

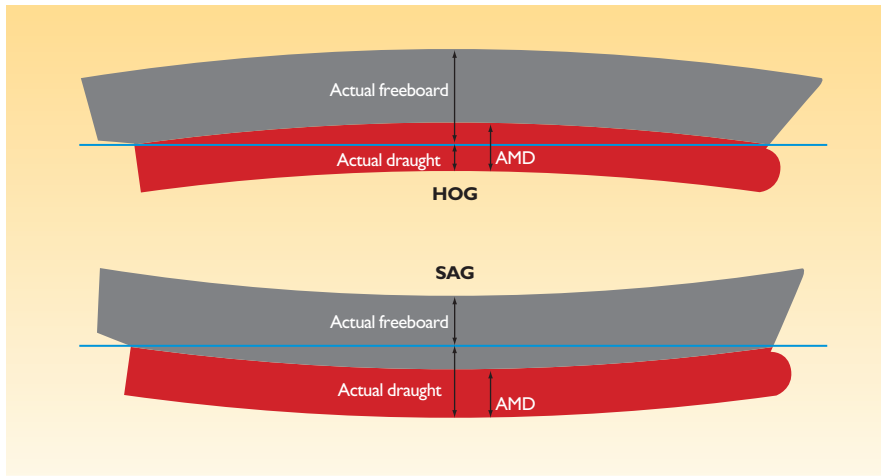


Figure 14. Identifying hog or sag using the arithmetical mean draught (AMD)

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

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

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

Methods of calculating hull-deflection correction

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

Method 1

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

Method 2 (the most common and simplest method)

Assume that the deformed shape of the vessel follows a regular mathematical curve. The correction is dependant on the block coefficient.

- (i) For finer-lined vessels

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

This is often referred to as 'the mean of mean of means'.

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

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

Where

mean adjusted draught = draught midships corrected for hog and sag

DM = draught midships

DFP = draught at forward perpendicular

DAP = draught at aft perpendicular.

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

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

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

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

Answer

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

Method 3

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

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

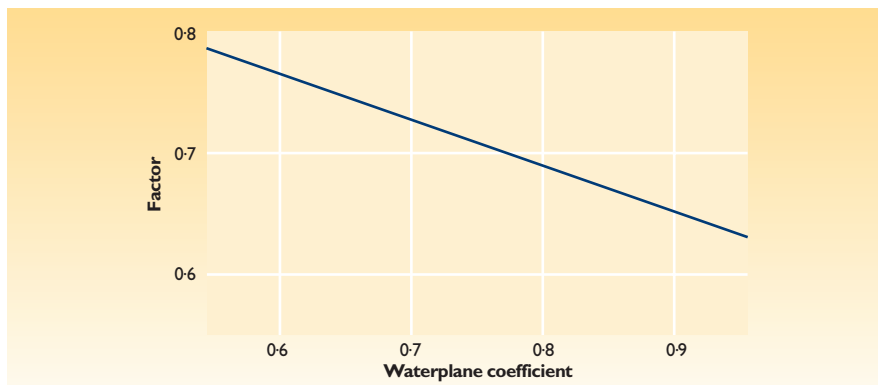


Figure 15. Example of graph used to obtain adjustment factor for waterplane coefficient

Then

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

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

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

Answer

Extracted factor 0.76

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

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

Method 3 alternative 1

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

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

Where

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

Method 3 alternative 2

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

Other methods

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

CORRECTIONS FOR TRIM

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

First trim correction (correction for layer)

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

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

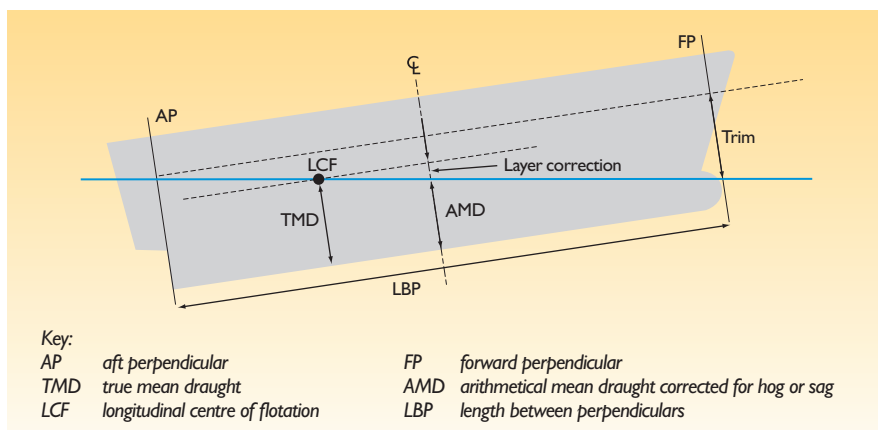


Figure 16. Correction for layer

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

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

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

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

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

Sign convention

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

Worked example: first displacement correction for trim

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

Answer

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

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

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

Second trim correction

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

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

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

Where

MCTC_2 = MCTC for the draught at the AP

MCTC_1 = MCTC for the draught at the FP

or vice versa when trimmed by the head.

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

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

Where

MCTC_2 = MCTC for mean adjusted draught + 0.5 m

MCTC_1 = MCTC for mean adjusted draught – 0.5 m

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

Sign convention

Always positive (+).

Worked example: second displacement correction for trim

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

Extracted values from hydrostatics:

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

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

Answer

Trim = 1.40 m

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

DENSITY

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

1. medium surface tension
2. apparent density in kg / l scale range between 0.990 to 1.040 (1.000 kg/l = 1.000 t/m³)
3. instrumental standard 15° C.

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

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

Correction for density

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

Where

density 1 = average density of water sampled

density 2 = density specified in the hydrostatic information.

Notes

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

1 cubic metre of fresh water 1 tonne

1 cubic metre of salt water 1.025 tonnes

or similar figures.

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

Worked example: displacement correction for density

The extracted hydrographic displacement equivalent to the observed draught of 5.30 m = 15,250 t for salt water where 1 m³ of salt water = 1.025 t.

Find: true displacement if the average observed apparent density = 1.015 t/m³

Answer

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