at MMCdraft} - \text{6 inch)}}{\text{1 foot}}$$

$$= \text{MTI (at MMC draft + 6 inch)} - \text{MTI (at MMC draft} - \text{6 inch)}$$

and MTI (feet x LT) = moment to change trim 1 inch.

When the MTI is expressed in feet x LT to change trim 1 foot, the value has to be divided by 12 to obtain feet x LT to change trim 1 inch.

When the MTI is not available, dm/dz can be estimated as follows:

$$\frac{dm}{dz} = \frac{30\text{ (TPI}^2\text{ (at the MMC + 6 inch)} - \text{TPI}^2\text{ (at the MMC} - \text{6 inch)}}{\text{breadth of the vessel (feet)}}$$

The sign of the second trim correction is always positive, and is therefore always to be added to the displacement.

8.5 Total trim correction (TTC)

The TOTAL TRIM CORRECTION (TTC) becomes:

Total Trim Correction = First Trim Correction + Second Trim Correction

Remark:
On several vessels, trim correction tables are available. Usually, these tables give a combined result of the first and the second trim correction.

Consider again the foregoing examples A and B.
Example A (see page 92)

Calculate STC and TTC

$$STC\ (t) = \frac{trim^2 \times 50 \times dm/dz}{LBP}$$

Trim : 2.000 m by the stern
As the MTC is not available, the $\frac{dm}{dz}$ has to be calculated as follows:

$$\frac{dm}{dz} = \frac{7.2\ (TPC^2\ (\text{at MMC} + 0.5\ m) - TPC^2\ (\text{at MMC} - 0.5\ m))}{\text{breadth of the vessel}}$$

$$= \frac{7.2\ ((10.2)^2 - (9.8)^2)}{15} = 3.84\ t$$

$$STC = \frac{2^2\ m \times 50 \times 3.84\ t}{70\ m} = +\ 10.971\ t$$

$$TTC = FTC + STC$$
$$= -8.571\ t + 10.971\ t = +\ 2.400\ t.$$

this is the total trim correction, in this case to be added to the displacement on the MMC draft.

Example B (see page 93)

Calculate STC and TTC

$$STC\ (L.T.) = \frac{Trim^2 \times 6 \times dm/dz}{LBP}$$

Trim : 4′ by the stern
$\frac{dm}{dz}$: MTI (at MMC + 6″) – MTI (at MMC – 6″)

$$= 2130 - 2080 = 50\ \text{long tons}$$

$$STC = \frac{(4')^2 \times 6 \times 50}{520'} = +\ 9.231\ \text{long tons}$$

$$TTC = FTC + STC$$
$$= +\ 19.458\ \text{long tons} + 9.231\ \text{long tons} = +\ 28.689\ \text{long tons}$$

Here also the total trim correction has to be added to the displacement on the MMC draft.

Figure 44 lists some practical trim correction results for various types of vessels and for various loading conditions.
As mentioned before the TTC depends also on the shape of the vessel. Consequently the TTC can vary considerably for ships with the same load capacity and with similar trim and MMC drafts.

Figure 44

Deadweight	L.B.P.	Trim	1st Trim Correction	2nd Trim Correction	Total Trim Correction
t	meters	meters	t	t	t
1 200	55.1	+ 2.580	− 12	+ 13	+ 1
1 470	64.0	+ 0.290	+ 2	–	+ 2
1 470	64.0	+ 0.400	− 2	–	− 2
1 550	56.5	+ 0.180	+ 3	–	+ 3
1 550	56.5	+ 1.860	− 16	+ 6	− 10
1 630	65.2	+ 1.520	− 16	+ 5	− 11
1 990	71.2	+ 1.390	− 24	+ 4	− 20
4 380	88.0	+ 1.560	+ 16	+ 13	+ 29
4 380	88.0	+ 4.430	− 13	+ 39	+ 26
4 470	91.0	+ 0.630	+ 9	+ 2	+ 11
4 470	91.0	+ 3.710	− 36	+ 34	− 2
4 800	68.9	+ 2.550	− 69	+ 16	− 53
14 500	132.0	+ 3.900	− 9	+ 45	+ 36
25 000	172.0	+ 3.710	− 269	+ 30	− 239
30 000	170.0	+ 0.120	+ 1	–	+ 1
30 000	170.0	+ 2.700	− 189	+ 9	− 180
30 000	182.3	+ 2.370	− 106	+ 31	− 75
40 000	204.3	+ 0.600	+ 21	+ 3	+ 24
52 000	205.2	+ 0.250	− 7	–	− 7
52 000	205.2	+ 0.920	− 90	+ 4	− 86
75 000	233.8	+ 1.830	− 244	+ 9	− 235
80 000	236.0	+ 0.840	− 55	+ 5	− 50

Note: + sign means trim by stern
− sign means trim by the head (stem)

Example

In the case of the MV "MINDIV" the calculation for FTC, STC, TTC and the corresponding displacement corrected for trim are shown below:–

$$FTC = \frac{TRIM \times LCF \times TPC \times 100}{LBP}$$

Trim : = 2.112 m by the stern
LCF at 6.01825 m = 2.200 m forward of the misperpendicular
TPC at 6.01825 m = 30.220 t/cm
LBP : 170 m.

$$FTC = \frac{2.112 \times 2.200 \times 30.220 \times 100}{170.000} = -82.597\ t$$

This correction is negative as the LCF (forward of the midperpendicular) is on the opposite as the deepest draft (trim by the stern).

$$STC = \frac{trim^2 \times 50 \times dm/dz}{LBP}$$

trim : = 2.112 m

$$\frac{dm}{dz} = MTC\ (at\ MMC + 0.5\ m) - MTC\ (at\ MMC - 0.5\ m)$$

$= MTC\ (at\ 6.500\ m) - MTC\ (at\ 5.500\ m)$
$= 277 - 247$
$= 30\ t.$

$$STC = \frac{(2.112)^2 \times 50 \times 30}{170.000\ m} = +39.358\ t$$

this correction is always positive.

$TTC = FTC + STC$
$= -82.597\ t + 39.358\ t = -43.239\ t$

Displacement at 6.01825 m : 18,035.933 t
Total trim correction –43.238 t

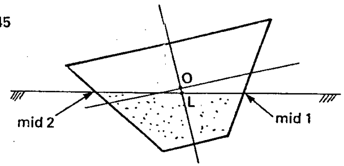
Displacement corrected for trim : 17,992.694 t

8.6 Correction for List

When a vessel is listing i.e. different midships draft port and starboard, the area of the waterplane increases according to the degree of list. The vessels lifts slightly out of the water and therefore the correction for list is always positive and is added to the displacement.

Few vessels have tables which give the correction for list, therefore an approximation has to made using the following formula:–
Since the formula is only an approximation every effort should be made to ensure that the vessel is as near to the upright before carrying out a draft survey.

Figure 45



Formula

$$\text{List correction (t)} = 6\ (\text{mid 2} - \text{mid 1})\ (TPC_2 - TPC_1)$$

where TPC_2 = tonnes per centimetre immersion at the greatest midships draft, mid 2 (m)
TPC_1 = tonnes per centimetre immersion at the smallest midships draft, mid 1 (m)

For the imperial system following formula can be applied:

$$\text{List correction (long tons)} = 0.72\ (\text{mid 2} - \text{mid 1})\ (TPI_2 - TPI_1)$$

where TPI_2 = tons per inch immersion at the greatest midships draft mid 2 (feet)
TPI_1 = tons per inch immersion at the smallest midships draft mid 1 (feet)

Example: Calculation of the list correction

Midships draft portside : 5.200 m
Midships draft starboardside : 4.700 m
Calculate the list correction.

From the hydrostatic particulars the following can be obtained:

TPC at 5.200 m = 39.2 t/cm
TPC at 4.700 m = 39.0 t/cm

List correction = 6(mid 2 – mid 1) $(TPC_2 - TPC_1)$
= 6(5.200 – 4.700) (39.2 – 39.0)
= + 0.600 t

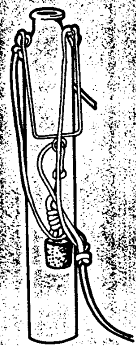
This value has to be added to the displacement on the MMC draft.

Note

For small ships, up to about 10,000t deadweight, list correction will be very small and can be neglected if the list is not large.

9

SAMPLING THE SURROUNDING WATER AND MEASURING THE APPARENT DENSITY



SECTION 9

SAMPLING THE SURROUNDING WATER AND MEASURING THE APPARENT DENSITY.

9.1 Introduction

In Section 1 we mentioned that a vessel floating in sea water will displace less volume of water than the same vessel floating in fresh water. This is due to the fact that sea water has a greater density, 1.025 as compared to fresh water of density 1.000.

A vessel's documents usually refer to a vessel floating in water of a particular density, typically for sea water at density 1.025.

In practice, however, the vessel may be surveyed when it is floating in water of a different density to that shown in the tables.

Therefore it is necessary to sample the surrounding water and measure it's density.

This section explains the correct procedures to follow.

Definitions

Apparent Density: weight in air per unit volume

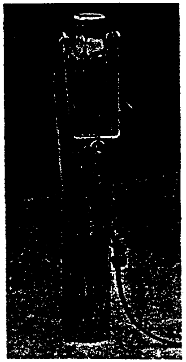
True density or density: weight in vacuo (=mass) per unit volume (equals the apparent density corrected for the effect of air buoyancy)

Relative density or specific gravity: the ratio of the density of the substance at T1 to the density of distilled water at T2.
Temperature T1 and T2 must be clearly specified.

9.2 Sampling the Surrounding Water

For various reasons the density of the surrounding water may differ with the depth (from surface to various lower levels) and, in certain circumstances the density may also differ alongships (from stem to stern). These variations can become significant, especially when larger vessels are concerned.

Fig. 46



Samples are drawn with a weighted sampling can as shown in Fig. 46.

The sampling can is sealed with a cork which is attached to the cord. The can is lowered into the water to the required depth, the cork is removed by jerking the cord and the can is allowed to fill with water. The sampling can is drawn up and the density is measured.

To avoid incorrect sampling operations, it is important that:–

- sampling is effected just before or after reading the drafts (since the density may change for example with the tide).
- care must be taken not to draw samples near shore outlets, near positions where the vessel is discharging cooling water or where ballast water has recently been discharged.
- samples are always taken at the water side of the vessel, as there could be stagnant water, with different density, trapped between ship and quay.
- once the sample is taken, the density must be read immediately. This to prevent the outside conditions (sun, wind, temperature . .) to alter the temperature and hence the density of the sample.

9.2.1 Number of samples and positions

Although the number of depths and positions at which samples are taken is largely a matter of experience, it will depend on the draft of the vessel and the local circumstances – tidal waters, fresh water from rivers flowing into the sea and so on. Nevertheless, the following guidelines apply:

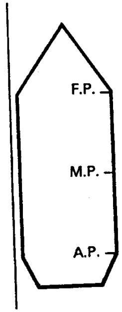
For small vessels, it is usually adequate to take two samples from the open water side of the vessel close to the midships draft marks and at a distance below the water line of about ⅓ and ⅔ of the midships draft.

For larger vessels, at least three samples should be taken at each sampling position at a distance below the water line corresponding to approximately ⅙, ½ and ⅚ of the midships draft.

Fig. 47 below shows the 3 sampling positions.

Fig. 47

Quayside



- Halfway between the midships and forward perpendicular.
- Midships perpendicular
- Halfway between the midships and aft perpendicular.

An average is made of all the density measurements and this figure for density is then used for further calculations (Section 10).

ZEAL

INSTRUCTION LEAFLET for

DRAFT SURVEY HYDROMETER

for determining the density of sea/fresh water

When carrying out a Draft Survey on bulk carrying cargo vessels, it is important that the weight to volume relationship of the supporting water is clearly understood and accurately reported.

Most hydrometers at present in use for Draft Surveys are not really suitable for the purpose but ZEAL have designed, in conjunction with S.G.S. Van Bree N.V., Antwerp, Member of the Société Générale de Surveillance S.A., Geneva, this special Draft Survey Hydrometer of the required accuracy, incorporating the following features:—

- A range of 0.990 to 1.040 kg/l suitable for use in sea and fresh water and thus covering the range of densities normally required for Draft Surveys.
- A scale graduated in *density* kg/l *in air* (density in air is sometimes termed apparent density). This permits the weight to be obtained by multiplying the scale reading by the volume in m^3 of water displaced.
- Calibration of the hydrometer for use in sea water, a liquid of medium surface tension.
- Manufactured from glass, thus permitting certification by the British Standards Institution if required.

  Alternatively, a ZEAL Certificate of Conformity of test for accuracy against a B.S.I. certified Standard hydrometer can be supplied.

INSTRUCTIONS FOR USE

1. A clean, representative sample of the supporting water should be obtained by means of a sampling can or other suitably designed sampling apparatus. (A sample of at least 1 litre will help to ensure that the temperature and density do not change unduly between collection of sample and taking of readings.) The depth of water in the container must be sufficient to allow at least 25mm clearance between the bottom of the hydrometer and the bottom of the container. The internal diameter of the container or jar should be at least 50mm.
2. The number of samples to be taken, also at which depths and at which positions outside the vessel they should be taken, may be important according to the circumstances.
3. Readings may be taken by lowering the hydrometer into a suitably shaped sampling apparatus or by transferring the water to a suitable glass test jar. If a metal or other non transparent container is used for taking readings ensure that it is full to the brim. If a glass test jar is used, it should preferably be rinsed first with part of the sample so as to avoid undue temperature changes. The container or test jar should be shielded from draughts, which might affect the readings.
4. The reading must be taken in the sampling apparatus or glass test jar as rapidly as possible. Undue delay in taking the reading could result in temperature changes leading to inaccurate results. In case of doubt, a repeat sample should be taken in order to verify the first observation.
5. Ensure that the stem of the hydrometer and the surface of the water sample are free from grease and oil since otherwise the accuracy of the readings could be adversely affected.
6. Hold the hydrometer vertically by the top of the stem and gently lower it into the water sample until it floats freely.
7. Take the hydrometer reading where the *level* liquid surface meets the graduated scale (see illustration overleaf).

CORRECTIONS TO HYDROMETER READING

1. If the instrument is supplied with a B.S.I. Certificate, the appropriate correction should be applied.
2. For most Draft Survey purposes, no further corrections to the readings are needed.

Note

A reading is most correct when the glass hydrometer is used at a temperature of 15°C. If immersed in water at temperatures higher or lower than 15°C, the instrument will expand or contract so that, for precise laboratory work, a small correction would be applicable.

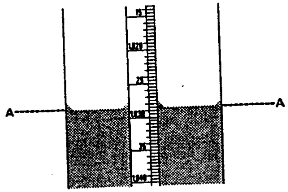
However, for Draft Survey work, it should be noted that the ship itself will normally expand or contract according to the temperature of the water in which it is floating. The corrections required to compensate for these changes in volume are of opposite sign and tend to compensate for each other.

As it is not practicable to calculate any temperature corrections for the ship, for most Draft Survey purposes no correction should be applied for the expansion or contraction of the hydrometer glass.

IMPORTANT

It is most important to note that the density required for Draft Survey purposes is the average density (in air) of the water in which the ship is floating. Any attempt to correct this water density to density at 15°C, 60°F or some other standard temperature can lead to very serious errors in the weight calculation.

TAKING A READING



The line A —— A indicates the correct reading position at eye level e.g. 1.0285 kg/litre in air.

APPENDIX

When necessary, a ZEAL Draft Survey hydrometer with a B.S.I. Correction Certificate may be used to verify the accuracy of a brass Loadline hydrometer graduated in Sp.Gr. 60°F/60°F in vacuo. If the two instruments are compared in fresh water at a temperature of 15°C or 60°F the following equation applies:

(1) Correct reading on glass hydrometer +0.0020 = correct reading on brass Loadline hydrometer.

If the comparison has to be made in water at some temperature substantially higher or lower than 15°C, the following corrections should be applied to the readings of the glass and brass instruments before using the equation (1).

Water temperature °C	Glass Hydrometer	Brass Hydrometer
5	+0.0003	+0.0006
10	+0.0001	+0.0003
15	0.0000	0.0000
20	−0.0001	−0.0002
25	−0.0003	−0.0005
30	−0.0004	−0.0008

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London England

SECTION 10

DISPLACEMENT CORRECTION FOR DENSITY

10.1 Introduction

The displacement, as calculated in section 7, and the trim and list correction as calculated in section 8, are expressed in tonnes (t) or long tons for a ship floating in salt water.

Since the density of the surrounding water is normally different from the density expressed in the hydrostatic particulars, a density correction has to be applied and this is explained in this section.

10.2 Calculation of Displacement Corrected for Density

$$\text{Displacement Corrected for Density} = \frac{\text{Displacement} \times \text{Density of Surrounding Water}}{\text{Density value shown in Hydrostatic Particulars}}$$

Example:

Displacement corrected for trim and list : 10,040.500 t
Density of the surrounding water : 1.005
The hydrostatic particulars are based on a density of 1.025

$$\text{Displacement corrected for density (t)} = \frac{10{,}040.500 \times 1.005}{1.025}$$

$$= 9{,}844.588 \text{ t}$$

NOTE:
The density correction can only be applied on displacement and never on deadweight because the volume of water displaced by the light ship itself is also dependent of the density.

If the ship's particulars show only deadweight, then the weight of the light ship is to be added prior to the density correction in order to obtain the displacement.

In case of doubt which density for salt water is used in the hydrostatic particulars, it is often useful to refer to the vessel's loadline marks, in particular to the summer loadline . By comparing the displacements corresponding to the summer loadline (S) and the fresh water loadline (F), it is possible to determine the density upon which the hydrostatic particulars are based using the following formula.

salt water density used in hydrostatic particulars.	$= \dfrac{\textbf{displacement at the fresh water loadline}}{\textbf{displacement at the summer loadline}}$

Example:

The fresh water loadline (11,07 m) = 25,975 t/SW
The summer loadline (10,84 m) = 25,340 t/SW
(difference = 0.23 m fresh water allowance)

$$= \frac{25{,}975}{25{,}340} = 1.025$$

To end this section let us return to the MV "MINDIV".

In Section 8 we found the displacement corrected for trim and list to be 17,992.694 t

Density from the hydrostatic particulars = 1.025 kg/l

Assuming a density of surrounding water = 1.010 kg/l

Displacement corrected for density

$$= \frac{17{,}992.694\ \text{t} \times 1.010\ \text{kg/hl}}{1.025}$$

$$= \underline{17{,}729.386\ \text{t}}$$

SECTION 11

MEASUREMENT OF DEDUCTIBLE LIQUIDS ON BOARD

11.1 Introduction

The displacement, after correction for trim, list and density, as calculated in section 10 has to be reduced by the weight of the liquids on board which may change between initial and final survey.

These are referred to as deductible liquids and comprise of:–

- ballast water
- fresh water
- bunker contents

In this section we will explain how to measure these deductible liquids.

11.2 Ballast Water

An empty vessel needs ballast to maintain its stability. Although the ballast water is normally pumped out during the loading of cargo, this does not necessarily mean that a vessel in a loaded condition will be completely free of ballast. All ballast tanks must therefore, be carefully checked during both the initial and final surveys in order to ascertain the quantity of ballast water in the tanks.

This can be done in three ways:

- by sounding (dipping)
- by taking ullages
- by overflowing

11.2.1 Sounding

This method can only be used when tank calibration tables are available.

Sounding is done using a metal tape or rope 'sounder' which is lowered through the sounding pipes into the liquid. The sounding pipes are usually situated on the vessel's deck.

The sounding is the wetted length of the sounder which can be read when the tape or rope is drawn up.

When taking soundings certain precautions must be taken:

Before taking a sounding the maximum possible reading must be ascertained. This is simply the distance between the upper reference point and the lower datum plate. This distance will be shown in the tank calibration tables and can be used to check that the sounding pipe is not blocked and that the tape is accurate.

Whenever possible, avoid using a rope sounder. Once the rope is wet, it is very difficult to read subsequent soundings.

Whenever possible, a surveyor should use his own sounder. When a vessel's sounder is used, its accuracy should be checked.

The use of "water finding paste" is recommended. This is simply a paste which changes colour on contact with water and can therefore be used to indicate the level of the water on the sounder.

Some ships are equipped with automatic gauges for measuring the ballast tanks, but as these may not be reliable they should not be used.

It is important to note that a zero sounding does not mean that the ballast tanks are empty. There may be water below the datum plate. The quantity of water corresponding to a "zero" reading will be given in the tank's calibration tables.

11.2.2 Taking Ullages

The ullage is the distance measured from a fixed reference point on the tank to the water level.

This method can only be applied when ullage calibration documents are available and on most vessels they are not.

This system usually applies for wing tanks with manholes on deck. If the ship is in a trimmed position and the calibration documents do not include trim corrections it is advisable to take a forward and an aft ullage.

The mean of these 2 ullage measurements equals the ullage corrected for trim and can be used for further calculations.

11.2.3 Overflowing

This method can only be used when the ballast tanks are full. In this case the ballast tanks are pumped until the water runs through the airpipes on deck. If the water overflows through an airpipe located on the opposite side of the tank to the deepest draft, (airpipe forward of the tank and trim by the stern or vice versa), the ballast tank is considered to be full.

On the other hand, the overflow through an airpipe situated on the same side of the tank as the deepest draft does not necessarily mean that the tank is completely full.

Due to the trim, air can be trapped forming an airlock, mainly when long tanks are concerned and especially when there is no airpipe fitted on the opposite side of the tank to the deepest draft. In this case, the overflow should additionally be checked by sounding or ullaging.

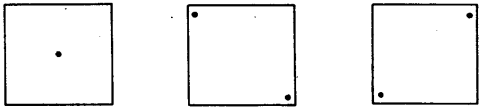
On certain large bulk carriers, ballast water may be present in the cargo holds and should be checked.

11.2.4 Measuring the Ballast Water

The corresponding quantity of ballast water is calculated using the calibration documents with corrections for trim and list.

If these documents do not provide trim and list corrections, soundings or ullages should be taken on the middle point of the hatchcover or on 2 opposite situated corners (figure 48).

Figure 48



The mean measurement in the case of sounding or ullaging represents the measurement corrected for trim and list.

After the quantity of ballast water is determined, (preferably expressed in m^3) the density has to be ascertained in order to calculate the total weight of ballast on board.

In case the ballast is taken at the same place of survey, all ballast water in each tank has the same density as the measured density of the surrounding water (assuming that the density of the surrounding water remains unchanged).

However, if a vessel arrives with ballast on board, each tank has to be checked separately since they may contain water of different density, collected at different locations.

Sampling of this ballast water can be performed with a miniature version of the sampling can (described in section 9) which can be lowered into the sounding pipe of the tank. Several samples, taken on different depths, are combined in the normal sized sampling can. The density can be ascertained with the SGS-Zeal hydrometer where the result is then directly the conversion factor from volume (m^3) into weight (t).

11.2.5 Special Notes Regarding Ballast Tanks

To improve accuracy the Chief Officer should be requested to have the tanks either completely full or empty at time of survey and to maintain the same ballast situation as much as possible till completion of the final survey.

Checking the ballast should not be effected when the vessel's trim exceeds the available trim corrections for the ballast tanks. The trim should always be reduced as much as possible and never exceed 3 metres.

Draft reading should only be taken after the tank capacities have been checked.

Figure 50 MV "MINDIV" F.O. + L.O. TANK CAPACITY

Item	Location of Frame N°	Capacity (V) in M3	Diesel O. in M.T. (Vx0.96x0.88)	Bunker O. in M.T. (Vx0.96x0.88)	Lub. O. in M.T. (Vx0.96x0.90)	Center of Gravity ■	Center of Gravity KG (M)	Max.Free Surface Moment at S.G.=1.0 (M.T.-M)
No.4 T.S.T. (P)	78-113	529.8		488.3		10.69	13.65	900
No.4 " (S)	"	529.8		488.3		10.69	13.65	900
No.5 " (P)	43-78	511.9		471.8		38.50	13.69	927
No.5 " (S)	"	511.9		471.8		38.50	13.69	927
No.6 F.O.T. (P)	22-42	101.3	85.6			58.87	1.13	199
No.6 " (S)	23-42	83.3	70.4			59.48	1.15	121
Heavy O. Serv. T.	37-42	23.5		21.7		55.33	13.39	9
" O. Sett. T.	"	23.6		21.7		55.33	13.39	10
Heavy O.Over Flow T.	38-42	13.9		12.8		55.27	1.00	2
Diesel O. Serv. T.		10.6	9.0			54.71	13.37	2
" O. Sett. T.	"	12.1	10.2			54.71	13.37	3
Cyl.O. Storage T.	"	(20.0)			(17.3)	54.69	13.35	11
Lub. O. Sump. T.	22-32	18.0			15.6	65.29	1.44	6
" O. Storage T.	32 -33	17.8			15.4	58.89	13.30	13
" O. Sett. T.	28 -31	16.2			14.0	63.09	13.38	13
Total Diesel Oil (S.G.=0.88)		207.3	175.2					
Total Bunker Oil (S.G.=0.96)		2,144.4		1,976.4				
Total Cylind.Oil (S.G.=0,90)		20.0			(17.3)			
Total Lub.Oil (S.G.=0,90)		52.0			45.0			

11.5 Correcting for Trim

Because tank calibration tables (fig 50) assume that the vessel is on an even keel (fig. 51), corrections must be applied to the observed soundings or ullages when the vessel is in a trimmed position. The correction will depend on the trim of the vessel – to the head or to the stern, and the position of the sounding pipe – in the forward or aft part of the tank.

When the sounding pipe is in the aft part of the tank, the sounding will be too low when the vessel is trimmed by the head (fig. 52), and too high, when it is trimmed by the stern (fig. 53).

If the sounding pipe were to be located in the forward part of the tank, the sounding would be too high when the vessel is trimmed by the head, and too low when it is trimmed by the stern.

If the sounding pipe is located in the middle of the tank, the trim does not effect the reading and the observed sounding equals the sounding corrected for trim.

Conclusion:

When the sounding pipe is in the same direction as the vessel's deepest draft, the observed reading will be too high, and the corresponding correction must be substracted.

When the sounding pipe is in the opposite direction as the vessel's deepest draft, the observed sounding will be too low and the corresponding correction must be added. The same rule applies also for the correction for list.

Most large bulk carriers have documents for trim and list corrections on board, but they often do not exist for smaller vessels.

Example;

Consider again the MV "MINDIV"

Observed sounding of water ballast tank no. 2 port side : 2.000 m.
Trim : 3.000 m by the stern
List : 1 degree to port side
Ballast water density : 1.022

Calculate the weight of water in the tank.

The calibration table and the appropricate trim and list correction tables are given in figs. 54, 55 and 56.

Observed sounding	:	2.000 m
Sounding correction for trim	:	– 0.303 m (fig. 54)
Sounding correction for list	:	+ 0.065 m (fig. 55)

Sounding corrected for trim and list : 1.726 m.

From the calibration table (fig. 56):

Sounding 1.800 m = 181.6 m^3
Sounding 1.700 m = 176.0 m^3

By interpolation

Sounding 1.726 m = 177.456 m^3

Weight of water in ballast tank = Volume (m^3) x Ballast Water Density

= 177.456 x 1.022

= 181.360 t

Figure 51

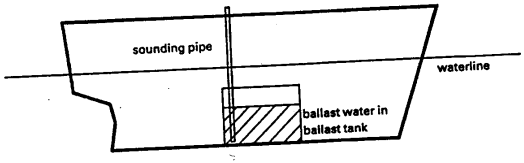


Figure 52

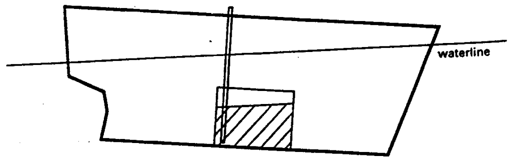
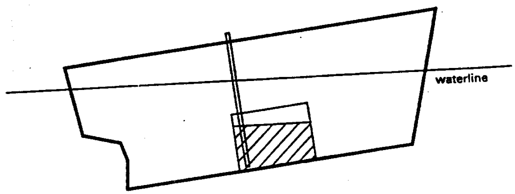


Figure 53

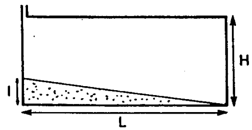


11.6 Calculating Trim & List Corrections

In cases where trim and list correction tables are not available and rectangular tanks are concerned, the observed soundings can be corrected as follows.

There are 2 possible correction formulae and to determine which formula has to be used the sounding l must be calculated (fig. 57).

Fig 57.



where l (m) = imaginary sounding for which the level of the liquid in the tank would intersect the corner of the tank opposite the sounding pipe.

L (m) = length of the tank

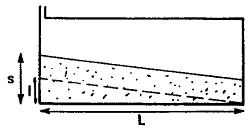
H (m) = height of the tank

and $l(m) = \dfrac{trim(m) \times L(m)}{LBP(m)}$

Correction Formula A

When the observed sounding is greater than or equal l: (fig. 58)

Fig 58.



Then the correction is:

$$correction(m) = \frac{\text{trim x distance sounding pipe and middle of the tank}}{LBP}$$

The rule for applying this correction is that when the sounding pipe is fitted on the same side as the deepest draft the correction is subtracted from the observed sounding.

If it is on the opposite side the correction is added.

or : trim by the stern-sounding pipe forward / trim by the head-sounding pipe aft — correction +

trim by the stern-sounding pipe aft / trim by the head-sounding pipe forward — correction –

In practice the sounding pipe is usually located totally forward or aft in the tank which simplifies the foregoing formula into:

$$correction(m) = \frac{trim(m) \times L(m)}{2 \times LBP(m)}$$

Example:

observed sounding : 3.500 m

trim : 2.500 m by the stern

length of the tank : 15.000 m

LBP : 180.000 m

The sounding pipe is located totally aft in the tank.

Calculate the sounding corrected for trim:

$$l(m) = \frac{trim(m) \times L(m)}{LBP(m)}$$

$$= \frac{2.500 \times 15.000}{180.000} = 0.208 \text{ m}$$

The observed sounding (3.500 m) is greater than the imaginary sounding (0.208 m) and since the sounding pipe is totally aft the following formula should be used:

$$correction(m) = \frac{trim(m) \times L(m)}{2 \times LBP(m)}$$

$$= \frac{2.500 \times 15.000}{2 \times 180.000} = -0.104 \text{ m}$$

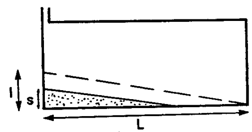
The sign of the correction is negative as the sounding pipe is located in the tank on the same side as the deepest draft.

Observed sounding	:	3.500 m
Trim correction	:	–0.104 m
Sounding corrected for trim :		3.396 m

Correction Formula B

When the observed sounding(s) is smaller than l (fig. 59)

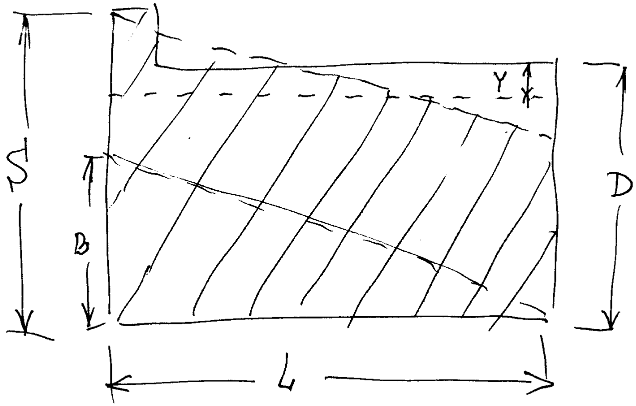
Fig. 59



$$\text{Sounding corrected for trim}(m) = \frac{s^2(m) \times LBP(m)}{2 \times trim(m) \times L(m)}$$

The same formula can be used to correct the soundings for list by replacing

* trim by list
* LBP by breadth of the vessel



$$B = \frac{L \times d}{L_{BP}};$$

d - TRIM

L - Length of TANK

$L_{BP} = L_{LL}$

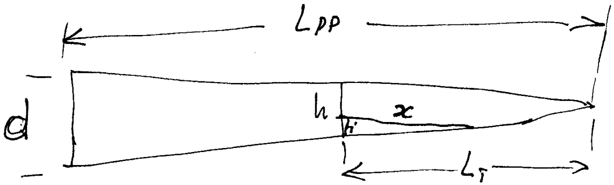
S - Sounding

D - Depth of TANK.

$$Y = \frac{L \times d - L_{BP}(S-D)}{d}; \quad (\text{FEET}) \; ; \; (M)$$

$$\text{ULLAGE} = \frac{Y^2 \times d \times 12}{2 \times L_{BP} \times L}; (\text{INCHES}) = \frac{Y^2 \times d}{2 \times L_{BP} \times L}; (M)$$

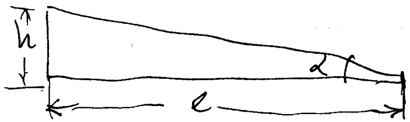
Correct Sounding = D - ULLAGES



$$\frac{h}{d} = \frac{L_T}{L_{pp}} \qquad h = \frac{L_T \times d}{L_{pp}}$$

$$\frac{h'}{h} = \frac{x}{L_T} \qquad x = \frac{h' \cdot L_T}{h}$$

$$V = \frac{x \times h' \times B_{танк}}{2};$$



$$h = tg(\alpha) \times l \quad (м)$$

$$\alpha = ArTg\left(\frac{h}{l}\right) (^{\circ})$$

SECTION 12

IMPORTANCE OF THE EMPTY SURVEY

12.1 Introduction

In Section 7 we stated that the

Total Weight of Water Displaced by the Vessel = { light ship's weight + weight of cargo + deductible liquids + the ship's constant }

In this section we will explain the meaning of ship's constant and why an empty survey is necessary to be able to measure this constant.

Definition

The **Ship's Constant** consists of all items which came on board after the ship was built, such as additional coats of paint, ropes, spare parts, ship's stores, the crew's luggage etc.

Therefore the **Ship's Constant** is the displacement of the empty vessel, less the measurable deductible liquids and the light ship's weight.

For example:

Empty Survey Displacement (corrected for trim, list and density)	=		10,000
Ballast Water	=	5,000t	
Fresh Water	=	300t	
Bunkers	=	600t	
Light Ship Weight	=	3,800t (from documents)	
		9,700t	9,700t
SHIP'S CONSTANT	=		300t

12.2 Importance of the Empty Survey

An empty survey must always be carried out at every draft survey even when the same vessel returns at short intervals to the same place, the reason being that the value of the ship's constant is always changing.

Reasons for this are due to such factors as:

- when ballast water is taken on a muddy river, an indefinite quantity of mud remains in the ballast tanks
- the weight of rust and coats of paint will add to the weight of the constant over time.

Over a period of time the loading capacity of older vessels will decrease and the Captain may try to overload or argue that the constant is far less than the weight found at the empty survey.

In certain cases the constant may be small or even negative. The reasons for this are explained below.

12.3 Negative Constants

There are many reasons why a negative or small constant may occur, typical reasons being:

- that the light ship's weight is not that shown in the vessel's document. This can occur when identical documents are supplied to a number of sister ships
- that the ship's hydrostatic particulars are incorrect
- that equipment may have been removed from the vessel e.g. a tweendeck, a crane or deck beams – a common practice on smaller vessels to improve their loading capacity.
- an under estimation of the vessel's draft
- an over estimation of the deductible liquids, in particular the ballast
- an unrepresentative density result.

If a negative constant is obtained, check if it can be explained by one of the foregoing reasons and should, if possible, be compared with any previous survey. If no acceptable reason is found it should be stated in the report, together with:

- the effective result of the draft survey
- the result of the loaded survey minus the light ship's weight (as per documents) and minus the constant (as declared by the Captain)
- The Captain should sign a statement of the constant that has been used.

Then it is up to the client to decide which weight is used for the Bill of Lading.

If the survey was carried out under difficult or doubtful circumstances, it can be suggested that the constant may be re-checked at the destination port, jointly by SGS and the Captain, a Letter of Reserve should be issued in such circumstances (refer to Appendix II).

Example:

Consider a coaster where the tweendeck has been removed and where hydrostatic particulars do not show this alteration.

The empty survey resulted in:

Net light displacement	400t
Deductible liquids	– 150t
Light ship weight	– 300t
Constant	– 50t

The loaded survey resulted in:

Net loaded displacement	1,200t
Deductible liquids	– 180t
Light ship weight	– 300t
Constant + weight of the cargo	720t

The cargo weight is the difference between the empty and the loaded survey or: 720t – (– 50t) = 770t.

For the same reasons as described in Section 11 not only the liquids but also all other weights on board, which will change between initial and final survey, must be determined.

For example anchors can be lowered or pontoons may be placed on the quay. As it is very often impossible to establish an accurate weight for these items, it is recommended to have them in the same position at time of both surveys.

Consequently they become a part of the constant.