Technical information bulletin

7

Calculation of liquid-phase heat transfer fluid system volume

During the design of a new heat transfer fluid (HTF) system or modification of an existing system, total system volume should be calculated. Early notification of how much new fluid will be needed helps the fluid supplier ensure the volume will be available, and help avoid purchasing more HTF than is needed. This is particularly important for larger systems.

The information in this document can help you develop an estimate of total system volume for a liquid-phase HTF system. This document addresses most sections of a new HTF system. When modifying an existing HTF system, only the volume change from the current volume needs to be calculated.

Every HTF system uses a heating or cooling source to transfer heat into or out of the system. The heating source could be a fired heater, electric heater or heat exchanger, which heats fluid using steam or another hot fluid. The cooling source could be cooling water, air or another fluid cool enough to absorb heat. The volume of heat transfer fluid in the source should be included in the system total. For example, a fired heater will have a significant volume of fluid inside the heater coil. For a given thermal capacity, a helical coil heater design will contain less volume than a serpentine coil heater design. Talking with the fired-heater supplier about the heater design can provide a good estimate of the volume contained in the heater coil.

Heat transfer fluid is pumped through the heating or cooling source in route to the users. The volume in the main loop pumps should be included in the system total. The HTF flow rate through the main pumps can be calculated from the heat duty needed, HTF supply temperature, fluid return temperature, fluid density and fluid-specific heat.

$$Q_{total} = q_{sh} / (Cp_{avg} * \rho * \Delta T) \qquad (1)$$

Where:

Q_{total} is HTF main loop flow.

q_{sh} is the total process sensible heat duty.

Cp_{avg} is the specific heat capacity of the HTF at the average temperature of the supply and return streams.

ρ is the liquid density of the HTF at the temperature where flow is measured.

ΔT is the difference between HTF supply and return temperatures.

For the main loop supply header, a pipe diameter should be selected that keeps velocity and pressure loss reasonable. Expansion loops in the main loop supply header accommodate thermal expansion of the piping. The number and location of expansion loops depend on the system operating temperature, main loop pipe diameter and piping layout. Expansion loops increase the length of the main loop supply header. If the piping layout is not well known, a rough assumption is that expansion loops could increase the main loop supply header length by at least 10%. The volume of heat transfer fluid in the main loop supply header can be calculated by using the selected pipe diameter and estimated piping length.

The pipe diameter of the main loop return header is typically the same as the main loop supply header. It will also include expansion loops. There is often a bypass line between the supply and return headers. This line contains a control valve to modulate supply header pressure. The volume of the bypass line should be included in the system total.

HTF from the main loop supply header is piped to each process user. Some process users may be supplied by a subloop with its own pump that circulates flow around the subloop. For each process user, the volume of piping, heat exchangers and subloop pumps should be included in the system total.

HTF may be used for heat tracing of equipment and piping. For each tracing loop, the volume contained in the supply and return piping, piping tracing and jumpers and equipment, and piping jackets should be included in the system total.

Many HTF systems use a side-stream filter to remove solids from the fluid. The volume of fluid in the filter housing and associated piping should be included in the system total.

Some HTF systems have recirculation piping to circulate fluid back to the expansion tank. This helps vent gases from the system. If the recirculation piping contains fluid during normal operation, its volume should be included in the system total.

The volume of HTF in the expansion tank must be included in the system total. The expansion tank should be sized so its volume is twice the system thermal expansion volume. Thermal expansion volume is the amount the HTF volume changes when the fluid increases from lowest ambient temperature to highest operating temperature. Using this approach, the expansion tank is about 25% full when the fluid is cold and 75% full when the fluid is hot.

Determining expansion tank volume is an iterative calculation. An initial expansion tank volume is assumed so that its 25% full volume can be included in the system total. Then the system thermal expansion volume is calculated as:

$$\Delta V = V_{total} * (\rho_{min} / \rho_{max}) - V_{total} \qquad (2)$$

Where:

ΔV is the volume of HTF thermal expansion.

V_{total} is the system total volume, including a 25% full expansion tank.

ρ_{min} is the liquid density of the HTF at lowest ambient temperature.

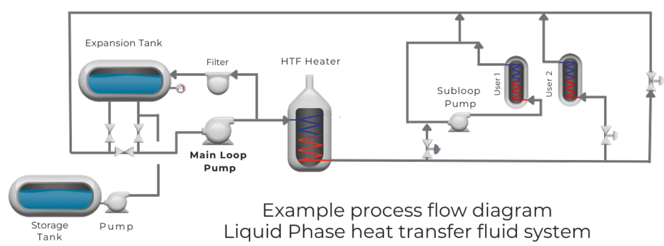
ρ_{max} is the liquid density of the HTF at greatest operating temperature.

The calculated thermal expansion volume is then compared to the assumed expansion tank volume. The calculation is iterated until the expansion tank volume is equal to twice the thermal expansion volume.

As HTF is exposed to high temperatures over time, some low-boiling compounds will be generated and vented from the system. More fluid will need to be added at some point. The system design may include a storage tank to hold fluid to top off the system. The expected volume of fluid in the storage tank and its associated pump and transfer piping, should be included in the system total.

To summarize, a total system volume calculation should consider the following areas. Depending on HTF system design, there may be other equipment or piping that should be included.

- Volume in the heating or cooling source equipment
- Volume in main loop pumps
- Volume in the main loop supply and return piping (including expansion loops)
- Volume in the bypass piping between the main loop supply and return headers
- Volume in piping, heat exchangers and subloop pumps supplying all process users (outside of the main loop supply and return piping)
- Volume in supply and return piping for piping tracing and jumpers and equipment, and piping jackets for all tracing loops
- Volume in the side-stream filter housing and associated piping
- Volume in recirculation piping
- Volume in the expansion tank
- Volume in the storage tank and its associated pump/piping



Example process flow diagram
Liquid Phase heat transfer fluid system

Eastman Corporate Headquarters
P.O. Box 431
Kingsport, TN 37662-5280 U.S.A.

U.S.A. and Canada, 800-EASTMAN (800-327-8626)
Other locations, +(1) 423-229-2000

eastman.com/locations

SFE-HTF-18066 8/24