

CHAPTER - 1
DENSITY & RELATIVE DENSITY

Chapter – 1

Density & Relative Density

Example 1

Given:-

1. Volume = 400 m³
2. Density = 1.025 t/m³

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Density} * \text{Volume} = \text{Mass}$$

$$\frac{1.025 \text{ t}}{\text{m}^3} * 400 \text{ m}^3 = \text{Mass}$$

410 t	= Mass
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The tank can hold 410 tonnes of SW.

Example 2

Given:-

1. Maximum mass of SW tank can hold = 320 t
2. RD of oil = 0.8 (Density of oil 0.8t/m³)

$$\text{Density of SW} = 1.025 \text{ t/m}^3$$

$$\text{Density of SW} = \frac{\text{Mass of S.W}}{\text{Volume of tank}}$$

$$\text{Volume of tank} = \frac{\text{Mass}}{\text{Density}}$$

$$\text{Volume of tank} = \frac{320 \text{ t} * \text{m}^3}{1.025 \text{ t}}$$

$$\text{Volume of tank} = 312.195 \text{ m}^3 \text{ -----(1)}$$

We know, **Volume of tank = 312.195 m³** (from equation 1)

Now,

$$\text{Density of Oil} = \frac{\text{Mass of oil}}{\text{Volume of tank}}$$

$$\text{Density of Oil} * \text{Volume of tank} = \text{Mass of oil}$$

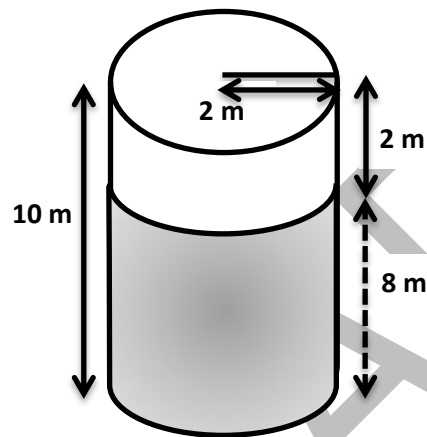
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$$\frac{0.8 \text{ t}}{\text{m}^3} * 312.195 \text{ m}^3 = \text{Mass of oil}$$

249.8 t	= Mass of oil
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The tank can hold 249.8 tonnes of oil.

Example 3



Given:-

1. Height of cylindrical tank = 10 m
2. Radius of cylindrical tank = 3 m
3. Ullage of cylindrical tank = 2 m
4. RD of oil = 0.7 (Density = 0.7 t/m³)

Total height of tank = Sounding of tank + Ullage of tank

Total height of tank – Ullage of tank = Sounding of tank

10 m – 2 m = Sounding of tank

8 m = Sounding of tank(1)

We know, **Sounding of tank = 8 m** (from equation 1)

Volume occupied in cylinder = $\pi * r^2 * h$

Volume occupied in cylinder = $\frac{22 * (3)^2 * 8}{7}$

Volume occupied in cylinder = $\frac{22 * 3 * 3 * 8}{7}$

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Volume occupied in cylinder = 226.286 m^3 -----(2)

We know, **Volume occupied in tank = 226.286 m^3** (from equation 2)

Density of Oil = $\frac{\text{Mass of oil}}{\text{Volume occupied in tank}}$

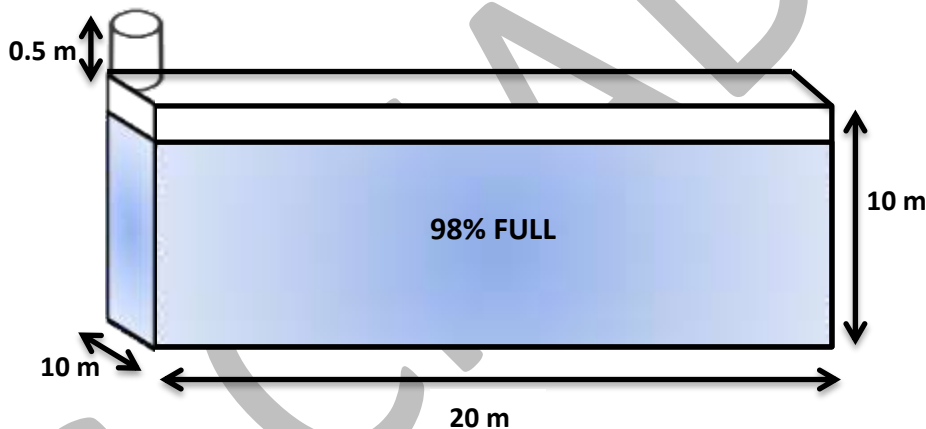
Density of Oil * Volume occupied in tank = Mass of oil

$\frac{0.7 \text{ t}}{\text{m}^3} * 226.286 \text{ m}^3 = \text{Mass of oil}$

158.4 t = Mass of oil

Mass of oil in tank is 158.4 t

Example 4



Given:-

1. Dimensions of tank = $20\text{m} * 10\text{m} * 10\text{m}$ (L * B * H)
2. Height of ullage pipe = 0.5m
3. Percentage of volume of FW in tank = 98%

Density of FW = 1.000 t/m^3

Volume occupied by FW in tank = $\frac{98}{100} * (L * B * H)$

Volume occupied by FW in tank = $\frac{98}{100} * (20\text{m} * 10\text{m} * 10\text{m})$

Volume occupied by FW in tank = 1960 m^3 -----(1)

We know, **Volume occupied in tank = 1960 m^3** (from equation 1)

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$$\text{Density of FW} = \frac{\text{Mass of FW}}{\text{Volume occupied in tank}}$$

$$\text{Density of FW} * \text{Volume occupied in tank} = \text{Mass of FW}$$

$$\frac{1 \text{ t}}{\text{m}^3} * 1960 \text{ m}^3 = \text{Mass of FW}$$

$$1960 \text{ t} = \text{Mass of FW} \text{-----}(2)$$

We know, **Mass of FW in tank = 1960 t** (from equation 2)

$$\text{Volume empty} = 100\% - 98\%$$

$$\text{Volume empty} = 2\%$$

$$\text{Volume empty in tank} = \frac{2}{100} * (L * B * H)$$

$$\text{Volume empty in tank} = \frac{2}{100} * (20\text{m} * 10\text{m} * 10\text{m})$$

$$\text{Volume empty in tank} = 40 \text{ m}^3 \text{-----}(3)$$

We know, **Volume empty in tank = 40 m³** (from equation 3)

$$\text{Volume of empty tank} = L * B * \text{Ullage}$$

$$\frac{\text{Volume of empty tank}}{L * B} = \text{Ullage}$$

$$\frac{40 \text{ m}^3}{20\text{m} * 10\text{m}} = \text{Ullage}$$

$$0.2 \text{ m} = \text{Ullage} \text{-----}(4)$$

We know, **Ullage of tank = 0.2 m** (from equation 4)

$$\text{Total ullage} = \text{Ullage of tank} + \text{Height of ullage pipe}$$

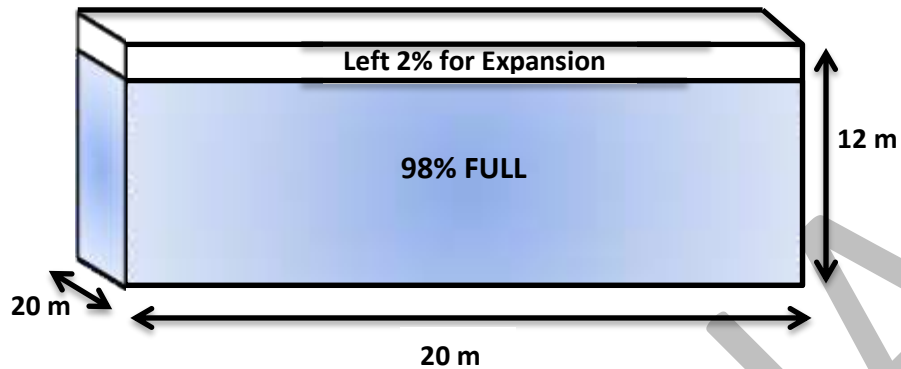
$$\text{Total ullage} = 0.2 \text{ m} + 0.5 \text{ m}$$

Total ullage = 0.7 m

- (a) Mass of FW in tank is 1960 tonnes.
- (b) Ullage of tank is 0.7 m.

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Example 5



Given:-

1. Dimensions of tank = $20\text{m} * 20\text{m} * 12\text{m}$ (L * B * H)
2. Percentage of volume left for expansion = 2% of tank
3. RD of oil = 0.8 (Density of oil = $0.8\text{t}/\text{m}^3$)

$$\text{Volume occupied by Oil in tank} = \frac{98}{100} * (L * B * H)$$

$$\text{Volume occupied by Oil in tank} = \frac{98}{100} * (20\text{m} * 20\text{m} * 12\text{m})$$

$$\text{Volume occupied by Oil in tank} = 4704 \text{ m}^3 \text{-----(1)}$$

We know, **Volume occupied in tank = 4704 m^3** (from equation 1)

$$\text{Density of Oil} = \frac{\text{Mass of Oil}}{\text{Volume occupied in tank}}$$

$$\text{Density of Oil} * \text{Volume occupied in tank} = \text{Mass of Oil}$$

$$\frac{0.8 \text{ t}}{\text{m}^3} * 4704 \text{ m}^3 = \text{Mass of Oil}$$

$$3763.2 \text{ t} = \text{Mass of Oil} \text{-----(2)}$$

We know, **Mass of Oil in tank = 3763.2 t** (from equation 2)

$$\text{Volume empty} = 100\% - 98\%$$

$$\text{Volume empty} = 2\%$$

$$\text{Volume empty in tank} = \frac{2}{100} * (L * B * H)$$

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$$\text{Volume empty in tank} = \frac{2}{100} * (20\text{m} * 20\text{m} * 12\text{m})$$

$$\text{Volume empty in tank} = 96 \text{ m}^3 \text{-----(3)}$$

We know, **Volume empty in tank = 96 m³** (from equation 3)

$$\text{Volume of empty tank} = L * B * \text{Ullage}$$

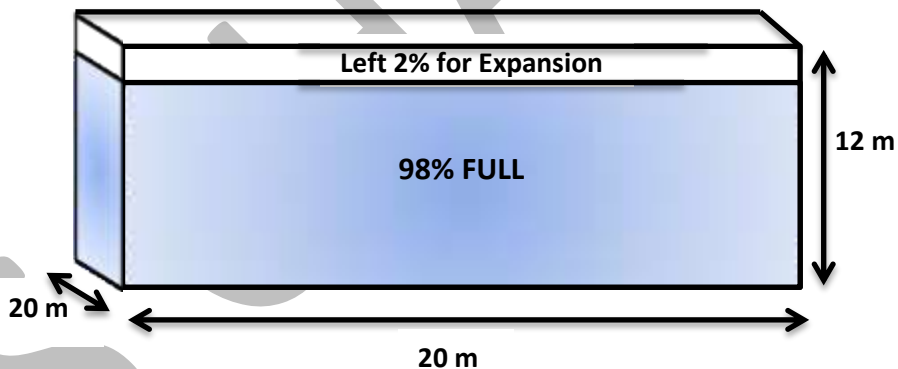
$$\frac{\text{Volume of empty tank}}{L * B} = \text{Ullage}$$

$$\frac{96 \text{ m}^3}{20\text{m} * 20\text{m}} = \text{Ullage}$$

0.24 m	= Ullage
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- (a) Mass of Oil in tank is 3763.2 tonnes.
- (b) Ullage of tank is 0.24 m.

Example 6



Given:-

1. Dimensions of tank = 20m * 20m * 12m (L * B * H)
2. Percentage of volume left for expansion = 2% of oil loaded
3. RD of oil = 0.8 (**Density of oil = 0.8t/m³**)

$$\text{Let Volume occupied in tank} = a \text{-----(1)}$$

$$\text{Volume empty in tank} = \frac{2}{100} * a$$

$$\text{Volume of tank} = L * B * H$$

$$100$$

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Volume of tank = 20m * 20m * 12m

Volume of tank = 4800 m³ -----(2)

We know, **Volume of tank = 4800 m³** (from equation 2)

Total volume of tank = Volume filled + Volume empty

$$4800 \text{ m}^3 = \left(\frac{2}{100} * a \right) + a$$

$$4800 \text{ m}^3 = \left(\frac{2a + 100 a}{100} \right)$$

$$4800 \text{ m}^3 * 100 = 102 a$$

$$480000 \text{ m}^3 = 102 a$$

$$\frac{480000 \text{ m}^3}{102} = a$$

$$4705.882 \text{ m}^3 = a$$

(From equation 1) we know that a = volume occupied in tank

$$4705.882 \text{ m}^3 = \text{volume occupied in tank} \text{ -----(3)}$$

$$\text{Density of Oil} = \frac{\text{Mass of Oil}}{\text{Volume occupied in tank}}$$

Density of Oil * Volume occupied in tank = Mass of Oil

$$\frac{0.8 \text{ t}}{\text{m}^3} * 4705.882 \text{ m}^3 = \text{Mass of Oil}$$

$$3764.7 \text{ t} = \text{Mass of Oil} \text{ -----(4)}$$

We know, **Mass of oil in tank = 3764.7 t** (from equation 4)

Total Volume = Volume occupied + Volume empty

Total Volume – Volume occupied = Volume empty

$$4800 \text{ m}^3 - 4705.882 \text{ m}^3 = \text{Volume empty}$$

$$94.118 \text{ m}^3 = \text{Volume empty} \text{ -----(5)}$$

We know, **Volume empty in tank = 94.118 m³** (from equation 5)

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Volume of empty tank = L * B * Ullage

$\frac{\text{Volume of empty tank}}{L * B} = \text{Ullage}$

$\frac{94.118 \text{ m}^3}{20\text{m} * 20\text{m}} = \text{Ullage}$

0.235 m = Ullage

- (a) Mass of Oil in tank is 3764.7 tonnes.
(b) Ullage of tank is 0.235 m.

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Exercise 1

Answer 1

Given:-

1. Dimensions of tank = 16m * 15m * 6m (l * b * H)
2. RD = 0.78 (Density = 0.78 t/m³)

Volume of tank = L * B * H

Volume of tank = 16m * 15m * 6m

Volume of tank = 1440 m³ -----(1)

We know **volume of tank = 1440 m³** (from equation 1)

Density = $\frac{\text{Mass}}{\text{Volume}}$

Density * Volume = Mass

$\frac{0.78\text{t}}{\text{m}^3} * 1440 \text{m}^3 = \text{Mass}$

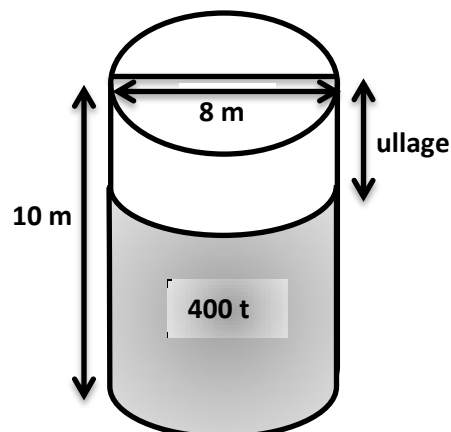
1123.2 t = Mass

The tank can hold 1123.2 tonnes of oil.

Answer 2

Given:-

1. Height of cylindrical tank = 10 m
2. Diameter of cylindrical tank = 8 m
3. Mass of oil poured in tank = 400 t
4. RD of oil = 0.9 (Density = 0.9 t/m³)
5. π = 3.1416



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$$\text{Radius} = \text{Diameter}/2$$

$$\text{Radius} = 8\text{m}/2$$

$$\text{Radius} = 4\text{m}$$

$$\text{Volume of cylinder} = \pi r^2 h$$

$$\text{Volume of cylinder} = 3.1416 \cdot (4\text{m})^2 \cdot 10\text{m}$$

$$\text{Volume of cylinder} = 3.1416 \cdot 16\text{m}^2 \cdot 10\text{m}$$

$$\text{Volume of cylinder} = 502.65 \text{ m}^3$$

$$\text{Weight poured in tank} = 400 \text{ t}$$

$$\text{Volume occupied by oil in tank} = \text{Mass} / \text{Density}$$

$$\text{Volume occupied by oil in tank} = 400 / 0.9$$

$$\text{Volume occupied by oil in tank} = 444.444 \text{ m}^3$$

$$\text{Volume left in tank} = \text{Total volume} - \text{volume occupied}$$

$$\text{Volume left in tank} = 502.656 \text{ m}^3 - 444.444 \text{ m}^3$$

$$\text{Volume left in tank} = 58.212 \text{ m}^3$$

$$\text{Volume left in tank} = \pi r^2 h$$

$$58.212 \text{ m}^3 = 3.1416 \cdot (4\text{m})^2 \cdot h$$

$$58.212 \text{ m}^3 = 3.1416 \cdot 16\text{m}^2 \cdot h$$

$$\boxed{1.158 \text{ m} = h}$$

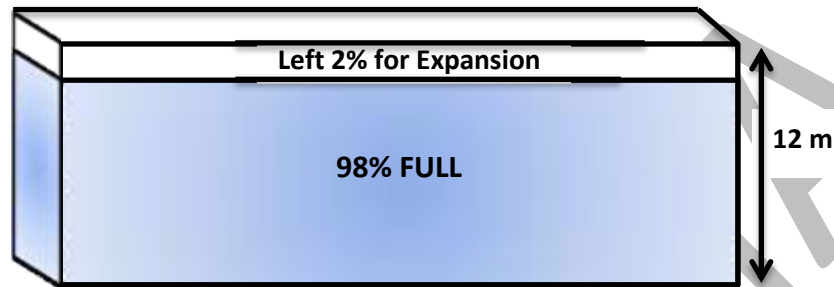
The ullage of tank is 1.158m

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Answer 3

Given:-

1. Volume of tank = 2400m^3
2. Depth of tank = 12m
3. RD of oil = 0.7
4. Percentage of volume left for expansion = 2% of the volume of tank



$$\text{Volume left for expansion} = \frac{2 \times (2400\text{m}^3)}{100}$$

$$\text{Volume left for expansion} = 48\text{m}^3$$

$$\text{Volume of oil in tank} = \text{Total volume of tank} - \text{Volume left for expansion}$$

$$\text{Volume of oil in tank} = 2400\text{m}^3 - 48\text{m}^3$$

$$\text{Volume of oil in tank} = 2352\text{m}^3$$

$$\text{Mass of oil in tank} = 2352 \times 0.7$$

$$\text{Mass of oil in tank} = 1646.4 \text{ t}$$

$$\text{Volume of tank} = L \times B \times H$$

$$2400\text{m}^3 = L \times B \times 12\text{m}$$

$$200 \text{ m}^2 = L \times B$$

$$\text{Volume left for expansion} = L \times B \times H$$

$$48\text{m}^3 = 200\text{m}^2 \times H$$

$$0.24 \text{ m} = H$$

(a) Mass of Oil in tank is 1646.4 tonnes.

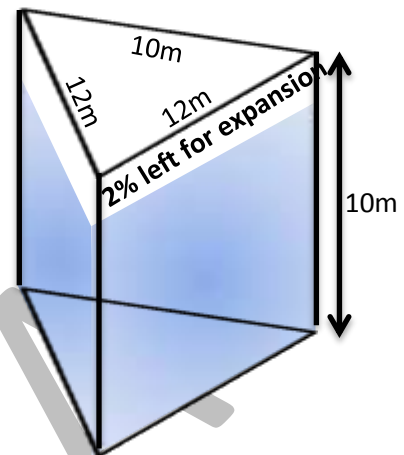
(b) Ullage of tank is 0.24 m.

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Answer 4

Given:-

1. Height of tank = 10m
2. Sides of triangle = 12m, 12m, 10m
3. RD of oil = 0.8
4. Volume left for expansion = 3% of volume of oil



$$\text{Surface area of isosceles triangle} = \frac{b \cdot \sqrt{4a^2 - b^2}}{4}$$

$$\text{Surface area of isosceles triangle} = \frac{10 \cdot \sqrt{4 \cdot (12)^2 - (10)^2}}{4}$$

$$\text{Surface area of isosceles triangle} = \frac{10 \cdot \sqrt{576 - 100}}{4}$$

$$\text{Surface area of isosceles triangle} = \frac{10 \cdot \sqrt{476}}{4}$$

$$\text{Surface area of isosceles triangle} = 54.544 \text{m}^2$$

$$\text{Volume of tank} = \text{Surface area of triangle} \cdot \text{Height}$$

$$\text{Volume of tank} = 54.544 \text{m}^2 \cdot 10 \text{m}$$

$$\text{Volume of tank} = 545.44 \text{m}^3$$

$$\text{Let volume of oil in tank} = a$$

$$\text{Volume left for expansion} = 0.03 \cdot a$$

$$\text{Total volume of tank} = \text{Volume of oil} + \text{Volume left for expansion}$$

$$545.44 \text{m}^3 = a + 0.03a$$

$$545.44 \text{m}^3 = 1.03 a$$

$$529.553 \text{m}^3 = a$$

$$\text{Volume of oil in tank} = 529.553 \text{m}^3$$

$$\text{Mass of oil in tank} = \text{RD} \cdot \text{Volume of oil}$$

$$\text{Mass of oil in tank} = 0.8 \cdot 529.553$$

$$\text{Mass of oil in tank} = 423.6 \text{ t}$$

$$\text{Volume of tank} = \text{Volume of oil} + \text{Volume left for expansion}$$

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$15.887\text{m}^3 = \text{Volume left for expansion}$

Volume left for expansion = Surface area of triangle * ullage

$$15.887\text{m}^3 = 54.544\text{m}^2 * \text{ullage}$$

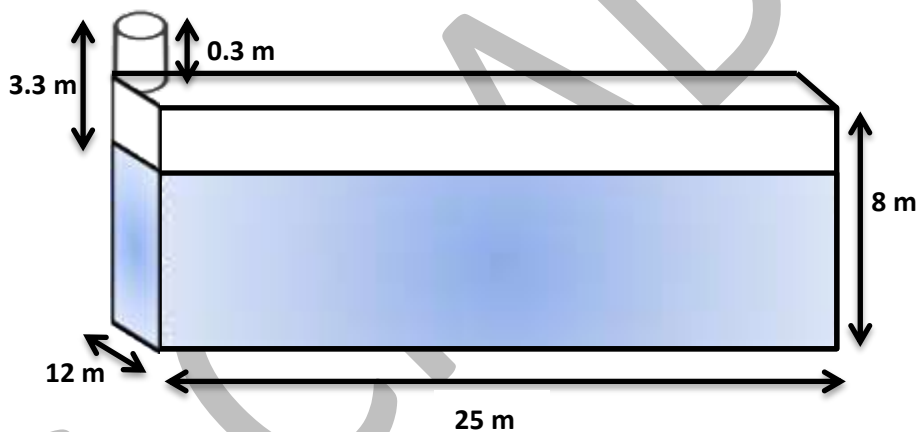
$$\boxed{0.291\text{m} = \text{ullage}}$$

- (a) Mass of Oil in tank is 423.6 tonnes.
- (b) Ullage of tank is 0.291 m.

Answer 5

Given:-

1. Measurement of tanks = $25\text{m} * 12\text{m} * 8\text{m}$
2. Height of ullage pipe above tank = 0.3m
3. Final ullage of tank = 3.3m



RD of seawater = 1.025

Final ullage = Ullage of tank + ullage of pipe

$$3.3\text{m} = \text{ullage of tank} + 0.3\text{m}$$

$$\mathbf{3.0\text{m} = \text{ullage of tank}}$$

Height of tank = Ullage of tank + Sounding of tank

$$8\text{m} = 3\text{m} + \text{Sounding of tank}$$

$$5\text{m} = \text{sounding of tank}$$

Volume occupied in tank = $L * B * H$

$$\text{Volume occupied in tank} = 25\text{m} * 12\text{m} * 5\text{m}$$

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Volume occupied in tank = 1500m^3

Density of SW = $\frac{\text{Mass}}{\text{Volume}}$

$$1.025 = \frac{\text{Mass}}{1500}$$

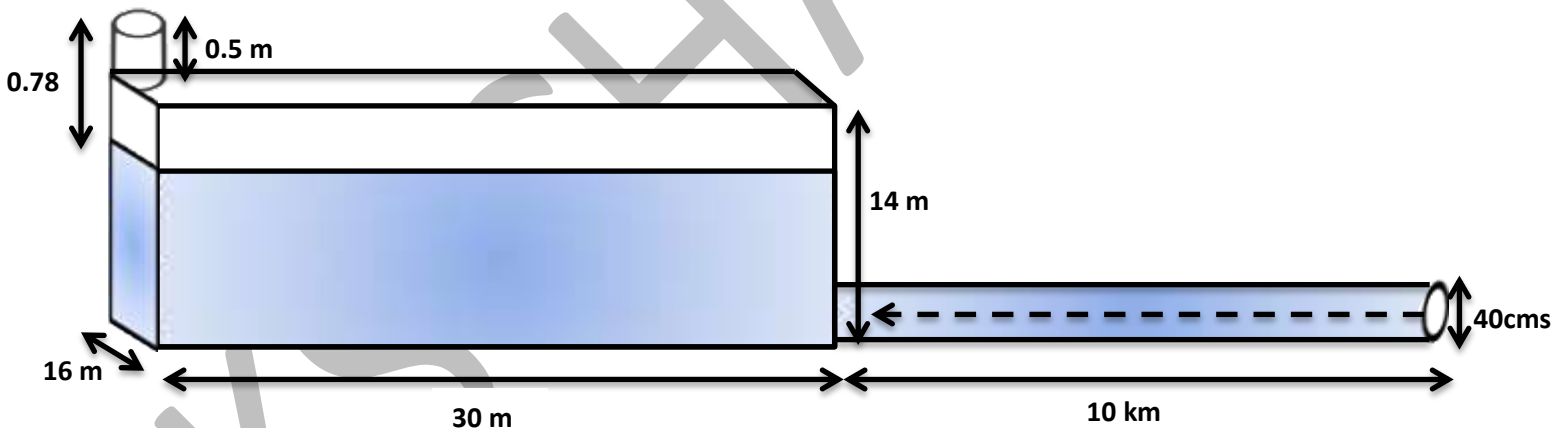
$$\boxed{1537.5 \text{ t} = \text{Mass}}$$

Mass of Oil in tank is 1537.5 tonnes.

Answer 6

Given:-

1. Measurements of tank = $30\text{m} \times 16\text{m} \times 14\text{m}$
2. Height of ullage pipe = 0.5m
3. RD of oil = 0.78
4. Length of pipe line = 10km (**10000m**)
5. Diameter of pipe line = 40 cms (**0.4m**)
6. Final ullage = 0.78m
7. $\pi = 3.1416$



Final ullage = Ullage of tank + ullage of pipe

$$0.78\text{m} = \text{ullage of tank} + 0.5\text{m}$$

$0.28 \text{ m} = \text{ullage of tank}$

Height of tank = Ullage of tank + sounding of tank

$$14 \text{ m} = 0.28\text{m} + \text{Sounding of tank}$$

$$13.72\text{m} = \text{sounding of tank}$$

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Volume required to be filled in tank = $L * B * H$

Volume required to be filled in tank = $30m * 16m * 13.72m$

Volume required to be filled in tank = $6585.6m^3$

Density = Mass / Volume

$0.78 = \text{Mass} / \text{Volume}$

$0.78 * 6585.6 = \text{Mass}$

$5136.8t = \text{Mass}$

Radius of pipeline = Diameter of pipeline/2

Radius of pipeline = $0.4m/2$

Radius of pipeline = $0.2m$

Volume of pipeline = $\pi r^2 h$

Volume of pipeline = $3.1416 * (0.2m)^2 * 10000m$

Volume of pipeline = $1256.64m^3$

Volume required to be filled in tank = Volume in tank + volume of pipeline

$6585.6m^3 = \text{Volume in tank} + 1256.64m^3$

$5328.96m^3 = \text{Volume in tank}$

Total volume of tank = $L * B * H$

Total volume of tank = $30m * 16m * 14m$

Total volume of tank = $6720m^3$

Total volume of tank = Volume in tank + empty volume

$6720m^3 = 5328.96m^3 + \text{empty volume}$

$1391.04m^3 = \text{empty volume}$

Empty volume = $L * B * H$

$1391.04m^3 = 30m * 16m * H$

$2.898m = H$

Final ullage at which the valve of the refinery must be shut = Ullage of tank + height of ullage pipe

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Final ullage at which the valve of the refinery must be shut = 2.898m + 0.5 m

Final ullage at which the valve of the refinery must be shut = 3.398m

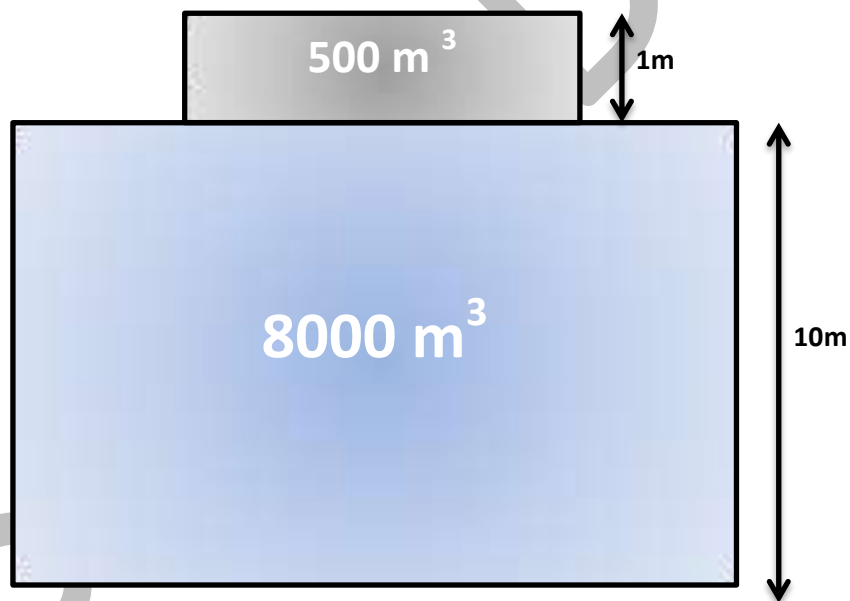
(a) Mass of Oil in tank is 5136.8 tonnes.

(b) Ullage at which the valve of the refinery must be shut = 3.398m

Answer 7

Given:-

1. Height of tank = 10m
2. Height of trunkway = 1m
3. Volume of tank = 8000m³
4. Volume of trunkway = 500m³
5. Mass of oil to be loaded = 5320 t
6. RD of oil = 0.7



Density = Mass/ Volume

Volume of vegetable oil = Mass of vegetable oil / Density

Volume of vegetable oil = 5320/0.7

Volume of vegetable oil = 7600m³

Volume of tank = L * B * H

8000m³ = L * B * 10m

800m² = L*B

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Volume left in tank = Total volume of tank – Volume occupied by oil

$$\text{Volume left in tank} = 8000\text{m}^3 - 7600\text{m}^3$$

$$\text{Volume left in tank} = 400\text{m}^3$$

Volume left in tank = L * B * ullage

$$400\text{m}^3 = L * B * \text{ullage}$$

$$400\text{m}^3 = 800\text{m}^2 * \text{ullage}$$

$$0.5\text{m} = \text{ullage}$$

Total ullage = Ullage of tank + ullage of trunkway

$$\text{Total ullage} = 0.5\text{m} + 1\text{m}$$

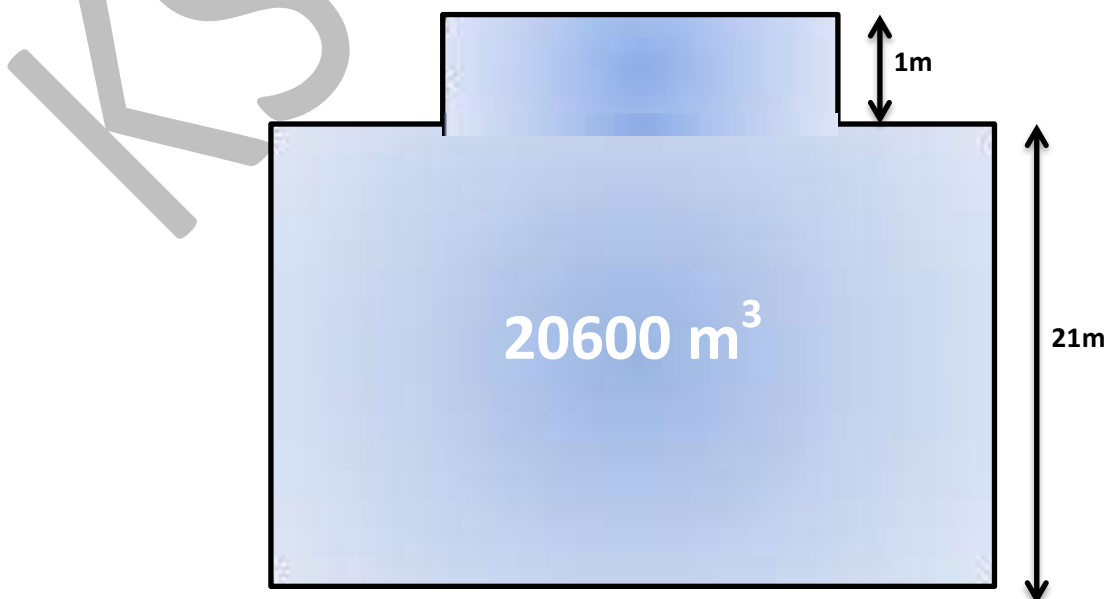
$$\text{Total ullage} = 1.5\text{m}$$

Ullage of tank after loading is 1.5m

Answer 8

Given:-

1. Height of tank = 21m
2. Height of trunkway = 1m
3. total volume of tank (including trunkway) = 20600m³
4. Volume of trunkway = 600m³
5. Mass of oil to be loaded = 16320 t
6. RD of oil = 0.8



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Density = Mass/ Volume

Volume of vegetable oil = Mass of vegetable oil / Density

Volume of vegetable oil = 16320/0.8

Volume of vegetable oil = 20400m³

Volume of trunkway = L * B * H

600m³ = L * B * 1m

600 m² = L*B

Volume left in tank = Total volume of tank – Volume occupied by oil

Volume left in tank = 20600m³ – 20400m³

Volume left in tank = 200m³

Volume left in tank = L * B * ullage

200m³ = L * B * ullage

200m³ = 600m² * ullage

0.333m = ullage

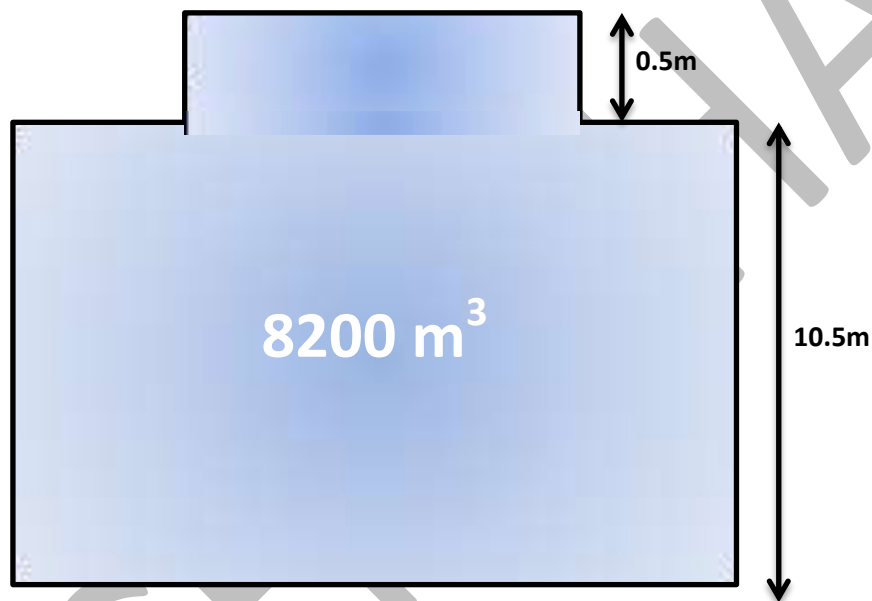
Ullage of tank after loading is 0.333m

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Answer 9

Given:-

1. Height of tank = 10.5m
2. Height of trunkway = 0.5m
3. Total volume of tank (including trunkway) = 8200m^3
4. Volume of trunkway = 200m^3
5. Volume left for expansion = 2% of the volume of tank
6. RD of oil = 0.8



$$\text{Volume left for expansion} = \frac{2 \times (8200\text{m}^3)}{100}$$

$$\text{Volume left for expansion} = 164\text{m}^3$$

Volume of oil in tank = Total volume of tank – Volume left for expansion

$$\text{Volume of oil in tank} = 8200\text{m}^3 - 164\text{m}^3$$

$$\text{Volume of oil in tank} = 8036\text{m}^3$$

$$\text{Mass of oil in tank} = 8036 \times 0.8$$

$$\text{Mass of oil in tank} = 6428.8 \text{ t}$$

$$\text{Volume of trunkway} = L \times B \times H$$

$$200\text{m}^3 = L \times B \times 0.5\text{m}$$

$$400 \text{ m}^2 = L \times B$$

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Volume left in tank = $L * B * \text{ullage}$

$$164\text{m}^3 = L * B * \text{ullage}$$

$$164\text{m}^3 = 400\text{m}^2 * \text{ullage}$$

0.41m = ullage

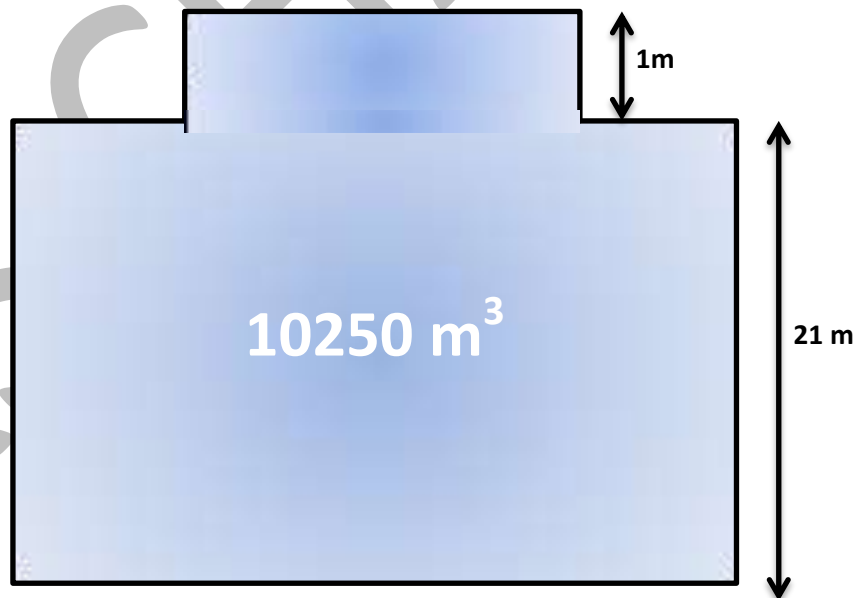
(a) Mass of Oil in tank is 6428.8 tonnes.

(b) Ullage of tank is 0.41 m.

Answer 10

Given:-

1. Height of tank = 21 m
2. Height of trunkway = 1m
3. Total volume of tank (including trunkway) = 10250m^3
4. Volume of trunkway = 250m^3
5. Volume left for expansion = 3% of the volume of oil
6. RD of oil = 0.9



Let volume of oil in tank = a

Volume left for expansion = $0.03 * a$

Total volume of tank = Volume of oil + Volume left for expansion

CHAPTER - 1
DENSITY & RELATIVE DENSITY

$$10250 \text{ m}^3 = a + 0.03a$$

$$10250 \text{ m}^3 = 1.03 a$$

$$9951.456 \text{ m}^3 = a$$

$$\text{Volume of oil in tank} = 9951.456 \text{ m}^3$$

$$\text{Mass of oil in tank} = \text{RD} * \text{Volume of oil}$$

$$\text{Mass of oil in tank} = 0.9 * 9951.456$$

$$\text{Mass of oil in tank} = 8956.3 \text{ t}$$

$$\text{Volume of tank only} = \text{Total volume of tank} - \text{Volume of trunkway}$$

$$\text{Volume of tank only} = 10250 \text{ m}^3 - 250 \text{ m}^3$$

$$\text{Volume of tank only} = 10000 \text{ m}^3$$

$$\text{Volume of tank only} = L * B * H$$

$$10000 \text{ m}^3 = L * B * 21$$

$$476.190 \text{ m}^2 = L * B$$

$$\text{Volume left in tank} = \text{Volume of tank} - \text{Volume occupied by oil}$$

$$\text{Volume left in tank} = 10000 \text{ m}^3 - 9951.456 \text{ m}^3$$

$$\text{Volume left in tank} = 48.544 \text{ m}^3$$

$$\text{Volume left in tank} = L * B * \text{ullage}$$

$$48.544 \text{ m}^3 = L * B * \text{ullage}$$

$$48.544 \text{ m}^3 = 476.19 \text{ m}^2 * \text{ullage}$$

$$0.102 \text{ m} = \text{ullage}$$

$$\text{Total ullage} = \text{Ullage of tank} + \text{Ullage of trunkway}$$

$$\text{Total ullage} = 0.102 \text{ m} + 1 \text{ m}$$

$$\text{Total ullage} = 1.102 \text{ m}$$

(a) Mass of Oil in tank is 8956.3 tonnes.

(b) Ullage of tank is 1.102 m.

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