FORMULA SHEET—METRIC UNITS

WELL CONTROL FOR DRILLING OPERATIONS

Acronyms used in the following formulas are defined in the WellSharp Acronyms document, available on the secure Provider Resources webpage. For instructions on rounding numbers when making calculations, refer to the following rounding rules and recommendations. Carry the rounded values forward into subsequent calculations.

ROUNDING RULES

- When calculating Kill Mud Weight, **ROUND UP** to two decimal places (for example, round up 1.212 kg/l to 1.22 kg/l; round up 1.463 kg/l to 1.47 kg/l).
- When calculating Leak Off Test Equivalent Mud Weight, **ROUND DOWN** to two decimal places (for example, round down 1.408 kg/l to 1.40 kg/l; round down 1.614 kg/l to 1.61 kg/l).
- When calculating Pressure Reduction Schedule, **ROUND DOWN** to two decimal places (for example, round down 1.334 bar/100 stks to 1.33 bar/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.

ROUNDING RECOMMENDATIONS

See Table to right where:

X= Whole number
X.XXXX = Number with 4 decimal places

MEASUREMENT	UNITS	ROUNDING and ANSWER FORMAT
Depth	meters	X.X
Pressure	bar	X.X
Pressure Gradient	bars/meter	X.XXX
Mud Weight	kg/liter	X.XX
Volume	liters	X
Capacity and Displacement	litres/meter	X.XX
Pump Speed in strokes per minute	SPM	X
Strokes	stk or stks	X
Speed in meters per hour	meters/hour	X.X
Area	cm^2	X.XX
Weight	kg	X
Force	decaNewtons (daN)	X
Wait and Weight Pressure Reduction Schedule	bar/100 stks or bar/10 steps*	X.XX

* 10 steps = Surface to Bit strokes divided by 10.

1. FORCE IN DECANEWTONS *(daN)* = Pressure $_{bar}$ x Area $_{cm2}$

2. PRESSURE *(bar)* = Force $_{daN}$ ÷ Area $_{cm2}$

3. TUBULAR CAPACITY *(litres/meter)* = $ID^2_{mm} \div 1273.236$ *(ID = Internal Diameter of Tubular in millimeters)*

4. ANNULAR CAPACITY *(litres/meter)* = $(D^2_{mm} - d^2_{mm}) \div 1273.236$ *(D = Hole Diameter or Casing ID, d = Outside Diameter of Tubular)*

5. HEIGHT OF FLUID IN A PIPE OR ANNULUS *(meters)* = Kick Volume $_{liters}$ ÷ Annular Capacity $_{liters/meter}$ or Pipe Capacity $_{liters/meter}$

6. HYDROSTATIC PRESSURE *(bars)* = Mud Weight $_{kg/l}$ x 0.0981 x TVD $_{meters}$

7. HYDROSTATIC PRESSURE GRADIENT *(bar/meter)* = Mud Weight $_{kg/l}$ x 0.0981

8. FORMATION PRESSURE *(bar)* = Hydrostatic Pressure in Drill String $_{bar}$ + SIDPP $_{bar}$

9. MUD WEIGHT *(kg/l)* = Pressure Gradient $_{bar/meter}$ ÷ 0.0981 or Pressure $_{bar}$ ÷ TVD $_{meters}$ ÷ 0.0981

10. EQUIVALENT MUD WEIGHT *(kg/l)* = Pressure $_{bar}$ ÷ 0.0981 ÷ TVD $_{meters}$

or (Surface Pressure $_{bar}$ ÷ TVD $_{meters}$ ÷ 0.0981) + Mud Weight $_{kg/l}$

11. EQUIVALENT CIRCULATING DENSITY *(kg/l)* = (Annular Pressure Loss $_{bar}$ ÷ 0.0981 ÷ TVD $_{meters}$) + Original Mud Weight $_{kg/l}$

12. KILL MUD WEIGHT *(kg/l)* = (SIDPP $_{bar}$ ÷ 0.0981 ÷ TVD $_{meters}$) + Original Mud Weight $_{kg/l}$

13. INITIAL CIRCULATING PRESSURE *(bar)* = Slow Circulating Rate Pressure $_{bar}$ + SIDPP $_{bar}$

14. FINAL CIRCULATING PRESSURE *(bar)* = Slow Circulating Rate Pressure $_{bar}$ x (Kill Mud Weight $_{kg/l}$ ÷ Original Mud Weight $_{kg/l}$)

15. NEW PUMP PRESSURE WITH NEW SPM *(bar)* = Current Pressure $_{bar}$ x **(**New SPM ÷ Old SPM**)^2** ***(only approximate!)***

16. NEW PUMP PRESSURE WITH NEW MUD WEIGHT *(bar)* = Current Pressure $_{bar}$ x **(**New Mud Weight ÷ Old Mud Weight**)** ***(only approximate!)***

17. MAXIMUM ALLOWABLE MUD WEIGHT *(kg/l)* = (Surface Leak Off $_{bar}$ ÷ 0.0981 ÷ Shoe TVD $_{meters}$) + Test Mud Weight $_{kg/l}$
(Fracture Mud Weight)

18. MAASP or MACP *(bar)* = (Maximum Allowable Mud Weight $_{kg/l}$ - Current Mud Weight $_{kg/l}$) x 0.0981 x Shoe TVD $_{meters}$

19. NEW MAASP AFTER KILL *(bar)* = (Maximum Allowable Mud Weight $_{kg/l}$ - Kill Mud Weight $_{kg/l}$) x 0.0981 x Shoe TVD $_{meters}$

20. ADDITIONAL MUD RETURNED BY SLUG *(litres)* = [(Slug Weight $_{kg/l}$ ÷ Mud Weight $_{kg/l}$) – 1] x Slug Volume $_{litres}$

21. TOTAL MUD RETURNED BY SLUG *(litres)* = (Slug Weight $_{kg/l}$ ÷ Mud Weight $_{kg/l}$) x Slug Volume $_{litres}$

22. LEVEL DROP AFTER PUMPING A SLUG *(meters)* = [(Slug Weight $_{kg/l}$ ÷ Mud Weight $_{kg/l}$) – 1] x Slug Volume $_{litres}$ ÷ Drill Pipe Capacity $_{litres/meter}$

23. RISER MARGIN *(kg/l)* = [(Riser Mud Hydrostatic $_{bar}$ – Seawater Hydrostatic $_{bar}$) ÷ 0.0981] ÷ (Well TVD $_{m}$ - Water Depth $_{m}$ – Air Gap $_{m}$)

24. CASING PRESSURE AFTER SUBSEA START-UP *(bar)* = Shut-In Casing Pressure $_{bar}$ – Choke Line Friction Loss $_{bar}$

25. BOYLES LAW FORMULAES $P_1 \times V_1 = P_2 \times V_2$ $P_2 = \frac{P_1 \times V_1}{V_2}$ $V_2 = \frac{P_1 \times V_1}{P_2}$ *Atmospheric Pressure = 1 bar*
P = Pressure: V = Volume

26. GAS MIGRATION RATE *(meters/hour)* = Shut-In Pressure Increase $_{bar/hour}$ ÷ Mud Gradient $_{bar/meter}$ *(can use SIDPP or SICP)*
(Increase over last hour)

27. VOLUME TO BLEED DUE TO GAS MIGRATION *(litres)* = (Working Pressure to Bleed $_{bar}$ ÷ Mud Gradient $_{bar/meter}$) x Annular Capacity $_{litres/meter}$
(For Volumetric Method)

WELL COMPLETION/WORKOVER FORMULA SHEET—FIELD UNITS

1. KILL FLUID WEIGHT *(kg/l)* = (SITP $_{bars}$ ÷ Top Perforations TVD $_{meters}$ ÷ 0.0981) + Original Fluid $_{kg/l}$

2. KILL FLUID WEIGHT *(kg/l)* = BHP $_{bars}$ ÷ TVD $_{meters}$ ÷ 0.0981

BULLHEADING FORMULAE

3. FORMATION FRACTURE PRESSURE *(bars)* = Formation Fracture Gradient $_{bars/meter}$ x Top Perforations TVD $_{meters}$

4. INITIAL HYDROSTATIC PRESSURE *(bars)* = Formation Pressure $_{bars}$ - SITP $_{bars}$

5. INITIAL AVERAGE FLUID DENSITY *(kg/l)* = Initial Hydrostatic Pressure $_{bars}$ ÷ Top Perforations TVD $_{meters}$ ÷ 0.0981

6. MAX INITIAL SURFACE PRESSURE *(bars)* = Formation Fracture Pressure $_{bars}$ - Initial Hydrostatic Pressure $_{bars}$

7. MAX FINAL SURFACE PRESSURE *(bars)* = Formation Fracture Pressure $_{bars}$ – (Kill Fluid Weight $_{kg/l}$ x 0.0981 x Top Perforations TVD $_{meters}$)

8. VOLUME TO BULLHEAD *(liters)* = Surface Lines $_{liters}$ + Surface to EOT $_{liters}$ + EOT to Top Perfs $_{liters}$ + Top Perfs to Bottom Perfs $_{liters}$
{EOT = End of Tubing Perfs = Perforations}

9. BULLHEAD SPM TO EXCEED GAS MIGRATION = Gas Migration Rate $_{meters/hour}$ ÷ 60 x Tubing Capacity $_{liters/meter}$ ÷ Pump output $_{liters/stroke}$

TEMPERATURE CORRECTION FORMULA FOR BRINES

10. FLUID DENSITY TO *MIX (kg/l)* = Fluid Density at Avg. Temp $_{kg/l}$ + [(Avg. Temp $_{C}$ - Surface Temp $_{C}$) x Weight Loss $_{kg/l/degree\ C}$]
{AVG = Average C = degrees Centigrade}

Example Weight Loss Chart
(Note: Values will vary based on type of fluid and other factors.)

Brine weight (kg/l)	Weight loss (kg/l/°C)
1.0 – 1.08	0.00037
1.09 – 1.32	0.00054
1.33 – 1.74	0.00071
1.75 – 2.04	0.00086
2.05 – 2.3	0.00104