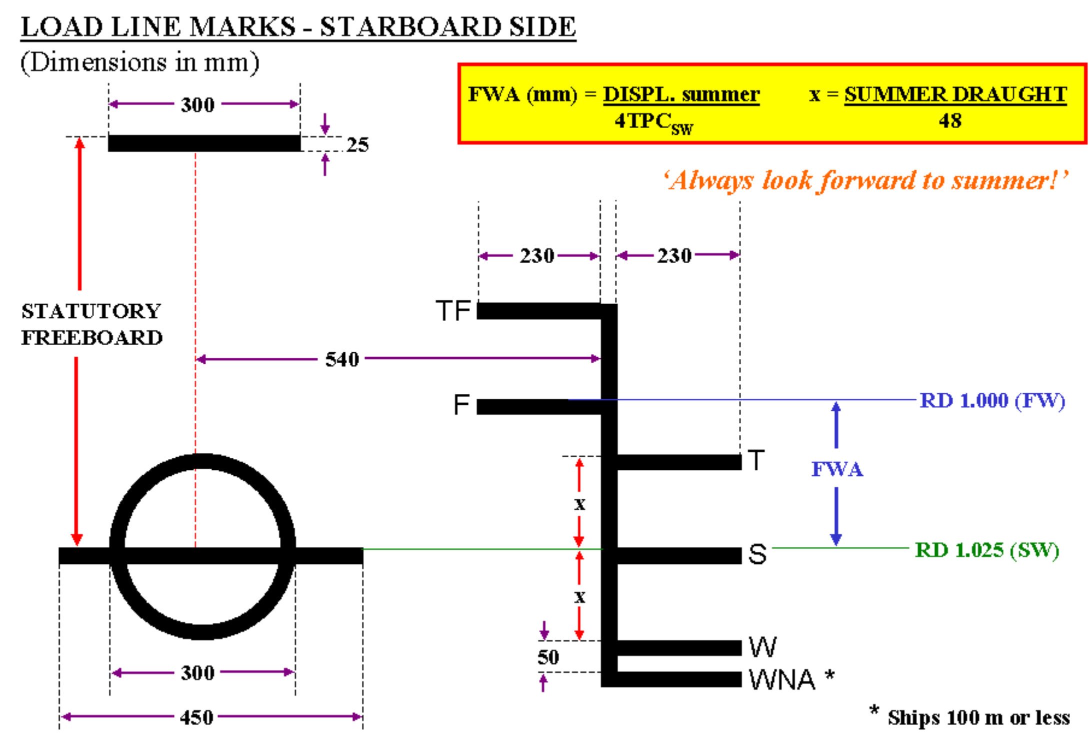
Outcome 1
LESSON 5
Load Line Calculations



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LOAD LINE CALCULATIONS

Introduction

Most ships will be assigned a ***minimum freeboard*** and a corresponding set of load lines. These will be permanently marked on each side of the ship (Certain classes of ship are exempt from these requirements).

Load lines assigned to a ship correspond to ocean areas or ‘zones’. Oceans around the world are divided into these zones in terms of both geographical location and time of year (season). By ensuring that the appropriate seasonal load line mark is not submerged at sea in salt water (RD 1.025) the ship will always have the necessary reserve buoyancy to ensure seaworthiness.

To ensure that the appropriate load line is never submerged at sea, it is essential that the learner has a thorough knowledge of the load line markings, their spacing and dimensions. The ability to perform calculations to determine the maximum amount to load is also important, especially to the ship owner, as the absolute maximum cargo in terms of weight should be carried whenever possible. It is also essential that the ship is never ‘overloaded’, as contravention of the conditions of load line assignment will arise, resulting in the ship being unseaworthy with respect to legislative requirements.

Calculating FWA & DWA

SAQ

A ship floats in SW at the summer displacement of 1680 tonnes. If the TPC_{SW} is 5.18, how much will the draught change by if the ship is towed to a berth where the density of the water is 1.000 t/m^3?

Answer

In moving from SW to FW the ship will experience sinkage by an amount equal to the FWA.

$$FWA\ (mm) = \frac{DISPL.\ Summer}{4TPC_{SW}}$$

$$FWA = \frac{1680}{4 \times 5.18} = \underline{81.1\ mm}$$

The draught will increase by 81.1 mm!

SAQ

A ship has a FWA of 200 mm. Calculate the change in draught that will occur if the ship proceeds from SW to a berth where the RD of the dock water is 1.018.

Answer

$$DWA\ (mm) = FWA \times \frac{(1025 - RD\ dock\ water)}{25}$$

Therefore:

$$DWA\ (mm) = 200 \times \frac{(1025 - 1018)}{25}$$

$$DWA = \underline{56\ mm}$$

The draught will increase by 56 mm!

SAQ

A ship is loaded to it's summer displacement and is to proceed down river from a berth where the dock water RD is 1.004 to another berth where the dock water RD is 1.016. If the FWA is 260 mm, calculate the change in draught that will occur and state whether it is an increase or a decrease.

Answer

$$DWA\ (mm) = FWA \times \frac{(RD_{DW1} \sim RD_{DW2})}{25}$$

Therefore:

$$DWA\ (mm) = 260 \times \frac{(1016 - 1004)}{25}$$

$$DWA = \underline{124.8\ mm}$$

The draught will decrease by 125 mm since the ship is moving into more dense water!

Answers need only be to the nearest mm!

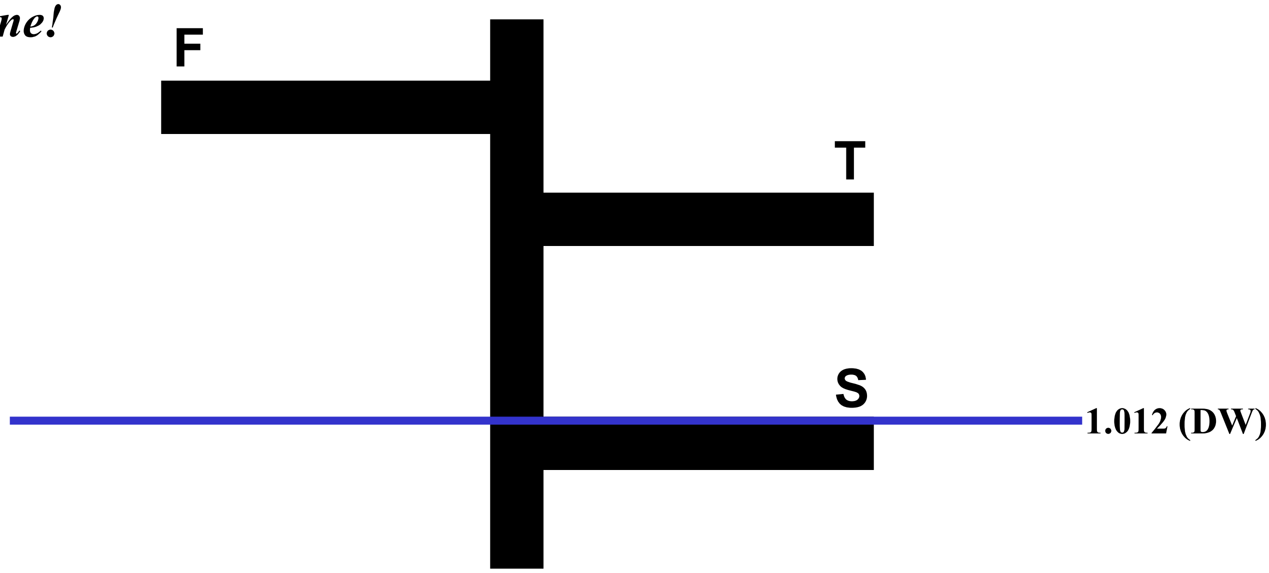
Typical load line calculations

When loading a ship it is desirable to load as much cargo as possible. If the ship is being loaded in water that is less dense than salt water, such as dock water, then allowance must be made for the ship ***rising*** out of the water on reaching the sea, salt water density being 1.025 t/m^3.

Consider the following situation:

A ship is loading in the Summer zone in dock water RD 1.012. It can legally load so that the <u>salt water</u> waterline is level with the top edge of the Summer Load Line.

Consider the situation where the officer in charge loads cargo until the dock water waterline is level with the Summer load line!

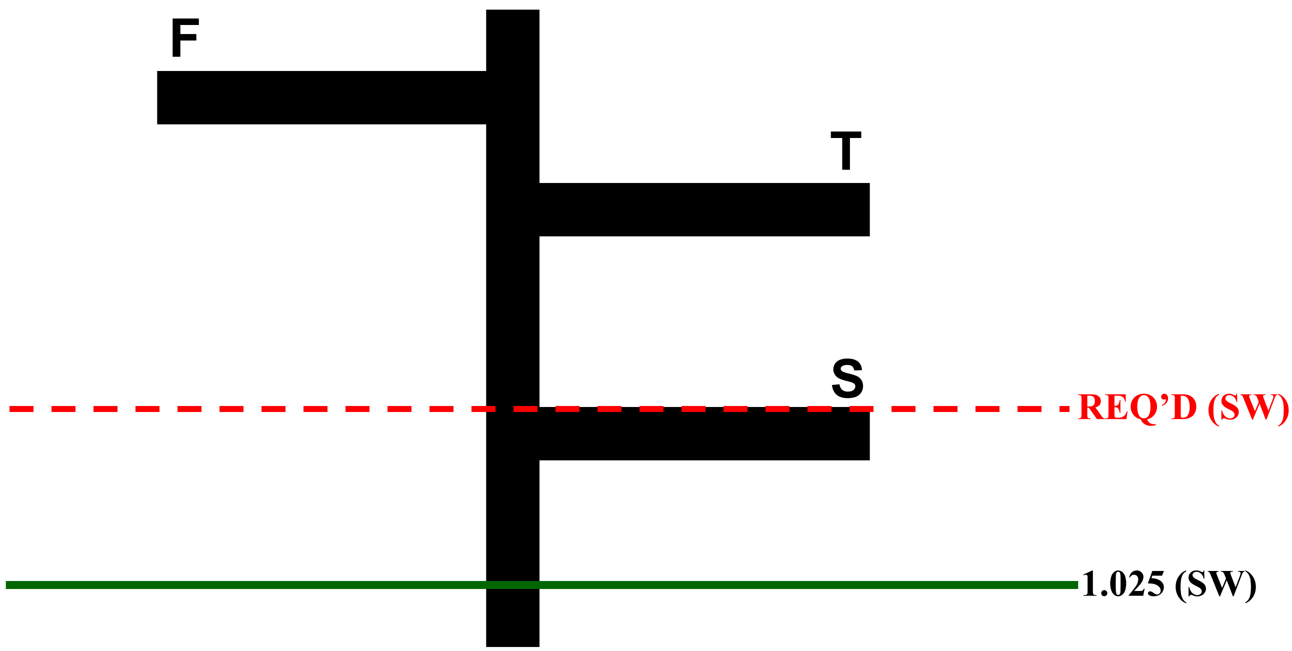


<u>SAQ</u>
What will be the situation when the ship reaches the sea?

<u>Answer</u>

On reaching seawater of greater density, the ship will be light of the summer marks as shown below.

MORE CARGO COULD HAVE BEEN LOADED!



To avoid this situation but to also ensure that too much cargo is never loaded, the amount to safely load can be readily calculated.

The aim of the problem is to ensure that on proceeding to sea the ship rises to the desired seasonal load line mark. This is achieved by considering the Fresh Water Allowance or Dock Water Allowance as appropriate in the calculation.

<u>Example 1</u>

A ship has a summer load draught of 5.80 m, FWA 140 mm and TPC of 21.82. The ship is loading at a berth in dock water RD 1.007 and the present draught is 5.74 m. Calculate the maximum amount of cargo that can still be loaded for the ship to be at the Summer load line mark on reaching the sea allowing for 26 tonnes of fuel still to be loaded prior to sailing.

The following procedure and layout should be followed ***exactly***.

1. Calculate DWA (to the nearest mm).

$$\text{DWA (mm)} = 140 \times \frac{(1025 - 1007)}{25} = 100.8 \text{ mm} \approx 101 \text{ mm}$$

2. Calculate the 'permitted sinkage' in dock water. Always start with the required load line draught and work as follows:

Required Summer draught	(1.025)	5.800 m
DWA		+0.101 m
Required draught	(1.007)	5.901 m
Initial draught	(1.007)	5.740 m
Permitted sinkage	(1.007)	0.161 m

3. Calculate the maximum amount that can still be loaded in dock water, ignoring any allowances for fuel or other items.

$$\text{Permitted sinkage (cms)} = \frac{w}{TPC}$$

Therefore:

$$w = \text{Permitted sinkage (cms)} \times TPC$$

$$w = 16.1 \times \left[21.82 \times \frac{1.007}{1.025}\right] = 345.1 \text{ tonnes}$$

Note that TPC must be corrected for the density of the dock water!

4. Make allowance now for items other than cargo that must be loaded.

Total that can be loaded	345.1 tonnes
Fuel	26.0 tonnes
Maximum cargo to load	***319.1 tonnes***

NOTE

Had the given TPC not been converted for the density of the dock water, the total that could be loaded would have worked out as:

$$w = 16.1 \times 21.82 = 351.3 \text{ tonnes;}$$

resulting in the ship being OVERLOADED BY 6.2 TONNES!

SAQ

A ship is floating in dock water RD 1.002 at a draught of 4.30 m. How much more cargo must be loaded to ensure that the ship will be at the Winter load line mark given that the Winter draught corresponding to the winter displacement is 4.32 m and the TPC is 21.60 and the FWA is 100 mm.

Note that the TPC value given will always be the one that corresponds to salt water for the waterline which is being loaded to.

Answer

1. Calculate DWA

$$DWA\ (mm) = 100 \times \frac{(1025 - 1002)}{25} = 92\ mm$$

2. Calculate the 'permitted sinkage' in dock water.

Required Winter draught	*(1.025)*	*4.320 m*
DWA		*+0.092 m*
Required draught	*(1.002)*	*4.412 m*
Initial draught	*(1.002)*	*4.300 m*
Permitted sinkage	*(1.002)*	*0.112 m*

3. Calculate the maximum amount that can still be loaded in dock water.

$$\text{Permitted sinkage (cms)} = \frac{w}{TPC}$$

Therefore: $w = \text{Permitted sinkage (cms)} \times TPC$

$$w = 11.2 \times \left[21.60 \times \frac{1.002}{1.025}\right] = 236.5\ \text{tonnes}$$

Total that can be loaded ***236.5 tonnes***

Sometimes a question may be a little more difficult whereby a knowledge of the load line dimensions is essential. ***It is essential that a sketch be drawn to fully understand what is being asked!***

Example 2

A ship is floating in dock water RD 1.006. The waterline to port is 12 cm below the lower edge of the 'S' mark and on the starboard side is 4 cm above the upper edge of the 'W' mark. If the summer displacement is 21620 tonnes (corresponding to a draught in salt water of 6.86 m, TPC 18.6), how much cargo remains to be loaded to ensure that the ship will be at the Winter mark in salt water.

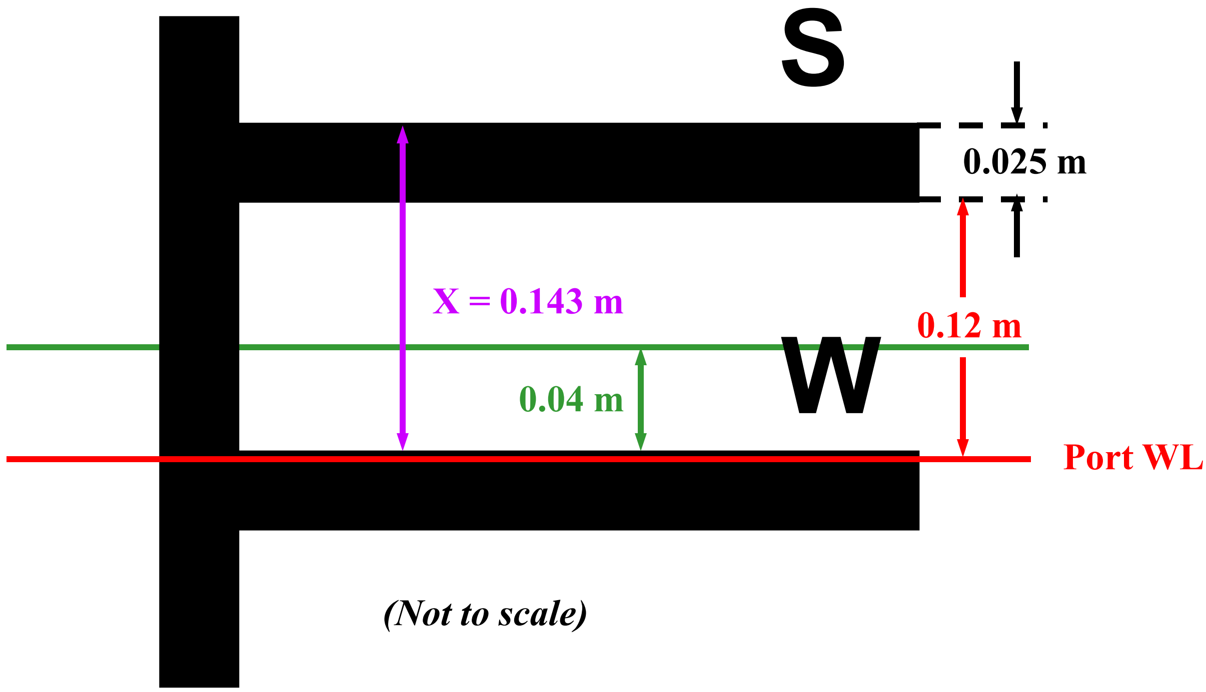
1. ***Identify the load lines that are mentioned in the question ('S' and 'W' in this case); sketch them and enter all known dimensions, calculating them as necessary.***

Thickness of the lines: 25 mm (2.5 cms; 0.025 m)

Distance between Winter and Summer load lines (X):

$$X = \frac{\text{Summer draught}}{48} = \frac{6.86}{48} = 0.143 \text{ m}$$

2. ***Draw a sketch (Port or Starboard side: it does not matter!)***



3. Starting with a known draught (Summer) calculate the draught on each side by applying the distances in the sketch.

	PORT		STBD
Summer draught	6.860		6.860
Line thickness	-0.025	'X'	-0.143
	-0.120		+0.040
Draught each side	6.715 m		6.757 m

4. Calculate initial mean draught.

$$\text{Initial mean draught (RD 1.006)} = \frac{6.715 + 6.757}{2} = 6.736 \text{ m}$$

5. Calculate DWA (in this case FWA must first be calculated.

$$FWA\ (mm) = \frac{DISPL.\ Summer}{4TPC_{SW}} = \frac{61620}{4 \times 18.6} = 290.6\ mm$$

$$DWA\ (mm) = 290.6 \times \frac{(1025 - 1006)}{25} = 220.8\ mm \approx 221\ mm$$

6. Calculate the 'permitted sinkage' in dock water

Required Winter draught (1.025)		6.717 m
DWA		+0.221 m
Required draught	(1.006)	6.938 m
Initial draught	(1.006)	6.736 m
Permitted sinkage	(1.006)	0.202 m

7. Calculate the maximum amount that can still be loaded in dock water.

$$\text{Permitted sinkage (cms)} = \frac{w}{TPC}$$

Therefore: $w = \text{Permitted sinkage (cms)} \times TPC$

$$w = 20.2 \times \left[18.6 \times \frac{1.006}{1.025}\right] = \underline{\boldsymbol{368.8\ tonnes}}$$

NOTE

Steps 5-7 apply to <u>all</u> load line questions and should be strictly followed!