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Technical information **bulletin**

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Heat transfer system expansion tank design

The design of the expansion tank in a liquid phase heat transfer system using Eastman Therminol® heat transfer fluid or other organic fluids is an important parameter in the total system's successful operation. A correctly installed and maintained expansion tank can contribute to increased fluid life along with lower maintenance associated with the various mechanical components of the system, such as pumps, gaskets, seals and heaters. A properly designed expansion tank can eliminate many problems from the initial start-up through everyday operation of the heat transfer system.

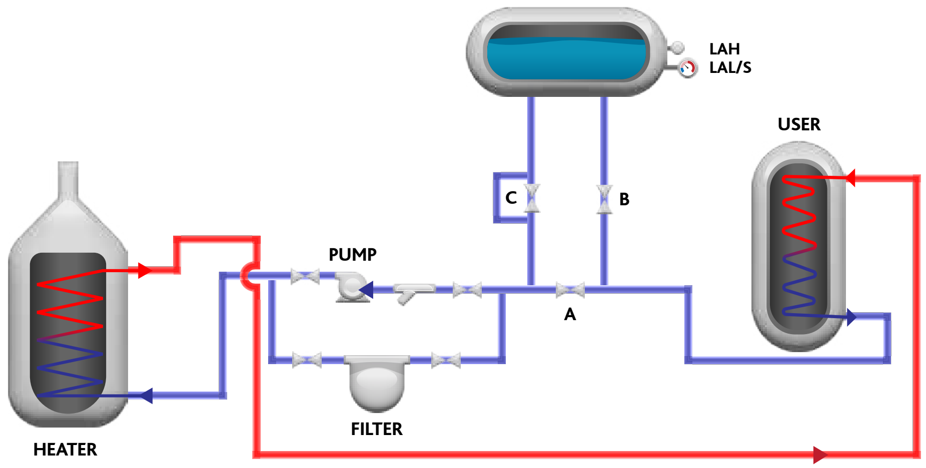
The following discussion will generally explore the purpose and design of an expansion tank in a heat transfer system. However, a qualified engineering firm should be consulted in connection with the design of an actual heat transfer system, since considerations outside the scope of this bulletin may be critical.

Purpose of the expansion tank in a heat transfer system

As the term implies, the main function of the expansion tank in a heat transfer system is to provide for fluid expansion, which can be greater than 25% of its original volume depending on the fluid used and the operating temperature.

Since the tank is usually installed at the highest point in the system, it can also serve as the main venting point of the system for excess levels of low boilers and moisture which may accumulate in the heat transfer fluid. The highest-point installation also creates positive head pressure to the pump's inlet, providing flooded pump suction with uninterrupted flow of fluid to the user station. A simplified drawing showing a suggested positioning of the expansion tank in a heat transfer system is shown in Figure 1.

Figure 1. Basic heat transfer system*



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Expansion tank design parameters

There are several basic design parameters which should be considered part of every heat transfer system's expansion tank so that the maximum benefit can be obtained from the tank relative to overall system operation.

Sizing

The expansion tank should be sized so that it is 25% full at ambient temperature and 75% full at normal operating temperature. This sizing should cause positive fluid pressure to the pump's suction side during system start-up and minimize the vapor space in the tank during normal operation.

Fluid expansion between two temperatures can be calculated by dividing the fluid's density at the lower temperature by the density of the fluid at the higher temperature. For example:

- The density of Therminol 66 at 40°F (4°C) is 8.47 lb/gal (1,015 kg/m^3) and changes to 6.72 lb/gal (805 kg/m^3) at 600°F (316°C).
- Thus the expansion of Therminol 66 is 8.47/6.72 = 126% of the original volume at 40°F (4°C) when heated to 600°F (316°C).
- Therefore, an expansion tank for a 1,000-gallon (3,785-liter) Therminol 66 fluid system operating between 40°F (4°C) and 600°F (316°C) should be sized for 260 gallons (984 liters) of expansion.
- Since this expansion represents 50% of the tank volume (the volume between 25% and 75% full), the expansion tank should be 520 gallons (1,968 liters) in size.

Double drop leg and valving

The expansion tank should be located at the highest point in the system with a double drop leg piping arrangement as shown in Figure 2. If the only purpose of the expansion tank was to provide for fluid expansion, a single drop leg would be sufficient; however, the expansion tank also provides the best point for system venting. To properly vent a heat transfer fluid system, the expansion tank must be capable of full system flow. The lines to and from the expansion tank should be sized to take full system flow at start-up conditions. Under normal operating conditions, valves A and C are open and valves B, D, E and F are closed. To add makeup fluid to a system in operation, valve D should be used. This provides minimum upset to an operating system. Any time makeup fluid is added to an operating system, normal safety precautions should be observed because of the high temperatures associated with an operating heat transfer system.

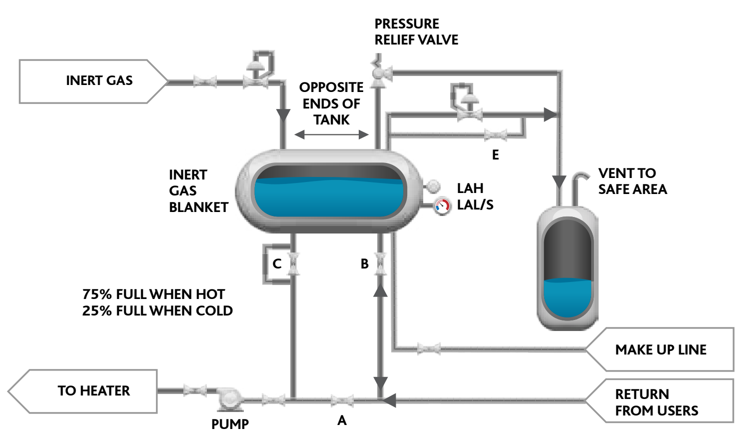
The initial fill of a system should be made through an initial fill valve at a low point in the system (not shown) with valves B, C and E open. This is the most efficient way of forcing air out of the system while avoiding unnecessary aeration of the fluid.

The expansion tank should be the primary point in the system for venting moisture and low-boiling degradation products from the system. New systems almost always contain some water from either hydrotesting or atmospheric condensation during construction. This moisture must be removed during system start-up or pump cavitation will occur. To use the expansion tank as a vent, valves A, D and E should be closed, while valves B, C and F should be open. System temperature should be gradually raised to 300°–350°F (149°–177°C). Once all evidence shows venting has stopped (steam plume disappears), valve A should be opened and valves B and F should then be closed. If low boilers accumulate in the fluid, this procedure should be repeated; however, in this case, the expansion tank should be allowed to reach full system temperature before opening valve A.

Instrumentation

In general, a policy striving for fail-safe instrumentation in the design of the expansion tank, as well as the other components of the heat transfer system, is essential. The expansion tank should be equipped with both high- and low-level alarms along with a low-level switch to automatically shut off the heater and pump in the event of accidental fluid loss. Pressure relief devices should be incorporated in the expansion tank's design with possible discharges of fluid directed to areas away from personnel and sources of ignition. A high-temperature sight glass should also be installed as a visual backup for level sensors.

Figure 2. Inert gas arrangement for expansion tank*



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Inert gas blanketing

All organic heat transfer fluids, including Therminol fluids, undergo oxidation when exposed to air. This fluid oxidation causes the vast majority of solids formation and fouling, which lessen heat transfer efficiency and impair mechanical seal function. The rate of insolubles formation is dependent on the amount of air exposure and temperature. The usual source of air infiltration in a heat transfer system is through the expansion tank.

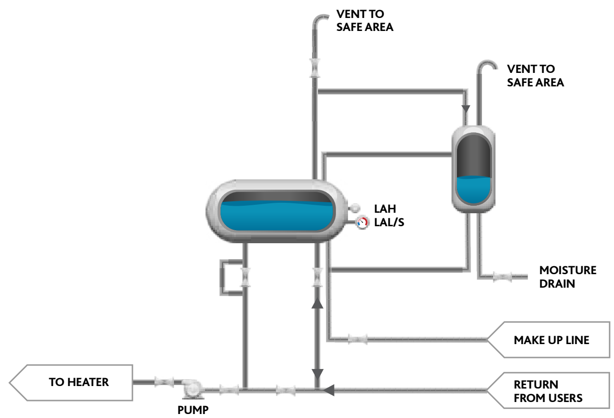
An effective method of minimizing fluid oxidation is to blanket the expansion tank with an inert gas, such as nitrogen or CO^2, or with natural gas. Figure 2 also details a suggested arrangement for inert gas blanketing of an expansion tank.

The purpose of inert gas blanketing is to maintain a nonreactive atmosphere in the vapor space of the expansion tank, preventing the entrance of air and moisture, which can adversely affect fluid life. An uninterrupted supply of inert gas, usually nitrogen, controlled by pressure regulators for both inlet and outlet flow is necessary to obtain this protection. A pressure relief valve is also required to protect the expansion tank from overpressure due to regulator failure, fire and other causes. Pressures used should be kept as low as possible inside the expansion tank to minimize inert gas usage. Maintaining a positive pressure slightly over atmospheric barometric pressure is all that is necessary to prevent air and moisture from entering the tank. A manual vent valve should also be installed to facilitate purging of the expansion tank's vapor space if it becomes necessary.

Cold-seal trap

Inert gas blanketing of the expansion tank is generally the most effective way of minimizing fluid oxidation. But when this option is not possible, there is another, less reliable arrangement: utilizing a cold-seal trap. Figure 3 illustrates a typical cold-seal trap on an expansion tank. Precautions should be taken to ensure the cold-seal tank fluid level does not drop below the dip tube. When this happens, the seal is broken and moisture-containing air will be allowed to enter the expansion tank during periods of fluid level fluctuations. Low boilers and moisture can collect in the cold-seal trap, so the fluid in the trap should be drained and discarded periodically. The primary shortfall of any cold-seal system is the turnover of fluid between the main system and the cold-seal tank during "in-breathing." Care should be taken to minimize this effect by properly sizing the cold-seal tank and vent lines.

Figure 3. Cold-seal trap arrangement for expansion tank*



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