In-Line Air Separators

The AC models of air separators deliver all the quality and performance you expect from Taco products. They are built to last with shell, heads and ANSI flanges with ASME constructed for 125, 150, 250 and 300psi working pressures all while providing outstanding performance in the field, up to a maximum operating temperature of 375˚F. The AC product line is available in standard sizes from 2" through 20" to meet the needs of a broad range of applications with custom unit sizes available up to 36" pipe size.

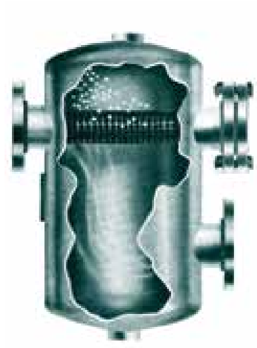
ISO CERTIFIED 9001

Taco®
Do your best work.

©Taco Catalog #400-1.1
Supersedes: 04/01/86

Effective Date: 04/09/13
Printed in USA

Features & Benefits

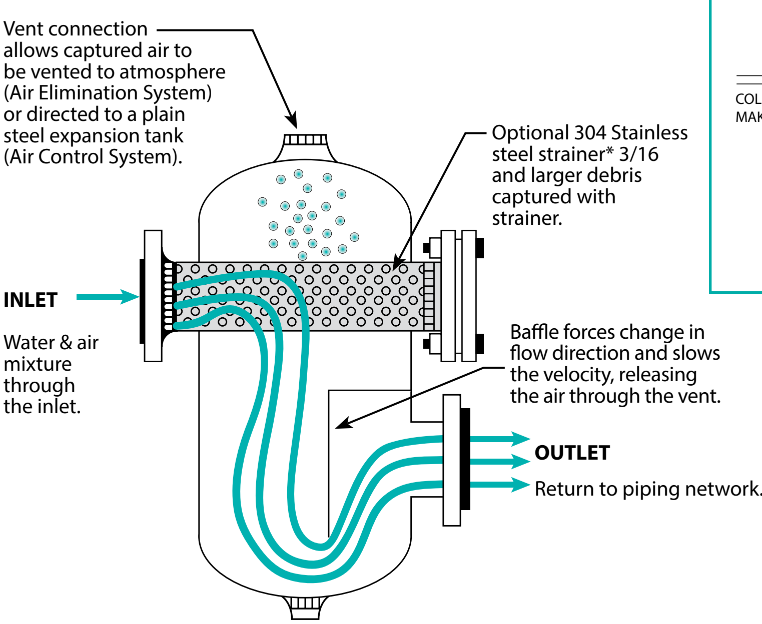


Air trapped in the system can produce major problems such as reduced heat transfer, loss of system efficiency, pipe corrosion, pump damage, increased energy consumption and irritating noise. The highly efficient Taco air separator clears the system of free air and reduces un-dissolved sediment to save money, energy and component wear. Unlike many competitive models each unit is designed, constructed and tested to the requirements of Section VIII, Division I of the ASME pressure vessel code as standard.

Designed for use in hydronic heating or cooling systems, Taco's compact, highly efficient air separator provides air separation while minimizing space requirements.

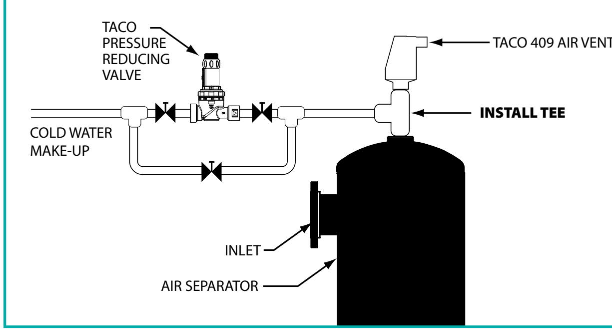
Taco offers these separators with or without strainers, in standard pipe line sizes from 2" to 20" with custom unit sizes up to 36" pipe size. The wide range of separator models have been developed for applications with flowrates up to 12,500 gpm. This wide range of models allows optimum selections with reduced pressure drop requirements. The standard product is designed for working pressures of 125 psi at 375˚F. Optional 150, 250 and 300 psi maximum pressure units, 375˚F maximum temperature units are also available. Taco air separators are manufactured from carbon steel listed in ASME Section II. Consult the factory for higher working pressures, larger sizes or non-standard materials of construction.

Air Separator Flow Pattern



** Provided as standard on F model units*

Recommended/Typical Installation



In-Line ASME Air Separators (AC)

Taco In-Line Air Separators are applied in commercial, institutional and industrial applications for the removal of free air in water or water/glycol systems. The In-Line designed air separator utilizes the advantages resulting from large body diameter in relation to the entering nozzle diameter.

The design of in-line air separators depends upon the **lowering of the system fluid velocity** within the separator, the **change in direction** of fluid flow within the unit, and **buoyant force** direct air to the automatic air vent normally positioned at the top of the separator.

These air separators are designed, built and stamped to the requirements of ASME. The rated working pressure of these units is dependent upon the design pressure of the hydronic system into which they are being installed. Manufacturers offer these unit working pressures of 125, 150, 250 and 300 psi and higher if required.

Optional stainless steel strainers are specified to **capture** and allow the removal of larger debris. (3/16" and larger) These screens are normally specified with 3/16 inch perforations and free area of not less than 5 times the open area of the nozzle to minimize pressure drop. Most manufacturers provide a blowdown connection at the bottom of the unit.

When In-Line Air Separators are installed in conventional **Air Control Systems** with plain steel expansion tanks (Figure A) care must be taken to insure that piping between the air separator and the plain steel expansion tank is pitched at least 3 degrees to facilitate the migration of captured air back into the expansion vessel. Systems with plain steel expansion tanks must not have automatic vents installed as this will lead to the loss of the expansion tank compression cushion.

Air Separator with Plain Steel Expansion Tank

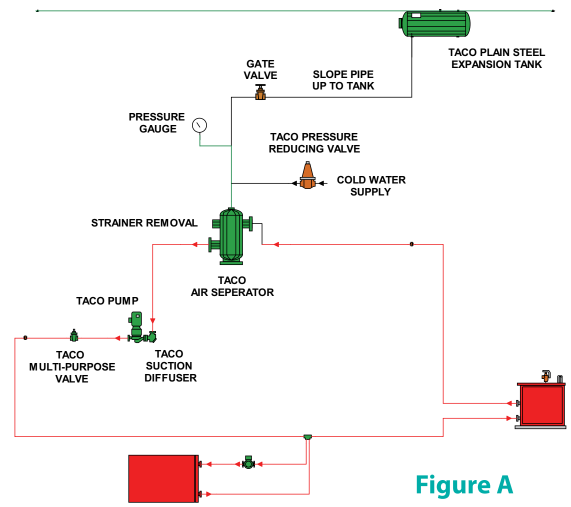


Figure A

When In-Line Air Separators are installed in **Air Elimination Systems** (Figure B) with Captive Air bladder or diaphragm style expansion tanks, automatic air vents should be installed at the top of each separator. As Air Elimination systems have a permanent separation provided by the bladder of diaphragm between the initial tank pre-charge and the system fluid no loss of pre-charge air will occur.

Applications

- **Larger systems**
- **Lower pressure drop**
- **Removal of larger particles**

Air Separator with Captive Air Tank

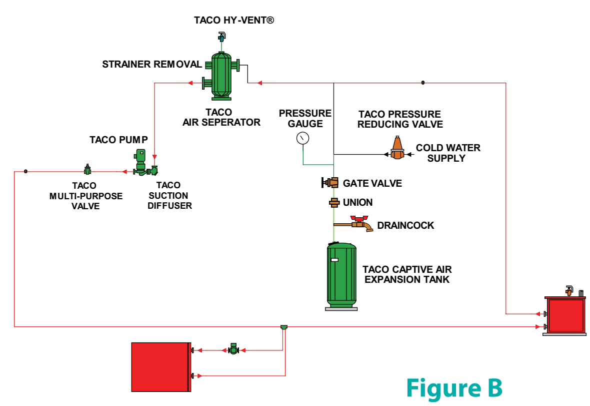


Figure B

Air Control and Elimination

Water contains a certain amount of entrained air. If this air comes out of solution, it can increase corrosion rates of metals within the system. In addition, air can form pockets at the top of pipes and heating units. These air pockets can actually restrict or block flow in a hydronic piping system. This is referred to as "air locking".

The table below shows a solubility curve for air in water. Note that at a fixed pressure, increasing the temperature reduces the amount of air that can be dissolved. For example, at 60 PSIA and 40°F, the water can contain just over 10% air by volume. At 60 PSIA and 200° F, the percentage decreases to just over 4%.

Conversely, at fixed temperature reducing the pressure reduces the amount of air that can be dissolved. For example at 100°F and 80 PSIA the water can contain 8% air by volume. At 100°F and 20 PSIA the percentage decreases to 2%.

Solubility Curve

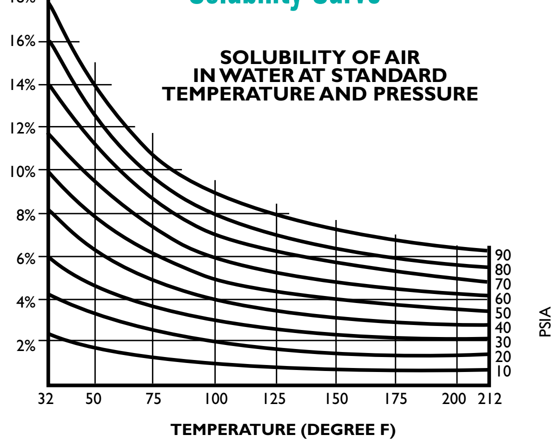


Figure 1

The conclusion is that air is least soluble in water at the highest temperature and lowest pressure. Air separators should therefore be located at these points.

The highest temperature in a system is typically on the discharge of boilers and inlet of chillers. Therefore, the general rule of thumb in hydronic systems is that ***"Air separators should be located downstream of boilers (Figure 2) and upstream of chillers (Figure 3)."***

The lowest pressure in a system is typically at the expansion tank, since this is the point of no pressure change and the location of the fill valve. Therefore, the general rule of thumb in hydronic systems is that ***"Air separators should be located at the expansion tank connection to the system."***

Boiler and Air Separator Location

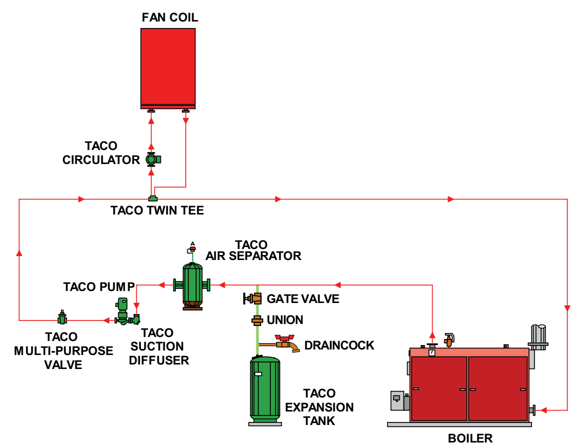


Figure 2

Chiller and Air Separator Location

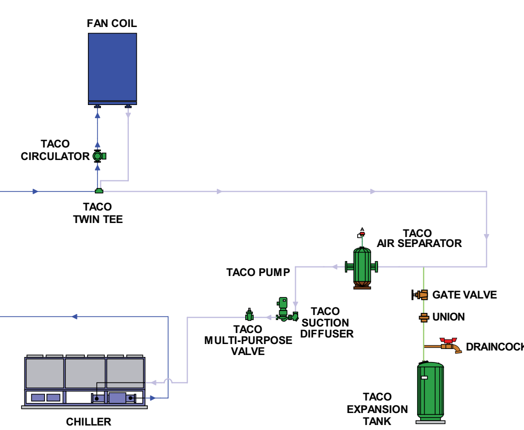


Figure 3

In addition, as water is heated from the fill temperature to the operating temperature, a great deal of air is released. Therefore, the simple act of bringing the water to operating temperature could lead to corrosion and air pockets, both of which should be avoided.

A method of removing this released air from the piping system is therefore required. Enter the air separator. An air separator is a device that is removes the air from the circulating fluid.

There are several types of air separators in use today. Depending upon the type of expansion tank used in the system, the air separator is part of an Air Control System or an Air Elimination System.

Air Control Systems

If a conventional (non-bladder) style expansion tank is used, it is desirable to redirect the separated air to the space above the water level in the expansion tank (Figure 4). The dotted line from the air separator (scoop) to the plain steel tank shows the proper connection, with the air piped from the scoop to the expansion tank through a special tank fitting.

Air Control System

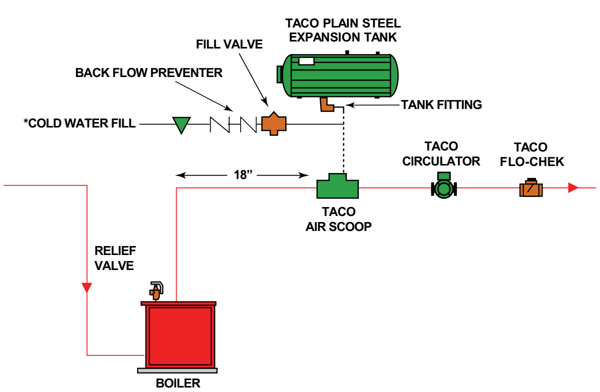


Figure 4

This fitting directs the air to the top portion of the tank, and discourages air from migrating back into the system (See Figure 5), when the system cools on the "off" cycle. Note that since the air is "recycled" to provide a cushion in the expansion tank, this system is called an "Air Control" system.

Note that the circulator is on the supply side of the boiler. This is the proper location, as it results in the highest pressure at the top of the system (if the circulator was on the return side of the boiler, the boiler pressure drop reduce the pressure at the top.) Having a higher pressure at the top keeps air in solution, and helps prevent problems and air binding.

Tank Fitting

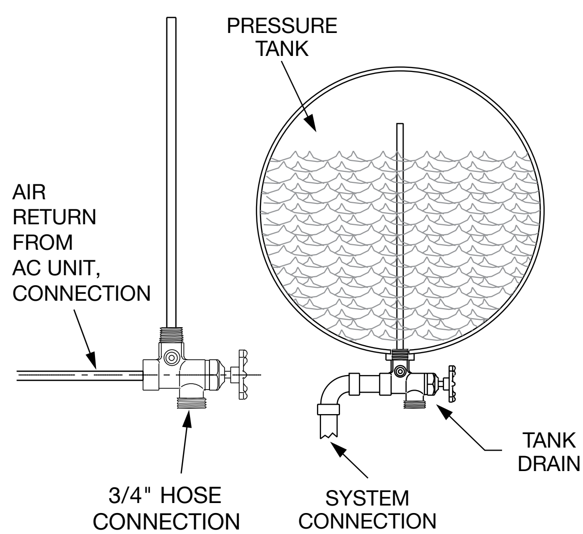


Figure 5

Air Elimination Systems

If a Captive Air or Bladder Style expansion tank is used, there is no reason to "save" the separated air (Figure 6). Therefore, if an air separator (scoop) is used in an air elimination system rather than an air control system, the separator is fitted with an automatic air vent (Taco's "Hy-Vent®" series), which discharges the separated air to the atmosphere. Note that since the air is eliminated through an air vent this system is called an "Air Elimination" system.

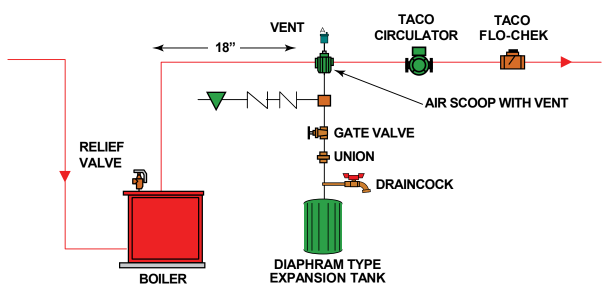


Figure 6

Types of Air Separators

Air Scoop

Taco Air scoops are applied in residential and light commercial applications for the removal of free air in water or water/glycol systems. The body of each air scoop provides an increased cross sectional area and lower velocity within the piping network thereby allowing free air to rise due to buoyant force. To assist with the removal of smaller air bubbles integral baffles are incorporated within most air scoops.

Optimum performance is achieved at line velocities up to 4 ft/sec. However, air scoops have been successfully installed on applications with velocities up to 8 ft/sec. Air scoops are specifically designed for the line size which they are to be installed. These sizes range from1 inch to 4 inch.

Most manufacturers rate their air scoop product lines for 125 psi with a maximum operating temperature of 300˚F. Air scoops are installed in conjunction with an expansion tank and air vent as shown in figure 7.

(See Taco Catalog# 100-7.2 for additional information.)

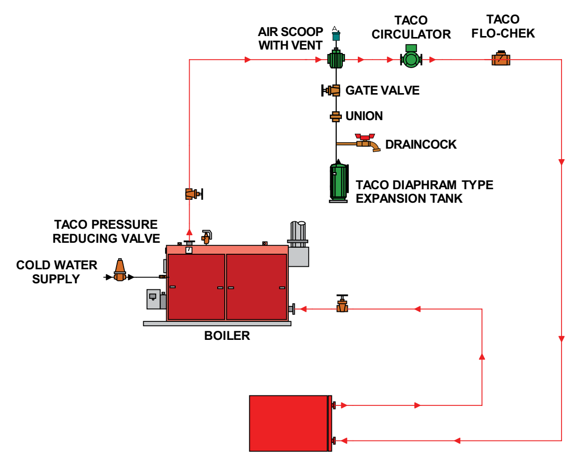


Figure 7

Applications
- **Smaller systems**
- **Lower cost**
- **Compact installation**

VorTech®

Taco VorTech® Air Separators are applied in residential and light commercial applications for the removal of free air in water or water/glycol systems. The body of a VorTech features a primary separation chamber where the process of air elimination is controlled and optimized.

The body of each VorTech is specially designed to direct the flow of the system fluid tangentially exiting at the bottom of the chamber. To assist with the removal of larger air pockets each VorTech incorporates a 300 series stainless bubble breaker cartridge to breakup larger air volumes.

Due to the tangential effect the system fluid with its higher density is pushed to the outside wall of the chamber as the less dense air is directed toward the vortex of the flow and vented from the system.

Optimum performance is achieved at line velocities up to 4 ft/sec. However, VorTech style units have been successfully installed on applications with velocities up to 8 ft/sec. VorTech separators are specifically designed for the line size which they are to be installed. These sizes range from 3/4 inch to 2 inch.

VorTech style separators are rated for 150 psi with a maximum operating temperature of 240°F. VorTech are commonly installed in conjunction with an expansion tank and air vent as shown in Figure 8.

4900 Series Air Separator

Taco 4900 Series Air Separators use a patented, independently proven method for removing gasses from water: the PALL ring process. Inside the 4900, PALL rings accumulate and then completely eliminate micro-bubbles from 15 microns and up. That's bubbles which are 3 times smaller than the nearest competitions scrubbing design. What's more, Taco's unique conical venting chamber with integral shut-off and protective plate keeps waterborne dirt and impurities well clear of the venting mechanisms so that fouling of the vent is eliminated during normal operation.

Applications

- **Smaller systems**
- **Higher efficiencies**
- **Compact installation**

(See Taco Catalog# 100-2.9 for additional information.)

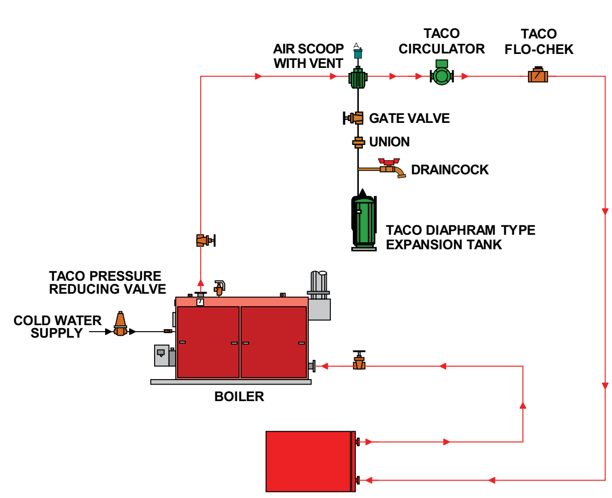


Figure 8

Applications

Tangential ASME Air Separators

Taco Tangential Air Separators are applied in commercial, institutional and industrial applications for the removal of free air in water or water/glycol systems. The Tangential design air separators utilize the difference in density to separate free air from system fluid.

System fluid within a tangential air separator is forced to the wall of the separator due to centrifugal force. The less dense air then mirgrates to the center of the separator for venting at the top of the unit. Tangential air separators produce higher pressure drops than in-line or micro-bubble separators due to the vortex development within the unit.

These units are designed, built, tested and stamped to the requirements of ASME. Manufacturers offer tangential separators in working pressures of 125, 150, 250, 300 psi and higher if required.

Optional stainless steel strainers are specified to capture and allow the removal of large debris. These screens are normally specified with 3/16 inch perforations and free area of not less than 5 times the open area of the nozzle to minimize pressure drop. Most manufacturers provide a blowdown connection at the bottom of the unit.

When Tangential Air Separators are installed in conventional Air Control systems with plain steel expansion tanks (Figure 9) care must be taken to insure that piping between the air vent and the plain steel tank is pitched at least 3 degrees to facilitate the migration of captured air back into the expansion vessel. Systems with plain steel expansion tanks must not have automatic air vents installed as this will lead to the loss of the expansion tank compression cushion. When Tangential Air Separators are installed in Air Elimination systems (Figure 10) with Captive Air bladder or diaphragm style expansion tanks, automatic air vents should be installed at the top of each air separator. As Air Elimination systems have a permanent separation provided by the bladder or diaphragm between the initial tank pre-charge and the system fluid no loss of pre-charge will occur.

(See Taco Catalog# 400-3.1 for additional information.)

Air Separator with Plain Steel Expansion Tank

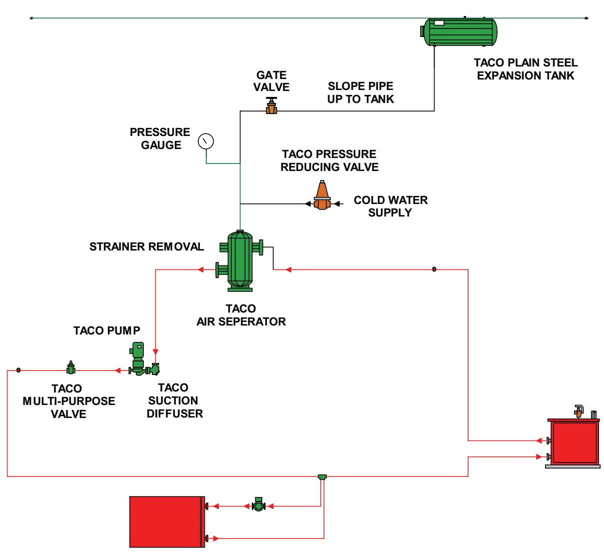


Figure 9

Air Separator with Captive Air Tank

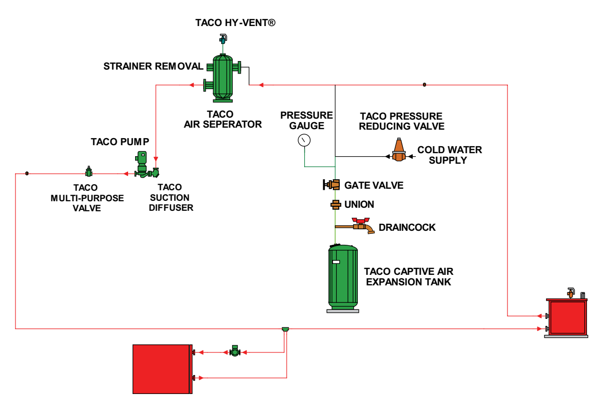


Figure 10

4900 Series High Efficiency Micro-Bubble Air and Dirt ASME Separator

Taco 4900 Series High Efficiency Micro-Bubble Air and Dirt Separators are applied in commercial, institutional and industrial applications for the removal of free and entrained air. The 4900 Series utilize the coalescence of micro air bubbles around PALL rings to separate free air from a system fluid.

The 4900 Series incorporates the highest available **coalescence** surface area available on the market today. This enhanced surface area allows the removal of micro-bubbles as small as 15 microns in diameter. **The 4900 Series separators remove up to 99.6% of the dissolved air through the action of coalescence.** This feature is especially beneficial in correcting problems in air entrained systems.

Units are designed for low Pressure drops typically under 2 PSIG.

An additional feature of the 4900 Series is the capability to remove dirt sizes as small as 5 microns from hydronic systems. **The 4900 Series separators remove up to 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system fluid.** This feature is especially beneficial in correcting problems in air entrained systems.

The 4900 Series has been designed in **two velocity ranges**, a standard product series suitable for line velocity to 4.9 ft/sec. and a high velocity series suitable for line velocities up 11 ft/sec. The performance of the 4900 product line has been independently tested and published. (These test results are available through your local Taco representative.)

These units are designed, built, tested and stamped to the requirements ASME Section VIII, Division 1. Manufacturers offer micro bubble air and dirt separators in working pressures of 125, 150, 250 psi.

When High Efficiency Micro Bubble Air and Dirt Separators are installed in conventional Air Control systems with plain steel expansion tanks (Figure 9) care must be taken to insure that piping between the air vent and the plain steel tank is pitched at least 3 degrees to facilitate the migration of captured air back in the expansion vessel. Systems with plain steel expansion tanks must not have automatic vents installed as this will lead to the loss of the expansion tank compression cushion.

When High Efficiency Micro Bubble Air and Dirt Separators are installed in Air Elimination systems (Figure 10) with Captive Air bladder or diaphragm style expansion tanks, automatic air vents should be installed at the top of each air separator. As Air Elimination systems have permanent separation provided by the bladder or diaphragm between the initial tank pre-charge and the system fluid no loss of pre-charge air will occur.

(See Taco Catalog# 400-1.4 for additional information.)

Applications

- **Larger systems**
- **Higher efficiencies**
- **Higher velocities**
- **Removal of smaller air bubbles, e.g. removal of air in air entrained systems (removes micro air bubbles)**
- **Removal of smaller particles, e.g. cleaning of dirty systems (removes particles and dirt)**

Example 1 [Less Strainer]

Problem:

Select an air separator for a new installation. The system will have better than average maintenance and the primary pumps in the system have suction diffusers with strainer.

Conditions:

Flow rate = 700 gpm
Pipe size = 8″
Velocity = 4.5 fps
Maximum pressure drop = 2 ft.

1. Determine the type of air separator required. For removal of air in a system of this larger flow rate this would require a Taco Air Separator with a model number beginning with "AC".

   For system with better than average maintenance and strainers in the pump suction diffusers select the standard unit without a strainer. No additional letter designation is required.

2. Determine the velocity range of the AC Series that is suitable for these conditions. The recommended velocity range for the standard unit is 10 fps. This would require a unit with a line size of 6″ (7.77 fps)

3. Determine the size of the AC for the specified maximum pressure drop. For a maximum pressure drop of 2 ft. the unit size required is a 6″ (1.8 ft.). **This is Model AC06**.

ACG06-I25R

Example 2 [With Strainer]

Problem:

Select an air separator for an existing installation. The system has less than average maintenance and there are no strainers in the suction diffusers in the orimary pumps.

Conditions:

Flow rate = 230 gpm
Pipe size = 4″
Velocity = 5.8 fps
Maximum pressure drop = 2 ft.

1. Determine the type of air separator required. For removal of air in a system of this larger flow rate would require a Taco AC Series Air Separator with a model number beginning with "AC".

   For a system with less than average maintenance and no strainers in the primary pumps select the unit with removable strainer for easier cleaning. This is a model number ending with an "F".

2. Determine the velocity range of the AC Series that is suitable for these conditions. The recommended velocity range for the AC unit is 10 fps. This would require a unit with a line size of 3″ (9.98 fps).

3. Determine the size of the AC for the specified maximum pressure drop. For a maximum pressure drop of 2 ft. the unit size required is a 4″ (1.6 ft.). **This is Model AC04F**.

AC04F-125

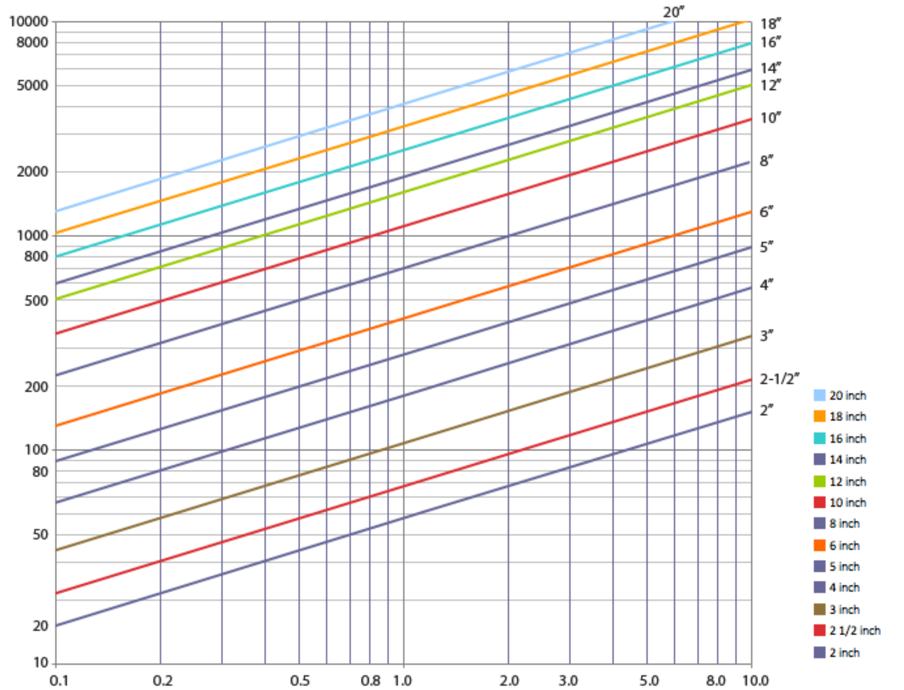
Specifications

Furnish and install as shown on plans an external air separator consisting of a steel tank ______" diameter X ______" long.

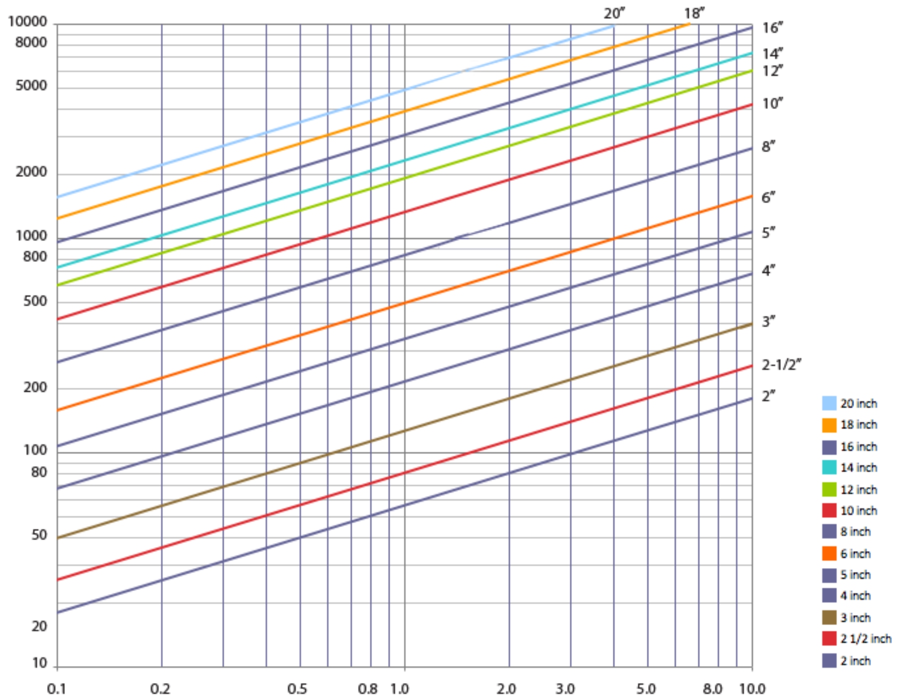
The unit shall have ______" (NPT/flanged) inlet and outlet connections and strainer removal connection where specified. The removable strainer shall be of 304 stainless steel with 3/16" diameter perforations and a free area of not less than five times the cross-sectional area of the connecting pipe. When strainer is specified, installer shall remove and clean strainer after 24 hours operation and after 30 days operation. There shall be a bottom connection for blowdown cleaning. Unit must be designed, constructed and tested in accordance with the ASME Boiler and Pressure Vessel Code and stamped 125, 150, 250 and 300 psig design pressure. Each air separation unit shall be Taco, Inc. Model No. ______________ or equal. ASME B16.5 flanges shall be provided on all units 3" or larger. ASME Code data reports are to be supplied by the air separator manufacturer upon request.

Pressure Drops

Air Separator Pressure Drop WITH Strainer



Air Separator Pressure Drop WITHOUT Strainer



Submittal Data Information
In-Line Air Separators

Submittal Data #401-107 Effective: 03/01/13
[Refer to all other submittals listed at bottom]

Supersedes: New

Pipe Size	Model Number		A Dia.	B Max.	C	D	E	F	G Dia.	H Inch	Max. Flow	Strainer Free Area	C_v Factor	Approx. Wt. (LBS.)	C_v Factor	Approx. Wt. (LBS.)
	Less Strainer	With Strainer														
Inch			Inch	Inch	Inch	Inch	Inch	Inch	Base Ring		GPM	Inch²	Less Strainer		With Strainer	
2	AC02	AC02F	12	22-1/8	13	7-9/16	7	14	-	-	80	31	86	40	72	45
2-1/2	AC025	AC025F	12	22-1/8	13	7-9/16	7	14	-	-	130	38	122	40	102	45
3	AC03	AC03F	14	27-1/4	22	8	11-1/4	24	12	6-1/2	190	51	190	90	162	110
4	AC04	AC04F	16	31-3/8	24	9-5/16	12-3/4	26	12	7	330	80	325	115	272	145
5	AC05	AC05F	16	32-1/2	24	9-3/8	13-3/4	26	12	7	550	112	510	130	422	165
6	AC06	AC06F	20	36-7/8	27	11-1/16	14-3/4	30	16	6-3/4	900	180	750	170	618	215
8	AC08	AC08F	20	45-1/2	27	14-1/16	17-3/8	30	16	6-3/4	1500	246	1260	270	1060	345
10	AC10	AC10F	24	47-3/4	32	14-15/16	17-7/8	36	20	6-3/4	2600	392	2000	350	1670	465
12	AC12	AC12F	30	59-3/4	37	17-5/8	24-1/2	42	24	7-3/4	3400	548	2900	600	2400	775
14	AC14	AC14F	36	68-1/2	44	20-3/4	27	48	30	7-3/4	4700	732	3500	805	2850	1035
16	AC16	AC16F	36	75-1/2	43	22-1/4	31	48	30	7-3/4	6000	845	4600	875	3800	1150
18	AC18	AC18F	48	84-1/4	56	24-5/8	35	64	40	7-3/4	8000	1290	5900	1550	4900	1900
20	AC20	AC20F	48	91	56	26	39	64	40	8 5/8	10000	1435	7400	1700	6200	2150

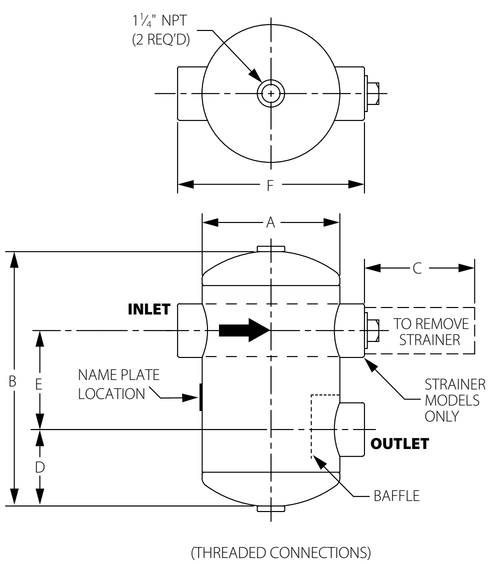
Larger units up to 36" (914 mm) are available. Please Contact the Factory.

SPECIFICATIONS

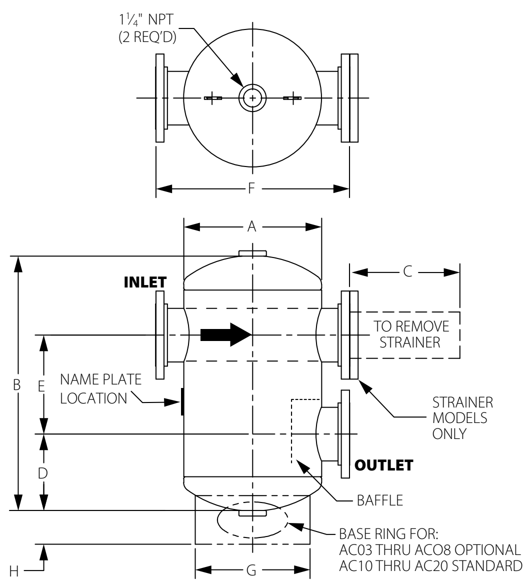
- Designed and constructed per ASME Code Section VIII, Division 1.
- Standard Design Pressure and Temperature
- Construction: Carbon Steel with exterior red oxide primer finish w/ optional 304SS Strainer
- Registered with the National Board of Pressure Vessel Manufacturers
- U-1A Data Report

OPTIONS (Consult Factory)

- Higher design pressures and temperatures
- Optional System Connection sizes available
- Larger sizes available up to 36" diameter
- Grooved Connections

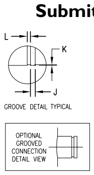


(THREADED CONNECTIONS)



(FLANGED CONNECTIONS)

Submittal Sheets Available at www.taco-hvac.com
Grooved Connections
125 PSI @ 375°F Document 401-108
150 PSI @ 375°F Document 401-111



Submittal Sheets Available at www.taco-hvac.com
Flanged Connections
125 PSI @ 375°F Document 401-107
150 PSI @ 375°F Document 401-110
250 PSI @ 375°F Document 401-095
300 PSI @ 375°F Document 401-096

Taco® Do your best work.

Taco Inc., 1160 Cranston Street. Cranston, RI 02920 / (401) 942-8000 / Fax (401) 942-2360
Taco (Canada) Ltd., 8450 Lawson Road, Unit #3, Milton, Ontario L9T 0J8 / (905) 564-9422 / Fax (905) 564-9436
www.taco-hvac.com

CA Expansion Tanks

Taco CA Expansion tanks are full acceptance Captive Air expansion tanks that provide separation of air and water. Tough, durable and long lasting. The Taco CA is available in a variety of sizes and capacities to fit your application.

comfort made easy

Features & benefits

Eliminate Pressure and Flow problems:

- Better comfort. Eliminate flow problems.
- Eliminate water logged expansion tanks
- Reduce expansion tank sizes up to 80%.
- Eliminate expansion tank corrosion problems.
- Reduce problems with burst bladders.

Dramatically Reduce Expansion Tank Sizes

Captive Air expansion tanks eliminate the many gallons of water required to compress atmospheric pressure air in an air cushion plain steel tank to the fill pressure. This allows a reduction in Captive Air expansion tank sizes of up to 80% compared to air cushion plain steel tanks.

Increase Reliability and Reduce Maintenance Costs

- Full Acceptance bladders eliminate burst bladders
- Eliminate tank corrosion by isolating water from tank

CA Specifications:

- Shell — Fabricated Steel Designed and Constructed per ASME Section VIII Div. I
- Bladder — Field Removable

	Standard	Optional
Working Pressure:	125 PSIG (862 KPA)	150 PSIG (1034 KPA) 175 PSIG (1206 KPA) 250 PSIG (1723 KPA) 300 PSIG (2068 KPA)
Operating Temperature:	240˚F (116C)	Consult Factory

Air Control Through Pressure Control

All hydronic systems operate under a variable amount of pressure. For closed systems the pressure varies primarily due to the expansion of water as it is heated or cooled. As the water is heated the pressure increases and as the water is cooled the pressure decreases.

The pressure in a closed system varies between a minimum and a maximum. The minimum is controlled by the fill valve and the initial fill pressure of the expansion tank. The maximum pressure is determined by the relief valve and the size of the expansion tank allowing the water to expand into the tank.

If the pressure is not maintained between these limits then the system will not perform properly.

Not maintaining minimum pressures will create air problems. Water contains a certain amount of entrained air. If this air comes out of solution at lower pressures, it can increase corrosion rates of metals within the system. In addition, air can form pockets at the top of pipes and coils of terminal units. These air pockets can actually restrict or block flow in a hydronic piping system. This is referred to as "air locking".

Figure 1 shows a solubility curve for air in water. Note that at a fixed temperature reducing the pressure reduces the amount of air that can be dissolved or entrained. For example at 100˚F and 80 PSIA water can contain 8% air by volume. At 100˚F and 20 PSIA the percentage decreases to 2%.

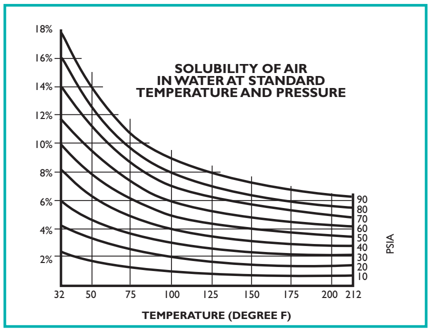


Figure 1

The conclusion is that air is least soluble in water at lowest pressure. Air separators should therefore be located at these points. The lowest pressure in a system is typically at the expansion tank, since this is the point of no pressure change and the location of the fill valve. Therefore, the general rule of thumb in hydronic systems is that **"Air separators should be located at the expansion tank connection to the system."**

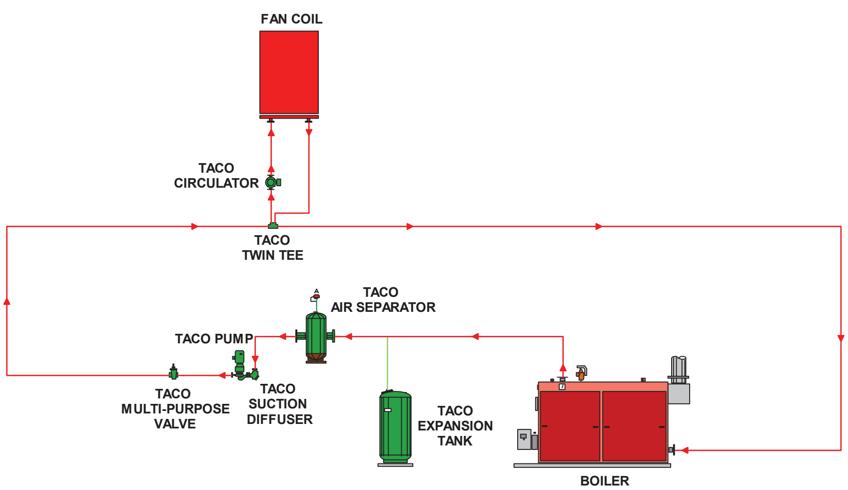


Figure 2 – Boiler and Expansion Tank/Air Separator Location

Applications

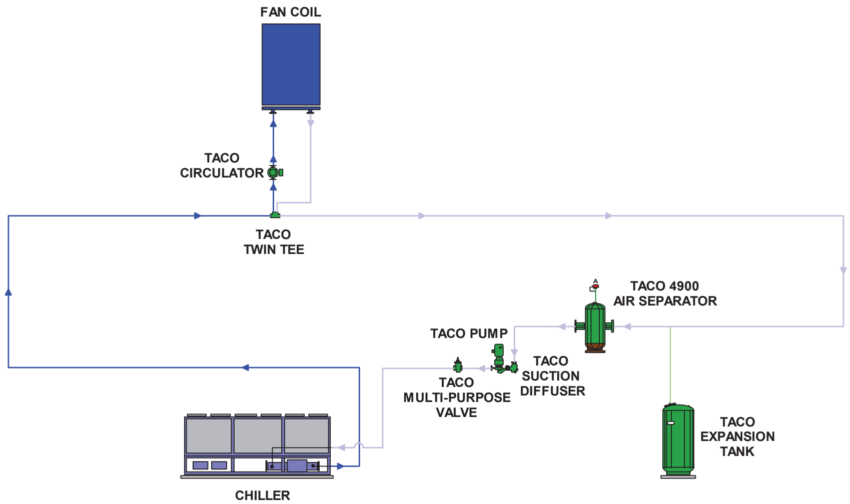


Figure 3 – Chiller and Expansion Tank/Air Separator Location

For multi-story buildings this is important. If the system pressure is not maintained above atmospheric at the top of the building then not only will air come out of solution, but air can actually be drawn into the system. This will result in loss of system performance with areas of low and no flow in this portion of the system.

For high rise buildings this is especially important. Frequently the expansion tank, air separator and fill valve are located at lower levels of the building. At upper levels air will come out of solution as the pressure decreases. This is similar to what divers experience as the "bends". One solution, which designers and maintenance personnel learned over time, was to "over pump" the system through high pump heads. This increased the pressure at upper levels of the building and forced air back into the system.

For example, in a 50 story building, the static pressure at the bottom of the system could be 250 psi. The solubility of air in water at this pressure and 40˚F is 45%. At the top of the building, assuming, 10 psi positive pressure, the solubility is only 4%.

Obviously air will come out of solution at the top of the building with the expansion tank and air separator located at the bottom. By "over pumping", to maintain 40 psi at the top of the building, the solubility of air goes back up to 10%.

For pumps located at upper levels of the building this is even more problematic. Pumps in these locations can actually be attempting to pump air. For centrifugal pumps the point at which their head falls off is in the range of 3% to 5% air volume in water.

Maintenance personnel and field engineers report many instance of poor pump performance due to unknown causes. A large portion of these mysterious problems have turned out to be secondary pumps located above expansion tanks.
A better solution to "over pumping" is to install additional air separators at upper levels of the building. A hydronic system can have multiple air separators, but should have only one expansion tank. These air separators should be high efficiency separators similar to Taco's 4900. See Taco Catalog #400-1.4 for additional information.

Another solution is to locate the expansion tank and air separator at the top of the building where the pressure is the lowest and the air is least soluble in water. This will require the running of a dedicated line from the top of the building to the suction of the system circulating pump. This will also reduce the size of the expansion tank since the difference between the initial fill or minimum pressure and relief valve or maximum pressure can be larger.

Not maintaining maximum pressure can result in several problems, including burst diaphragm or bladders in partial expansion captive air tanks, weeping relief valves and failure of components

Causes of over system pressurization can be undersized expansion tanks, water logged air cushion plain steel expansion tanks and burst diaphragms or bladders in Captive Air tanks.

Pressure Control Through Air Control

Many systems designed in the past and some designed today, attempt to control air by means of an old style air cushion plain steel tank and air vents in the piping.

The air cushion plain steel tank uses a tank filled with water and an air cushion at the top of the tank for water to expand into as it is heated. The initial atmospheric air in the tank must be initially compressed to the fill pressure. This requires an initial charge or fill of water to accomplish this as shown in Figure 4.

The tank must now be sized for the initial fill volume plus the volume of any expanded water. This makes the tank much larger.

As air is released through air vents, the air cushion in the tank can be absorbed into the system fluid leaving the tank water logged and eliminating the system pressure control provided by the plain steel tank. When this occurs the expanded water volume must now seek a new outlet which is normally the relief valve or thru the rupture of one of the other system componets.

A better solution is to use a Captive Air tank. In a Captive Air tank the air is held captive by the use of a bladder or diaphragm with the expanded water being held on one side of the diaphragm or bladder and the air on the other side.

This permanent separation allows the tank to be precharged on the air side of the bladder to the minimum operating or fill pressure. This eliminates the initial water volume needed to compress the air from atmospheric pressure to the system minimum (fill) pressure. This allows the bladder expansion tank to be charged to the fill pressure without the introduction of system fluid offering a sizable reduction in the required tank volume (see figure 5 A). The use of a Captive Air expansion tank often allows the reduction in required tank sizes up to 80% compared to air cushion or plain steel tanks.

During system operation any expanded water, in the diaphragm or bladder, compresses the precharge air to the maximum pressure. This compressed air cushion then pushes the fluid back into the system when it contracts.

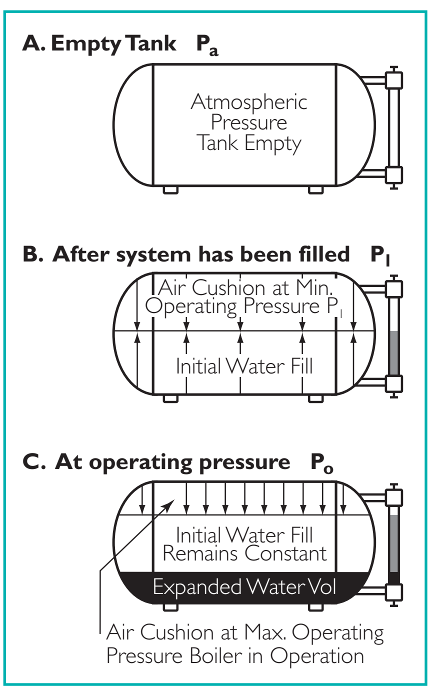


Figure 4
Plain steel pressurization process

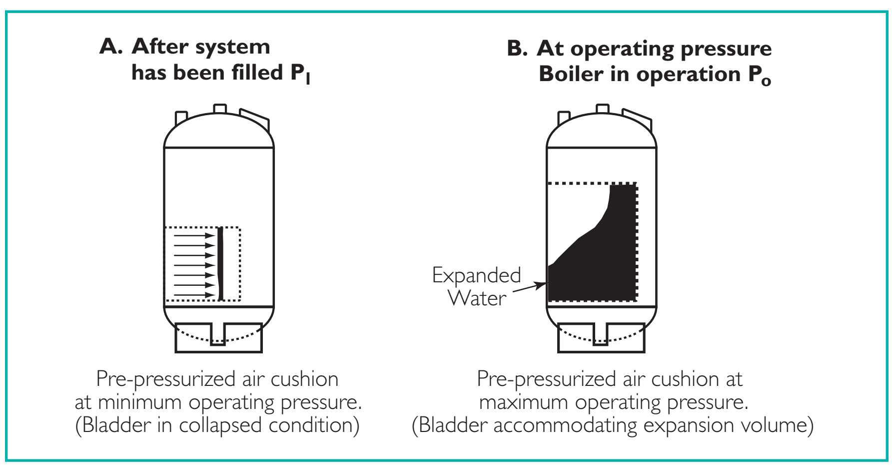


Figure 5 – Captive Air pressurization process

Applications

This can be seen in the following example problem.

System: Chilled water at 40˚F
System volume: 3000 gallons
System piping : Steel

The ASHRAE formula for plain steel expansion tank sizing is:

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

Where

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_a = atmospheric pressure, psia

P_1 = pressure at lower temperature, psia

P_2 = pressure at higher temperature, psia

v_1 = specific volume of water at lower temperature, ft^3/lb

v_2 = specific volume of water at higher temperature, ft^3/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

$\Delta T = (t_2 - t_1)$, ˚F

Chilled water sizing example:
Sizing a plain steel tank for a chilled water system with a temperature range of 40˚F to 100˚F (ambient temperature).

System fill pressure of 10 psig, System volume of 3000 gallons, with steel piping system, System fill pressure of 65 psig and a 90 psig maxiumum operating pressure.

Sizing a plain steel expansion tank

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

For

V_s = 3000 gallons
v_1 = .01602 ft^3/lb (40˚F)
v_2 = .01613 ft3/lb (100˚F)
P_a = 14.7 psia
P_1 = 65psig +14.7psia = 79.7psia
P_2 = 90psig+14.7 psia = 104.7 psia
α = $6.5\text{x}\ 10^{-6}$ in/in˚F for steel
Δt = 60˚F

V_t = 388.83 gallons

Sizing of a Captive Air expansion tank

$P_a = P_1$

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

For
V_s = 3000 gallons
V_1 = .01602 ft^3/lb (40˚F)
V_2 = .01613 ft^3/lb (100˚F)
P_a = 79.7psia (due to tank precharge)
P_1 = 65psig + 14.7psia = 79.7psia
P_2 = 90psig + 14.7psia = 104.7psia
α = 6.5x 10-6in/in F for steel
Δt = 60˚F
V_t = 71.55 gallons

This is a difference of greater than 81% reduction in required tank size

Another advantage of the permanent separation of air and water in a Captive Air tank is to eliminate the absorption of air back into the water that is found in air cushion or plain steel tanks.

Location of Expansion Tank

Location of the expansion tank in the system will also affect system performance.

The expansion tank is the point of no pressure change in the system. This can be seen from Boyle's Law:

$$P_1V_1/T_1 = P_2V_2/T_2$$

If the temperature (T_1 and T_2) and volume (V_1 and V_2) are constant with the pump on or off, then the pressure (P_1 and P_2) must also remain constant.

Therefore the point of connection of the expansion tank to the system is a point of no pressure change. Typically located at the suction side of the system pumps.

To prevent air from being drawn into the system the pressure in the system must be everywhere above atmospheric pressure.

The location of the expansion tank relative to the pump suction will then determine if the system is everywhere above atmospheric pressure. This can be seen in the following figures.

In Figure 6 the expansion tank is located on the discharge side of the pump.

The fill pressure is 25 psi. The pump differential pressure is 35 psi. Since the expansion tank is the point of no pressure change the pump differential pressure is subtractive from the fill pressure. The pump suction pressure is now -10 psi (25 – 35) or below atmospheric. This will cause air problems with air potentially being drawn into the system.

Figure 7 is the expansion tank located on the suction side of the pump.

The fill pressure, and pump suction pressure, is 25 psi. The pump differential pressure is 35 psi. Since the expansion tank is the point of no pressure change the pump differential pressure is additive to the fill pressure. The pump discharge pressure is now 60 psi (25 + 35) or above atmospheric. Everywhere in the system the pressure is above atmospheric.

Therefore, the general rule of thumb in hydronic systems is that **"Expansion tanks should be located on the suction side of pumps."**

Multiple expansion tanks will cause pressure problems in systems. The location of the expansion tank in the system is the point of no pressure change. The pump head does not affect the pressure in the tank. If there are multiple tanks in the system then the pump head will affect the pressure in the tank. The pump will be able to transfer water from one tank to the other depending on the pressure difference generated by the pump between the tanks.

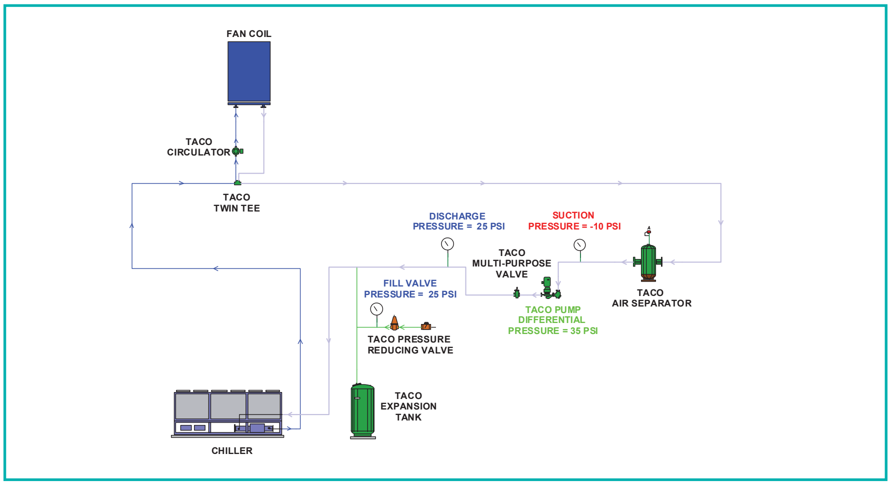


Figure 6 – Expansion tank located on discharge of pump

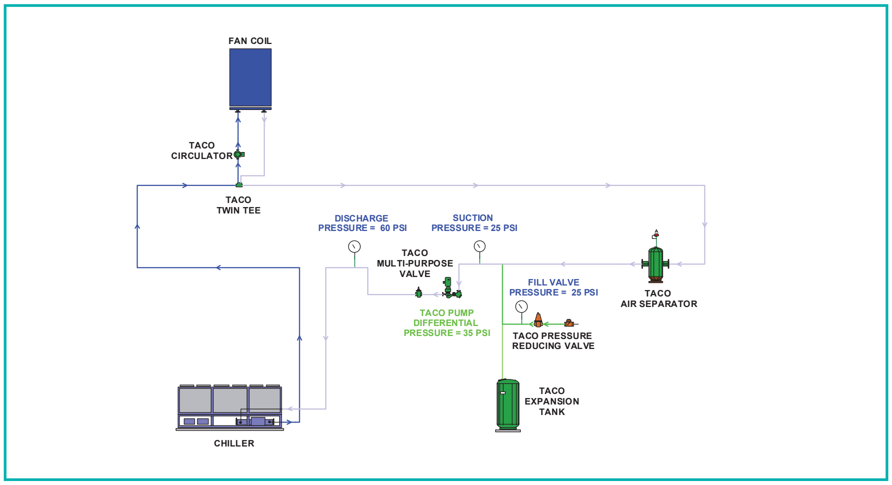


Figure 7 – Expansion tank located on suction side of pump

Applications

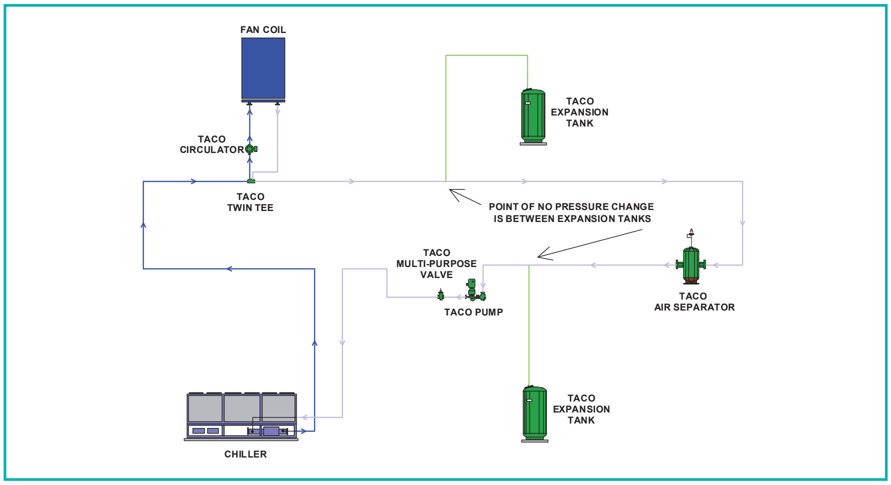


Figure 8 – Multiple expansion tanks in system

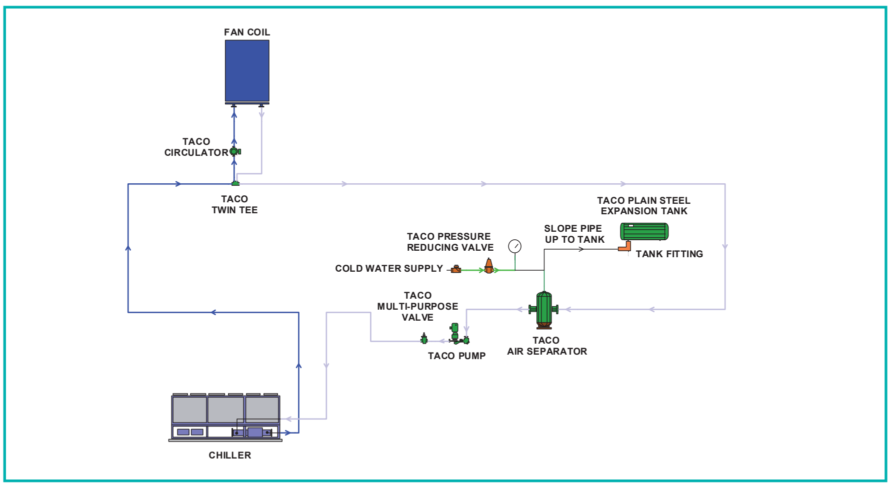


Figure 9 – Air cushion or plain steel expansion tank

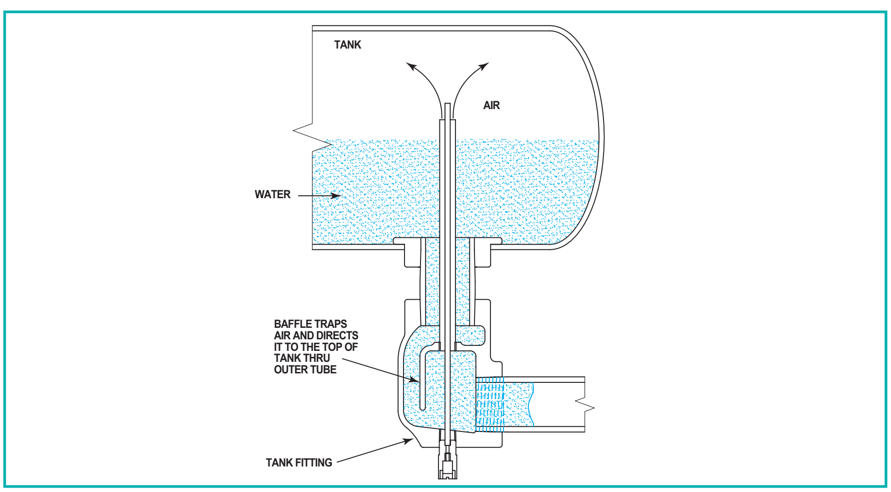


Figure 10 – Expansion tank air fitting

Figure 8 is a system with two expansion tanks. The point of no pressure change will be somewhere between the two tanks.

Therefore, the general rule of thumb in hydronic systems is that **"Multiple expansion tanks in a system is not recommended"** since unstable pressure conditions will result.

Types of Expansion Tanks

Air Cushion Plain Steel Expansion Tank

Taco air cushion plain steel tanks are applied in commercial, institutional and industrial applications for the control of pressure in hydronic systems. The air cushion plain steel tank uses a tank filled with water and an air cushion at the top of the tank for water to expand into as it is heated.

In this tank it is desirable to direct the separated air from the air separator to the space above the water level in the expansion tank (Figure 9). The air from the air separator is piped to the expansion tank through a special tank fitting.

This fitting directs the air to the top portion of the tank, and discourages air from migrating back into the system (Figure 10), when the system cools. Note that since

the air is "recycled" to provide a cushion in the expansion tank, this system is called an "Air Control" system. As noted previously the air cushion in the tank can be depleted due to absorption of air into the water. It can also be depleted by loosing air through air vents in the piping. Care must also be taken to insure that piping between the air separator and the plain steel expansion tank is pitched at least 3 degrees (Figure 9) to facilitate the migration of captured air back into the expansion vessel. Systems with plain steel expansion tanks must not have automatic air vents installed as this will lead to the loss of the expansion tank air cushion. if air is lost in the tank then the tank will become water logged. With a water-logged expansion tank, the expanded water must now seek a new outlet which can be the relief valve on one of the major components.
As note previously the tank must be sized for the expansion of the water in the system plus the initial charge of water to compress atmospheric air in the tank to the fill pressure. This makes the tank much larger. The tank is also subject to corrosion with the presence of air and oxygen in the tank.

Applications
- Smaller systems
- Lower cost
- Ceiling mounted to save floor space

Partial Acceptance Captive Air Diaphragm Expansion Tank
Taco CX partial acceptance Captive Air diaphragm expansion tanks are applied in commercial, institutional and industrial applications for the control of pressure in hydronic systems. Diaphragm tanks use a diaphragm to permanently separate the air and water.

In a diaphragm tank the air is held captive by the use of a diaphragm with the expanded water being held on one side of the diaphragm and air on the other.
This permanent separation allows the tank to be precharged on the air side to the minimum operating or fill pressure. This eliminates many gallons of water to compress atmospheric pressure air in an air cushion or plain steel tank to the fill pressure. This allows the reduction in Captive Air expansion tank sizes of up to 80% compared to air cushion or plain steel tanks.
In a diaphragm tank the diaphragm is attached to the tank wall and cannot move inside the tank. As a result the tank has a limited acceptance volume. In addition, there is some water in contact with the tank wall providing an opportunity for corrosions.

Applications
- Smaller systems
- Lower cost

Partial Acceptance Captive Air Bladder Expansion Tank

Taco CBX partial acceptance bladder Captive Air expansion tanks are applied in commercial, institutional and industrial applications for the control of pressure in hydronic systems. CBX bladder tanks use a field replaceable bladder to permanently separate the air and water.
This permanent separation allows the tank to be precharged on the air side to the minimum operating or fill pressure. This eliminates many gallons of water to compress atmospheric pressure air in an air cushion or plain steel tank to the fill pressure. This allows the reduction in Captive Air expansion tank sizes of up to 80% compared to air cushion or plain steel tanks.

In a bladder tank the bladder is not attached to the tank wall like a diaphragm tank. Rather it is suspended inside the tank very much like a balloon. Expanded water flows into the inside of the bladder. Air is on the outside of the bladder between the bladder and the tank. As a result no water is in contact with the tank wall minimizing corrosion In a partial acceptance bladder tank the bladder is of limited acceptance volume and does not stretch. As a result, if there is an overpressure condition in the system the bladder will burst, again, very much like a balloon.

Applications
- Larger systems
- Lower cost

Applications

Full Acceptance Captive Air Bladder Expansion Tank

Taco CA full acceptance bladder Captive Air expansion tanks are applied in commercial, institutional and industrial applications for the control of pressure in hydronic systems. CA tanks use a field replaceable bladder to permanently separate the air and water.

This permanent separation allows the tank to be precharged on the air side to the minimum operating or fill pressure. This eliminates many gallons of water to compress atmospheric pressure air in an air cushion or plain steel tank to the fill pressure. This allows the reduction in Captive Air expansion tank sizes of up to 80% compared to air cushion or plain steel tanks.
In a bladder tank the bladder is not attached to the tank wall like a diaphragm tank. Rather it is suspended inside the tank very much like a balloon. Expanded water flows into the inside of the bladder. Air is on the outside of the bladder between the bladder and the tank. As a result no water is in contact with the tank wall minimizing corrosion.

In a full acceptance bladder tank the bladder is of full acceptance volume and can expand to the full volume of the tank. As a result, the bladder will not burst if the system experiences an overpressure condition.

Applications

- Larger systems
- Systems where reliability and lower maintenance costs are important

EXAMPLE 1

Problem:
Select a full acceptance bladder style expansion tank for a chilled water installation. The mechanical room and expansion tank are located on the lower level. Reliability and maintenance costs are a consideration. Steel system piping.

Conditions:
System Volume = 10,000 gallons
Minimum temperature = 40˚F
Maximum temperature = 100˚F
Building height = 100 ft.
Relief valve (chiller) = 90psig

Sizing of a Captive Air expansion tank

$P_a = P_l$

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

v_t = .01602 ft^3/lb (40˚F)
v_2 = .01613 ft^3/lb (100˚F)

α = 6.5x 10^{-6}in/in ˚F for steel
Δt = 60˚F

P_l = 100 ft * .434 psi/ft + 5 psig (for positive pressure at top of building) + 14.7 psia

= 48.4 psia

P_2 = 90psig + 14.7psia = 104.7 psia

Calculation of Net system expansion —

Net System Expansion = $V_s \{[(v_2/v_1)-1] - 3\,\alpha\,\Delta t\}$

= 3000 {[(.01613/.01602) -1] – 3 (6.5x10^{-6}) 60}

= 3000 {.005696}

= 17.09 gallons

Calculate required tank volume –

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

V_t = 3000 {[(.01613/.01602) -1] – 3 (6.5x10^{-6}) 60}/ (1 – 48.4/104.7)

= 31.78 gallons

For a system where reliability and maintenance are important select tank with full acceptance. Captive Air bladder tank model CA140. The bladder on this tank is unaffected by overpressure conditions in the system and is more reliable. Acceptance volume of the tank is 37 gallons and the volume of the tank is 37 gallons.

Selection Procedure

EXAMPLE 2

Problem:
Select an expansion tank for a heating water installation. The mechanical room and expansion tank are located on the roof. First cost is a major consideration. System piping copper.

Conditions:
System volume 1,000 gallons.
Minimum temperature = 40 F
Maximum temperature = 240 F
Building height = 50 ft
Relief Valve at boiler = 50 psig

Sizing of a Captive Air expansion tank

$P_a = P_1$

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

v_1= .01602 ft3/lb (40˚F)
v_2= .01692 ft3/lb (240˚F)
α=9.5x 10^{-6}in/in F for copper piping
Δt=200 F

Determine minimum pressure –
Minimum pressure equals static pressure plus 5 psi positive pressure at top of the building (assume 10 ft of static pressure).

P1
= 10ft x .434 psi/ft + 5 psi (positive pressure) + 14.7 psia

= 24.04 psi

Maximum pressure equal the relief valve setting

P2 = 50 psig +14.7 psia
= 64.7 psia

Calculation of Net system expansion –

Net System Expansion
$= V_s \{[(v2/\ v1)-1] - 3\ \alpha\ \Delta t\}$

$= 1000 \{[(.01692/.01602) -1] - 3\ (9.5\times10^{-6})\ 200\}$

= 1000 {.05047}

= 50.48 gallons

Calculate required tank volume –

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

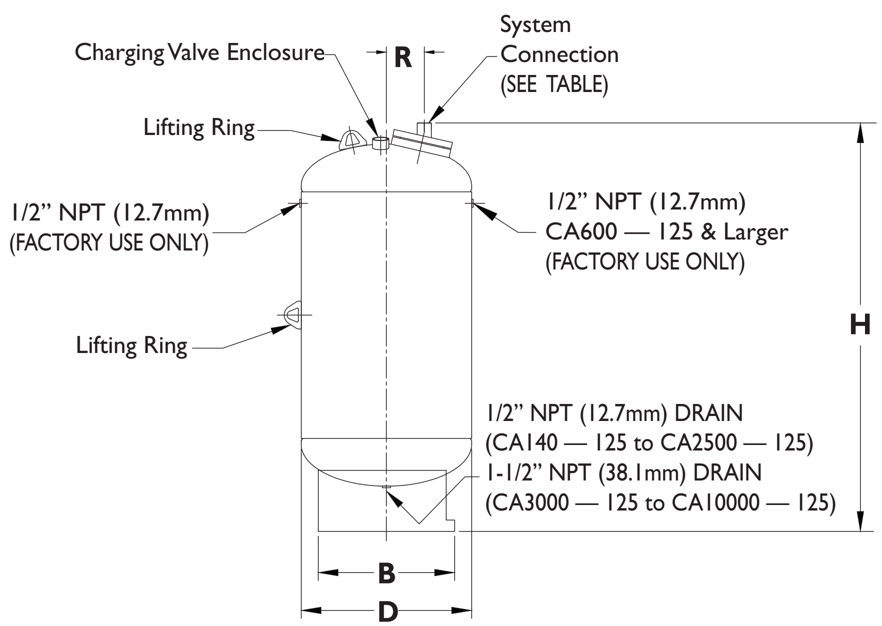
$V_t = 1000 \{[(.01692/.01602) -1] - 3\ (9.5\times10^{-6})\ 200\}/\ (1 - 24.04/64.7)$

= 80.32 gallons

Because first cost is a major consideration select a partial acceptance Captive Air bladder tank model CBX425. This tank is lower first cost than a full acceptance Captive Air tank. However, it is subject to a burst bladder under over pressure conditions. Acceptance volume of the tank is 61 gallons. The volume of the tank is 112 gallons.

Product Data

MODEL NUMBER	TANK VOLUME		H HEIGHT		B DIAMETER		D DIAMETER		R RADIUS		SHIPPING WEIGHT		SYSTEM CONNECTION SIZE
	GAL.	LIT.	INCH	MM	INCH	MM	INCH	MM	INCH	MM	LBS.	Kg	
CA90-125	23	90	29-1/8	740	16	406	20	508	4-1/4	108	120	55	1" NPT (25.4mm)
CA140-125	37	140	40-1/8	1019	16	406	20	508	4-1/2	114	195	88	1" NPT (25.4mm)
CA215-125	57	215	58-7/8	1495	16	406	20	508	4-1/2	114	290	132	1" NPT (25.4mm)
CA300-125	79	300	57-3/4	1467	20	508	24	610	5	127	320	145	1-1/2" NPT (38.1mm)
CA450-125	119	450	77-3/8	1965	20	508	24	610	5	127	400	181	1-1/2" NPT (38.1mm)
CA500-125	132	500	85-3/4	2178	20	508	24	610	5	127	420	191	1-1/2" NPT (38.1mm)
CA600-125	158	600	71-7/8	1826	24	610	30	762	6-1/4	159	460	209	1-1/2" NPT (38.1mm)
CA700-125	185	700	80-5/8	2048	24	610	30	762	6-1/4	159	525	238	1-1/2" NPT (38.1mm)
CA800-125	211	800	89-7/8	2283	24	610	30	762	6-1/4	159	590	268	1-1/2" NPT (38.1mm)
CA900-125	238	900	73-1/8	1857	30	762	36	914	7-7/16	189	690	313	1-1/2" NPT (38.1mm)
CA1000-125	264	1000	79	2007	30	762	36	914	7-7/16	189	790	358	1-1/2" NPT (38.1mm)
CA1100-125	291	1100	85-1/4	2165	30	762	36	914	7-7/16	189	865	392	1-1/2" NPT (38.1mm)
CA1200-125	317	1200	91	2311	30	762	36	914	7-7/16	189	940	426	1-1/2" NPT (38.1mm)
CA1300-125	344	1300	97	2464	30	762	36	914	7-7/16	189	980	445	1-1/2" NPT (38.1mm)
CA1400-125	370	1400	103	2616	30	762	36	914	7-7/16	189	1020	463	1-1/2" NPT (38.1mm)
CA1500-125	396	1500	73-3/8	1864	40	1016	48	1219	10-15/16	278	1200	544	1-1/2" NPT (38.1mm)
CA1600-125	422	1600	76-5/8	1946	40	1016	48	1219	10-15/16	278	1380	626	1-1/2" NPT (38.1mm)
CA1800-125	475	1800	83-1/2	2121	40	1016	48	1219	10-15/16	278	1515	687	1-1/2" NPT (38.1mm)
CA2000-125	528	2000	90-3/8	2296	40	1016	48	1219	10-15/16	278	1650	748	1-1/2" NPT (38.1mm)
CA2500-125	660	2500	107-1/8	2721	40	1016	48	1219	10-15/16	278	1838	834	1-1/2" NPT (38.1mm)
CA3000-125	792	3000	94-1/8	2391	44	1118	54	1372	11-7/16	291	2025	919	2" NPT (50.8mm)
CA4000-125	1056	4000	120-3/4	3067	44	1118	54	1372	11-7/16	291	2400	1089	2" NPT (50.8mm)
CA5000-125	1320	5000	150-1/4	3816	44	1118	54	1372	11-7/16	291	3100	1406	2" NPT (50.8mm)
CA7500-125	1980	7500	128-3/4	3270	62	1575	72	1829	11-1/2	292	3850	1746	3" NPT (76.2mm)
CA10000-125	2640	10000	158-1/4	4020	62	1575	72	1829	11-1/2	292	4500	2041	3" NPT (76.2mm)



Mechanical Specifications

Part 1 GENERAL

1.1 SECTION INCLUDES

A. Expansion tanks

1.2 RELATED SECTIONS

A. Section - Hydronic Piping.

1.3 REFERENCES

A. ASME (BPV VIII, 1) - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers; 2006.

1.4 SUBMITTALS

A. See Section 01300 - Administrative Requirements, for submittal procedures.

B. Product Data:
Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

C. Certificates: Inspection certificates for pressure vessels from authority having jurisdiction.

D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

E. Project Record Documents: Record actual locations of flow controls.

F. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum five years of documented experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept equipment on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

C. Protect piping components from entry of foreign materials by temporary covers, com pleting sections of the work, and isolating parts of completed system.

1.7 MAINTENANCE SERVICE

A. Contractor to furnish service and maintenance for one year from date of substantial completion.

1.8 EXTRA MATERIALS

A. See Section 01400 - Project Requirements, for additional provisions.

Part 2 PRODUCTS

2.1 ASME Full Bladder TYPE EXPANSION TANKS

A. Manufactures:
1. Taco, Inc; Model CA _______: www.taco-hvac.com

2. ITT Bell & Gossett

3. Amtrol Inc

4. Substitutions:
See Section 01600 - Product Requirements.

B. Construction: Welded steel, designed, tested and stamped in accordance with ASME (BPV code sec VIII, div 1); supplied with National Board Form U-1, rated for working pressure of 150 psi , with flexible heavy duty butyl rubber bladder. Bladder shall be able to accept the full volume of the expansion tank and shall be removable and replaceable.

C. Accessories: Pressure gage (field installed in adjacent piping by others) and air-charging fitting ; precharge to _____ psi.

D. Automatic Cold Water Fill Assembly (field installed by others): Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.

E. Size:
1. HW Tank Capacity:
_____________.,
____
acceptance volume.

2. CW Tank Capacity:
_____________.,
____
acceptance volume.

F. Hot Water Heating System:

1. Select expansion tank pressure relief valve at ______ psi maximum.

2. Set pressure reducing valve at _____ psi.

G. Chilled Water System:

1. Select expansion tank pressure relief valve at ______ psi maximum.

2. Set pressure reducing valve at ______ psi.

Part 3 EXECUTION

3.1 INSTALLATION

A. Install specialties in accordance with manufacturer's instructions.

B. Where large air quantities can accumulate, provide enlarged air collection standpipes.

C. Provide manual air vents at system high points and as indicated.

D. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

E. Air separator and expansion tank to be installed on the suction side of the system pumps. Expansion tank to be tied into system piping in close proximity to air separator and system fill line.

F. Provide valved drain and hose connection on strainer blow down connection.

G. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.

Mechanical Specifications

H. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

I. Pipe relief valve outlet to nearest floor drain.

J. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

K. Clean and flush glycol system before adding glycol solution. Refer to Section 15189.

L. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.

M. Feed glycol solution to system through make-up line with pressure regulator, venting system high points. Set to fill at ____ psi.

N. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.

O. Perform tests determining strength of glycol and water solution and submit written test results.

Notes

Notes

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