

Air Elimination from Hydronic Heating Systems – TD11

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The vast majority of hydronic heating systems are designed as closed-loop systems. The water they contain remains in the system for years, often the entire life of the system.

To function properly such systems must rid themselves of air that’s always present when the system is first filled and operated. Not doing so can lead to several problems including:

- Flow stoppage in portions of the system due to air binding
- Inefficient circulator operation because of the compressibility of water / air mixtures
- Noise in the system due to water cascading in piping containing air
- Internal corrosion of ferrous components due to dissolved oxygen in the water

In most systems air elimination can be broken into two stages:

1. Elimination of “bulk air” when the system is first filled
2. Elimination of dissolved air when the system is first operated.

BULK AIR REMOVAL

The vast majority of the air in a newly constructed hydronic system (or an existing system that has been drained) is best removed by forced-water purging. The schematic in Figure 1 demonstrates the piping and valve arrangement often used for such purging.

The piping and valves are arranged so that water can flow through the distribution system in one direction and at a relatively high velocity. The fast-moving water pushes most of the air in the piping ahead of it like a piston moving up through the cylinder of an engine. The air leaves the system through a drain valve as more and more water enters the system. Purging continues until the water stream exiting the drain valve flows smoothly with no visible air bubbles.

Flow velocities of at least two feet per second (2 fps) are required to efficiently entrain air bubbles and bring them to the drain valve. This is especially true of vertical piping with downward flowing water. If this is not the case larger air bubbles may be able to rise upward faster than the water is flowing downward, and thus not be pushed along to where they can be captured and expelled from the system. Table 1 lists the flow rates required in various sizes of type M copper tubing to achieve a flow velocity of 2 feet per second.

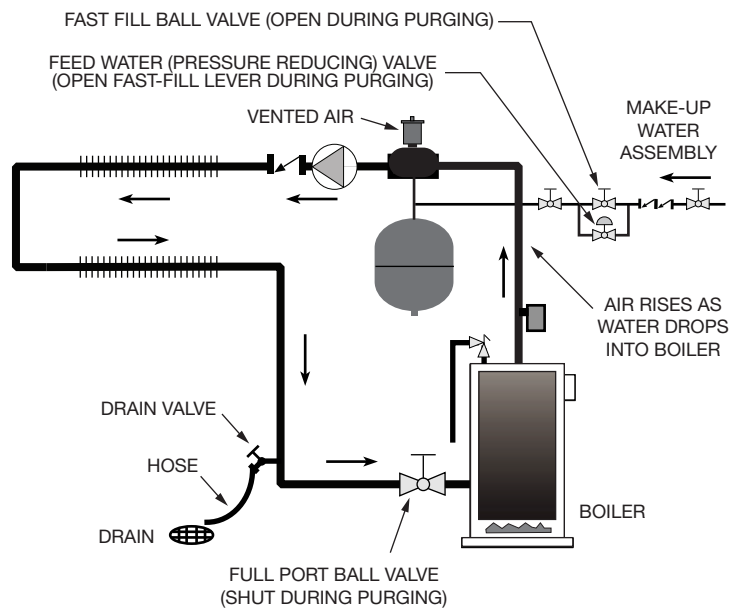


Figure 1

COPPER TUBE SIZE	FLOW RATE TO ACHIEVE 2 FPS (gallons/minute)
¾ inch	3.2 gpm
1 inch	5.5 gpm
1¼ inch	8.2 gpm
1½ inch	11.4 gpm
2 inch	19.8 gpm
2½ inch	30.5 gpm
3 inch	43.6 gpm

Table 1

Taco Product Catalogs:

- 100-2.9 - VorTech® & 4900 Series Air Separator
- 100-7.2 - Air Scoop
- 100-7.7 - Automatic Air Vents

The source of the purging water flow can be a "fast-fill" water feed system connected to the building's pressurized cold water piping, such as a Taco Model 329 or 3350. The piping in Figure 1 shows the typical piping of a make-up water assembly consisting of isolation valves, backflow preventer, pressure-reducing valve, and fast-fill valve.

Although properly executed forced-water purging removes the majority of bulk air from the system when it is filled, this is not the only air in the system. Cold water contains dissolved gases such as oxygen, nitrogen, carbon dioxide, and the other gases that constitute air. These gas molecules are dissolved in with the water (H₂O) molecules, and thus cannot be seen. A given volume of cold water at a temperature of 50°F and pressure of 50 psi can be up to 10 percent dissolved gas molecules (90 percent H₂O, 10 percent gases).

As water is heated its ability to retain these gas molecules decreases. The gas molecules coalesce into tiny bubbles along the surface that is heating the water. This is usually the inside surface of the boiler's heat exchanger. The tiny bubbles eventually merge into visible bubbles and rise upward within the boiler. This mixture of bubbles and liquid water is not desirable for the reasons cited earlier. Hence, it makes sense to "grab" the air bubbles where they are available and eject them from the system as soon as possible.

A central air-separating device serves this purpose. This device may be a simple air scoop, a more efficient centrifugal type separator, or an even more efficient microbubble separator. Taco provides options for all three.

AIR SCOOPS

The Taco cast-iron air scoop is a traditional air-separating device. Air bubbles being carried along with the flow rise to the top of the air-separating chamber as the flow enters the air scoop. Air accumulates at the top of the chamber and then upward into an automatic float-type air vent that ejects it from the system. Figure 2A shows the Taco air scoop. Figure 2B illustrates the internal construction and operating concept.



Figure 2A

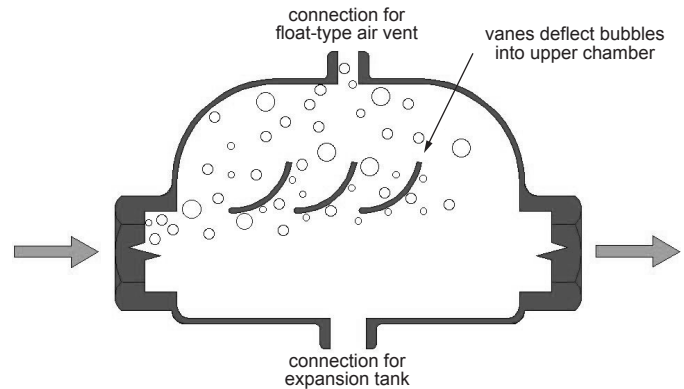


Figure 2B

For good performance, the flow velocity entering an air scoop should be no higher than 4 feet per second. Slower velocities increase the air collection efficiency of the air scoop. Table 2 below lists the maximum flow rates (based on 4 feet per second flow velocity) for some sizes of copper tubing.

COPPER TUBE SIZE	FLOW RATE PRODUCING 4 FPS FLOW VELOCITY
¾ inch	6.5 gpm
1 inch	10.9 gpm
1¼ inch	16.3 gpm
1½ inch	22.9 gpm
2 inch	39.6 gpm
2½ inch	61.1 gpm
3 inch	87.1 gpm

Table 2

THE VORTECH[®] AIR SEPARATOR

Another air separator available from Taco is called the VorTech[®]. This device, shown in Figure 3, creates a rapid internal swirling action (e.g. a vortex) of the liquid / air mixture. As in a tornado, a low-pressure region develops near the center of this vortex. The reduced pressure causes dissolved air to be released from the water. Because the density of water is much higher than that of air, it is driven to the outer edge of the circulating pattern while the separated air remains near the center of the vortex. The air and water part company as the water flows downward toward the outlet and the air rises to the top of the chamber. A $\frac{3}{4}$ inch float-type vent is located at the top of this chamber to capture and rapidly eject the collected air.

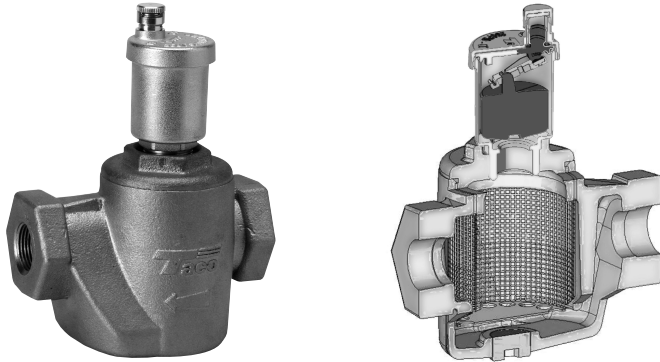


Figure 3

TACO VORTECH[®] AIR SEPARATOR

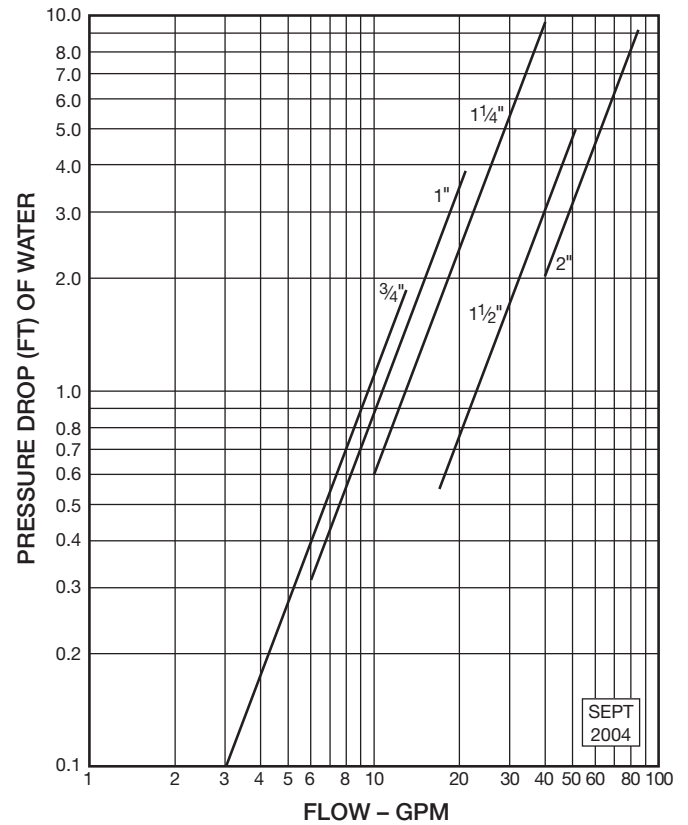


Figure 4

Taco VorTech[®] Air Separators are available in cast iron and bronze construction and in nominal pipe sizes from $\frac{3}{4}$ inch to 2 inch. For best results, the entering flow velocity should be approximately 4 feet per second. Table 2 lists the flow rates associated with these velocities. Higher entering flow velocities of up to 10 feet per second are acceptable, but will decrease the separating efficiency of the VorTech[®] unit.

The head loss of the VorTech[®] Air Separator should also be factored into the overall system head loss when selecting a circulator. The graph in Figure 4 gives head loss versus flow rate information for VorTech[®] Air Separators.

4900 SERIES AIR SEPARATORS

Taco's top-of-the-line air separator is called the 4900 Series Air Separator. These brass bodied air separators use patented PALL-Ring technology for ultra-efficient air/water separation; see Figure 5.



Figure 5

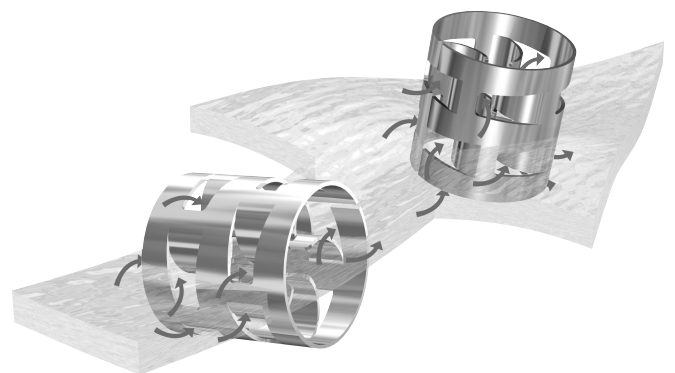


Figure 6

PALL rings are small stainless steel cylinders; see Figure 6. A 3/4 inch pipe size 4900 Series Air Separator contains approximately 115 randomly oriented PALL rings within the air-separating chamber. Larger size separators contain several hundred PALL rings.

Each PALL ring contains specially formed tangential slots and vanes that cause the flow to slowly pass over many square inches of PALL ring surface area. Bubbles with diameters as small as 8/10000 of an inch will cling to these surfaces due to an effect called coalescence. These tiny microbubbles then merge to form bigger bubbles that will rise into the upper float chamber of the vent where they are ejected from the system.

WHERE TO INSTALL THE AIR SEPARATOR

All three types of Taco air separators (air scoop, VorTech, and 4900 series) should be located where the fluid is at a relatively high temperature and modest pressure. The higher the fluid's temperature, the lower its ability to retain dissolved gases such as oxygen and nitrogen. Hence, the greater the amount of gases available for collection and ejection from the system. Lowering the pressure of the water also decreases its ability to retain dissolved gases.

The best location for a central deaerator in a hydronic heating system is usually downstream of the boiler and upstream of the circulator as shown in Figure 1. This location offers optimal location for air separation and capture.

All three types of Taco air separators have 1/2 inch FPT tapping at the bottom of the air-separating chamber to accommodate a diaphragm-type expansion tank. If the system contains a make-up water assembly, it is usually tapped into the system at this location as shown in Figure 1.

HIGH POINT AIR VENTS

In addition to central deaerators, Taco offers automatic float-type air venting devices called Hy-Vents™. These devices are installed at high points in system piping where large air bubbles might collect. One example would be at the top of vertical "risers" that provide supply and return flow to heat emitters on several floors. Another common location is where a pipe must go up and over a structural beam and thus form a high point.

An example of a Taco Hy-Vent™ is shown in Figure 7. As air accumulates in the vent's cylinder, the float lowers and eventually opens the spring-loaded venting valve. If the system pressure at the location of the vent is greater than atmospheric pressure, the accumulated air is driven out of the vent valve. As soon as the float rises within the chamber, the vent valve is closed. This action repeats itself each time the chamber fills with air.

It is vitally important that the fluid pressure at all vent locations remains above atmospheric pressure while the system is operating. As a rule, the pressure at all vent locations should be at least 3 psi above atmospheric pressure. If this is not the case air can be pulled into the system through an automatic float-type vent. When verifying this minimum pressure condition at the vent locations the designer should account for the drop in static pressure due to pipe elevation as well as the drop in pressure due to head loss along the piping circuit.



Figure 7

SUMMARY

Proper air elimination is essential in achieving a quiet and efficient closed-loop hydronic heating system. Every closed loop system should include a properly sized and properly located central air separator. This is also true of subassemblies such as the glycol side of a heat exchanger serving snowmelting circuits. All closed-loop hydronic systems should also include forced water purging valves for bulk air removal. Use the hardware and piping techniques described in this article for fast and easy air removal.

