TRIM


7M
80
60
40
20
6M
80
60
40
20
5M
80
60

Trim is measured as the difference between the draft forward and aft.

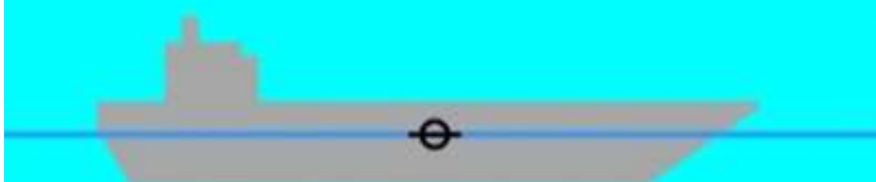
- If difference is zero → ship is on even keel
- If forward draft is greater than aft draft → trimming by bow
- If aft draft is greater than forward draft → trimming by stern

DRAFT

SEAWATER & FRESHWATER

Sea-water draft

Due to the *salinity* of sea water draft in sea water is less than draft in fresh water



Fresh-water draft

Sea water has a higher *specific gravity* than fresh water.

EVEN KEEL

When a vessel is floating on even keel, there is no difference between *draft fore* and *draft* aft

("She is well trimmed").

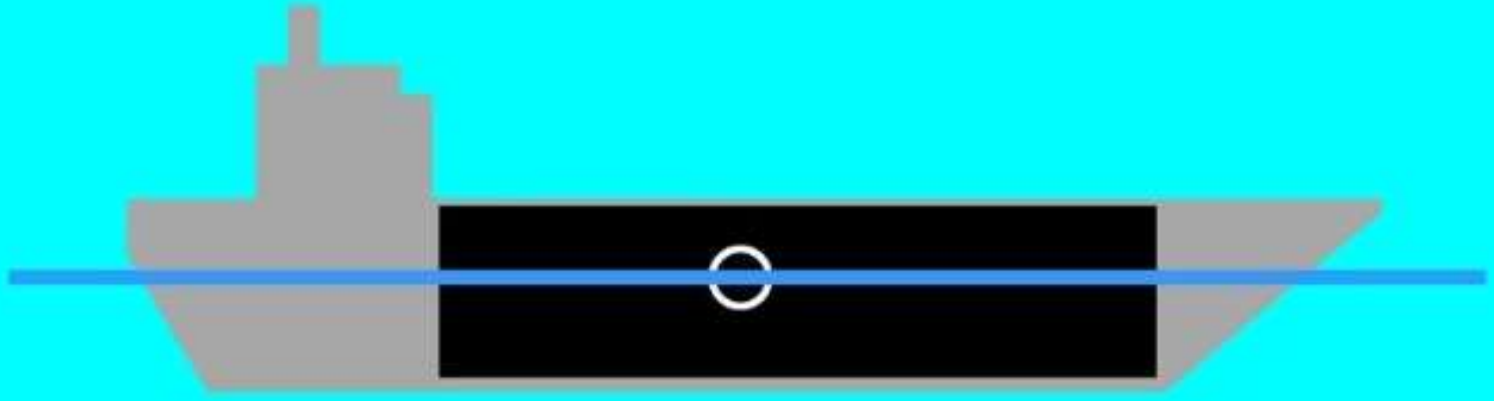
DOWN BY THE HEAD

When draft fore is greater than draft aft she is *down by the head (trimmed by the head).*

DOWN BY THE STERN

When draft aft is greater than draft fore she is *down by the stern (trimmed by the stern).*

FULL AND DOWN



By "full and down" is meant that the vessel is *fully laden* and is floating on her load line.

EFFECT OF ADDING SMALL MASSES

It is useful to assume that when a small mass is added to the ship it is first placed at the centre of flotation and then moved forward or aft to its final position. Thus the effect of an added mass on the draughts may be divided into:

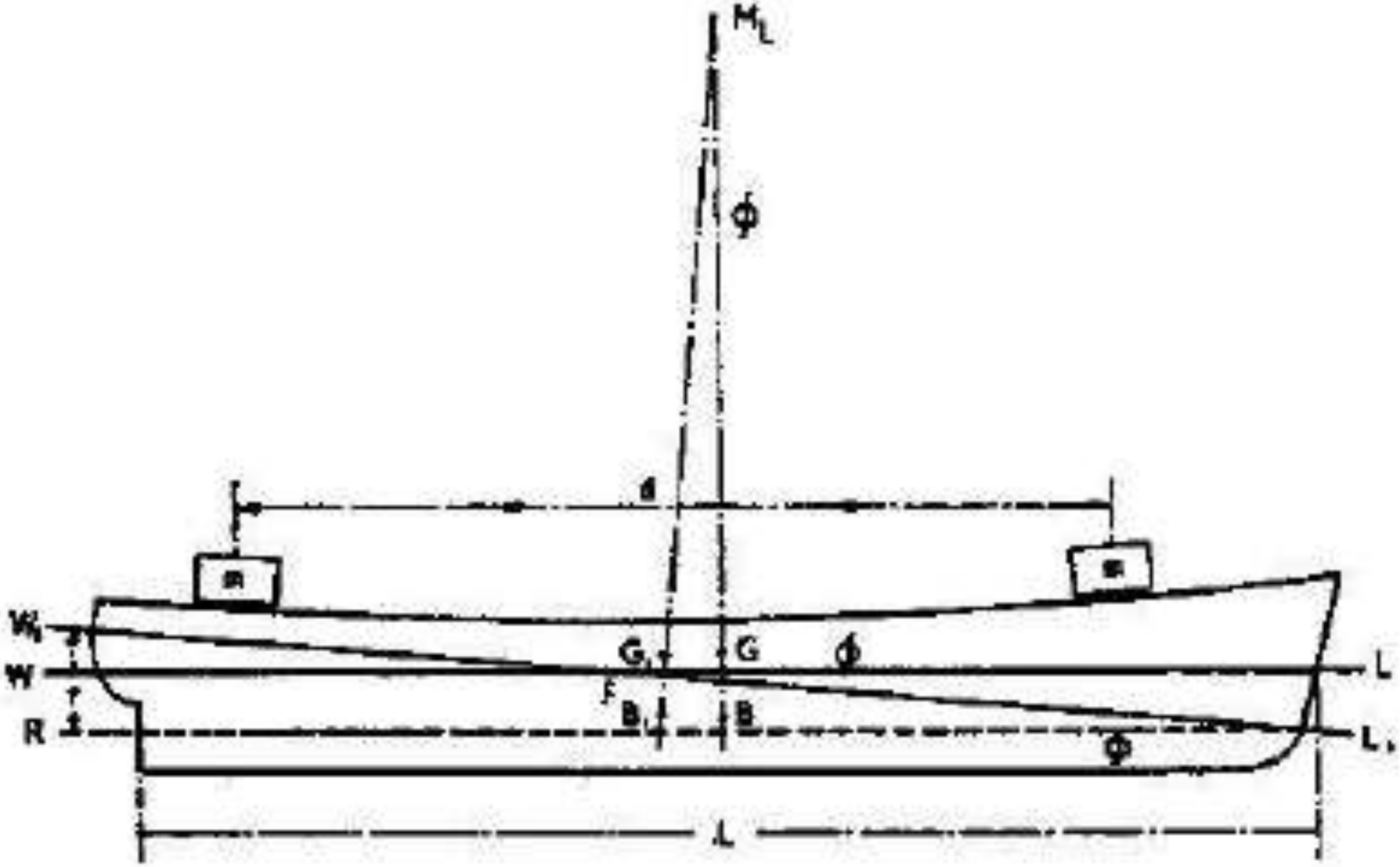
(a) a bodily increase in draught

(b) a change in trim due to the movement of the mass from the centre of flotation to its final position.

The bodily increase in draught may be found by dividing the mass by the TPC.

The change in trim due to any longitudinal movement of mass may be found by considering its effect on the centre of gravity of the ship.

Consider a ship of displacement Δ and length L, lying at waterline WL and having a mass m on the deck (Fig. 6.1). The centre of gravity G and the centre of buoyancy B lie in the same vertical line.



M_L
ϕ
d
m
m
W_1
W
R
G_1
G
ϕ
L
F
B_1
B
L_1
ϕ
L

If the mass is moved a distance d aft, the centre of gravity moves aft from G to G_1, and

$$GG_1 = \frac{m \times d}{\Delta}$$

The ship then changes trim through the centre of flotation F until it lies at waterline W_1L_1. This change in trim causes the centre of buoyancy to move aft from B to B_1, in the same vertical line as G_1. The vertical through B_1 intersects the original vertical through B at M_L, the *longitudinal metacentre*. GM_L is known as the *longitudinal metacentric height*,

$$GM_L = KB + BM_L - KG$$

$$BM_L = \frac{I_F}{\nabla}$$

Where I_F = second moment of area of the waterplane about a transverse axis through the centre of flotation F.

If the vessel trims through an angle ϕ, then

$$GG_1 = GM_L \tan \phi$$

and

$$GM_L \tan \phi = \frac{m \times d}{\Delta}$$

$$\tan \phi = \frac{m \times d}{\Delta \times GM_L}$$

Draw RL_1 parallel to WL.

$$\begin{aligned} \text{Change in trim} &= W_1W + LL_1 \\ &= W_1R \\ &= \frac{t}{100} \text{ m} \end{aligned}$$

Where t = change in trim in cm over length L m.

But $$\tan \phi = \frac{t}{100L}$$

$$\therefore \frac{t}{100L} = \frac{m \times d}{\Delta \times GM_L}$$

$$t = \frac{m \times d \times 100L}{\Delta \times GM_L} \text{ cm}$$

The change in trim may therefore be calculated from this expression. $m \times d$ is known as the trimming moment.

It is useful to know the moment which will cause a change in trim of one cm.

$$m \times d = \frac{t \times \Delta \times GM_L}{100\ L} \text{ tonne m}$$

Let $$t = 1 \text{ cm}$$

Then moment to change trim one cm

$$\text{MCTI cm} = \frac{\Delta \times GM_L}{100L} \text{ tonne m}$$

Change in trim

$$t = \frac{\text{trimming moment}}{\text{MCTI cm}} \text{ cm}$$

$$= \frac{m \times d}{\text{MCTI cm}} \text{ cm by the stern}$$

It is now possible to determine the effect of this change in trim on the end draughts. Since the vessel changes trim by the stern, the forward draught will be reduced while the after draught will be increased.

By similar triangles.

$$\frac{t}{L} = \frac{LL_1}{FL} = \frac{W_1W}{WF}$$

t, LL_1 and W_1W may be expressed in cm while L, FL and WF are expressed in m.

$$\text{Change in draught forward } LL_1 = -\frac{t}{L} \times FL \text{ cm}$$

$$\text{Change in draught aft } W_1W = +\frac{t}{L} \times WF \text{ cm}$$

SOLVED PROBLEM :

A ship of 5000 tonne displacement, 96 m long, floats at draughts of 5.60 m forward and 6.30 m aft. The TPC is 11.5, GM_L 105 m and centre of flotation 2.4 m aft of midships.

Calculate:

(a) the MCTI cm

(b) the new end draughts when 88 tonne are added 31 m forward of midships.

(a)

$$\text{MCTI cm} = \frac{\Delta \times GM_L}{100L}$$

$$= \frac{5000 \times 105}{100 \times 96}$$

$$= 54.69 \text{ tonne m}$$

CONTINUED…..

(b) Bodily sinkage $= \frac{88}{11.5}$

$= 7.65$ cm

$d = 31 + 2.4$

$= 33.4$ m from F

Trimming moment $= 88 \times 33.4$ tonne m

Change in trim $= \frac{88 \times 33.4}{54.69}$

$= 53.74$ cm by the head

Distance from F to fore end $= \frac{96}{2} + 2.4$

$= 50.4$ m

Distance from F to after end $= \frac{96}{2} - 2.4$

$= 45.6$ m

CONTINUED....

$$\text{Change in trim forward} = +\frac{53.74}{96} \times 50.4$$

$$= +\ 28.22 \text{ cm}$$

$$\text{Change in trim aft} = -\frac{53.74}{96} \times 45.6$$

$$= -\ 25.52 \text{ cm}$$

$$\text{New draught forward} = 5.60 + 0.076 + 0.282$$

$$= 5.958 \text{ m}$$

$$\text{New draught aft} = 6.30 + 0.076 - 0.255$$

$$= 6.121 \text{ m}$$

If a number of items are added to the ship at different positions along its length, the total mass and nett trimming moment may be used to determine the final draughts.

SOLVED PROBLEM :

A ship 150 m long has draughts of 7.70 m forward and 8.25 m aft, MCTI cm 250 tonne m, TPC 26 and LCF 1.8 m forward of midships. Calculate the new draughts after the following masses have been added:

50 tonne, 70 m aft of midships
170 tonne, 36 m aft of midships
100 tonne, 5 m aft of midships
130 tonne, 4 m forward of midships
40 tonne, 63 m forward of midships

SOLUTION :

Mass (tonne)	Distance from F (m)	moment forward (tonne m)	moment aft (tonne m)
50	71.8A	—	3590
170	37.8A	—	6426
100	6.8A	—	680
130	2.2F	286	—
40	61.2F	2448	—
Total 490		2734	10 696

Excess moment aft = 10 696 − 2734
= 7962 tonne m

CONTINUED....

$$\text{Change in trim} = \frac{7962}{250}$$
$$= 31.85 \text{ cm by the stern}$$

$$\text{Change in trim forward} = -\frac{31.85}{150}\left(\frac{150}{2} - 1.8\right)$$
$$= -15.54 \text{ cm}$$

$$\text{Change in trim aft} = +\frac{31.85}{150}\left(\frac{150}{2} + 1.8\right)$$
$$= +16.31 \text{ cm}$$

$$\text{Bodily sinkage} = \frac{490}{26}$$
$$= 18.85 \text{ cm}$$

$$\text{New draught forward} = 7.70 + 0.189 - 0.155$$
$$= 7.734 \text{ m}$$

$$\text{New draught aft} = 8.25 + 0.189 + 0.163$$
$$= 8.602 \text{ m}$$

DETERMINATION OF DRAUGHT AFTER ADDITION OF LARGE MASS

When a large mass is added to a ship the resultant increase in draught is sufficient to cause changes in all the hydrostatic details. It then becomes necessary to calculate the final draughts from first principles. Such a problem exists every time a ship loads or discharges the major part of its deadweight.

The underlying principle is that after loading or discharging the vessel is in equilibrium and hence the final centre of gravity is in the same vertical line as the final centre of buoyancy.

For any given condition of loading it is possible to calculate the displacement Δ and the longitudinal position of the centre of gravity G relative to midships.

From the hydrostatic curves or data, the mean draught may be obtained at this displacement, and hence the value of MCTI cm and the distance of the LCB and LCF from midships. These values are calculated for the level keel condition and it is unlikely that the LCB will be in the same vertical line as *G*. Thus a trimming moment acts on the ship. This trimming moment is the displacement multiplied by the longitudinal distance between *B* and *G*, known as the *trimming lever*.

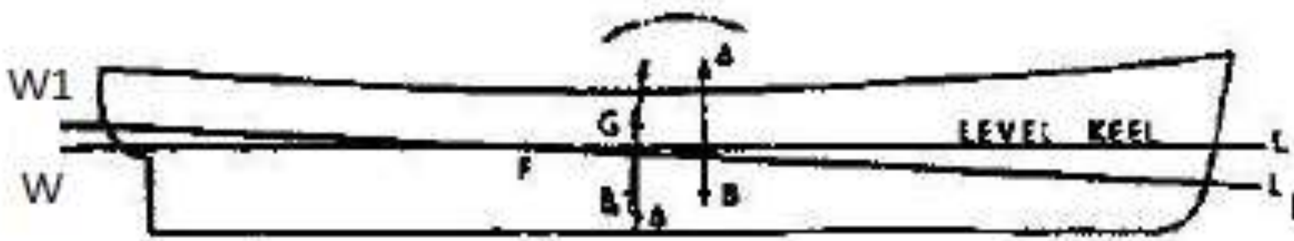


Fig.

The trimming moment, divided by the MCTI cm, gives the change in trim from the level keel condition, i.e. the total trim of the vessel. The vessel changes trim about the LCF and hence it is possible to calculate the end draughts. When the vessel has changed trim in this manner, the new centre of buoyancy B_1 lies in the same vertical line as *G*.

SOLVED PROBLEM:

A ship 125 m long has a light displacement of 4000 tonne with LCG 1.60 m aft of midships. The following items are now added:

Cargo	8500 tonne	Lcg	3.9 m forward of midships
Fuel	1200 tonne	Lcg	3.1 m aft of midships
Water	200 tonne	Lcg	7.6 m aft of midships
Stores	100 tonne	Lcg	30.5 m forward of midships.

At 14 000 tonne displacement the mean draught is 7.80 m, MCT1 cm 160 tonne m, LCB 2.00 m forward of midships and LCF 1.5 m aft of midships.

Calculate the final draughts.

SOLUTION :

Item	mass (t)	Lcg (m)	moment forward	moment aft
Cargo	8500	3.9F	33 150	—
Fuel	1200	3.1A	—	3720
Water	200	7.6A	—	1520
Stores	100	30.5F	3050	—
Lightweight	4000	1.6A	—	6400
Displacement	14 000		36 200	11 640

Excess moment forward = 36 200 − 11 640
= 24 560 tonne m

$$\text{LCG from midships} = \frac{24\,560}{14\,000}$$

$$= 1.754 \text{ m forward}$$

$$\text{LCB from midships} = 2.000 \text{ m forward}$$

$$\text{trimming lever} = 1.754 - 2.000$$

$$= 0.246 \text{ m aft}$$

$$\text{trimming moment} = 14\,000 \times 0.246 \text{ tonne m}$$

$$\text{trim} = \frac{14\,000 \times 0.246}{160}$$

$$= 21.5 \text{ cm by the stern}$$

$$\text{Change in draught forward} = -\frac{21.5}{125}\left(\frac{125}{2} + 1.5\right)$$

$$= -\ 11.0 \text{ cm}$$

$$\text{Change in draught aft} = +\frac{21.5}{125}\left(\frac{125}{2} - 1.5\right)$$

$$= +\ 10.5 \text{ cm}$$

$$\text{Draught forward} = 7.80 - 0.110$$

$$= 7.690 \text{ m}$$

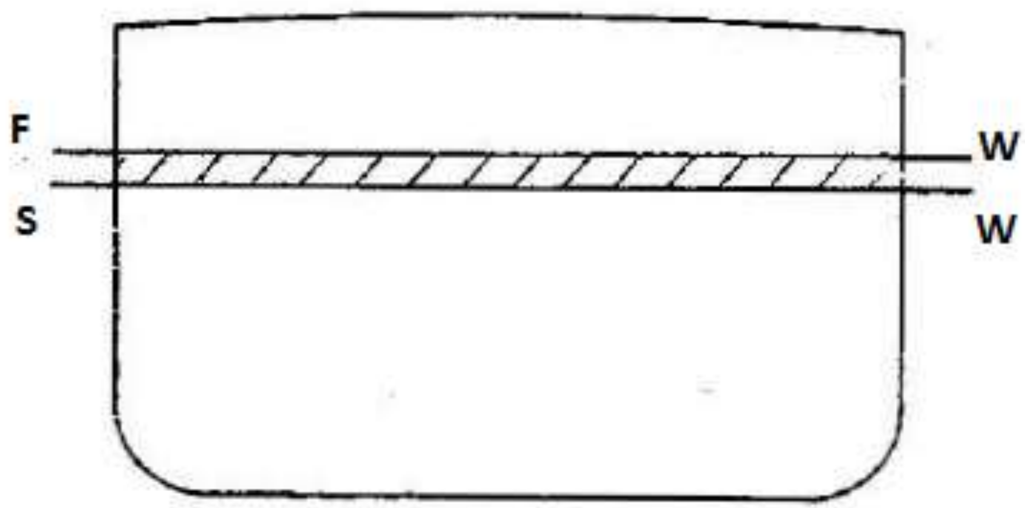
$$\text{Draught aft} = 7.80 + 0.105$$

$$= 7.905 \text{ m}$$

CHANGE IN MEAN DRAUGHT DUE TO CHANGE IN DENSITY OF WATER

The displacement of a ship floating freely at rest is equal to the mass of the volume of water which it displaces. For any given displacement, the volume of water displaced must depend upon the density of the water. When a ship moves from sea water into river water without change in displacement, there is a slight increase in draught.

Consider a ship of displacement Δ tonne, waterplane area A_W m^2, which moves from sea water of ρ_S t/m^3 into river water of ρ_R t/m^3 without change in displacement.



Volume of displacement in sea water

$$\nabla_S = \frac{\Delta}{\rho_S} \text{ m}$$

Volume of displacement in river water

$$\nabla_R = \frac{\Delta}{\rho_R} \text{ m}^3$$

Change in volume of displacement

$$v = \nabla_R - \nabla_S$$

$$= \frac{\Delta}{\rho_R} - \frac{\Delta}{\rho_S}$$

$$= \Delta \left(\frac{1}{\rho_P} - \frac{1}{\rho_S}\right) \text{ m}^3$$

This change in volume causes an increase in draught. Since the increase is small, the waterplane area may be assumed to remain constant and the increase in mean draught may therefore be found by dividing the change in volume by the waterplane area.

$$\text{Increase in draught} = \frac{\Delta}{A_W}\left(\frac{1}{\rho_R} - \frac{1}{\rho_S}\right) \text{ m}$$

$$= \frac{100\ \Delta}{A}\left(\frac{\rho_S - \rho_R}{\rho_R \times \rho_S}\right) \text{cm}$$

The tonne per cm immersion for sea water is given by

$$\text{TPC} = \frac{A_w}{100} \times \rho_S$$

$$\therefore \quad A_W = \frac{100\ \text{TPC}}{\rho_S}\ \text{m}^2$$

Substituting for A_w in the formula for increase in draught:

$$\text{Increase in draught} = \frac{100\ \Delta\ \rho_S}{100\ \text{TPC}}\left(\frac{\rho_S - \rho_R}{\rho_R \times \rho_S}\right)$$

$$= \frac{\Delta}{\text{TPC}}\left(\frac{\rho_S - \rho_R}{\rho_R}\right) \text{cm}$$

A particular case occurs when a ship moves from sea water of 1.025 t/m^3 into fresh water of 1.000 t/m^3, the TPC being given in the sea water.

$$\text{Increase in draught} = \frac{\Delta}{\text{TPC}}\left(\frac{1.025 - 1.000}{1.000}\right)$$

$$= \frac{\Delta}{40\ \text{TPC}}\ \text{cm}$$

This is known as the *fresh water allowance*, used when computing the freeboard of a ship and is the difference between the S line and the F line on the freeboard markings.

SOLVED PROBLEM: 1

A ship of 10 000 tonne displacement has a water-plane area of 1300 m². The ship loads in water of 1.010 t/m³ and moves into water of 1.026 t/m³. Find the change in mean draught.

Since the vessel moves into water of a greater density there will be a reduction in mean draught.

$$\text{Reduction in mean draught} = \frac{100\ \Delta}{A_w}\left(\frac{\rho_S - \rho_R}{\rho_R \times \rho_S}\right)\text{cm}$$

$$= \frac{100 \times 10\,000}{1300}\left(\frac{1.026 - 1.010}{1.010 \times 1.026}\right)$$

$$= 11.88\ \text{cm}$$

When a vessel moves from water of one density to water of a different density, there may be a change in displacement due to the consumption of fuel and stores, causing an additional change in mean draught. If the vessel moves from sea water into river water, it is possible in certain circumstances for the increase in draught due to change in density to be equal to the reduction in draught due to the removed mass. In such a case there will be no change in mean draught.

SOLVED PROBLEM: 2

215 tonne of oil fuel and stores are used in a ship while passing from sea water of 1.026 t/m³ into river water of 1.002 t/m³. If the mean draught remains unchanged, calculate the displacement in the river water.

Let Δ = displacement in river water

Then $\Delta + 215$ = displacement in sea water

Since the draught remains unaltered, the volume of displacement in the river water must be equal to the volume of displacement in the sea water.

$$\nabla_R = \frac{\Delta}{\rho_R}$$

$$= \frac{\Delta}{1.002}\ m^3$$

$$\nabla_S = \frac{\Delta + 215}{\rho_S}$$

$$= \frac{\Delta + 215}{1.026}\ m^3$$

Solution Continued.....

Hence $\nabla_R = \nabla_S$

$$\frac{\Delta}{1.002} = \frac{\Delta + 215}{1.026}$$

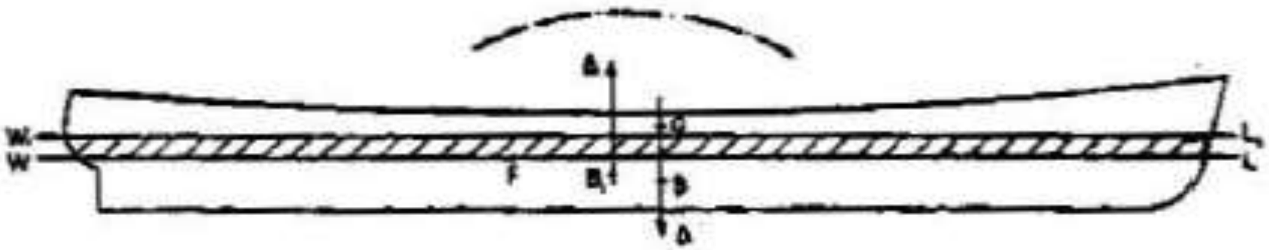
$$1.026\ \Delta = 1.002\ \Delta + 1.002 \times 215$$
$$0.024\ \Delta = 1.002 \times 215$$

$$\Delta = \frac{1.002 \times 215}{0.024}$$

$$= 8976 \text{ tonne}$$

CHANGE IN TRIM DUE TO CHANGE IN DENSITY

When a ship passes from sea water into river water, or vice versa, without change in displacement, there is a change in trim in addition to the change in mean draught. This change in trim is always small.



Consider a ship of displacement Δ lying at waterline WL in sea water of density ρ_s t/m³. The centre of gravity *G* and the centre of buoyancy *B* are in the same vertical line.

If the vessel now moves into river water of ρ_R t/m³, there is a bodily increase in draught and the vessel lies at waterline W_1L_1. The volume of displacement has been increased by a layer of volume *v* whose centre of gravity is at the centre of flotation *F*. This causes the centre of buoyancy to move from *B* to B_1, the centre of gravity remaining at *G*.

Volume of displacement in sea water

$$\nabla_S = \frac{\Delta}{\varrho_S} \text{ m}^3$$

Volume of displacement in river water

$$\nabla_R = \frac{\Delta}{\varrho_R} \text{ m}^3$$

Change in volume of displacement

$$\begin{aligned} v &= \nabla_R - \nabla_S \\ &= \Delta\left(\frac{1}{\varrho_R} - \frac{1}{\varrho_S}\right) \\ &= \Delta\left(\frac{\varrho_S - \varrho_R}{\varrho_R \times \varrho_S}\right) \text{ m}^3 \end{aligned}$$

Shift in centre of buoyancy

$$\begin{aligned} BB_1 &= \frac{v \times FB}{\nabla_R} \\ &= \Delta\left(\frac{\varrho_S - \varrho_R}{\varrho_R \times \varrho_S}\right) FB \times \frac{\varrho_R}{\Delta} \\ &= FB \left(\frac{\varrho_S - \varrho_R}{\varrho_S}\right) \text{ m} \end{aligned}$$

Since B_1 is no longer in line with G, a moment of $\Delta \times BB_1$ acts on the ship causing a change in trim by the head.

$$\text{Change in trim} = \frac{\Delta \times BB_1}{\text{MCTI cm}} \text{ cm}$$

$$= \frac{\Delta \, FB}{\text{MCTI cm}} \left(\frac{\varrho_S - \varrho_R}{\varrho_S} \right) \text{ cm by the head}$$

Note: If the ship moves from the river water into sea water, it will change trim by the stern, and:

$$\text{Change in trim} = \frac{\Delta \, FB}{\text{MCTI cm}} \left(\frac{\varrho_S - \varrho_R}{\varrho_R} \right) \text{ cm by the stern}$$

SOLVED PROBLEM :

A ship 120 m long and 9100 tonne displacement floats at a level keel draught of 6.50 m in fresh water of 1.000 t/m^3. MCT1 cm 130 tonne m, TPC in sea water 16.5, LCB 2.30 m forward of midships. LCF 0.6 m aft of midships.

Calculate the new draughts if the vessel moves into sea water of 1.024 t/m^3 without change in displacement.

SOLUTION:

$$\text{Reduction in mean draught} = \frac{\Delta}{\text{TPC}}\left(\frac{\rho_S - \rho_R}{\rho_R}\right)$$

$$= \frac{9100}{16.5}\left(\frac{1.024 - 1.000}{1.000}\right)$$

$$= 13.24 \text{ cm}$$

$$\text{Change in trim} = \frac{\Delta\ FB}{\text{MCT1 cm}}\left(\frac{\rho_S - \rho_R}{\rho_R}\right)$$

$$= \frac{9100 \times (2.30 + 0.60)}{130}\left(\frac{1.024 - 1.000}{1.000}\right)$$

$$= 4.87 \text{ cm by the stern}$$

CONTINUED….

$$\text{Change forward} = -\frac{4.87}{120}\left(\frac{120}{2} + 0.6\right)$$

$$= -\ 2.46 \text{ cm}$$

$$\text{Change aft} = -\frac{4.87}{120}\left(\frac{120}{2} - 0.6\right)$$

$$= +\ 2.41 \text{ cm}$$

$$\text{New draught forward} = 6.50 - 0.132 - 0.025$$

$$= 6.343 \text{ m}$$

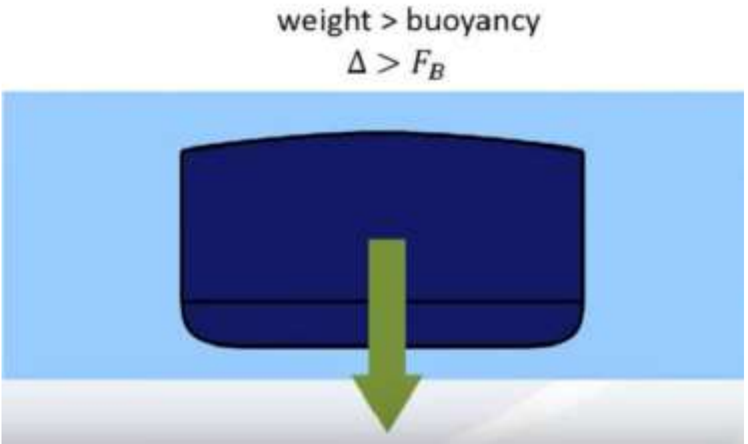
$$\text{New draught aft} = 6.50 - 0.132 + 0.024$$

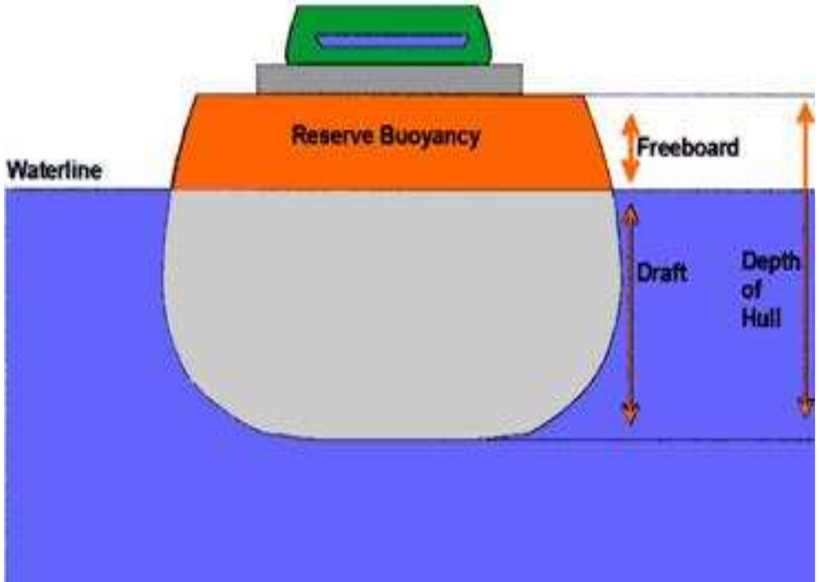
$$= 6.392 \text{ m}$$

CHANGE IN MEAN DRAUGHT DUE TO BILGING

BUOYANCY is the upthrust exerted by the water on the ship and depends upon the volume of water displaced by the ship up to the waterline.

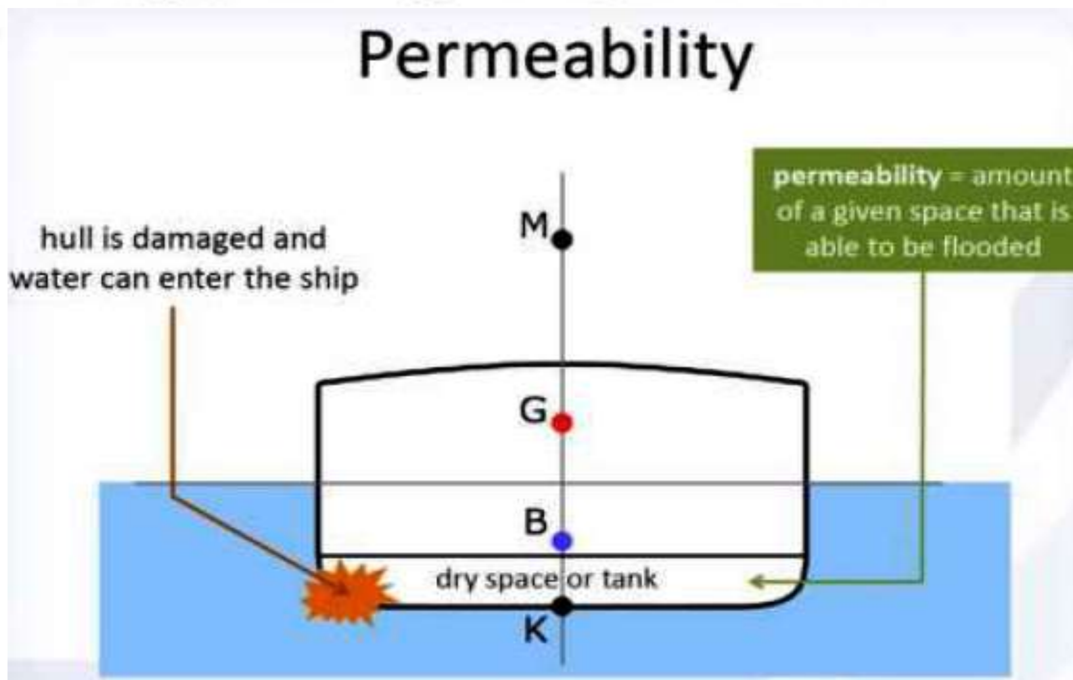
RESERVE BUOYANCY is the potential buoyancy of a ship and depends upon the intact, watertight volume above the waterline. When a mass is added to a ship, or buoyancy is lost due to bilging, the reserve buoyancy is converted into buoyancy by increasing the draught. If the loss in buoyancy exceeds the reserve buoyancy the vessel will sink.





PERMEABILITY μ is the volume of a compartment into which water may flow if the compartment is laid open to the sea, expressed as a ratio or percentage of the total volume of the compartment. Thus, if a compartment is completely empty, the permeability is 100 per cent. The permeability of a machinery space is about 85 per cent and accommodation about 95 per cent. The permeability of a cargo hold varies considerably with the type of cargo, but an average value may be taken as 60 per cent.

The effects of bilging a mid-length compartment may be shown most simply by considering a box barge of length L, breadth B and draught d having a mid-length compartment of length l, permeability μ.

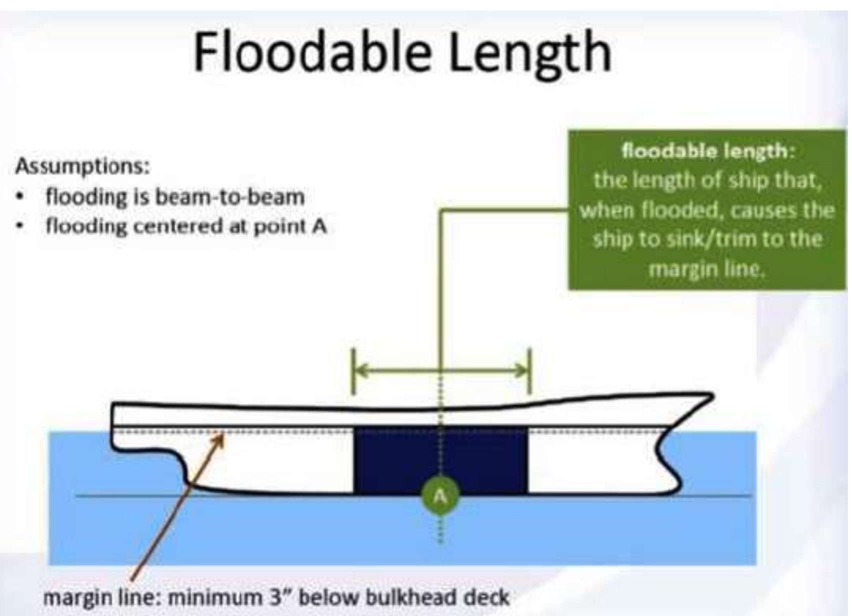


If this compartment is bilged, buoyancy is lost and must be replaced by increasing the draught. The volume of buoyancy lost is the volume of the compartment up to waterline WL, less the volume of water excluded by the cargo in the compartment.

$$\text{Volume of lost buoyancy} = \mu\, lBd$$

This is replaced by the increase in draught multiplied by the area of the intact part of the waterplane, i.e. the area of waterplane on each side of the bilged compartment plus the area of cargo which projects through the waterplane in the bilged compartment.

$$\begin{aligned} \text{Area of intact waterplane} &= (L-l)B + lB(1-\mu) \\ &= LB - lB + lB - \mu lB \\ &= (L - \mu l)B \end{aligned}$$



$$\text{Increase in draught} = \frac{\text{volume of lost buoyancy}}{\text{area of intact waterplane}}$$

$$= \frac{\mu\, lBd}{(L - \mu l)B}$$

$$= \frac{\mu l d}{L - \mu l}$$

μl may be regarded as the *effective length* of the bilged compartment.

SOLVED PROBLEM:

A box barge 30 m long and 8 m beam floats at a level keel draught of 3 m and has a mid-length compartment 6 m long. Calculate the new draught if this compartment is bilged:

(a) with $\mu = 100\%$

(b) with $\mu = 75\%$

(a) Volume of lost buoyancy $= 6 \times 8 \times 3 \text{ m}^3$

Area of intact waterplane $= (30 - 6) \times 8 \text{ m}^2$

$$\text{Increase in draught} = \frac{6 \times 8 \times 3}{24 \times 8}$$

$$= 0.75 \text{ m}$$

$$\text{new draught} = 3 + 0.75$$

$$= 3.75 \text{ m}$$

(b) Volume of lost buoyancy $= 0.75 \times 6 \times 8 \times 3 \text{ m}^3$

Area of intact waterplane $= (30 - 0.75 \times 6) \times 8 \text{ m}^2$

$$\text{Increase in draught} = \frac{0.75 \times 6 \times 8 \times 3}{25.5 \times 8}$$

$$= 0.529 \text{ m}$$

$$\text{New draught} = 3 + 0.529$$

$$= 3.529 \text{ m}$$

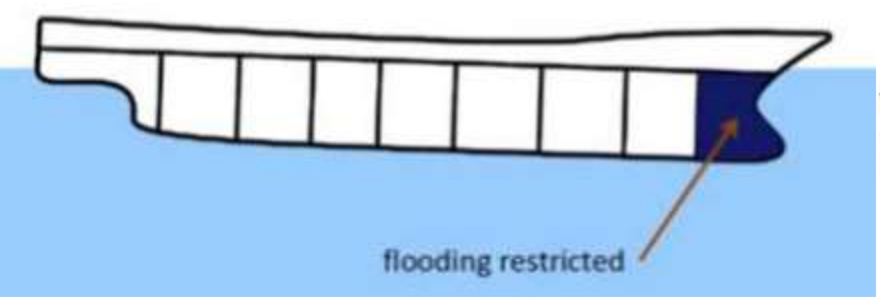
CHANGE IN DRAUGHT DUE TO BILGING AT END COMPARTMENT

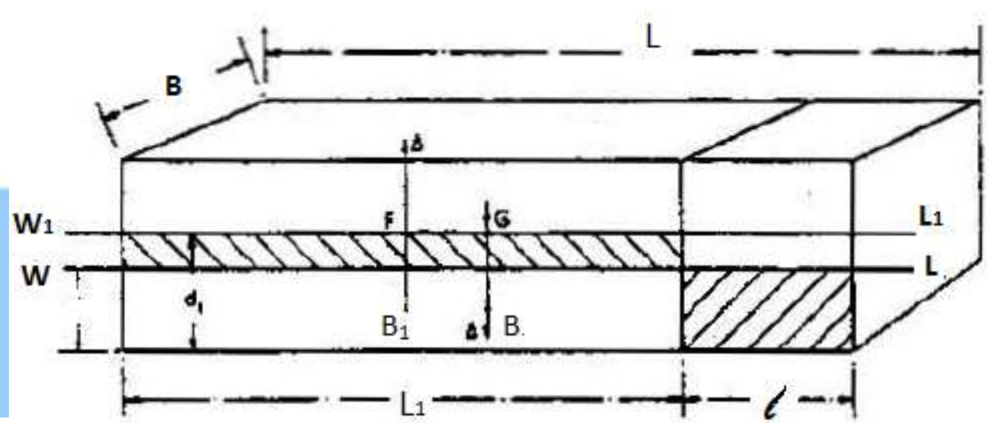
If a bilged compartment does not lie at the mid-length, then there is a change in trim in addition to the change in mean draught.

Consider a box barge of length L, breadth B and draught d having an empty compartment of length l at the extreme fore end.

Before bilging, the vessel lies at waterline WL, the centre of gravity G and the centre of buoyancy B lying in the same vertical line.

After bilging the end compartment, the vessel lies initially at waterline W_1L_1. The new mean draught d_1 may be calculated as shown previously assuming that the compartment is amidships.





The volume of lost buoyancy has been replaced by a layer whose centre is at the middle of the length L_1. This causes the centre of buoyancy to move aft from B to B_1, a distance of $\frac{1}{2}l$. Thus a moment of $\Delta \times BB_1$ acts on the ship causing a *considerable* change in trim by the head. The vessel changes trim about the centre of flotation F which is the centroid of the *intact* waterplane, i.e. the mid-point of L_1.

$$\text{Trimming moment} = \Delta \times BB_1$$

$$\text{Change in trim} = \frac{\Delta \times BB_1}{\text{MCT1 cm}} \text{ cm by the head}$$

$$\text{MCT1 cm} = \frac{\Delta \times GM_L}{100\,L} \text{ tonne m}$$

GM_L must be calculated for the *intact* waterplane

$$KB_1 = \frac{d_1}{2}$$

$$B_1M_L = \frac{L_1^3\,B}{12\;\nabla}$$

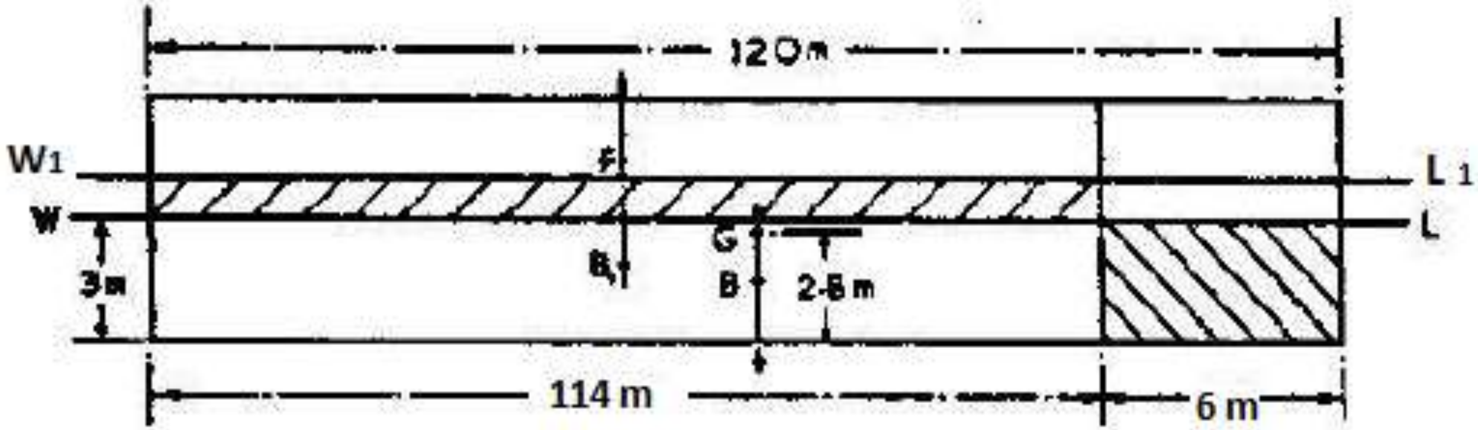
$$\text{where } \nabla = L\,B\,d$$
$$= L_1\,Bd_1$$
$$GM_L = KB_1 + B_1M_L - KG$$

$$\text{Change in trim} = \frac{\Delta \times \frac{1}{2}\,l}{\Delta \times GM_L} \times 100\,L$$

$$= \frac{50\,L\,l}{GM_L} \text{ cm by the head.}$$

SOLVED PROBLEM:

A box barge 120 m long and 8 m beam floats at an even keel draught of 3 m and has an empty compartment 6 m long at the extreme fore end. The centre of gravity is 2.8 m above the keel. Calculate the final draughts if this compartment is bilged.



SOLUTION:

$$\text{Increase in mean draught} = \frac{6 \times 8 \times 3}{(120 - 6) \times 8}$$

$$= 0.158 \text{ m}$$

$$\text{New draught } d_1 = 3.158 \text{ m}$$

$$KB_1 = \frac{d_1}{2}$$

$$= 1.579 \text{ m}$$

$$B_1M_L = \frac{114^3 \times 8}{12 \times 120 \times 8 \times 3}$$

$$= 342.94 \text{ m}$$

$$GM_L = 1.58 + 342.94 - 2.80$$

$$= 341.72 \text{ m}$$

SOLUTION CONTINUED…..

$$\text{Change in trim} = \frac{50 \times 120 \times 6}{341.72}$$

$$= 105.3 \text{ cm by the head}$$

$$\text{Change forward} = + \frac{105.3}{120} \times \left(\frac{120}{2} + 3\right)$$

$$= + 55.3 \text{ cm}$$

$$\text{Change aft} = - \frac{105.3}{120} \times \left(\frac{120}{2} - 3\right)$$

$$= - 50.0 \text{ cm}$$

$$\text{New draught forward} = 3.158 + 0.553$$
$$= 3.711 \text{ m}$$

$$\text{New draught aft} = 3.158 - 0.500$$
$$= 2.658 \text{ m}$$

THANK YOU