Operating a Hot Oil Heat Transfer Fluid System is Not Too Hard When You Know the Basics



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Operating a hot oil heat transfer fluid system can be easy if one understands the components of a system, how to start-up and shut-down the system properly and general operational procedures. Some other things that one should know are how to drain a hot oil system, how to recharge the system and the proper start-up procedure after recharging with new heat transfer fluid. This article will provide the basic knowledge needed to operate a hot oil heat transfer fluid system.

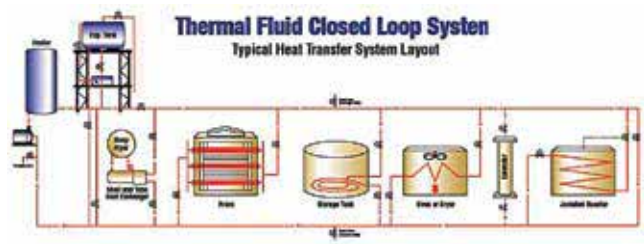
System components and their function – The system is made up of a pump that pushes the heat transfer fluid though an insulated ridged or flexible piping system to a heater and to the process equipment. There is an expansion tank on the system to allow for the expansion and contraction of the hot oil as it heats up and cools down. To remove particulate from the system, some systems have in-line or side stream (preferred method) filtration units. The in-line filters 100% of the flow, where the side stream takes 10% or less of the system flow rate.



A centrifugal pump.

There are two types of pumps used in a hot oil system. There is a gear pump (not as commonly used) and centrifugal pump (the preferred type of pump because it can allow higher flow rates to ensure that there is turbulent flow through the heater). The pump is like a heart. It keeps the heat transfer fluid flowing and if it ever stops, there will be major problems with the system. For humans, if our heart stops, it means death. So, we need to do everything in our power to keep that pump pushing the heat transfer fluid through the system when the heat is on! Hooking the pump up to a battery/generator backup system would be a smart thing to do to make sure the system flow is maintained during an electrical outage or during rapid shut down for whatever reason.

There are many types of heat transfer fluids. I prefer the non-hazardous, non-toxic, organic petroleum-based heat transfer fluid. Most systems of any size run very efficiently with this type of fluid. Some benefits are that disposal is the same as used motor oil or hydraulic oil and that the oil protects the system from rusting on the inside. There are synthetic heat transfer fluids that require companies to meet EPA standards and regulations for operation and disposal. That seems to be way too much work when the end result with organic fluids provides the user with a safe and efficient alternative. However, there are certain applications when only a synthetic product will do. I like to think that the heat transfer fluid in a hot oil system is similar to the blood in our circulatory system. Healthy blood makes us live longer and run more efficient and the heat transfer fluid is no different in a hot oil system. So why wouldn't someone put something in their system that would promote a safe and healthy system?

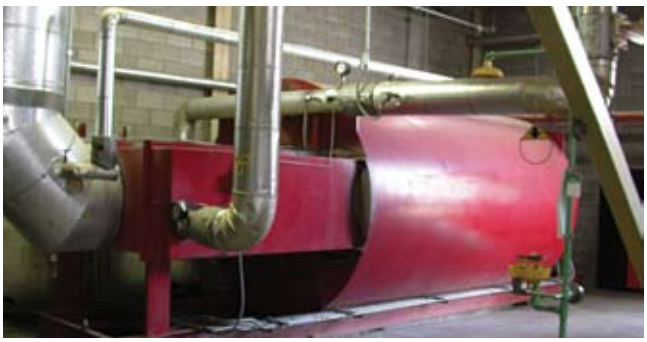


This is a typical heat transfer fluid system flow diagram showing different applications.

Piping is like the veins in our bodies. It carries the fluid from one location to another in the most direct path possible. The preferred method for pipe joints is welding them together because the viscosity of the fluid is so thin at elevated temperatures that it can find its way past threads and seep out of the system. There are also flexible pipes and hoses that can be used in a system. These are perfectly fine, but just know that if there is not a perfect seal on the connections, there will be some seeping of the oil. For organic fluids, there are only three materials that cannot be used – cooper, aluminum and brass. These materials are oxidation catalysts. Oxidation is one of the ways to break down an organic heat transfer fluid. Steel or stainless steel are the preferred materials used. You can use rubber or plastic but you need to make sure they can handle the low viscosity of the oil as well as the high temperatures.

Like all the other components, there are many types of heaters. Heaters are classified by the amount of BTU or kilowatts produced and the fuel that is used to generate the heat such as electric, gas, oil and wood. A heater OEM can

provide specific recommendations to meet the application needs. Some systems are smaller in size and come with a pump, heater and expansion tank so that all the hoses can be hooked to them from the application and it is ready to go. Other systems are not that easy. They all have separate components that are purchased and installed when the piping is run. It is a good rule to think of systems according to the amount of heat transfer fluid required in the system. Most of the smaller heaters described above can handle a volume of 20 to 500 gallons. Installed systems could range from 300 to 60,000 gallons.



This is what a large heater looks like.

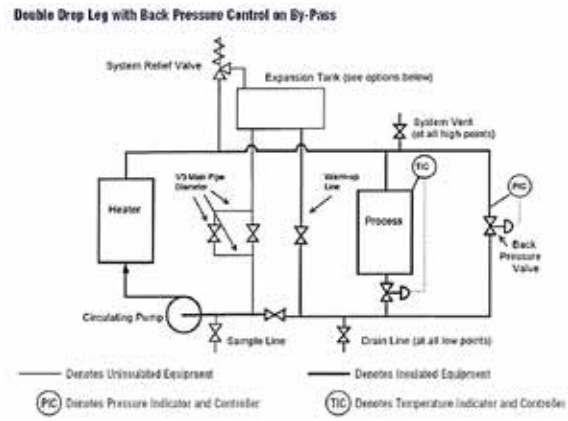
There are many different processes or applications for hot oil systems. These processes are better known as the users. Some applications include heating dies, cooling dies, heating molds, cooling molds, heating reactors, heating vats, heating process machines, heating rolls, heating storage tanks, and the list goes on and on. The main thing to know is that each application has its own specific requirements and each system is designed to meet those requirements. The smaller systems are relatively simple, but the larger systems can become very complicated. The larger systems require design work from engineering or consulting firms and can take many months to design as well as install.

The final component of a hot oil system is the expansion tank. This tank is critical to the operation of the system. Its main purpose is to allow some place for the heat transfer fluid to expand into when heated and fluid to draw from when cooled. It is also a built-in reserve tank for the system, so if there is a leak, the expansion tank will feed the system to keep the system full. That is why it is important to keep an eye on the level of the expansion tank daily. If the level drops from its normal position, it means the system has developed a leak.



Expansion tanks are critical to the operations of the system. This one has a nitrogen blanket and runs at over 140°F (60°C).

One general rule of thumb is to fill the expansion tank up 1/3 full when the system is cold. When the system is running hot, it should be 2/3 to 3/4 full. There are usually two pipes or legs that run to an expansion tank and when running, one leg needs to be closed to prevent thermal currents from running into the expansion tank and heating up the fluid. The temperature of the fluid in the expansion tank should be less then 140°F (60°C). The reason for this is to prevent fluid oxidation with the air inside the tank. If the expansion tank needs to run hotter than 140°F (60°C), then a nitrogen blanket should be installed on the head of the tank to remove any oxygen molecules and prevent oxidation.



A typical heat transfer fluid system layout.

The Start Up Procedure

This procedure is very simple but I estimate that less than 20% of all hot oil system operators are doing this. So, here is the proper start up procedure for a hot oil system.

1. First, start the system pump to get the fluid flowing through the system.
2. Second, after you know you have good flow, apply the heat. Heat should be applied in 20°F (11°C) to 25°F (14°C) increments until the heat transfer fluid gets to a viscosity of 10 cP (centipoise) or less. The reason for this is to ensure that there is turbulent flow through the heater (where the heat transfer fluid can remove just as much heat as the heater can supply to the coil in the heater) and prevent thermal cracking of the oil.
3. These increment steps are done by taking a system from 70°F (21°C) and increasing the heat by 20°F (11°C) and letting the system run until the temperature on the heater reads 90°F (32°C). Once the heater reads that, then dial it up another 20°F (11°C).
4. Once the heat transfer fluid is 10 cP or less, the heater can be dialed to the operating temperature. For example, if a company runs MultiTherm PG-1® in its system, it will reach 10 cP at 132°F (55.5°C). So from ambient to 132°F the company may have to do 2 or 3 increments before dialing the heater to the 340°F operating temperature.

One should watch the level in the expansion tank (it should rise as the heat transfer fluid expands). If it does not, the line may be clogged or there may not be enough fluid in the system. Also, at 200°F (93°C), some pump cavitations may occur. If this happens, that means there is water or some light end molecules in the system that are boiling off.

The Shut-down Procedure

This procedure is more than just going to the heater and shutting the pump and heater off at the same time. If the shut-down is performed this way, the residual heat that is left in the heater can exceed the maximum film temperature of the oil and thermal crack the oil that is not moving through the coil in the heater. This is the suggested shut-down procedure:

1. Turn off the heater first.
2. Let the pump continue to circulate the heat transfer fluid to remove any residual heat that is in the heater, the process and the pipes. For some systems, this may take awhile depending on the system size. The reason for this is to make sure that when the pump gets turned off, the residual heat in the various components of the system does not thermally crack the heat transfer fluid.
3. Once the temperature has dropped below 200°F (93°C) the residual heat has been removed and it is safe to shut off the pump. It is recommended that the pump be on some type of auxiliary power source, so that if a facility loses power for some reason (and there are many) or something happens to the main power source, the pump continues to run and push the fluid through the system. This type of occurrence is a major reason that the heat transfer fluid in a system starts to breakdown. By-products of thermal cracking are a heavy end molecule (made up of 90-95% carbon) and a light end molecule or low boiler.

Standard Operating Procedures

Once the heat transfer fluid system is up and running, it should run pretty much on its own. But here are some daily things to keep an eye on when operating a system:

1. Check the temperature of the oil returning to the heater as well as the oil exiting the heater. When a system is running smooth and efficiently, the temperature difference should remain constant. If the temperature difference increases, that is an indication that something is changing in the system.
2. When checking the temperatures, also check the pressure drop across the pump and through the heater. If there are no changes in pressure drops, everything is fine. If there are changes, then the system is telling you there is a problem.
3. Check the pump out – is it running smooth, making noise, leaking oil or what appears to be smoking?
4. Check the heater out – walk around it and make sure that the outer case is ok. Check for leaking oil, burning of paint, making sure nothing appears to be loose or out of place. If there is something that changes, call your heater manufacture immediately. There may be a very serious problem.
5. If there is a flow meter, make sure that the flow rate does not change.
6. Check the expansion tank – is the paint burnt off, are there leaks, does it make noise, does it smell, is the oil at the normal level, does the level tube appear to be clogged, is there what appears to be smoking coming from the vent pipe?
7. Walk the piping system – check all elbows and connections for leaks (if there is — never open up insulation to find the leak when the system is hot, this is one of the ways you can start a fire — let the system cool down before investigating the leak), any weird odors, all gates or vents or valves appear to be operating properly? Is there what appears to be smoke coming from any of the connections, or any different noises from normal?
8. Check the filter system – if the pressure drop is the same, everything is ok and the filter does not need replacement. If there is a greater pressure drop then normal, the filter is being filled with particulate and needs to be replaced.

These types of things do not require much time or effort. If the whole operations team is trained, everyone can do this on a normal working basis. Then, when something out of the norm happens, it can be reported to the right person and identified before the problem causes unscheduled downtime that costs the company money and you a headache trying to fix the problem as quickly as possible.

Draining Procedure

Draining the system of the heat transfer fluid is not very difficult, but it is rather messy and time consuming. If it is done right, almost all the heat transfer fluid from the system can be removed so that when the system is recharged with new heat transfer fluid, it will operate more efficiently. Here are the general steps on how to drain the fluid from your system:

1. Shut the heater or heat source off and let the pump continue to circulate the oil through the system. All the residual heat needs to be removed from the system as well and the oil needs to be cooled down.
2. Once the oil is at a safe temperature to drain from the system, shut off the pump and allow fluid to stop circulating.
3. If there is a nitrogen blanket on the expansion tank, turn that off.
4. If there are high point vents, open them.
5. Make note of all positions of closed or partially closed valves or gates. Once noted, open them all up, but please do not forget the closed leg to the expansion tank.
6. Attach hoses to all the low point drains. In most cases, the two low point drains will be at the pump and another at the process/user.
7. Use a secondary pump (NOT THE SYSTEM PUMP) to pull the fluid out of the system and into an empty drum, tote or tanker (depending on the size of your system). Make sure to label the containers as used heat transfer fluid, so a drum of used fluid is never accidentally put back into the system.
8. When you think you have all the oil out of the system, allow the system to sit for 10 to 15 minutes and try pumping again (sometimes it can take a while for some of the more viscous fluid to settle to the low points).

Now the system has been drained of the heat transfer fluid. If it is drained as hot as possible, almost all the sludge and particulate will be removed from the system. This procedure does not remove any of the caked on or carbonized material in a system. To do that, consider either a process system cleaner or flushing fluid, which can be purchased from your supplier.

Recharging Procedure

Recharging the system with either new heat transfer fluid or flushing fluid is just draining the system in reverse and pumping the fluid into the system. Make sure there is enough new heat transfer fluid to fill the system. There is nothing more aggravating than not having enough fluid when recharging the system. If this happens, do not settle for using some of the used fluid or even something that is not acceptable to mix with the new oil. Call your supplier for recommendations if you are caught in this situation.

Follow this procedure to recharge your system:

1. Once you feel that you have removed all the used oil from the system, use the secondary pump (DO NOT USE YOUR SYSTEM PUMP) to draw new oil from the container and push it into the system.
2. First, pump new fluid into the system from the low point at the process/user. If the drain is left open at the system pump or high point vents open and fluid starts to come out, that is the indication that all the piping at the process/user side is full. This should be repeated at all the process/user low points.
3. If there are high point vents, close them.
4. Once all the process/user loops are all full, attach the secondary pump to the drain at the system pump and start pushing fluid into the system.
5. Keep an eye on the expansion tank; keep filling the system until the expansion tank is 1/3 full.
6. Make sure that all drains and vents are closed tight.
7. Reset all the valves or gates to the same positions as during normal operations, except the one to the expansion tank. Leave both of the legs to the expansion tank open and if there is a nitrogen blanket on the tank, do not turn that on yet.
8. Make sure that the pump did not lose its lubrication or prime on the backside of the seal. If this step is not done, the seal will be burned out and will need to be replaced in the near future. If unsure about what needs to be done, call the pump manufacture for guidance.

Start-Up Procedure after Recharging

Starting the system after a recharge is much different than starting the system after shutting it down. Below is the procedure to restart a system after a recharge:

1. Start the system pump. Do not apply heat yet. Allow the fluid to circulate and remove any air pockets in the system. The air pockets will find their way to the expansion tank and thus out of the system. There may be some funny noises. When they go away, it is safe to say that the air pockets have been removed and system circulation is back to normal. Also, make sure that the expansion tank is open to atmosphere.
2. If the expansion tank level has fallen below 1/3 full, pump some more new oil into the system using the secondary pump through the drain at the system pump location.
3. Once the system is circulating fine and there is the proper level in the expansion tank, it is ok to apply the heat.
4. Apply heat in 20°F (11°C) to 25°F (14°C) increments until the heat transfer fluid gets 195°F (90°C). Hold this temperature and walk the system to make sure everything is fine.
5. Increase heat to 200°F (93°C) (this is where water starts to boil). At this point, if there is water in the system from the draining and recharging procedure, you will find out. If the pump starts to cavitate or if you get spitting and spurting of hot oil out of the expansion tank, there is water in the system. If water is in your system, make sure that the pipe from the expansion tank is pointed into an empty drum or in a safe location so that it cannot hurt anyone. Allow this to go on until the pump cavitations and the spitting and spurting from the expansion tank stops. Depending on the amount of water in your system, this could take a long time (hours and even days).
6. After it is determined that there is no water in the system, turn the heat up to 220°F (104°C). Run the system at this temperature until it is certain that there is no water or moisture in the system.
7. If there is no water and you have a nitrogen system for the expansion tank, this is the time to turn it back on.
8. Close one of the legs to the expansion tank.
9. It is now safe to dial the heater to its operating temperature.

This explains all the components of the system and how each affects the operations of the heat transfer fluid system. It has also provided the basic procedures for shut-downs, start-ups, operating, draining and recharging your system. It may seem confusing to some, but it is important to understand so that systems can be kept running safe and efficient.