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

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

1. HYDROSTATIC PRESSURE (psi)
   \[ \text{Mud Density (ppg)} \times 0.052 \times \text{TVD (ft)} \]

2. PRESSURE GRADIENT (psi/ft)
   \[ \text{Mud Density (ppg)} \times 0.052 \]

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)**
   \[
   \frac{\text{Annular Pressure Loss (psi)}}{\text{TVD (ft) x 0.052}} + \text{Mud Density (ppg)}
   \]

8. **MUD DENSITY WITH TRIP MARGIN INCLUDED (ppg)**
   \[
   \frac{\text{Safety Margin (psi)}}{\text{TVD (ft) x 0.052}} + \text{Mud Density (ppg)}
   \]

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)**
    \[
    \frac{\text{Surface LOT Pressure (psi)}}{\text{Shoe TVD (ft) x 0.052}} + \text{LOT Mud Density (ppg)}
    \]

12. **MAASP (psi)**
    \[
    \left[\text{Maximum Allowable Mud Density (ppg)} - \text{Current Mud Density (ppg)}\right] \times 0.052 \times \text{Shoe TVD (ft)}
    \]

13. **KILL MUD DENSITY (ppg)**
    \[
    \frac{\text{SIDPP (psi)}}{\text{TVD (ft) x 0.052}} + \text{Original Mud Density (ppg)}
    \]

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

18. PERCOLATION RATE (ft/hr)
\[
\frac{\text{Increase in Surface Pressure (psi/hr)}}{\text{Drilling Mud Density (ppg)}} \times 0.052
\]

19. GAS LAWS
\[P_1 \times V_1 = P_2 \times V_2\]
\[P_2 = \frac{P_1 \times V_1}{V_2}\]
\[V_2 = \frac{P_1 \times V_1}{P_2}\]

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)

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

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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