Process Heating 10 TIPS

Hot Oil Systems

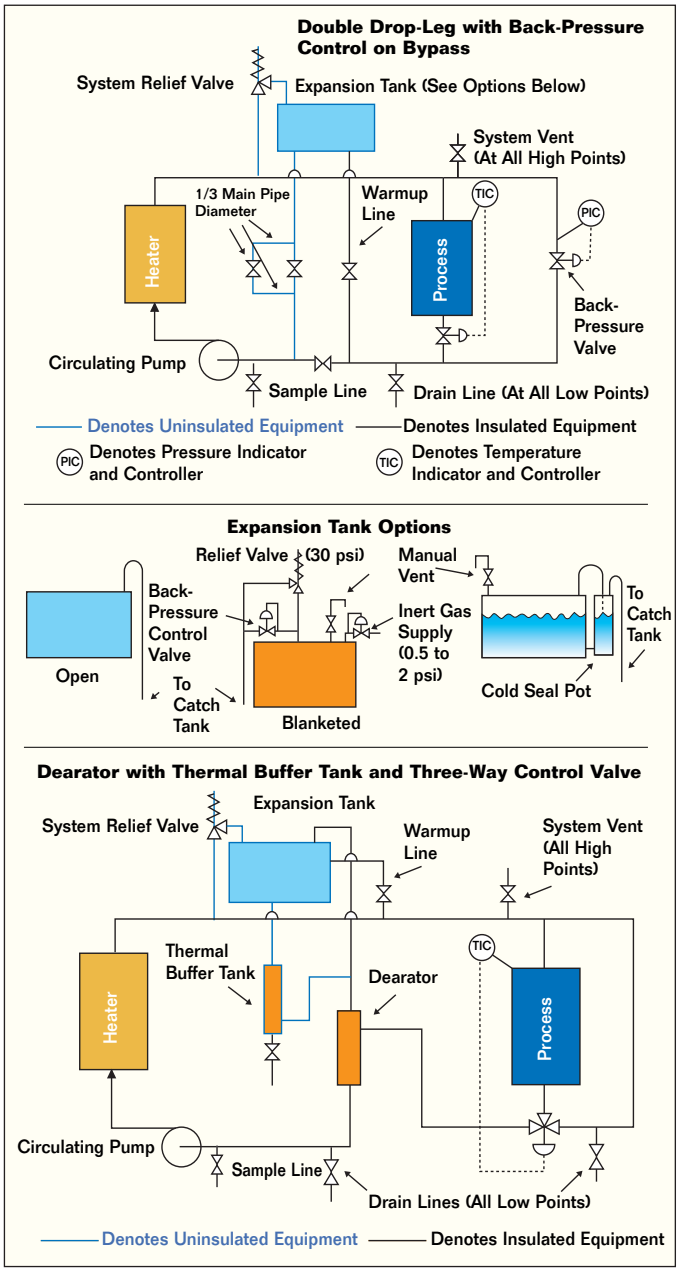


Figure 1. Each thermal fluid heating system should be designed specifically for your facility to meet your process needs. An inert gas blanketed expansion tank, which can be insulated if necessary, is recommended for systems that operate with a bulk temperature above 500°F (260°C). A cold seal pot is recommended if the expansion tank operates above 140°F (60°C) or if you are located in an area that has high humidity.

Good system design, smart fluid-handling procedures and regular maintenance can help you maximize the performance of your thermal fluid heating system.

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Designing, building and operating a thermal oil heat transfer system can be cost-effective if planned for properly from the start. Starting with common design layouts and continuing through operations, cleaning and troubleshooting, these 10 tips will help you maximize your investment.

TIP 1: Plan Thermal Fluid System Layout Carefully

There are an infinite number of layouts, and that is because each layout must be specifically designed for your facility to meet your process needs. Some typical layouts are shown in figure 1. At a minimum, every system needs a heater, pump and expansion tank.

TIP 2: Select System Components Wisely

System components comprise piping, threaded installations, flanges, gaskets, studs, nuts, insulation, valves and pumps. When specifying components for a hot oil system, be sure that they are designed for hot oil systems and for temperatures that exceed your system's bulk temperature.

Piping. Welded installations are recommended. If you use threaded installations, back-weld all connections or use thread sealant.

Flanges. Select flanges with the following characteristics: 300 lb forged steel construction; welding neck; 1/16" raised face, Schedule 40 bore; and ASTM A 181 rating. The use of backing rings at pipe-to-flange welds is recommended.

Gaskets. Select spiral-wound, graphite-filled or expanded/filled PTFE gaskets.

Studs. Choose alloy steel, continuously threaded, ASTM A 193, Grade B7 or higher studs.

Nuts. Use heavy hex nuts, ASTM A 194, Grade 2H or higher.

Insulation. Calcium silicate or fiberglass rated to 850°F (454°C) is acceptable where the potential for leaks is minimal. Closed-cell foamed glass is recommended within several feet of flanges, valves, pipe taps or other potential leak points. Flanges should be left uninsulated to ease leak detection.

Valves. Select cast or forged carbon steel valves with a socket weld or flanged

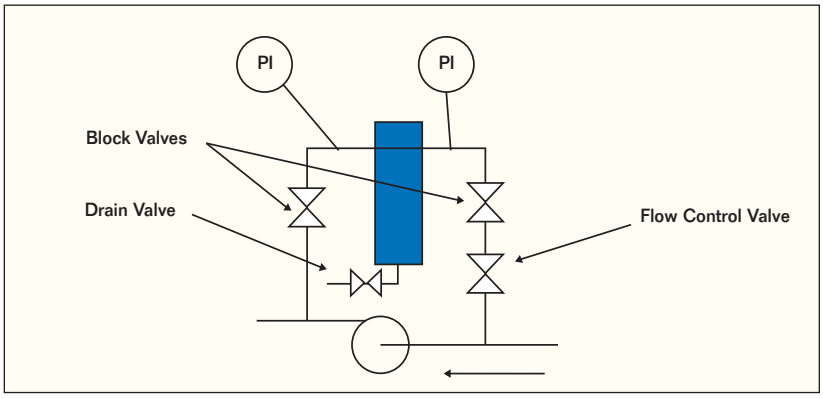


Figure 2. A side-stream filtration system is recommended for systems with centrifugal pumps.

(300 lb) design. Graphite or expanded/filled PTFE valve-stem packing or bellows seal is recommended. Isolation valves should be ball-type valves; for these uses, control valves or globe valves are recommended. Install valve stems pointing down to allow any leaking fluid to drain away from the insulation.

Pumps. For positive-displacement pumps, select those made of alloy steel with a gear-within-a-gear or sliding-vane design. For centrifugal pumps, be sure the pump selected has ductile or cast iron wetted parts. For the pumps' mechanical seals, select bellows type. For applications with low particulate loading, carbon seal faces are recommended over silicon or tungsten carbide seal faces. For applications with high particulate loading, use tungsten carbide seal faces rather than silicon carbide.

TIP 3: Keep Thermal Fluid Safety in Mind

The potential for fire should be considered in the design and operation of the thermal fluid system.

Flashpoint and Fire Point. The flashpoint and fire point of a thermal fluid are determined through laboratory testing of unused fluid. The most common test method is the ASTM D92 Cleveland Open Cup (COC). The lowest temperature at which the vapor ignites is called the flashpoint. The temperature at which sufficient vapor is generated to support a continuous flame is the fire point.

While these test results provide data for comparing different fluids, any extrapolation of these results into real-life situations must recognize the three basic conditions required for a vapor ignition to occur:

- The fluid must be at or above the flashpoint or fire point while in contact with air for any vapor combustion to occur. This situation may not exist around leaks because the leaking fluid will cool rapidly on exposure to air.
- Enough vapor must be present to support combustion. Any dissipation of the vapor may reduce the concentration below the level required for ignition.
- The source of ignition must be located within the vapor cloud. Good electrical installation practice dictates that potential ignition sources are located a distance from piping or are enclosed properly.

If any one of these three conditions is not met, vapor ignition cannot occur.

Leaks. Normal thermal fluid system leaks consist of fluid seeping from threaded fittings, flange gaskets, mechanical seals and valve-stem and pump-shaft-packing glands. Any droplets formed will cool rapidly on exposure to air. Extremely low volume leaks may produce a light gray smoke. This is an indication that the fluid is oxidizing immediately on exposure to air.

There are several conditions under which "normal" leaks can present a risk of fire:

- Certain types of insulation such as mineral wool, fiberglass or calcium silicate have an open or porous structure that allows fluid to wick away from the source of a leak. As the fluid disperses within the insulation, its surface area increases dramatically while its temperature remains at or near the system operating temperature. The danger is that a substantial percentage of the leaked fluid will remain unreacted within the insulation due to the limited amount of oxygen available. If the supply of oxygen suddenly increases, the remaining fluid in the insulation will burst into flames. Prevent insulation fires by using nonporous insulation within several feet of areas prone to leaks such as valves and flanges.
- If a low volume leak occurs within a tightly enclosed area such as a cabinet, the available oxygen may be consumed, allowing unreacted vapor to accumulate. Prevent this by ensuring that all portions of a thermal fluid system are located in areas with adequate ventilation.

Catastrophic Equipment Failure. A catastrophic equipment failure may result in the rapid release of large quantities of thermal fluid. As the fluid is released, the relatively larger surface area of the droplets and their velocity will result in rapid cooling. When this occurs, there will be a certain amount of smoke present due to the hot fluid reacting with air (oxidizing). Any resulting fire or catastrophic failure hazards can be minimized through proper design, operation and maintenance of the equipment:

- Never operate a thermal fluid above its boiling point.
- Maintain good ventilation in the area around equipment.
- Minimize the fuel available for a fire. To do this, the expansion tank should be equipped with a low level switch to shut down the entire system.

Loss of Circulation in the Heater. Severe potential for fires can exist if the thermal fluid flow is interrupted without causing the heater to shutdown. Under this no-flow condition, the temperature of the fluid inside the still-energized heater increases rapidly to well above its boiling point.

Equipment failures may result in spontaneous ignition of any leaking fluid. The most effective protection is to install a high/low pressure switch on the pump discharge or a low differential pressure switch across an orifice plate or similar type flow meter. The switch should be wired to shutdown the system immediately on loss of flow.

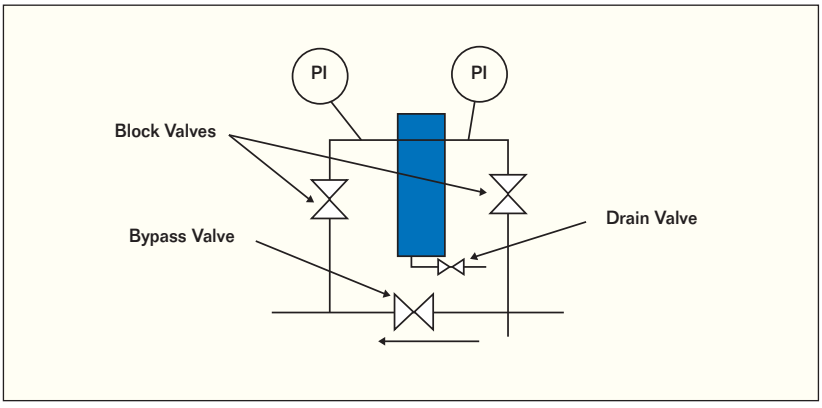


Figure 3. Inline filters only should be used with positive-displacement pumps.

TIP 4: Practice Safe Fluid Handling

Following a few simple recommendations for storing the fluid, filling the system and removing air pockets will ensure safe fluid handling.

When storing the fluid, the drums should be protected from exposure to direct sunlight and precipitation.

Before filling or refilling the system, open all of the vent or bleed valves, process block valves, control valves and any valves connecting the system to the expansion tank. To pump the heat transfer fluid into the system, any portable or drum pump with sufficient capacity is acceptable. Do not use the system-circulating pump to add fluid because seal damage can result from running the pump dry.

Once the valves are open, add the fluid to the system. Fluid should be added at the lowest point of the system, preferably at the suction side of the circulating pump. Avoid aerating

the fluid; do not add fluid directly to the expansion tank. Close the vent and bleed valves when the fluid runs out. Stop filling the system when fluid runs out of the highest point.

To remove air pockets, use the system-circulating pump to circulate fluid slowly through system until all of the gas bubbles have escaped into the expansion tank or vented through vent/bleed valves. Add fluid as required to maintain the expansion tank level at quarter-full.

TIP 5: Extend Fluid Life Through Good Operating Practices

The fluid service life and the process operating efficiency can be increased by minimizing thermal fluid cracking, oxidation and contamination.

Thermal Cracking. Under certain conditions, all heaters are capable of exceeding the maximum recommended film temperature of the heat transfer fluid. Exceeding this temperature for a period of time can cause excessive thermal cracking and premature fluid failure. Excessive thermal cracking can be minimized by following good operating practices:

- Maintain the design fluid velocity at all times through the heater.
- Bring cold systems up to temperature slowly.
- Avoid rapid shutdowns.
- Maintain system instrumentation.
- Check the combustion chamber for improper flame propagation or burner alignment.

Oxidation. When a heat transfer fluid oxidizes, it can cause fouling or corrosion of the expansion tank. Minimizing oxidation is relatively simple:

- Keep the expansion tank temperature below 140°F (60°C).
- Maintain positive net pump suction head (NPSH) at all times.

Contamination. Contaminants can promote fluid degradation as well

TABLE 1. TROUBESHOOTING TIPSHEET

Potential Problem	Potential Causes
Carbon Buildup on Heater Rods	Thermal Cracking; Contamination
Pump Seals Require Frequent Replacement	Heater; Heat User; Thermal Cracking; Contamination
Fluid Turns Dark and Thick	Heater; Heat User; Thermal Cracking; Oxidation
Uneven System Temperature Control	Heater; Heat User
Frequent Y Strainer Plugging	Oxidation; Thermal Cracking; Contamination
Pump Cavitation	Thermal Cracking; Contamination
Smoking	Oxidation

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as cause operational problems. Contaminants can enter the system in several ways. Guard against their entry by following good operating practices:

- In new systems, make sure that all fabrication debris or protective coatings are removed before assembly. Pressure test the system with either heat transfer fluid or inert gas. Never pressure test with water.
- In daily operation, always use fresh fluid to top off system.
- When using organic-based solvents or flushing fluids, completely drain the system from all system low points during system cleaning.

TIP 6: Start and Stop Sensibly

Good startup and shutdown procedures can help ensure that you are not promoting thermal cracking. During startup, it is recommended that the system pump be used to circulate the fluid through the system prior to turning on the heater. Once there is circulation through the heater, the operator should increase the temperature of the bulk fluid by 20 to 25°F (11 to 14°C) increments until the fluid reaches a viscosity of 10 cP. At this point, there will be turbulent flow through the heater, and the heater can be turned up to the process temperature.

During shutdown, it is recommended that the circulating pump be run independently of the heater to maintain continuous fluid circulation until the bulk fluid temperature falls below 250°F (121°C). Once the fluid has reached this temperature, the residual heat in the heater has been removed and the entire system is starting to cool down.

TIP 7: Perform Regular Fluid Analysis

Organic heat transfer fluids degrade over time due to thermal cracking, oxidation and contamination. Regular fluid analysis will evaluate the fluid condition and help identify when system maintenance or fluid replacement is necessary.

Thermal Cracking. Thermal cracking is the phenomena by which large oil molecules decompose into solid coke (90 to 95 percent carbon) and small, lower boiling molecules. The presence of these smaller and larger molecules can be determined by tests that measure fluid properties affected by molecular weight, and the results then can be compared to the properties of clean fluid. Other tests measure specific byproducts of cracking.

Among the tests that can be conducted to determine whether thermal cracking has occurred are tests for distillation range, kinematic viscosity, fluid flashpoint and pentane insoluables.

- The distillation range test establishes the relative amounts of large and small molecules in a sample by measuring the temperature at which certain volume fractions boil.
- The kinematic viscosity of chemically similar fluids is proportional to the average molecular weight. The results for the heat transfer fluid being analyzed may or may not deviate from characteristics of unused

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fluid due to mix of larger (high viscosity) and smaller (low viscosity) molecules, so this test alone is not a valid indicator of fluid condition.

- Flashpoint is the temperature at which the fluid vapor will flash when a small flame is passed a specified distance above the sample. The fluid's flashpoint may drop as smaller, more volatile molecules are formed.
- Pentane insolubles testing measures the amount of coke and other particulate matter that is suspended in the fluid. To conduct the test, the solids are removed by filtering, washed with pentane to remove the heat transfer fluid, dried and weighed.

Oxidation. All organic heat transfer fluids react with air to form organic acids. This oxidation rate is low at ambient temperature but increases rapidly as the fluid temperature rises. These acids can undergo free-radical polymerization, which will increase the fluid viscosity and ultimately can result in deposits. The most common test used to determine the level of fluid oxidation is the total acid number (TAN) test, which is a measure of the organic acid concentration in the fluid.

Contamination. Contaminants can catalyze fluid degradation and result in severe operating and equipment problems. The most common contaminant in heat transfer fluids is water. The Karl Fischer water test determines the amount of water present in the fluid.

DO NOT USE WATER TO CLEAN OUT AN ASSEMBLED SYSTEM OR TO PRESSURE TEST THE SYSTEM. INSTEAD, **USE A FLUSHING FLUID, THE HEAT TRANSFER FLUID OR INERT GAS**.

Evaluation and Recommendations. The laboratory data from these tests provide a snapshot of the fluid condition. The data must be put into a time perspective along with the operating history to obtain a complete system analysis. This allows corrective action to be implemented before the fluid life or equipment efficiency is compromised.

When preparing a fluid sample to send out for analysis, take the sample from a "live" part of the system, preferably at the heat user or the circulating pump. The fluid should be circulating at a temperature of 200°F (111°C). Do not sample from the expansion or drain tank. Also, it is important that the sample be put directly into the sample jar.

TIP 8: Install Effective Thermal Fluid Filters

Filtration will extend the service life of the fluid and reduce system maintenance costs. These benefits increase as the system operating temperature increases.

For general components, a 10 µm filter is recommended. Block valves should be a positive-shutoff type to

allow for filter cleaning without shutting system down.

A side-stream filtration system is recommended for systems with centrifugal pumps (figure 2). With a side-stream configuration, the optimal flow rate through the filter is 10 percent of full system flow. At a minimum, circulate at least 3 percent of the full system flow through the side-stream filter.

Inline filters only should be used with positive-displacement (gear-type) pumps (figure 3). Never install an inline filter on a system that uses a centrifugal pump. A second filter in parallel (duplex) can be installed in place of the manual bypass for critical applications such as high temperature electric systems.

TIP 9: Clean the System with a Flushing Fluid

A flushing fluid is intended for use in startup or general maintenance of heat transfer fluid systems. New systems may contain mill scale, weld splatter, slag, flux, quench oil, protective coatings, dirt and water. The abrasive contamination can damage pump seals, bearings and control valves. Mill scale and weld splatter can promote fluid oxidation and cracking. The oil, coatings and flux are thermally unstable and can cause fluid degradation. Using a flushing fluid to clear these contaminants out of the system before adding the clean heat transfer fluid will minimize maintenance concerns and help extend fluid life. Flushing fluid also is useful to remove particulate, sludge, some coked-on material and left behind, used heat transfer fluid prior to recharging a system with new heat transfer fluid during a fluid changeout.

Do not use water to clean out an assembled system or to pressure test the system. Instead, use either a flushing fluid, the heat transfer fluid or inert gas. Also, pressurize the fluid with nitrogen rather than air to minimize fluid oxidation.

When filling the system with the flushing fluid, slowly pump the fluid into the system from the bottom up to vent air. Filling from the top (pouring into the expansion tank) hinders air venting and needlessly aerates the fluid. Often, a convenient place to fill the system is through the blowdown connection on the strainer. Use a small positive-displacement pump to transfer the fluid rather than the system pump.

TIP 10: Use a Troubleshooting Tipsheet

Table 1 shows a list of problems that you may have with your system and the possible causes. If you can identify the causes, then you can systematically work through them to get your system back to running smooth and efficiently. **PH**

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