Intertek Formula Sheet

Pressure Calculations (psi):

1. Pressure Gradient, psi/ft = Mud Weight, ppg \times 0.052
2. Hydrostatic Pressure, psi = Mud Weight, ppg \times 0.052 \times True Vertical Depth, ft
3. Formation Pressure, psi = Hydrostatic Pressure in Drill String, psi + SIDPP, psi
4. Initial Circulating Pressure, psi = SIDPP, psi + Slow Circulating Rate Pressure (SCRP), psi
5. Final Circulating Pressure, psi = (Kill Weight Mud, ppg \div Original Mud Weight, ppg) \times SCRP, psi
6. Shut In Casing Pressure, psi = SIDPP, psi + [Influx Height ft \times (Mud Gradient, psi/ft - Influx Gradient, psi/ft)]
7. Pump Pressure/Pump Stroke Relationship, psi = (New SPM \div Old SPM)^2 \times Present Pressure, psi
8. Bottom Hole Pressure (static) = Hydrostatic Pressure
9. Bottom Hole Pressure (circulating) = Hydrostatic Pressure + Annular Pressure Loss
10. Bottom Hole Pressure (reverse circ.) = Hydrostatic Pressure + Tubular Pressure Loss

Fluid Weight Calculations (ppg):

11. Mud Weight, ppg = Pressure Gradient, psi/ft \div 0.052
12. Equivalent Mud Weight, ppg = Pressure, psi \div 0.052 \div True Vertical Depth, ft
13. Kill Weight Mud, ppg = (SIDPP, psi \div 0.052 \div T.V.D., ft) + Original Mud Weight, ppg
14. Equivalent Circulating Density, ppg = (Annular Pressure Loss, psi \div 0.052 \div TVD, ft) + OMW, ppg
Shoe/MASP Calculations:

15. Max. Allowable Mud Weight, ppg (Fracture Mud Weight, ppg) = (Surface Leak-Off Pressure psi ÷ 0.052 ÷ Casing Shoe, TVD ft) + Test Mud Weight, ppg

Note: If Fracture Gradient given: MAMW = Fracture Gradient ÷ 0.052

16. New MAASP, psi = (Max Allowable MW, ppg - Current MW, ppg) x 0.052 x Casing Shoe TVD ft

17. FIT Pressure to Test = (FIT, ppg - Current MW, ppg) x 0.052 x Casing Shoe TVD ft

Influx Calculations:

18. Height of Influx, ft = Kick Size, bbls ÷ Open Hole or Annular Capacity, bbl/ft

19. Gradient of Influx, psi/ft = (Mud Weight, ppg x 0.052) - \left(\frac{SICP, \ psi - SIDPP, \ psi}{\text{Influx Height, ft}}\right)

20. Gas Migration Rate, ft/hr = Casing Pressure Increase psi/hr ÷ Fluid Gradient, psi/ft

Subsea Calculations:

21. Loss of Hydrostatic Pressure Due to Loss or Unlatch of Riser, psi = (Riser MW x .052 x Riser Length) - (Water Gradient x Water Depth)

22. Riser Margin, ppg = (Loss of HP Due to Disconnect) ÷ .052 ÷ (TVD - Air Gap - Water Depth)

23. Mud Weight Needed for Planned Disconnect, ppg = Riser Margin + Current MW (note: round up like kill mud)

24. Dynamic Casing Pressure = SICP - Choke Line Friction

25. Dynamic MASP = MASP - Choke Line Friction

Volumetric Calculations:

26. Hp/bbl, psi/bbl = Pressure Gradient, psi/ft ÷ Annular Capacity, bbl/ft

27. Volume to Bleed per Cycle, bbls = Working Pressure Range, psi ÷ Hp/bbl, psi/bbl
Lubrication Calculations – Volume Method:

28. Volume Lubricated, bbls
29. HP Increase, psi
30. Pressure to Bleed Off, psi

\[ \text{Volume Lubricated, bbls} = \text{Strokes pumped} \times \text{Pump output, bbl/stk} \]
\[ \text{HP Increase, psi} = \text{Volume Lubricated, bbls} \times \text{Hp/bbl, psi/bbl} \]
\[ \text{Pressure to Bleed Off, psi} = \text{SICP, psi} - \text{Working Pressure, psi} - \text{HP Increase, psi} \]

Lubrication Calculations – Pressure Method:

31. \[ P_3 = \frac{(P_1)^2}{P_2} \]

\[ P_1 = \text{The original Shut-in Casing Pressure} \]
\[ P_2 = \text{The increased Casing Pressure due to lubricating fluid into the well.} \]
\[ P_3 = \text{Pressure to bleed down to.} \]

Tripping Calculations:

32. Additional Mud Returned By Slug, bbls
33. Total Mud Returned By Slug, bbls
34. Press Drop/ft Tripping Dry Pipe, psi/ft
35. Press Drop/ft Tripping Wet Pipe, psi/ft
36. Level Drop for Pulling Collars Out of the Hole, ft
37. Length of Pipe to Pull Before Well Starts to Flow, ft.
38. New Casing Pressure, psi (Stripping Back to Bottom)
39. Level Drop after Pumping Slug

\[ \text{Additional Mud Returned By Slug, bbls} = \left( \frac{\text{Slug Wt, ppg}}{\text{MW, ppg}} - 1 \right) \times \text{Slug Volume, bbls} \]
\[ \text{Total Mud Returned By Slug, bbls} = \left( \frac{\text{Slug Wt, ppg}}{\text{MW, ppg}} \right) \times \text{Slug Volume, bbls} \]
\[ \text{Press Drop/ft Tripping Dry Pipe, psi/ft} = \frac{\text{Mud Gradient, psi/ft} \times \text{Metal displacement, bbl/ft}}{\text{Drill Pipe Capacity, bbl/ft} + \text{Annular Capacity, bbl/ft}} \]
\[ \text{Press Drop/ft Tripping Wet Pipe, psi/ft} = \frac{\text{Mud Gradient psi/ft} \times \left( \text{Pipe Capacity bbl/ft} + \text{Metal Displacement bbl/ft} \right)}{\text{Annular Capacity bbl/ft}} \]
\[ \text{Level Drop for Pulling Collars Out of the Hole, ft} = \frac{\text{Length of Collars, ft} \times \text{Metal Displacement, bbl/ft}}{\text{Casing Capacity, bbl/ft}} \]
\[ \text{Length of Pipe to Pull Before Well Starts to Flow, ft.} = \frac{\text{Overbalance, psi} \times \left( \text{Casing Capacity, bbl/ft} - \text{Pipe Displacement, bbl/ft} \right)}{\text{Mud Gradient, psi/ft} \times \text{Pipe Displacement, bbl/ft}} \]
\[ \text{New Casing Pressure, psi (Stripping Back to Bottom)} = \text{Old Casing Pressure, psi} + \left[ \left( \text{H}_{\text{BHA}} - \text{H}_{\text{OH}} \right) \times \left( \text{G}_m - \text{G}_l \right) \right] \]
\[ \text{Level Drop after Pumping Slug} = \left( \frac{\text{Slug Weight, ppg} \div \text{Mud Weight, ppg}}{1} \right) \times \text{Slug Volume, bbls} \div \text{Drill Pipe Cap., bbls/ft} \]
Bullheading Calculations:

40. Kill Weight Fluid, ppg:
    \[
    \text{KWF, ppg} = \frac{\text{Reservoir Pressure, psi}}{0.052} \div \text{Depth to Top-Perfs, ft}
    \]
    Or use
    \[
    \text{KWF, ppg} = [\text{SITP, psi} \div 0.052 \div \text{TVD to Top-Perfs, ft}] + \text{Original Fluid Weight, ppg}
    \]

41. Maximum Initial Surface Pressure at pump start-up:
    \[
    \text{Psi} = (\text{Fracture mud density, ppg} - \text{Current fluid density, ppg}) \times 0.052 \times \text{TVD to Top-Perfs, ft}
    \]
    Or use
    \[
    \text{Psi} = \text{Formation Fracture Pressure, psi} - \text{Initial Hydrostatic Pressure, psi}
    \]

42. Maximum Final Surface Pressure with KWF at the perforations:
    \[
    \text{Psi} = (\text{Fracture mud density, ppg} - \text{Kill weight fluid, ppg}) \times 0.052 \times \text{TVD to Top-Perfs, ft}
    \]
    Or use
    \[
    \text{Psi} = \text{Formation Fracture Pressure, psi} - (\text{Kill weight fluid, ppg} \times 0.052 \times \text{TVD to Top-Perfs, ft})
    \]

43. Volume to Bullhead
    \[
    \text{Volume to Bullhead} = \text{Surface Lines, bbls} + \text{Tubing Length, bbls} + (\text{Bottom of Perfs} - \text{Tubing Length}), \text{bbls}
    \]

44. Formation Fracture Pressure, psi = Formation Fracture Gradient, psi/ft \times \text{TVD to Top-Perfs, ft}

45. Initial Hydrostatic Pressure, psi = \text{Formation Pressure, psi} - \text{SITP, psi}

46. Initial Average Fluid Density, ppg = \text{Initial Hydrostatic Pressure, psi} \div 0.052 \div \text{TVD to Top-Perfs, ft}

47. Bullhead SPM to Exceed Gas Migration
    \[
    = (\text{Gas Migration Rate per hour} \div 60) \times \text{Tubing Capacity, bbl/ft} \div \text{Pump Output}
    \]

Temperature Correction Formula for Brines:

48. Fluid Density to Mix, ppg = \text{Fluid Density at Surface Temp, ppg} + [(\text{Avg. Downhole Temp} - \text{Surface Temp}) \times \text{Weight Loss, ppg/degree}]

Example Weight Loss Chart:
(Note: Values will vary based on type of fluid, etc.)

<table>
<thead>
<tr>
<th>Brine weight (ppg)</th>
<th>Weight loss (ppg/°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.4 – 9.0</td>
<td>0.0017</td>
</tr>
<tr>
<td>9.1 – 11.0</td>
<td>0.0025</td>
</tr>
<tr>
<td>11.1 – 14.5</td>
<td>0.0033</td>
</tr>
<tr>
<td>14.6 – 17.0</td>
<td>0.0040</td>
</tr>
<tr>
<td>17.1 – 19.2</td>
<td>0.0048</td>
</tr>
</tbody>
</table>

© 2011 Intertek Consulting & Training Unpublished work. All rights reserved Revised Feb. 3, 2017
Miscellaneous Calculations:

49. Tubular Internal Capacity  =  ID² ÷ 1029.4

50. Volume Delivered gals  =  Bottle Volume, gals x  \[
\left( \frac{\text{Precharge psi}}{\text{Final psi}} \times \frac{\text{Precharge psi}}{\text{System psi}} \right) x \]

51. Boyle’s Law  =  P₁ x V₁ = P₂ x V₂  \[
P₂ = \frac{P₁ x V₁}{V₂} \quad V₂ = \frac{P₁ x V₁}{P₂}
\]

52. Barite, lb/bbl  =  \[
\frac{1500 x (W₂ - W₁)}{35.8 - W₂}
\]

53. Force, lbs  =  Pressure, psi x Diameter² x 0.7854

54. Pressure, psi  =  Force, lbs ÷ Diameter² ÷ 0.7854

55. Tubular Metal Displacement  =  (OD² - ID²) ÷ 1029.4

56. Tubular Closed End Displacement  =  OD² ÷ 1029.4

57. Annular Capacity, bbls/ft  =  (D² - d²) ÷ 1029.4  \(D = \text{Hole Diameter or Casing ID}, \ d = \text{Outside Diameter of Tubular}\)

IADC Rounding Rules:

- When calculating Kill Mud Weight, **ROUND UP** to one decimal place (for example: round up 10.73 ppg to 10.8 ppg; round up 11.03 ppg to 11.1 ppg).
- When calculating Leak Off Test Equivalent Mud Weight, **ROUND DOWN** to one decimal place (for example: round down 11.76 ppg to 11.7 ppg; Round down 13.89 ppg to 13.8 ppg). In other words, take it to only one decimal place with no rounding.
- When calculating Pressure Reduction Schedule, **ROUND DOWN** to a whole number (for example: round down 21.6 psi/100 stks to 21 psi/100 stks).
- If the Kill Mud Weight or Leak Off values are to be used in subsequent calculations, use the rounded value in the future calculation. Do not use the unrounded calculated value.