POCKET TOOLBOX

TANK VOLUME

Barrels per Inch of Depth

Width of Tank (ft) \ Length of Tank (ft)	10	12	14	16	18	20	25	30
6	0.891	1.060	1.240	1.420	1.500	1.780	2.220	2.580
7	1.030	1.250	1.450	1.680	1.860	2.080	2.600	3.110
8	1.180	1.420	1.560	1.900	2.130	2.370	2.980	3.550
9	1.330	1.500	1.860	2.130	2.400	2.870	3.330	4.000
10	1.460	1.780	2.080	2.370	2.680	2.980	3.710	4.460

Width of Tank (ft) \ Length of Tank (ft)	35	40	45	50	55	60	65	70
6	3.110	3.550	4.000	4.410	4.900	5.330	5.790	6.250
7	3.630	4.600	4.660	5.200	5.730	6.250	6.750	7.250
8	4.180	4.750	5.330	5.910	6.530	7.120	7.730	8.290
9	4.870	5.330	6.010	6.660	7.350	8.000	8.680	9.330
10	5.910	5.910	6.660	7.410	8.160	8.910	9.680	10.330

PUMP OUTPUT – bbls/stroke

100% Efficiency

Stroke \ Liner Size	5.00	5.25	5.50	5.75	6.00	6.25	6.50	6.75
12	0.090	0.100	0.111	0.121	0.133	0.144	0.157	0.170
14	0.102	0.114	0.125	0.138	0.152	0.166	0.191	0.195
15	0.108	0.121	0.134	0.147	0.162	0.176	0.192	0.207
16	0.116	0.130	0.143	0.157	0.173	0.188	0.205	0.225
18	0.126	0.144	0.158	0.176	0.194	0.211	0.228	0.248
20	0.142	0.158	0.175	0.195	0.213	0.233	0.254	0.275
G700	0.096	0.110	0.121	0.134	0.147	0.162	0.175	0.191
G1000	0.104	0.116	0.131	0.145	0.161	0.176	0.193	0.212

Stroke \ Liner Size	7.00	7.25	7.50	7.75	8.00	8.25	8.50
12	0.183	0.197	0.212	—	—	—	—
14	0.211	0.226	0.244	0.261	0.278	—	—
15	0.225	0.242	0.261	0.278	0.298	—	—
16	0.241	0.258	0.277	0.298	0.318	0.340	0.361
18	0.268	0.288	0.311	0.333	0.356	0.380	0.405
20	0.297	0.321	0.345	0.371	0.396	0.422	0.451
G700	0.206	0.222	0.240	0.256	0.274	0.292	0.310
G1000	0.228	0.246	0.265	0.286	0.366	0.327	0.348

FORMULAS

Optimum Solids: % by volume = [*Mud Weight (lb/gal) – 6*]*32*

Approximate Capacity of Open Hole: Diameter (in)^2 *= bbls/1,000 ft*

Buoyancy Factor = *1* – [*Mud Weight (lb/gal) x 0.015*]

Hydraulic Horsepower = $\dfrac{\text{psi x gpm}}{1714}$ or $\dfrac{\text{psi x bpm}}{40.8}$

Hydrostatic Pressure, psi = *Mud Weight (lb/gal) x depth x 0.052*
or $\text{Mud Weight (lb/ft}^3\text{) x depth x 0.00695}$

Annular Velocity, ft/min = $\dfrac{\text{Pump output in bbl/min}}{\text{Annular volume in bbl/ft}}$

Volume of Cylindrical Tank:
$\text{[Diameter (ft)]}^2 \text{ x [depth (ft)] x 0.1399 = volume in bbls (x 42 = gals)}$

Volume of Rectangular Tank:
length (ft) x width (ft) x depth (ft) x 0.1781 = volume in bbls

Displacement of Metal in Pipe:
Weight of pipe (lbs) x 0.03638 = bbls/100 ft

Converting API Gravity to Specific Gravity (SG)

$$\text{SG at 60°F} = \frac{141.5}{\text{APIGravity} + 131.5}$$

CHEMICAL FORMULAS

Barite	$BaSO_4$
Lime	CaO
Gypsum or Anhydrite	$CaSO_4\ 2H_2O$
Limestone	$CaCO_3$
Calcium Chloride	$CaCl_2$
Caustic Soda	$NaOH$
Sodium Bicarbonate	$NaHCO_3$
Salt	$NaCl$
Soda Ash	Na_2CO_3
SAPP	$Na_2H_2P_2O_7$
Sodium Tetraphosphate	$Na_6P_4O_{13}$

MISC FORMULAS

Round Tank => *gal/in = 0.003402 x diameter (in)*^{2}

Rectangular Tank => *length x width x 0.6258 = gallons/in*

Cylindrical Tank on its Side
=> *length x height x √(0.017 x depth) + (1.7 dh - h*^{2}*)= in*^{3} *(in*^{3} *÷ 231 = gallons)*

Rod Content => *4.081 x (ID in inches)*^{2} *= gallons/100 ft*

Rod Displacement => *(4.081 x (OD in inches)*^{2}*) – Rod Content*
= gallons/100 ft

Note: Dh = Diameter of hole (inches) Dp = Diameter of pipe (inches)

Annular Volume => $\frac{Dh^2 - Dp^2}{24.52}$ *x depth (ft) = gallons/ft*

Hole Volume/Pipe Capacity => $\frac{Dh^2}{24.52}$ *x depth (ft) = gallons/ft*

Annular Velocity (Air) => *cfm x* $\frac{183.4}{Dh^2 - Dp^2}$ *= ft/min*

Annular Velocity (Fluid) => Pump Output (gal/min) x $\frac{24.52}{Dh^2 - Dp^2}$ = ft/min

Hydrostatic Pressure =>*lbs/in*^{2} *= 0.052 x mud weight (lbs/gal) x depth (ft)*

METRIC CALCULATIONS

Note: Dh = Diameter of hole (mm) Dp= Diameter of pipe (mm)

Annular Volume => $\frac{Dh^2 - Dp^2}{1273}$ *x depth (m) = l/m*

Annular Volume => $\frac{Dh^2 - Dp^2}{1273000}$ *x depth (m) = m*^{3}*/m*

Hole Volume/Pipe Capacity => $\frac{Dh^2}{1273}$ *x depth (m) = l/m*

Hole Volume/Pipe Capacity => $\frac{Dh^2}{1273000}$ *x depth (m) = m*^{3}*/m*

Hydrostatic Pressure => *kPa – 0.00981 x mud weight (kg/m*^{3}*) x depth (m)*

SPECIFIC GRAVITY

of Common Materials

Barite	4.0 - 4.5
Cement	3.1 - 3.2
Dolomite	2.8 - 3.0
Limestone	2.7 - 2.9
Quartz	2.65
Native Clay	2.5 - 2.7
Bentonite	2.3 - 2.4
Gypsum	2.3
Salt	2.16
Water	1

CASING CAPACITY

Size O.D.	Cap bbl/100 ft
5	1.96
5 1/2	2.32
6	2.78
6 5/6	3.41
7	3.71
7 5/8	4.59

Size O.D.	Cap bbl/100 ft
8 5/8	5.95
9 5/6	7.45
10 3/4	9.62
13 3/8	15.22
16	22.22
20	35.53

CAPACITY

Capacity Tubing API Standard

Size Nominal	Size O.D. in	Size I.D. in	Weight lb/ft	Cap bbl/100 ft
1 1/2	1 15/16	1.810	2.75	0.252
2	2 3/8	1.995	4.80	0.387
2 1/2	2 7/8	2.441	8.40	0.579
3	3 1/2	2.992	10.20	0.829
3 1/2	4	3.476	11.00	1.174
4	4 1/2	3.958	12.60	1.522

CAPACITY

Displacement of Drill Pipe API Standard

Size Nominal	Size I.D. in	Weight lb/ft	Cap bbl/100 ft	Dspl bbl/100 ft
2 3/8	1.815	6.7	0.320	0.287
2 7/8	2.151	10.4	0.450	0.406
3 1/2	2.764	13.3	0.742	0.513
3 1/2	2.502	15.5	0.659	0.585
4	3.340	14.0	1.113	0.566
4 1/2	3.820	16.6	1.422	0.643
4 1/2	3.640	20.0	1.288	0.771
5	4.276	19.5	1.780	0.750
5 5/8	4.776	21.9	2.220	0.871
5 5/8	4.570	24.7	2.110	0.954
5 5/8	5.965	26.2	3.456	0.984

PARTICLE SIZES

U.S. Mesh	Microns	in²	Wentworth Size Class
4	4760.00	0.1870	Pebbles
5	4000.00	0.1570	
6	3360.00	0.1320	
7	2830.00	0.1110	Granule
8	2000.00	0.0937	
10	1680.00	0.0787	
12	1410.00	0.0661	
14	1190.00	0.0555	Very Coarse Sand
16	1000.00	0.0469	
18	841.00	0.0394	
20	707.00	0.0331	
25	595.00	0.0278	Coarse Sand
30	500.00	0.0234	
35	420.00	0.0197	
40	354.00	0.0165	
45	297.00	0.0139	Medium Sand
50	250.00	0.0117	
60	210.00	0.0098	
70	177.00	0.0083	
80	149.00	0.0070	Fine Sand
100	125.00	0.0059	
120	105.00	0.0049	
140	88.00	0.0041	
170	74.00	0.0035	Very Fine Sand
200	63.00	0.0029	
230	53.00	0.0025	
270	44.00		
325	37.00		Coarse Silt
400	31.00		
	15.60		Medium Silt
	7.80		Fine Silt
	3.90		Very Fine Silt
	8.00		
	0.98		Clay
	0.49		
	0.24		
	0.12		Colloid
	0.06		

CONVERSION FACTORS

Multiply	by	To Obtain
atmospheres	14.7000	psi
barrels	5.6100	ft^3
barrels	42.0000	gallons (U.S.)
barrels	350.0000	lbs of water
ft^3	1728.0000	in^3
ft^3	7.4805	gallons (U.S.)
ft^3	0.1781	bbls
ft^3 of water	62.4000	lbs of water
ft^3	28.3170	liters
diameter of a circle	3.1416	circumference
ft of water	0.4335	psi
gallons (U.S.)	8.3300	lbs water
gallons (U.S.)	3.7850	liters
grains per gallon (U.S.)	17.1180	ppm
gram/liter	56.4170	grains per gallon (U.S.)
gram/liter	1000.0000	ppm
grains per gallon (U.S.)	7000.0000	lbs of water
inches	2.5400	centimeters
inches of mercury	13.5600	inches of water
kilogram	2.2046	pounds (Avoir)
k/cm^2	14.2230	psi
liter	1.0567	quarts (liquid)
liter	1000.0270	cm^3
meter	3.2910	feet
micron	0.0010	millimeter
pounds (Avoir)	16.0000	ounces
pounds (Avoir)	453.6000	grams
pounds per gallon	7.4500	lbs/ft^3
pounds per gallon	0.1200	specific gravity
ppm Cl	1.6500	ppm NaCl
ppm Ca	2.5000	ppm $CaCO_3$
quart (U.S.)	946.3580	cm^3

EQUATIONS

Used in Calculating Hydraulics

The following are terms used in the equations listed below.

AV = Fluid velocity in ft/min

CS = Chip diameter in inches

E = Hydraulic diameter
(pipe ID or hole size – pipe OD)

ECD = Equivalent circulating density in ppg

MW = Mud Weight

PK = Q3/(511*PN)

PL = Pipe length in feet

PN = 3.32*log10(Q6/Q3)

PV = Plastic viscosity in op

Q3 = YP + PV

Q6 = PV + Q3

Re = Reynolds number 2000/4000

Rep = Particle Reynolds number

TFA = Total Flow Area

TS = Intermediate result (misc #)

Vs = Slip velocity in ft/sec

YP = Yield point in lbs/100 ft^2

Nozzle Pressure Drop = $\dfrac{\textit{flow rate x 2 x mud weight}}{\textit{10858 x TFA x 2}}$

Estimated Plastic Viscosity = *0.1 x MW x 2.16*

Hydraulic Horsepower = *flow rate x pressure drop/1714*

Hydrostatic Head = *0.0519444 x MW x depth*

Nozzle Velocity = flow rate x 0.32086/TFA

Impact Force = Nozzle Velocity x MW x flow rate/1932

Critical Velocity = $\dfrac{60 \times Re}{1856 \times MW \times E(PV + (PV^2 + (18560/Re) \times ME \times E \times 2 \times YP) \times 5)}$

Critical Flow Rate = *Critical Velocity x (Hole Size x 2 – Pipe OD* x 2)/24.51

Rep = 928 x MW x Vs x CS/PV

For Rep < 100

Vs = 0.0075 x TS x ((36800 x CS/TS x 2 x (21.6 – MW)/MW + 1)x 0.5 – 1)

For Rep > 100

Vs = 1.89 x (CS/1.72 x (21.6 – MW)/MW) x 0.5

Find Radius with Known Depth and Horizontal Distance

HD = 500
TVD = 50 Right or Left may be substituted for TVD (Elevation)

$$\frac{HD^2 + TVD^2}{2 \times TVD} = 2525 \text{ Radius}$$

Rules of Thumb and Formulas

Normal set back from target depth ratio = 8 to 1

Non-compressed bend radius of steel pipe
= 100 ft x 1 in diameter (5 in diameter x 100 ft = 500 ft radius)

Non-compressed bend radius of HDPE
= 40 x diameter (4 in x 40 = 160 in diameter)

% OF SOLIDS

Recovered Mud Weight	_____lbs/gal
Original Mud Weight	- 8.4 lbs/gal
Equals Solids Weight	_____lbs/gal
Constant	x 8
Percentage of solids	_____%

Example

Recovered Mud Weight	11.4 lbs/gal
Original Mud Weight	- 8.4 lbs/gal
Solids Content	3 lbs/gal
Constant	x 8
Percentage of Solids	24%

(11.4 – 8.4) x 8 = 24% solids

HORIZONTAL DRILLING FLUIDS

Drilling Conditions	Minimum Mixture of Products Added to Water
Sandy (Fine)	HYDRAUL-EZ 25 lbs/100 gal + 0.5 lb REL-PAC XTRA-LOW/100 gal
Sand (Coarse)	HYDRAUL-EZ 25 lbs/100 gal + 0.5 lb REL-PAC XTRA-LOW/100 gal
Sand & Gravel	HYDRAUL-EZ 30 lbs/100 gal + 1 - 1.5 lbs REL-PAC XTRA-LOW + 0.5 lb SUSPEND-IT/100 gal
Gravel	HYDRAUL-EZ 30-35 lbs/100 gal + 1.5 lbs REL-PAC XTRA-LOW + 0.5 lb SUSPEND-IT/100 gal
Cobble	HYDRAUL-EZ 35 lbs/100 gal + 1.5 lbs REL-PAC XTRA-LOW + 1 lb SUSPEND-IT/100 gal
Sand, Gravel, Clay, or Shale	HYDRAUL-EZ 25 lbs/100 gal + 0.5 - 1 lb/100 gal REL-PAC XTRA-LOW + 2 qts/100 gal DRILL-TERGE
Clay	CLAY CUTTER DRY 0.25 - 1 lb/100 gal **or** HYDRAUL-EZ 15 lbs/100 gal + CLAY CUTTER 0.5 gal/1000 gal + DRILL-TERGE 2 qts/100 gal
Clay (Swelling & Sticky)	INSTA-VIS PLUS 16 oz/100 gal + DRILL-TERGE 2 qts/100 gal **or** HYDRAUL-EZ 15 lbs/100 gal + CLAY CUTTER 1 gal/1000 gal + DRILL-TERGE 3 qts/100 gal ***Note:*** *Increase DRILL-TERGE as needed*
Make-up Water	**Action Required**
pH - 8.5 to 9.5	Add SODA ASH 1 lb/100 gal
Salt	Change source or dilute with freshwater if detected
Chlorine	Change source or add DE-CHLOR if smelled or detected
Solids	Pre-filter into tank to remove sand

SPECIALTY PRODUCTS		
Name	**Function**	**Dosage**
CLAY CUTTER	To lower torque and increase flow in reactive clay	1 gal/1000 gal
CLAY CUTTER DRY	To lower torque and increase flow in reactive clay	0.5-2 lbs/100 gal
DRILL-TERGE	To reduce torque and/or sticking	2-3 qts/100 gal
INSTA-VIS PLUS	Additive for a non-bentonite system in clay and mixed soils	16 oz/1000 gal
MACRO-FILL	For lost circulation control and hole stabilization in cobble	As needed
REL-PAC XTRA-LOW	To decrease filtrate and improve filter cake	1-2 lbs/100 gal
SUSPEND-IT	To increase gel strength	0.5-2 lbs/100 gal

General Comments

Add HYDRAUL-EZ first, then Polymer

DRILL-TERGE may foam when used in higher concentrations or very viscous bentonite fluids

0.25 - 0.5 lbs additional SODA ASH per 100 gal may be helpful in saltwater area

SUSPEND-IT, REL-PAC XTRA-LOW, and CLAY CUTTER all work in saltwater areas with dosage adjustments

These are general mixing instructions and adjustments may need to be made to get the proper results.

HORIZONTAL DIRECTIONAL DRILLING APPLICATIONS

Hole Volume Calculation

$$\frac{(\text{hole diameter})^2}{24.52} = \text{gal/ft} = \text{gal/ft x rod length} = \text{volume of soil (gallons)/rod length}$$

Time Requirement

$$\text{minutes/rod} = \frac{\text{volume of soil (gallons)/rod length}}{\text{actual pump output (gal/min)}}$$

Fluid to Soil Ratio

The fluid to soil ratio is important as the soil encountered must be put into a flowable slurry in order to make the bore ready to accept the product line. The ratio must be at least 1:1 and with changes in soil that ratio may increase.

Non-problematic/non-reactive soils, rock	2:1
Sand, gravel, cobble, and rock mixed with clay	2-3:1
Clay or reactive shale	3-5:1

Pump Output

Actual pump output will vary with length and height of suction and the physical operating condition of the pump. These factors combined with the overall percentage of solids and viscosity of the drilling fluid affect efficiency and must be taken into consideration when determining the pump output.

EFFICIENCY OF HYDRAULIC DRIVEN PUMPS

Funnel Seconds	Percentage of Volume	Dosage
26	Water	95-100%
45	Drilling Fluid	80-90%
60	Drilling Fluid	60-70%
80	Drilling Fluid	50%

Once the horsepower of the hydraulic motor is overcome, then the efficiency of the pump drops dramatically.

The lowest viscosity in funnel seconds with the most gel strength will use the least horsepower, give the most volume, carry solids, and stabilize the hole.

Formulas

Horsepower

Mechanical $HP = \frac{TS}{5252}$

Hydraulic $HP = \frac{PQ}{1714}$

T = Torque
S = Speed
P = Pressure Drop (Psi)
Q = Flow Rate (GPM)
HP = Horsepower

SUCTION PIPE SIZING		
Gpm	Water Min Size Min Pipe Size (in)	Mud (80 Sec) Min Pipe Size (in)
5	3/4	1 1/4
10	1 1/4	1 1/2
20	1 1/2	2
30	2	2 1/2
40	2 1/2	3
50	2 1/2	3 1/2
60	3	3 1/2
80	3 1/2	4
100	4	4 1/2

The lower the velocities, (3 ft/sec) or less, the better.

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