

FEMA Calculation of Buoyancy for UG LP tanks

$F_b = .134 V_t \gamma FS$

- F_b** = Net Buoyancy Force
- 0.134** = Gallon to cubic foot conversion number
- V_t** = Tank Volume in gallons
- γ** = Specific gravity of flood water (62.4 for Fresh water, 64.1 for Salt water)
- FS** = Safety correction factor (* 1.3)

Net Buoyancy = F_b - Tank weight - Equivalent Flood Weight of Soil

Number of hold down straps required = Net buoyancy / allowable working load of strap
 (Minuteman Tie down straps are designed for 3600# seismic lateral load, 5500# breaking strength, 3630# working load)

$V_c = (\text{Net buoyancy} / \text{Density of concrete}) \text{ Safety correction factor (FS)}$
 V_c = Volume of Concrete Density used 148 lbs per cubic foot

Tank Size (V_t)	Net tank Buoyancy (F_b) (in fresh water)	Net tank Buoyancy (F_b) (in Salt water)	Pad Length	Pad Width	9" pad weight	12" pad weight	# of Straps required
120	1304	1340	6'	4'	2664		2
250	2718	2792	8.5'	4.5'	4246		2
320	3478	3573	10.5'	4.5'	5245		2
500	5435	5583	11'	5.25	6410		2
1000	10870	11166	17'	5.25'		12580	2
1990	21631	22221	26	6		23088	4

Tank size	Tank Diameter (ft)	Tank Length (ft)	Tank Area	Shroud/Lid size	UG Tank Shroud Volume (18" -23" cover)	Suggested hole depth min/max	Equivalent Flood weight of soil (sand only, lightest case) above tank and pad less shroud volume
120	2.00	5.67	11.3	20" x 24"	5.01/ 6.42 cf	55/60	1385
250	2.50	7.67	19.2	20" x 24"	5.01/ 6.42 cf	61/66	2653
320	2.50	9.50	23.8	20" x 24"	5.01 / 6.42 cf	61/66	3888
500	3.08	10.00	30.8	20" x 24"	5.01 / 6.42 cf	68/73	4341
1000	3.42	15.83	54.1	20" x 24"	5.01 / 6.42 cf	75/80	7989
1990	3.83	23.92	91.7	20" x 24"	5.01 / 6.42 cf	80/85	16219

Tank sizes are for Quality Steel standard Lp tanks other tank sizes might require different pad sizes

Soil type	S, Equivalent fluid Weight of Moist Soil (lbs per cf)	Equivalent Fluid Weight of Submerged Soil and Water (lbs per cf)
Clean sand and gravel: GW, GP, SW, SP	30	75
Dirty sand and gravel of restricted permeability: GM, GM-GP, SM, SM-SP	35	77
Stiff residual silts and clays, silty fine sands, clayey sands and gravels: CL,ML,CH,MH,SC,GC	45	82
Very soft to soft clay, silty clay, organic silt and clay: CL,ML,OL,CH,MH,OH	100	106
Medium to stiff clay deposited in chunks and protected from infiltration: CL, CH	120	142

Soil Type	Group Symbol	Description per USDA Unified Soil Classification
Gravels	GW	Well-graded gravels and gravel mixtures
	GP	Poorly graded gravel-sand-silt mixtures
	GM	Silty gravels, gravel-sand-clay mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
Sands	SW	Well-graded sands and gravelly sands
	SP	Poorly graded sands and gravelly sands
	SM	Silty sands, poorly graded sand-silt mixtures
	SC	Clayey sands, poorly graded sand-clay mixtures
Fine grain silt and clays	ML	Inorganic silts and clayey silts
	CL	Inorganic clays of low to medium plasticity
	OL	Organic silts and organic silty clays of low plasticity
	MH	Inorganic silts, micaceous or fine sands or silts, elastic silts
	CH	Inorganic clays of high plasticity, fine clays
	OH	organic clays of medium to high plasticity