ASME expansion tanks

WHY AN EXPANSION TANK?

An expansion tank is required in a closed loop heating or chilled water HVAC system for two very important reasons:

1. **To control the systems operating pressure range;**
2. **To give the expanded water in the system a place to go as the water is heated. In a heating system this occurs when the system is heated from its coldest fill temperature to operation temperature. In a chilled water system this expansion occurs when the system is shut down and the system temperature rises from operating to ambient.**

The goal in sizing any expansion tank is to make the system able to accommodate the expansion of the system water throughout the heating or cooling cycles without allowing the system to exceed the pressure limits of the lowest pressure rated component in that system. The lowest rated component in most systems is, by design, the pressure relief valve. The maximum system pressure is normally set at 90% of the pressure relief valve rating at its point of installation.

BLADDER OR DIAPHRAGM TANKS COMPARED TO PLAIN STEEL TANKS

The plain steel expansion tank has been used for many years, and, in some systems, has worked very well. Using a plain steel expansion tank makes the system an air control system. One must control the air volume or air cushion above the water level of the tank. The common interface between this air cushion and the water in the tank allows the air to be absorbed by the water. If the air is not removed properly from the water and placed back into the air cushion, the expansion tank will become waterlogged.

A waterlogged tank is an expansion tank that no longer has an air cushion large enough to allow all the expanded water from the system to enter the tank without exceeding the maximum system pressure. When this occurs, the safety relief valve will open and heated system water will be discharged to the drain.

CAUTION: An expansion tank does not need to be 100% full to be waterlogged. The same symptoms will also show if the expansion tank is sized too small.

The advantage of a plain steel tank is that the initial purchase cost is lower than a diaphragm/bladder tank, but in many cases the operation costs will offset this advantage.

The bladder / diaphragm expansion tank has been developed to allow the system's air cushion to be separated from the system's water. No waterlogging of the tank can occur as the air is held between the tank wall and the exterior of a bladder placed inside the tank, while the system water is contained inside the bladder. This changes the system to an air elimination system, as any air extracted from the system water is passed out of the system into the atmosphere.

The bladder tank is usually smaller than a plain steel tank for the same application as they are precharged with air to the system operating pressure before the system is filled with water. The only water that needs to be accommodated by a bladder/diaphragm tank is the expanded water. In a heating system, this occurs when the water is heated from the fill temperature to the operating temperature. In a chilled water system the water temperature rises from operating temperature to ambient temperature. The air elimination system allows the air vent and air separator to be placed at the most advantageous point in the system for air removal, usually at the system's high point where the pressure is the lowest or at the boiler outlet where the water temperature is the highest. The expansion tank can now be placed at floor level, since air no longer needs to be returned to the tank. The diaphragm/ bladder tank can also be placed at the most advantageous point in the system.

TYPICAL POSITIONING OF AN EXPANSION TANK

The system connection of an expansion is known as "The Point of No Pressure Change". This means that wherever the expansion tank is connected to the system, the pressure will always be the same as the pressure inside the tank. This is true if the tank is a plain steel or bladder/diaphragm type. This is also true whether the system pump is on or off. This pressure is only changed as water or air are added to or removed from the tank. To better understand this "Point of No Pressure Change", an in-depth study of Boyle's Law is necessary.

Because of this "Point of No Pressure Change", the system sees a pump additive pressure from the pump discharge to the expansion tank connection. From the expansion tank connection back to the pump suction, the system receives a negative pressure change from the tank pressure, due to the friction loss when there is flow.

With this loss of pressure added by the pump and the loss due to flow, it is usually better to place the "Point of No Pressure Change" or expansion tank system connection as close to the pump suction as possible.

CONVERSION

CALEFACTIO

Converting plain steel tanks to diaphragm expansion tanks

Job Name: ______________________ Date: ______________

Job Location: ______________________ Model #: ______________

Contact Name: ______________________ Date submitted: ______________

Engineer: ______________________ Approved by: ______________

Contractor: ______________________ Date of approval: ______________

INFORMATION REQUIRED

1. Determine plain steel tanks volume (table 2, p. 22) **(1)** ________ gal ________ L
2. Temperature of water when system is filled **(2)** ________ °F ________ °C
3. Maximum operating temperature **(3)** ________ °F ________ °C
4. Minimum operating pressure (usually fill pressure) **(4)** ________ psi ________ kPa
5. Maximum operating pressure (10% below relief valve) **(5)** ________ psi ________ kPa

SIZING FOR HYDRONIC HEATING/COOLING SYSTEMS

6. Determine the acceptance by $(P_a \div P_f)$ $(P_a \div P_o)$,
   where P_a = Pressure (atmospheric)
   P_f = Pressure at fill (atmospheric)
   P_o = Pressure at operation (atmospheric)
   and enter the result. **(6)** ________ ________
7. Enter volume of plain steel tank
   line **(1)**. **(7)** ________ gal ________ L
8. Calculate expanded water volume.
   Multiply line **(6)** by line **(7)** and enter. **(8)** ________ gal ________ L
9. Using Acceptance Factors table (see pages 23 and 24),
   and enter the acceptance factor. **(9)** ________ ________
10. Divide line **(8)** by line **(9)**,
    enter tank volume required. **(10)** ________ gal ________ L

    Line **(8)** ________, expanded water (acceptance volume)

    Line **(10)** ________, total tank volume

MODEL SELECTION

Select expansion tank model from fixed/replaceable bladder section.
• HGT (non-code) or OT models must satisfy both lines **(8)** and **(10)**.
• AL models are selected by total volume only from line **(10)**.

For large systems, multiple tanks can be manifolded together.

CAUTION: The expansion chart is for water only. Add 60% to the expansion factors for 50/50 glycol/water solutions or contact your local Calefactio representative for other concentrations.

SIZING GUIDE

CALEFACTIO

ASME expansion tanks for potable water – BFA, TXA and FTTE-C Series

Job Name:____________________ Date: ____________________

Job Location: ____________________ Model #: ____________________

Contact Name:____________________ Date submitted: ____________________

Engineer:____________________ Approved by: ____________________

Contractor: ____________________ Date of approval:____________________

INFORMATION REQUIRED

1. Total volume of hot water tank	**(1)**__________	gal	__________ L
2. Water temperature setting	**(2)**__________	°F	__________ °C
3. Minimum operating pressure at the tank	**(3)**__________	psi	__________ kPa
4. Maximum allowable pressure or relief valve setting	**(4)**__________	psi	__________ kPa

SIZING ASME THERMAL EXPANSION TANKS FOR POTABLE WATER

5. Enter the total volume of hot water tank from line **(1)**.	**(5)**__________	gal	__________ L
6. Find and enter the "Expansion Factor". (Refer to the table on page 43).	**(6)**__________	°F	__________ °C
7. Multiply line **(5)** by line **(6)** to determine the quantity of expanded water.	**(7)**__________	gal	__________ L
8. Find and enter the "Acceptance Factor" according to the pressures on line **(3)** and **(4)**. (Refer to the tables on pages 44 and 45)	**(8)**__________	psi	__________ kPa
9. Divide line **(7)** by line **(8)** to obtain the minimum tank volume required	**(9)**__________	gal	__________ L

MODEL SELECTION

Refer to the appropriate submittal datasheet (BFA, FTTE-C or TXA models) and select the model which is equal to or greater than the minimum volume required **(9)** and the minimum acceptance volume required **(7)**.

EXPANSION FACTORS TABLE

TABLE 1

Expansion Factors based on 40 °F / 4.4 °C minimum water temperature

EXPANSION FACTORS Different level of maximum temperature				
120 °F / 48.8°C	**140 °F / 60 °C**	**160 °F / 71.1 °C**	**180 °F / 82.2 °C**	**200 °F / 93.3°C**
0.01006	0.01503	0.02094	0.02765	0.03512

For other temperatures, please refer to table on p. 21

ACCEPTANCE FACTORS TABLE

TABLE 2

Acceptance factors (use gauge pressures)

Maximum pressure (psig / kPa)	Minimum operating pressure at the tank (psig / kPa)							
	60 / 413.7	**65 / 448.2**	**70 / 482.6**	**75 / 517.1**	**80 / 551.6**	**85 / 586.1**	**90 / 620.5**	**95 / 655.0**
100 / 689.5	0.347	0.305	0.261	0.218	0.174	0.131	0.087	0.043
125 / 861.8	0.465	0.429	0.394	0.358	0.322	0.286	0.250	0.215

ACCEPTANCE FACTORS TABLE

CALEFACTIO

Use gauge pressure

(P_0) Maximum operating pressure		P_f – Minimum operating pressure at tank (psig)/kPa											
psig	kPa	5 34.5	10 68.9	12 82.7	15 103.4	20 137.9	25 172.4	30 206.8	35 241.3	40 275.8	45 310.3	50 344.7	55 379.2
10	**68.9**	0.202	–										
12	**82.7**	0.262	0.075	–									
15	**103.4**	0.337	0.168	0.101	–								
20	**137.9**	0.432	0.288	0.231	0.144	–							
25	**172.4**	0.504	0.378	0.328	0.252	0.126							
27	**186.1**	0.527	0.408	0.360	0.288	0.168	–						
30	**206.8**	0.560	0.447	0.403	0.336	0.224	0.112	–					
35	**241.3**	0.604	0.503	0.463	0.403	0.302	0.202	0.101	–				
40	**275.8**	0.640	0.548	0.512	0.457	0.366	0.274	0.183	0.091	–			
45	**310.3**	0.670	0.586	0.553	0.503	0.419	0.335	0.251	0.168	0.084	–		
50	**344.7**	0.696	0.618	0.587	0.541	0.464	0.386	0.309	0.232	0.155	0.078	–	
55	**379.2**	0.717	0.646	0.617	0.574	0.502	0.430	0.359	0.287	0.215	0.144	0.072	–
60	**413.7**	0.736	0.669	0.643	0.602	0.536	0.469	0.402	0.335	0.268	0.201	0.134	0.067
65	**448.2**	0.753	0.690	0.665	0.627	0.565	0.502	0.439	0.376	0.314	0.251	0.188	0.125
70	**482.6**	0.767	0.708	0.685	0.649	0.590	0.531	0.472	0.413	0.354	0.295	0.236	0.177
75	**517.1**	0.780	0.725	0.702	0.669	0.613	0.558	0.502	0.446	0.390	0.333	0.279	0.223
80	**551.6**	0.792	0.739	0.718	0.686	0.634	0.581	0.528	0.475	0.422	0.370	0.317	0.264
85	**586.1**	0.802	0.752	0.732	0.702	0.652	0.602	0.552	0.502	0.451	0.401	0.351	0.301
90	**620.5**	0.812	0.764	0.745	0.716	0.669	0.621	0.573	0.525	0.478	0.430	0.382	0.335
95	**655.0**	0.820	0.775	0.757	0.729	0.684	0.638	0.593	0.547	0.501	0.456	0.410	0.365
100	**689.5**	0.828	0.785	0.767	0.741	0.698	0.654	0.610	0.567	0.523	0.479	0.436	0.392
105	**723.9**	0.835	0.794	0.777	0.752	0.710	0.668	0.626	0.585	0.543	0.501	0.459	0.418
110	**758.4**	0.842	0.802	0.786	0.762	0.723	0.682	0.642	0.601	0.561	0.521	0.481	0.441
115	**792.9**	0.848	0.810	0.794	0.771	0.734	0.694	0.655	0.617	0.578	0.540	0.501	0.463
120	**827.4**	0.854	0.817	0.802	0.780	0.742	0.705	0.668	0.631	0.594	0.557	0.520	0.483
125	**861.8**	0.859	0.823	0.809	0.787	0.752	0.716	0.680	0.644	0.608	0.573	0.537	0.501
130	**896.3**	0.864	0.829	0.815	0.795	0.760	0.726	0.691	0.657	0.622	0.586	0.553	0.519
135	**930.8**	0.868	0.835	0.822	0.802	0.768	0.735	0.701	0.6&8	0.635	0.601	0.563	0.534
140	**965.3**	0.873	0.840	0.827	0.808	0.776	0.743	0.711	0.679	0.647	0.614	0.582	0.550
145	**999.7**	0.877	0.845	0.833	0.814	0.783	0.751	0.720	0.689	0.658	0.626	0.595	0.564
150	**1034.2**	0.880	0.850	0.838	0.820	0.789	0.759	0.729	0.699	0.668	0.638	0.608	0.577
155	**1068.7**	0.884	0.854	0.843	0.825	0.795	0.766	0.736	0.707	0.677	0.648	0.618	0.589
160	**1103.2**	0.887	0.859	0.847	0.830	0.801	0.773	0.744	0.716	0.687	0.658	0.630	0.601
165	**1137.6**	0.890	0.863	0.851	0.835	0.807	0.779	0.751	0.724	0.696	0.668	0.640	0.612
170	**1172.1**	0.893	0.866	0.855	0.839	0.812	0.785	0.758	0.731	0.704	0.677	0.649	0.622
175	**1206.6**	0.896	0.870	0.859	0.843	0.817	0.791	0.764	0.738	0.711	0.685	0.659	0.632
180	**1241.1**	0.899	0.873	0.863	0.847	0.822	0.796	0.770	0.745	0.719	0.693	0.668	0.642
185	**1275.5**	0.901	0.876	0.866	0.851	0.826	0.801	0.776	0.751	0.726	0.701	0.676	0.651
190	**1310.0**	0.904	0.879	0.870	0.855	0.831	0.806	0.782	0.757	0.733	0.709	0.684	0.660
195	**1344.5**	0.906	0.882	0.873	0.858	0.835	0.811	0.787	0.7&3	0.739	0.716	0.692	0.668
200	**1379.0**	0.908	0.885	0.876	0.862	0.838	0.815	0.792	0.768	0.745	0.722	0.699	0.675
205	**1413.4**	0.910	0.888	0.878	0.865	0.842	0.819	0.796	0.774	0.751	0.728	0.705	0.682
210	**1447.9**	0.912	0.890	0.881	0.868	0.845	0.823	0.801	0.779	0.756	0.734	0.712	0.689
215	**1482.4**	0.914	0.892	0.884	0.871	0.849	0.827	0.805	0.783	0.762	0.740	0.718	0.696
220	**1516.8**	0.916	0.895	0.886	0.873	0.852	0.831	0.810	0.788	0.767	0.746	0.724	0.703
225	**1551.3**	0.918	0.897	0.889	0.876	0.855	0.834	0.813	0.792	0.772	0.751	0.730	0.709
230	**1585.8**	0.919	0.899	0.891	0.879	0.858	0.838	0.817	0.797	0.777	0.756	0.736	0.715
235	**1620.3**	0.921	0.901	0.893	0.881	0.861	0.841	0.821	0.801	0.780	0.760	0.740	0.720
240	**1654.7**	0.923	0.903	0.895	0.883	0.864	0.884	0.825	0.805	0.785	0.766	0.746	0.727
245	**1689.2**	0.924	0.905	0.897	0.886	0.866	0.847	0.828	0.808	0.789	0.770	0.751	0.731
250	**1723.7**	0.926	0.907	0.899	0.888	0.869	0.850	0.831	0.812	0.793	0.774	0.755	0.737

ACCEPTANCE FACTORS TABLE

CALEFACTIO

Use gauge pressure

(P_0) Maximum operating pressure		P_f – Minimum operating pressure at tank (psig)/kPa											
psig	kPa	60 413.7	65 448.2	70 482.6	75 517.1	80 551.6	85 586.1	90 620.5	95 655.0	100 689.5	105 723.9	110 758.4	115 792.9
60	413.7	–											
65	448.2	0.062	–										
70	482.6	0.118	0.059	–									
75	517.1	0.167	0.111	0.056	–								
80	551.6	0.211	0.158	0.106	0.053	–							
85	586.1	0.251	0.201	0.151	0.101	0.050	–						
90	620.5	0.287	0.239	0.191	0.143	0.096	0.048	–					
95	655.0	0.319	0.273	0.228	0.182	0.137	0.091	0.045	–				
100	689.5	0.347	0.305	0.261	0.218	0.174	0.131	0.087	0.043	–			
105	723.9	0.376	0.334	0.292	0.250	0.208	0.167	0.125	0.083	0.041	–		
110	758.4	0.401	0.361	0.321	0.281	0.241	0.200	0.160	0.120	0.080	0.040	–	
115	792.9	0.424	0.386	0.347	0.309	0.270	0.232	0.193	0.155	0.116	0.007	0.039	–
120	827.4	0.446	0.408	0.371	0.334	0.297	0.260	0.223	0.186	0.149	0.111	0.074	0.037
125	861.8	0.465	0.429	0.394	0.358	0.322	0.286	0.250	0.215	0.179	0.143	0.107	0.071
130	896.3	0.484	0.450	0.415	0.381	0.346	0.312	0.277	0.243	0.208	0.173	0.138	0.104
135	930.8	0.501	0.468	0.439	0.401	0.367	0.334	0.301	0.267	0.234	0.200	0.167	0.134
140	965.3	0.517	0.485	0.453	0.420	0.388	0.356	0.324	0.291	0.259	0.226	0194	0.162
145	999.7	0.532	0.501	0.470	0.438	0.407	0.376	0.344	0.313	0.282	0.250	0.219	0.188
150	1034.2	0.547	0.517	0.486	0.456	0.426	0.396	0.365	0.335	0.305	0.273	0.243	0.213
155	1068.7	0.559	0.530	0.500	0.471	0.441	0.412	0.382	0.353	0.323	0.295	0.265	0.236
160	1103.2	0.573	0.544	0.515	0.487	0.458	0.430	0.401	0.372	0.344	0.315	0.286	0.258
165	1137.6	0.585	0.557	0.529	0.501	0.473	0.446	0.418	0.390	0.362	0.334	0.306	0.278
170	1172.1	0.595	0.568	0.541	0.514	0.487	0.460	0.433	0.460	0.378	0.352	0.325	0.298
175	1206.6	0.606	0.579	0.553	0.527	0.500	0.474	0.447	0.421	0.395	0.369	0.343	0.316
180	1241.1	0.616	0.590	0.565	0.539	0.513	0.488	0.462	0.436	0.411	0.385	0.360	0.334
185	1275.5	0.626	0.601	0.576	0.551	0.526	0.501	0.476	0.451	0.426	0.401	0.376	0.351
190	1310.0	0.635	0.611	0.587	0.562	0.538	0.513	0.489	0.465	0.440	0.415	0.391	0.366
195	1344.5	0.644	0.620	0.597	0.573	0.549	0.525	0.501	0.478	0.454	0.429	0.405	0.381
200	1379.0	0.652	0.629	0.605	0.582	0.559	0.535	0.512	0.489	0.466	0.443	0.419	0.396
205	1413.4	0.660	0.637	0.614	0.591	0.568	0.546	0.523	0.450	0.477	0.455	0.432	0.410
210	1447.9	0.667	0.645	0.622	0.600	0.578	0.556	0.533	0.510	0.489	0.467	0.445	0.423
215	1482.4	0.674	0.653	0.631	0.609	0.587	0.565	0.544	0.522	0.500	0.479	0.457	0.435
220	1516.8	0.682	0.660	0.639	0.618	0.597	0.575	0.554	0.533	0.511	0.490	0.469	0.447
225	1551.3	0.688	0.667	0.646	0.625	0.604	0.583	0.563	0.542	0.521	0.501	0.478	0.459
230	1585.8	0.695	0.675	0.654	0.634	0.613	0.593	0.573	0.552	0.532	0.511	0.490	0.470
235	1620.3	0.700	0.680	0.660	0.640	0.620	0.600	0.579	0.559	0.539	0.521	0.501	0.481
240	1654.7	0.707	0.687	0.668	0.648	0.629	0.609	0.589	0.570	0.550	0.530	0.510	0.491
245	1689.2	0.712	0.693	0.673	0.654	0.635	0.615	0.596	0.577	0.558	0.539	0.520	0.501
250	1723.7	0.718	0.699	0.680	0.661	0.642	0.623	0.604	0.585	0.566	0.548	0.529	0.510

$$\textbf{Acceptance Factor} = 1 - \frac{P_f}{P_o}$$

P_f = minimum absolute pressure, P_o = maximum absolute pressure