

Derivation for converting an atmospheric compression tank to a pre-charge bladder/diaphragm tank

The equations for calculating a tank's size depends on three (3) factors:

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|---|-------|
| 1. How much fluid storage is required | V_s |
| 2. What is the desirable starting pressure (psig) | P_1 |
| 3. What is the desirable ending pressure (psig) | P_2 |

The governing equation is:

$$T_v = \frac{V_s}{\frac{P_s}{(P_1+P_a)} - \frac{P_s}{(P_2+P_a)}} \quad (1)$$

Where:

- | | | |
|-------|---|--------------------------------------|
| P_s | = | Starting pressure in the tank (psia) |
| P_a | = | Atmospheric pressure (psia) |

For an atmospheric compression tank; $P_s = P_a$ and equation (1) becomes:

$$T_{v(\text{comp})} = \frac{V_s}{\frac{P_a}{(P_1+P_a)} - \frac{P_a}{(P_2+P_a)}} \quad (2)$$

For a pre-charged bladder or diaphragm tank; $P_s = P_1+P_a$ and equation (1) becomes:

$$T_{v(\text{bladder})} = \frac{V_s}{1 - \frac{(P_1+P_a)}{(P_2+P_a)}} \quad (3)$$

To find the ratio of bladder to compression tank, divide equation (3) by (2) which yields:

$$\frac{T_{v(\text{bladder})}}{T_{v(\text{comp})}} = \frac{\frac{P_a}{(P_1+P_a)} - \frac{P_a}{(P_2+P_a)}}{1 - \frac{(P_1+P_a)}{(P_2+P_a)}} \quad (4)$$

Simplifying into common denominators yields:

$$\frac{T_{v(\text{bladder})}}{T_{v(\text{comp})}} = \frac{\frac{P_a(P_2+P_a) - P_a(P_1+P_a)}{(P_1+P_a)(P_2+P_a)}}{\frac{(P_2+P_a) - (P_1+P_a)}{(P_2+P_a)}}$$

Which ultimately simplifies to:

$\frac{T_{v(\text{bladder})}}{T_{v(\text{comp})}} = \frac{P_a}{(P_1+P_a)} \quad (5)$
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Converting Compression Tank to Bladder or Diaphragm Tank

Compression Tank Size				Bladder/Diaphragm Tank Size (Gal.)					
Dia (in.)	Over Heads (in.)	Shell Length	Cap. (gal.)	Pre-charge pressure (psig) = PRV setting					
				12	20	30	40	50	60
12	33	26	15	8.3	6.4	4.9	4.0	3.4	3.0
	51	44	23	12.7	9.7	7.6	6.2	5.2	4.5
14	48	40	30	16.5	12.7	9.9	8.1	6.8	5.9
	63	55	40	22.0	16.9	13.2	10.7	9.1	7.9
16	48	39	39	21.5	16.5	12.8	10.5	8.9	7.7
	60	51	49	27.0	20.8	16.1	13.2	11.1	9.6
	72	63	59	32.5	25.0	19.4	15.9	13.4	11.6
20	48	37	60	33.0	25.4	19.7	16.1	13.6	11.8
	62	51	80	44.0	33.9	26.3	21.5	18.2	15.7
	72	61	93	51.2	39.4	30.6	25.0	21.1	18.3
	78	67	101	55.6	42.8	33.2	27.1	22.9	19.9
24	48	34	86	47.3	36.4	28.3	23.1	19.5	16.9
	60	46	109	60.0	46.2	35.8	29.3	24.8	21.4
	65	51	118	65.0	50.0	38.8	31.7	26.8	23.2
	72	58	131	72.1	55.5	43.1	35.2	29.8	25.8
	84	70	154	84.8	65.2	50.6	41.4	35.0	30.3
30	96	82	177	97.4	75.0	58.2	47.6	40.2	34.8
	48	31	133	73.2	56.3	43.7	35.7	30.2	26.2
	62	45	175	96.3	74.1	57.6	47.0	39.8	34.4
	72	55	204	112.3	86.4	67.1	54.8	46.3	40.1
	77	60	219	120.6	92.8	72.0	58.9	49.8	43.1
	84	67	240	132.1	101.7	78.9	64.5	54.5	47.2
	96	79	275	151.4	116.5	90.4	73.9	62.5	54.1
	105	88	302	166.3	127.9	99.3	81.2	68.6	59.4
36	120	103	346	190.5	146.6	113.8	93.0	78.6	68.1
	60	40	242	133.2	102.5	79.6	65.0	55.0	47.6
	72	52	293	161.3	124.1	96.4	78.7	66.6	57.7
	84	64	344	189.4	145.7	113.1	92.4	78.2	67.7
	93	73	390	214.7	165.2	128.3	104.8	88.6	76.7
	96	76	403	221.9	170.7	132.5	108.3	91.6	79.3
42	120	100	505	278.0	213.9	166.1	135.7	114.7	99.4
	72	48	404	222.4	171.1	132.9	108.6	91.8	79.5
	84	60	473	260.4	200.4	155.6	127.1	107.5	93.1
	96	72	526	289.6	222.8	173.0	141.4	119.5	103.5
	120	96	665	366.1	281.7	218.7	178.7	151.1	130.9
	144	120	804	442.7	340.6	264.4	216.1	182.7	158.2
	168	144	942	518.6	399.1	309.8	253.2	214.0	185.4
48	192	168	1081	595.2	457.9	355.5	290.5	245.6	212.7
	84	57	593	326.5	251.2	195.0	159.4	134.7	116.7
	96	69	683	376.0	289.3	224.6	183.5	155.2	134.4
	120	93	865	476.2	366.4	284.5	232.5	196.5	170.2
	144	117	1046	575.9	443.1	344.0	281.1	237.7	205.8
	168	141	1228	676.1	520.2	403.8	330.0	279.0	241.7
54	192	165	1409	775.7	596.9	463.4	378.7	320.1	277.3
	96	66	861	474.0	364.7	283.1	231.4	195.6	169.4
	120	90	1090	600.1	461.8	358.5	292.9	247.7	214.5
	144	114	1320	726.7	559.2	434.1	354.7	299.9	259.8
	168	138	1549	852.8	656.2	509.4	416.3	351.9	304.8
	192	162	1779	979.4	753.6	585.0	478.1	404.2	350.1
60	216	186	2009	1106.1	851.1	660.7	539.9	456.4	395.3
	120	87	1341	738.3	568.1	441.0	360.4	304.7	263.9
	144	111	1624	894.1	688.0	534.1	436.4	369.0	319.6
	168	135	1907	1049.9	807.9	627.1	512.5	433.3	375.3
	192	159	2191	1206.3	928.2	720.5	588.8	497.8	431.2
72	216	183	2474	1362.1	1048.1	813.6	664.9	562.1	486.9
	120	81	1915	1054.3	811.3	629.8	514.6	435.1	376.8
	144	105	2323	1279.0	984.1	763.9	624.3	527.8	457.1
	168	129	2731	1503.6	1156.9	898.1	733.9	620.5	537.4
72	192	153	3140	1728.8	1330.2	1032.6	843.8	713.4	617.9
	216	177	3548	1953.4	1503.0	1166.8	953.5	806.1	698.2

Compression Tank Size to Wessels Model

Dia (in.)	Over Heads (in.)	Shell Length	Cap. (gal.)	Pre-charge pressure (psig) = PRV setting						
				12	20	30	40	50	60	
12	33	26	15	NTA-20	NTA-15					
	51	44	23		NTA-20					
14	48	40	30			NTA-20				
	63	55	40							
16	48	39	39							
	60	51	49							
	72	63	59	NTA-60	NTA-40					
20	48	37	60							
	62	51	80	NTA-80						
	72	61	93							
	78	67	101							
24	48	34	86							
	60	46	109							
	65	51	118	NTA-120						
	72	58	131	NTA-144						
	84	70	154	NTA-180	NTA-120					
	96	82	177	NTA-200	NTA-144					
30	48	31	133	NTA-144	NTA-120					
	62	45	175	NTA-200	NTA-144					
	72	55	204	NTA-200	NTA-180	NTA-120				
	77	60	219	NTA-240	NTA-200	NTA-144				
	84	67	240							
	96	79	275	NTA-260	NTA-240	NTA-180	NTA-144			
	105	88	302	NTA-280	NTA-260	NTA-200	NTA-144			
36	60	40	242							
	72	52	293	NTA-280	NTA-240	NTA-144	NTA-120			
	84	64	344							
	93	73	390							
	96	76	403	NTA-280	NTA-240	NTA-200	NTA-180	NTA-144		
	120	100	505							
	120	103	346							
42	72	48	404							
	84	60	473	NTA-280	NTA-260	NTA-240	NTA-180			
	96	72	526							
	120	96	665							
	144	120	804							
	168	144	942							
	192	168	1081							
48	84	57	593							
	96	69	683							
	120	93	865							
	144	117	1046							
	168	141	1228							
	192	165	1409							
54	96	66	861			NTA-280				
	120	90	1090							
	144	114	1320							
	168	138	1549							
	192	162	1779							
60	120	87	1341							
	144	111	1624							
	168	135	1907							
	192	159	2191							
	216	183	2474							
72	120	81	1915							
	144	105	2323							
	168	129	2731							
	192	153	3140							
	216	177	3548							

Pre-charge pressure (psig) = PRV setting					
12	20	30	40	50	60
NTA-35					
		NTA-50			
		NTA-85			
NTA-300			NTA-130		
		NTA-200			
NTA-400					
NTA-400					
NTA-500	NTA-400	NTA-300			
NTA-600	NTA-500				
NTA-800	NTA-600	NTA-500			
NTA-600	NTA-600		NTA-500	NTA-200	
NTA-800	NTA-600	NTA-500			
NTA-1000	NTA-800	NTA-600	NTA-500	NTA-400	
NTA-1200	NTA-1000	NTA-800	NTA-600	NTA-500	NTA-400
NTA-1000	NTA-800	NTA-600	NTA-500		
NTA-1200	NTA-1000	NTA-800	NTA-600	NTA-500	
NTA-1400	NTA-1200			NTA-800	NTA-600
NTA-2000	NTA-1400	NTA-1200	NTA-1000		NTA-800
NTA-2500	NTA-2000	NTA-1400	NTA-1200	NTA-500	
NTA-1400	NTA-1000	NTA-800	NTA-600	NTA-500	
NTA-1600	NTA-1200	NTA-1000	NTA-800	NTA-600	NTA-500
NTA-2000	NTA-1400	NTA-1200	NTA-1000	NTA-800	
NTA-2500	NTA-2000	NTA-1400	NTA-1200	NTA-1000	NTA-800
NTA-3000	NTA-2500	NTA-2000	NTA-1400	NTA-1200	NTA-1000
NTA-2000	NTA-1400	NTA-1200	NTA-1000	NTA-800	
NTA-2500	NTA-2000	NTA-1400	NTA-1200	NTA-1000	
NTA-3000	NTA-2500	NTA-2000	NTA-1400	NTA-1200	NTA-1000
NTA-4000	NTA-3000	NTA-2500	NTA-2000	NTA-1600	NTA-1400
NTA-5000	NTA-4000	NTA-3000	NTA-2500	NTA-2000	NTA-1600
NTA-3000	NTA-2500	NTA-2000	NTA-1400	NTA-1200	NTA-1000
		NTA-3000	NTA-1400		
NTA-5000			NTA-2500	NTA-2000	NTA-1600
NTA-7500	NTA-4000	NTA-3000	NTA-2500		
		NTA-2500	NTA-2000		NTA-1600
NTA-5000			NTA-3000	NTA-2500	NTA-2000
		NTA-5000	NTA-3000	NTA-2500	NTA-2000
		NTA-7500	NTA-5000	NTA-4000	NTA-3000
		NTA-5000	NTA-4000	NTA-3000	NTA-2500