

Fundamentals of Hydronic Design



Radiant Based HVAC Systems

Fundamentals of Hydronic Design



Expansion Tank Sizing

Fundamentals of Hydronic Design

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Some slides contained animations in the original .ppt format which have been eliminated in the conversions to Adobe's .pdf format.

Fundamentals of Hydronic Design

- To properly size an expansion tank you must have...
 - The fluid volume of the system
 - The lowest temperature that is used to fill the systems
 - The maximum operating temperature
 - The minimum fill pressure (static pressure)
 - The relief valve setting
 - The type of fluid
 - 100% water
 - 50/50 glycol
 - Some other mix

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- Methods
 - Calculation as per ASHRAE
 - Manufactures Software
 - Spreadsheets
 - Use Expansion and Acceptance Tables

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- ASHRAE sizing formula for a diaphragm expansion tank

$$\left[\frac{\left[(v_2/v_1) - 1 \right] - 3\alpha\Delta t}{1 - (P_1/P_2)} \right] \times V_s = V_t$$

V_t = volume of expansion tank, gal

V_s = volume of water in system, gal

t_1 = lower temperature, °F

t_2 = higher temperature, °F

P_1 = pressure at lower temp., psia

P_2 = pressure at higher temp., psia

v_1 = specific volume of water at lower temp., ft³/lb

v_2 = specific volume of water at higher temp., ft³/lb

α = linear coefficient of thermal expansion, in/in · °F

= 6.5×10^{-6} in/in · °F for steel,

= 9.5×10^{-6} in/in · °F for copper

Δt = ($t_2 - t_1$), °F

P_1 & P_2 are absolute pressures, add 14.7 psi to gauge.

Specific volumes are taken from Table 1 next page.

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- Table 1, Specific Volumes (Typical for Hydronic Systems)

Thermodynamic Properties of Water at Saturation												
Temp., °F t	Absolute Pressure		Specific Volume, ft ³ /lb _w			Specific Enthalpy, Btu/lb _w			Specific Entropy, Btu/lb _w ·°F			Temp., °F t
	p, psi		Sat. Solid/Liq.	Evap.	Sat. Vapor	Sat. Solid/Liq.	Evap.	Sat. Vapor	Sat. Solid/Liq.	Evap.	Sat. Vapor	
	p, in. Hg		vf	vfg	vg	hf	hfg	hg	sf	sfg	sg	
32*	0.09	0.18	0.02	3302.07	3302.09	-0.02	1075.15	1075.14	0	2.1867	2.1867	32
40	0.12172	0.24783	0.01602	2443.67	2443.69	8.03	1070.62	1078.65	0.0162	2.1426	2.1589	40
45.00	0.15	0.30	0.02	2035.91	2035.92	13.05	1067.79	1080.84	0.03	2.12	2.14	45.00
130.00	2.23	4.53	0.02	157.11	157.12	97.99	1019.42	1117.41	0.18	1.73	1.91	130.00
140.00	2.89	5.89	0.02	122.82	122.84	107.98	1013.60	1121.58	0.20	1.69	1.89	140.00
150.00	3.72	7.58	0.02	96.93	96.94	117.98	1007.73	1125.72	0.22	1.65	1.87	150.00
160.00	4.75	9.66	0.02	77.18	77.19	127.99	1001.82	1129.81	0.23	1.62	1.85	160.00
165.00	5.34	10.88	0.02	69.08	69.10	133.00	998.84	1131.84	0.24	1.60	1.84	165.00
170.00	6.00	12.21	0.02	61.97	61.99	138.01	995.84	1133.85	0.25	1.58	1.83	170.00
175.00	6.72	13.69	0.02	55.69	55.71	143.02	992.83	1135.86	0.26	1.56	1.82	175.00
180.00	7.52	15.31	0.02	50.16	50.17	148.04	989.81	1137.85	0.26	1.55	1.81	180.00
185.00	8.39	17.09	0.02	45.25	45.27	153.05	986.77	1139.82	0.27	1.53	1.80	185.00
190	9.3493	19.0353	0.01657	40.901	40.918	158.07	983.71	1141.78	0.2787	1.5141	1.79	190
195	10.40	21.1653	0.0166	37.035	37.052	163.1	980.63	1143.73	0.2864	1.4979	1.7843	195
200	11.5374	23.4904	0.01663	33.594	33.61	168.13	977.54	1145.66	0.2941	1.4818	1.7759	200

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- Example: Size an expansion tank for a heating water system that will be operated at a design temperature range between 40 °F and 180 °F. The minimum pressure at the tank is 15 psig (29.7 psia) and the maximum pressure is 30 psig (44.7 psia). (Atmospheric pressure is 14.7 psia.) The volume of water is 3000 gal. The piping is steel.

$$\left[\frac{ \left(0.01650 / 0.01600 \right) - 1 }{ 1 - (29.7 / 44.7) } - 3 \left(6.5 \times 10^{-6} \right) (180 - 40) \right] \times 3000 = 254 \text{ gal}$$

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- Spreadsheets from www.healthyheating.com

DESIGN CRITERIA		For 50% Glycol	For 100% Water	
Fd	System Fluid, 100% Water or 50% Glycol			
Vs	Volume of water in system, gal	Enter	3000.0	3000.0 supplied
T1	Lower temperature, f, ie: fill temperature	Enter , 40 or 60	40.0	40.0 supplied
T2	Higher temperature, f, ie: maximum operating temp.	Enter, Max 200 °f	180.0	180.0 supplied
Pa	Atmospheric pressure, psia		14.7	14.7 default
Pf	Minimum pressure or fill pressure, ie: pressure regulator setting	Enter	15.0	15.0 supplied
Pr	Maximum pressure or pressure relief valve setting	Enter	30.0	30.0 supplied
P1	Absolute pressure at lower temperature, psia		29.70	29.7 calculated
P2	Absolute pressure at higher temperature, psia		44.70	44.7 calculated
V1	Specific volume of water at lower temperature, ft ³ /lb	ASHRAE chpt 6. Table	0.02	0.016020 default
V2	Specific volume of water at higher temperature, ft ³ /lb	ASHRAE chpt 6. Table	0.02	0.016510 default
Xs	Thermal expansion for steel, in/in * f		0.00	6.50E-06 for steel
Delta T (T2-T1), f			140.00	140.0 calculated
Af	Acceptance factor		0.34	0.3356
Ef	Expansion factor		0.05	0.0279
EXPANSION CALCULATION RESULTS		For 50% Glycol	For 100% Water	
Mvv	Minimum vessel volume required for all bladder/diaphragm models, USgal.	413.11	249.04	
Mav	Minimum acceptance volume required for diaphragm tanks only, USgal.	138.63	83.57	
Vt	Minimum vessel volume required for closed tanks, plain steel, USgal.	834.64	503.16	

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- Tables from Manufacturers
- Acceptance Volume = water content x expansion factor
- Total Tank Volume = Acceptance Volume/acceptance factor
- $(3000 \text{ USg} \times .02763) / .33 = 251 \text{ US gal.}$

Expansion Factor							
Max. Operating Temperature, °F	Fill Temperature, °F						
	40	45	50	55	60	65	70
110	0.00771	0.00773	0.00765	0.00746	0.00716	0.00678	0.00622
115	0.00879	0.00881	0.00873	0.00854	0.00824	0.00786	0.00730
120	0.01004	0.01006	0.00998	0.00979	0.00949	0.00911	0.00855
125	0.01111	0.01113	0.01105	0.01086	0.01056	0.01018	0.00962
130	0.01236	0.01238	0.01230	0.01211	0.01181	0.01143	0.01087
135	0.01368	0.01370	0.01362	0.01342	0.01313	0.01275	0.01219
140	0.01501	0.01503	0.01495	0.01476	0.01446	0.01408	0.01352
145	0.01643	0.01645	0.01637	0.01618	0.01588	0.01550	0.01494
150	0.01787	0.01787	0.01779	0.01760	0.01730	0.01692	0.01636
160	0.02092	0.02094	0.02086	0.02067	0.02037	0.01999	0.01943
170	0.02418	0.02420	0.02412	0.02393	0.02363	0.02325	0.02269
180	0.02763	0.02765	0.02757	0.02738	0.02708	0.02670	0.02614
190	0.03127	0.03129	0.03121	0.03102	0.03072	0.03034	0.02978
200	0.03512	0.03510	0.03504	0.03485	0.03455	0.03417	0.03361

For 50/50 Glycol, add 60% to above numbers

Acceptance Factors				
Pressure Relief Valve Setting	Fill Pressure At Expansion Tank, psig			
	10	12	15	20
30 psig	0.44	0.4	0.33	0.22

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- A Note on Types



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