API (Field) Units Formula Sheet

Section 1. Filled-in Kill Sheet Exercises - Gauge Problem Actions.

Gauge Problem Exercises are constructed from a completed kill sheet 'filled-in' with all relevant volume and pressure calculations.

Each question is based on the strokes, pump rate, drill pipe and casing gauge readings at a specific point in time during a well kill operation. Any one or a combination of these readings could indicate the action required. Options are shown in the multiple-choice answers.

The casing and/or drill pipe pressures will only be relevant to the action if –

- The casing and/or drill pipe pressures given in the question are below the expected pressures, or
- The casing and/or drill pipe pressures given in the question are 70 psi or more above the expected pressures.

Section 2. Calculation Formula.

Abbreviations Used in this Document

bbl/ft	**=**	**Barrels (US) per foot**
bbl/min	**=**	**Barrels (US) per minute**
bbl/stroke	**=**	**Barrels (US) per stroke**
BHP	**=**	**Bottom Hole Pressure**
BOP	**=**	**Blowout Preventer**
ft	**=**	**Feet**
ft/hr	**=**	**Feet per hour**
ft/min	**=**	**Feet per minute**
lbs/bbl	**=**	**Pounds per barrel**
LOT	**=**	**Leak-off Test**
MAASP	**=**	**Maximum Allowable Annular Surface Pressure**
ppg	**=**	**Pounds per gallon**
psi	**=**	**Pounds per square inch**
psi/ft	**=**	**Pounds per square inch per foot**
psi/hr	**=**	**Pounds per square inch per hour**
SICP	**=**	**Shut in Casing Pressure**
SIDPP	**=**	**Shut in Drill Pipe Pressure**
SPM	**=**	**Strokes per minute**
TVD	**=**	**True vertical depth**
0.052	**=**	**Constant factor**

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1. HYDROSTATIC PRESSURE (psi)

Mud Density (ppg) x 0.052 x TVD (ft)

2. PRESSURE GRADIENT (psi/ft)

Mud Density (ppg) x 0.052

3. DRILLING MUD DENSITY (ppg)

$$\frac{\text{Pressure (psi)}}{\text{TVD (ft)} \times 0.052}$$

4. FORMATION PORE PRESSURE (psi)

Hydrostatic Pressure in Drill String (psi) + SIDPP (psi)

5. PUMP OUTPUT (bbl/min)

Pump Displacement (bbl/stroke) x Pump Rate (SPM)

6. ANNULAR VELOCITY (ft/min)

$$\frac{\text{Pump Output (bbl/min)}}{\text{Annular Capacity (bbl/ft)}}$$

7. EQUIVALENT CIRCULATING DENSITY (ppg)

$$\frac{\text{Annular Pressure Loss (psi)}}{\text{TVD (ft)} \times 0.052} + \text{Mud Density (ppg)}$$

8. MUD DENSITY WITH TRIP MARGIN INCLUDED (ppg)

$$\frac{\text{Safety Margin (psi)}}{\text{TVD (ft)} \times 0.052} + \text{Mud Density (ppg)}$$

9. NEW PUMP PRESSURE WITH NEW PUMP RATE (psi) approximate

$$\text{Old Pump Pressure (psi)} \times \left(\frac{\text{New Pump Rate (SPM)}}{\text{Old Pump Rate (SPM)}}\right)^2$$

10. NEW PUMP PRESSURE WITH NEW MUD DENSITY (psi) approximate

$$\text{Old Pump Pressure (psi)} \times \frac{\text{New Mud Density (ppg)}}{\text{Old Mud Density (ppg)}}$$

11. MAXIMUM ALLOWABLE MUD DENSITY (ppg)

$$\frac{\text{Surface LOT Pressure (psi)}}{\text{Shoe TVD (ft)} \times 0.052} + \text{LOT Mud Density (ppg)}$$

12. MAASP (psi)

[Maximum Allowable Mud Density (ppg) – Current Mud Density (ppg)] x 0.052 x Shoe TVD (ft)

13. KILL MUD DENSITY (ppg)

$$\frac{\text{SIDPP (psi)}}{\text{TVD (ft)} \times 0.052} + \text{Original Mud Density (ppg)}$$

14. INITIAL CIRCULATING PRESSURE (psi)

Kill Rate Circulating Pressure (psi) + SIDPP (psi)

15. FINAL CIRCULATING PRESSURE (psi)

$$\text{Kill Rate Circulating Pressure (psi)} \times \frac{\text{Kill Mud Density (ppg)}}{\text{Original Mud Density (ppg)}}$$

16. SHUT IN CASING PRESSURE (psi)

{[Drilling Mud Density (ppg) - Influx Density (ppg)] x 0.052 x Influx Vertical Height (ft)} + SIDPP (psi)

17. BARYTE REQUIRED TO INCREASE DRILLING MUD DENSITY (lb/bbl)

$$\frac{[\text{Kill Mud Density (ppg)} - \text{Original Drilling Mud Density (ppg)}] \times 1500}{35.8 - \text{Kill Mud Density (ppg)}}$$

18. PERCOLATION RATE (ft/hr)

$$\frac{\text{Increase in Surface Pressure (psi/hr)}}{\text{Drilling Mud Density (ppg)} \times 0.052}$$

19. GAS LAWS

$$P_1 \times V_1 = P_2 \times V_2 \qquad P_2 = \frac{P_1 \times V_1}{V_2} \qquad V_2 = \frac{P_1 \times V_1}{P_2}$$

20. PRESSURE DROP PER FOOT TRIPPING DRY PIPE (psi/ft)

$$\frac{\text{Drilling Mud Density (ppg)} \times 0.052 \times \text{Metal Displacement (bbl/ft)}}{\text{Riser/Casing Capacity (bbl/ft)} - \text{Metal Displacement (bbl/ft)}}$$

21. PRESSURE DROP PER FOOT TRIPPING WET PIPE (psi/ft)

$$\frac{\text{Drilling Mud Density (ppg)} \times 0.052 \times \text{Closed End Displacement (bbl/ft)}}{\text{Riser/Casing Capacity (bbl/ft)} - \text{Closed End Displacement (bbl/ft)}}$$

22. LEVEL DROP PULLING REMAINING COLLARS OUT OF HOLE DRY (feet)

$$\frac{\text{Length of Collars (ft)} \times \text{Metal Displacement (bbl/ft)}}{\text{Riser/Casing Capacity (bbl/ft)}}$$

23. LENGTH OF TUBULARS TO PULL DRY BEFORE OVERBALANCE IS LOST (ft)

$$\frac{\text{Overbalance (psi)} \times [\text{Riser/Casing Capacity (bbl/ft)} - \text{Metal Displacement (bbl/ft)}]}{\text{Mud Gradient} \times \text{Metal Displacement (bbl/ft)}}$$

24. VOLUME TO BLEED OFF TO RESTORE BHP TO FORMATION PRESSURE (bbl)

$$\frac{\text{Increase in Surface Pressure (psi)} \times \text{Influx Volume (bbl)}}{\text{Formation Pressure (psi)} - \text{Increase in Surface Pressure (psi)}}$$

25. SLUG VOLUME (bbl) FOR A GIVEN LENGTH OF DRY PIPE

$$\frac{\text{Length of Dry Pipe (ft)} \times \text{Pipe Capacity (bbl/ft)} \times \text{Drilling Mud Density (ppg)}}{\text{Slug Density (ppg)} - \text{Drilling Mud Density (ppg)}}$$

26. PIT GAIN DUE TO SLUG U-TUBING (bbl)

$$\text{Slug Volume (bbl)} \times \left(\frac{\text{Slug Density (ppg)}}{\text{Drilling Mud Density (ppg)}} - 1\right)$$

27. RISER MARGIN (ppg)

$$\frac{[\text{Air Gap (ft)} + \text{Water Depth (ft)}] \times \text{Mud Density (ppg)} - [\text{Water Depth (ft)} \times \text{Sea Water Density (ppg)}]}{\text{TVD (ft)} - \text{Air Gap (ft)} - \text{Water Depth (ft)}}$$

28. BOP CLOSING RATIO

$$\frac{\text{Wellhead Pressure at BOP (psi)}}{\text{Hydraulic Pressure Required to Close (psi)}}$$

29. BOP OPENING RATIO

$$\frac{\text{Wellhead Pressure at BOP (psi)}}{\text{Hydraulic Pressure Required to Open (psi)}}$$

30. HYDROSTATIC PRESSURE LOSS IF CASING FLOAT FAILS

$$\frac{\text{Mud Density (ppg)} \times 0.052 \times \text{Casing Capacity (bbl/ft)} \times \text{Unfilled Casing Height (ft)}}{\text{Casing Capacity (bbl/ft)} + \text{Annular Capacity (bbl/ft)}}$$

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