Laboratory Calculations

In the laboratory, we mix small amounts (in grams) so it is necessary to convert field units to small laboratory units.

$$\frac{\mathbf{gm}}{\mathbf{cm^3}} = \frac{\mathbf{Ib}}{\mathbf{bbl}} * \frac{\mathbf{454\ {}^{gm}/_{Ib}}}{\mathbf{3785 \frac{cm^3}{gal} * \frac{42\ gal}{bbl}}} = \frac{\mathbf{1}}{\mathbf{350}}$$

$$\frac{\mathbf{Ib}}{\mathbf{bbl}} = \frac{\mathbf{x\ gm}}{\mathbf{350\ cm^3}} \quad \text{---------- (16)}$$

Where (x gm) is the amount in grams used in the laboratory to match (1 lb) in the field. So, in the laboratory, we work on a volume of liquid equal to 350 cm^3 (1 bbl in field) and we add to it in grams (1 lb in field).

Case-2: Dilution of mud (liquid is added)

* Assume water or oil is used for dilution

$$\mathbf{V_{m2} = V_{m1} + V_L}$$

$$\mathbf{W_{m2} = W_{m1} + W_L}$$

$$\mathbf{\rho_{m2}\ V_{m2} = \rho_{m1}\ V_{m1} + \rho_L V_L}$$

$$\mathbf{\rho_{m2}\ (V_{m1} + V_L) = \rho_{m1}\ V_{m1} + \rho_L V_L}$$

$$\mathbf{\rho_{m2}\ V_{m1} + \rho_{m2}\ V_L = \rho_{m1}\ V_{m1} + \rho_L V_L}$$

$$\mathbf{\rho_{m2}\ V_L - \rho_L V_L = \rho_{m1}\ V_{m1} - \rho_{m2}\ V_{m1}}$$

$$V_L (\rho_{m2} - \rho_L) = V_{m1} (\rho_{m1} - \rho_{m2})$$

$$V_L = V_{m1} \frac{(\rho m1 - \rho m2)}{\rho m2 - \rho_L} \quad \text{---------- (17)}$$

L = Water or oil

Ex.1: A **9** ppg drilling mud composed for Bentonite (sp.gr = **2.5**) and water has volume of **500** bbl was weighted –up by barite (sp.gr = **4.3**) to the density **12** ppg, calculate:

1) Total volume **%** of solid in mud?
2) Total weight **%** of solid in mud?
3) Amount of barite in sack and ton?

Solution:

1) $v_s = \frac{v_{m2}(\rho_{m2} - \rho_{m1})}{\rho_s - \rho_{m1}}$

$$\frac{v_s}{v_{m2}} * 100\% = \frac{\rho_{m2} - \rho_{m1}}{\rho_s - \rho_{m1}} * 100\%$$

Case 1 (v_{m1} water only and v_{m2} water and Bentonite)

For Bentonite $\frac{v_s}{v_{m2}} * 100\% = \frac{9 - 8.33}{20.8 - 8.33} * 100\% = 5.3\%$

Case 2 (v_{m1} water and Bentonite and v_{m2} water, Bentonite, and Barite)

For Barite $\frac{v_s}{v_{m2}} * 100\% = \frac{12 - 9}{35.8 - 12} * 100\% = 12.6\%$

Total volume of solids = 5.3+12.6 = 17.9 %

2) $\rho_s v_s = \frac{\rho_s v_{m2}(\rho_{m2}-\rho_{m1})}{\rho_s-\rho_{m1}}$

$\frac{\rho_s v_s}{\rho_{m2} v_{m2}} * 100\% = \frac{\rho_s(\rho_{m2}-\rho_{m1})}{\rho_{m2}(\rho_s-\rho_{m1})}$

For Bentonite

$\frac{\rho_s v_s}{\rho_{m2} v_{m2}} * 100\% = \frac{20.8*(9-8.33)}{9*(20.8-8.33)} = 12.5\%$

For Barite $\frac{\rho_s v_s}{\rho_{m2} v_{m2}} * 100\% = \frac{35.8*(12-9)}{12*(35.8-12)} = 37.6\%$

Total weight = 12.5+37.6 = 50%

3) $v_s = \frac{v_{m1}(\rho_{m2}-\rho_{m1})}{\rho_s-\rho_{m2}}$

$v_s = \frac{500*(12-9)}{35.8-12} = 63$ bbl

1 bbl of Barite = 15 sack

No. of Barite sack = 15*63 =945 sack

Weight of 1 sack of Barite = 100 Ib

Weight of Barite =$\frac{945*100}{2000} = 47.25$ ton

1 ton = 2000 Ib

Ex.2: Drilling mud has a volume of **1000** bbl and density **9** ppg. Calculate the volume of barite that required increasing density to **14** ppg provided that:

1) The volume of mud remains constant.
2) The volume of mud increase.

Solution:

1) $v_s = \frac{v_{m2}(\rho_{m2}-\rho_{m1})}{\rho_s-\rho_{m1}}$

$v_s = \frac{1000*(14-9)}{35.8-9} = 186.5$ bbl

2) $v_s = \frac{v_{m1}(\rho_{m2}-\rho_{m1})}{\rho_s-\rho_{m2}}$

$v_s = \frac{1000*(14-9)}{35.8-14} = 229.4$ bbl

The final volume = $v_{m1} + v_s = 1000 + 229.4 = 1229.4$ bbl

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Ex.3: 1) How much fresh water must be added to **1000** bbl of **12** ppg mud to read its density **10** ppg.

2) What will be the result volume?

Solution:

$v_w = \frac{v_{m1}(\rho_{m1}-\rho_{m2})}{\rho_{m2}-\rho_w}$

$v_w = \frac{1000*(12-10)}{10-8.33} = 1197$ bbl

The total volume = 1000 + 1197 = 2197 bbl

Ex.4: A well of diameter **12** ½ in (capacity = **0.15** bbl/ft) is drilled by drilling mud of density **9.6** ppg at drilling velocity of **23** ft/min and flow rate **720** gpm, if the density of cutting rock is **20.8** ppg. Find the density of drilling mud in the annulus taking in to account effect of cutting rock?

Solution:

Volume of cutting rock = capacity * drilling velocity = 0.15 * 23 = 3.45 bbl / min

$$= 3.45 \frac{\text{bbl}}{\text{min}} * 42 \frac{\text{gal}}{\text{bbl}} = 144.9 \text{ gal / min}$$

$$v_s = \frac{v_{m1}(\rho_{m2} - \rho_{m1})}{\rho_s - \rho_{m2}}$$

$$144.9 = \frac{720*(\rho_{m2}-9.6)}{20.6-\rho_{m2}}$$

ρ_{m2} = 11.48 ppg

Ex.5: 800 bbls of mud prepared from water and bentonite (vol. % = **5**%). Barite was added and density became **12.5** ppg. Find the amount of barite in tons.

Solution:

$$v_s = \frac{v_{m2}(\rho_{m2}-\rho_{m1})}{\rho_s-\rho_{m1}}$$

$$\frac{v_s}{v_{m2}} * 100\% = \frac{\rho_{m2}-\rho_{m1}}{\rho_s-\rho_{m1}} * 100\%$$

$$0.05 = \frac{\rho_{m2}-8.33}{20.8-8.33} * 100\%$$

ρ_{m2} = 8.9 ppg

$$v_s = \frac{v_{m1}(\rho_{m2}-\rho_{m1})}{\rho_s-\rho_{m2}}$$

$$v_s = \frac{800*(12.5-8.9)}{35.8-12.5} = 123.6 \text{ bbl for Barite}$$

$W_{Br} = \rho_{Br}\, v_{Br}$

= 35.8 *123.6*42 = 185844 Ib

$$w_{Br} = \frac{185844}{2000} = 92.9 \text{ tons}$$

Ex.6: Drilling mud with **16** ppg density. The volume percentage of solids in it is (**32**%). Calculate the percentage of each on in the mud.

Solution:

$W_s + W_{m1} = W_{m2}$

$\rho_s V_s + \rho_{m1} V_{m1} = \rho_{m2} V_{m2}$

$\rho_{bn} V_{bn} + \rho_{br} V_{br} + \rho_{m1} V_{m1} = \rho_{m2} V_{m2}$

$V_{bn} + V_{br} = 32\%$

$V_{bn} = 0.32 - V_{br}$

$V_w = 100\% - 32\% = 68\%$

$20.8*(0.32- V_{br}) + 35.8*V_{br} + 8.33*0.68 = 16*1$

$V_{br} = 24.6\%$

$V_{bn} = 0.32 – 0.24.6 = 7.4\%$

Ex.7: A drilling fluid mud in surface pit of dimensions (12*14*20 ft) and surface connection volume **23** ft^3 had been used to drill a well of depth **7300** ft and diameter **10** in. It composed of water, Bentonite, and filter agent (sp.gr = **1.8**). The percent weight of Bentonite and filter agent to total liquid are (**7**%) and (**75**%) respectively. A diesel oil (sp.gr = **0.8**) was added to the mud and change its density to **8.4** ppg.

Calculate the volumes of water, oil in bbls and amount of Bentonite and filter agent in ton. Assume system volume is fixed.

Solution:

Total volume of system $= 12 * 14 * 20 + \frac{\pi}{4}(10)^2 * \frac{1ft^2}{144in^2} * 7300 + 23 =$

$7362\ ft^3 = 1312$ bbl

Mud density before dilution, $\rho_m = \frac{\sum weight}{\sum volume}$

$\rho_m = \frac{0.07+0.0075+0.9225}{\frac{0.07}{2.5}+\frac{0.0075}{1.8}+\frac{0.9225}{1}} = 1.047 \frac{gm}{cc} = 8.726ppg = \rho_{m2}$

$v_o = \frac{v_{m1}(\rho_{m1}-\rho_{m2})}{\rho_{m2}-\rho_o}$

$v_o = \frac{(v_{m2} - v_o) * (\rho_{m1} - \rho_{m2})}{\rho_{m2} - \rho_o}$

$v_o = \frac{(1312 - v_o) * (8.726 - 8.41)}{8.41 - 6.66}$

v_o = 201.06 bbl

Volume of mud without diesel = 1312 – 201.06 = 1110.94 bbl

Total weight of mud = 1110.94*42*8.726 = 407150 Ib

volume of water $= \frac{407150*0.9225}{8.33*42} = 1073$ bbl

weight of Bentonite $= \frac{407150*0.07}{2000} = 14.25$ ton

weight of filter agent $= \frac{407150*0.0075}{2000} = 1.526$ ton