SPECIAL REPORT

Heat Transfer Fluids:
Do's, Don'ts, and Best Practices

Sponsored by:

Paratherm Corporation
HEAT TRANSFER FLUIDS

PutmanMedia®

HEAT TRANSFER FLUIDS: DO'S, DON'TS, AND BEST PRACTICES

CONTENTS

HOW TO EASILY TRACK THE PERFORMANCE OF YOUR HEAT TRANSFER SYSTEM

THERMAL OIL systems tend to be exceptionally smooth-running and trouble-free. It's not uncommon to hear of systems that have been operating quietly and efficiently for years with nary a hint of problems.

To keep your system "in the pink" there are some simple—and inexpensive—checks that you can perform in-house. These procedures can help you detect problems before they become real headaches.

LISTENING TO THE SYSTEM

Like your car, each thermal oil system has its own sounds that tell you it's operating properly. But if you hear snapping, cracking and popping noises in the piping or tubing, it's highly likely water has gotten into the system. If the pump is making loud noises, it may be cavitating. This is a significant problem and should be dealt with immediately. If any part of the system is vibrating excessively, you'll want to know why.

LOOKING AT THE SYSTEM

Hot fluid weeping from welds, flanges, instrument ports, valve stem packings or gaskets is certainly a housekeeping problem - and could become a burn hazard. Leaks of thermal fluid should be taken care of as soon as possible.

(DANGER: If any hydrocarbon liquid (oil, grease, heat transfer fluid, hydraulic fluid) is allowed to enter porous insulation, it will begin to oxidize, raising the insulation's internal temperature. If this temperature exceeds the fluid's autoignition temperature, the fluid is likely to spontaneously combust into a smoldering fire. Thoroughly inspect all insulation for signs of wetness and other damage.)

During each inspection include the pressure equalization line (vent). Steam coming from the vent can signal water in the system. If you see oil mist, it may mean that the heat transfer fluid is vaporizing at the heated surfaces. Both situations require immediate attention.

Closely inspect the catch-container. The container should be steel. It should be positioned so that overflows from relief, vent or overflow lines are safely contained. Do you see fluid in the container? If so, you'll want to know what the fluid is and why it's there. If it's heat transfer fluid, you'll want to determine what caused the relief valve to trip or the system to overflow. If it's water, oil, solvent or other liquid, it's a safety hazard and must be removed. The catch container should always be clean and dry.

UNUSUAL SMELLS

Sniff the air in the heater room, and in the area near the heat user. If you detect a "varnishy," "burnt" or "acidy" pungent odor, the fluid is probably "bruised" and the odors may be escaping from the system. You'll want to find the source of the leak, and determine if repairs are necessary.

OBSERVING THE FLUID

With the heater off, start the circulating pump(s) in the morning and wait ten or fifteen minutes. Open a low-point valve, allowing a small amount of fluid and any accumulated grit to drain into a can. After the grit has cleared, place a clean water glass or beaker under the valve and fill about 3/4 full. Put the beaker on a bench and let it sit.

If liquid has "beaded" in the glass or if you see a phase separation (one fluid "floating" on top of the other), water has likely infiltrated the system. If you see particles on the bottom (or floating in the liquid), it could mean that the fluid is "coking" or that mill scale or other hard contamination is present. Either condition should be investigated before problems can escalate.

Gently tilt the beaker left then right. Does the used fluid look thicker than new fluid? Does the film appear thick or thin as it slides down the inside of the glass? If thick—especially if it has visible suspended solid matter—the fluid's viscosity may have substantially changed and it is probably bruised. A fluid analysis may be a good idea.

Sniff the fluid. If it smells burnt, "varnishy" or "acidy," the fluid is most likely bruised—another reason to consider a formal fluid analysis.

If you check the system every week or two, these simple and inexpensive procedures will help you keep your system humming, and can reduce or eliminate nasty surprises.

REGULAR FLUID ANALYSIS HELPS ASSURE PROPER SYSTEM FUNCTIONING

An effective preventive maintenance program should always include regularly scheduled analysis of heat transfer fluids. However, the response these fluids have to adverse conditions is different from the response of lubricating oils, so users need to collect different analytical data. The three most critical tests to track are:

- *Acid Number.* Shows current oxidation level of the fluid. This is predictive of future fouling and sludge problems.
- *Viscosity.* Determines whether fluid has become too viscous (thick) for efficient heat transfer.
- *Distillation Range.* Analyzes fluid composition for alteration caused by overheating.

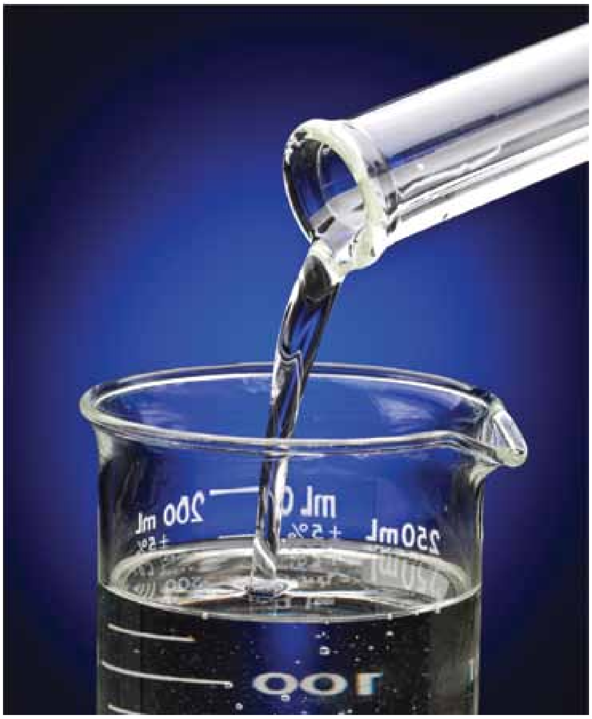
If testing concludes that fluid degradation has occurred, equipment and/or operational abnormalities may be the cause. Correcting such problems before they cause serious product quality issues or production shutdowns will save money and increase efficiency.

For a technical data sheet on analyzing your fluids, click here.

HEAT TRANSFER FLUID TIPS

HEAT TRANSFER fluids (hot oils, thermal liquids) are manufactured from highly refined petroleum, synthetically formulated hydrocarbons or siloxanes (silicone). Able to provide high temperatures at very low system pressures, heat transfer fluids offer safety, low maintenance and extended operating lifetimes as major benefits.

The pressure of 600°F steam is over 1500 psig. At the same temperature, Paratherm fluids have vapor pressures less than ⅓ atmospheric pressure.



MIXING HEAT TRANSFER FLUIDS

Mixing various hydrocarbons and subjecting the mixture to high temperatures and turbulence can be highly unpredictable.

Compound the problem with the possible catalytic effects of normal system contaminants and your system may be creating unknown and unwanted chemicals. We strongly suggest never mixing fluids.

CLEANING NEW SYSTEMS

There are many contaminants that can find their way into heat transfer systems. New systems are no exception. Hard contaminants such as weld slag and spatter, and mill scale can damage pump bearings and seals and control valves. The mill scale can promote fluid oxidation.

"Soft" contaminants such as protective lacquers and coatings, oils and welding flux are thermally unstable and can cause degradation of the fluid. While you can replace damaged fluid somewhat inexpensively, it's another matter to go through the cost and downtime of replacing mechanical seals, control valves and pumps.

(Caution: We strongly recommend that your system be completely clean and dry before charging with heat transfer fluid.)

WATER IN YOUR SYSTEM

No system we've seen has been entirely free of water. The more complex the system, the more water is usually present—and the more difficult its removal. One proven method is to locate system low points having drain valves. Open each valve and drain a small quantity of fluid into a beaker.

If you see a phase separation (one liquid floating on top of another), keep draining until you draw pure fluid. Jog the pump, bringing "new" fluid to each low point. Continue the sampling and jogging procedure until no phase separation is observed (allow enough time for the water to work its way down to the low point).

Any remaining water can be "steamed off" by running the system at about 225°F with all vents and the expansion tank warm-up valve open. Once the vent system stops "steaming," the system can be carefully taken to operating temperature safely.

Note: Although "hydro" testing is a commonly accepted practice with heat transfer systems, alternatives such as pressure-testing with inert

WHEN AND HOW TO TEST THERMAL FLUID

Sooner or later in the life of any thermal fluid system, the question of when to test the thermal fluid arises. In some cases, the issue comes up when the system performance falters or when it just flat out won't run. At that point, the issue of "when" or "if ever" the fluid has been tested is not as important as figuring out what went wrong. Helping to pinpoint the cause of the failure is the hidden benefit of fluid monitoring, since many equipment and/or operational problems that can lead to catastrophic fluid failure will show up in the test results. Therfore, here are tips on when to test the thermal fluid:

- During the first year of operation for brand new systems—any major screwups in the equipment design or layout that can affect the fluid will show up in the test results.
- A week or so after a fluid change—even if you don't change brands, there will have been enough change in the old fluid properties so that any residue will show up in the test results of the new charge.
- Annually—scheduling an annual preventive-maintenance item takes the guess work out of "when" and more important, keeps a current report on file for your insurance company.

How to test the fluid is another issue. Lube oil tests (which include dissolved metals and particles) are cheap but are not designed to identify changes in the properties required for high temperature operation. Outside labs may be able to run the correct tests but can't properly interpret the results. The most effective test results are provided by the thermal fluid supplier.

gas or with the heat transfer fluid itself should be considered. Water in a system can cause pump cavitation and corrosion and, if trapped in a "dead leg" and hit by high-temperature oil, can flash to steam and literally blow the pipe or tubing apart. And if the pipe doesn't burst, the expansion can push a slug of hot oil out the expansion tank's vent—a serious safety hazard.

LEAK TESTING/PREVENTION

Pressurize the system with inert gas and use soap-bubble detection fluids at potential leak points. Heat transfer fluids can leak through gaskets, seals and packing if they're not properly installed. Refer to the bulletin "Recommended Hot Oil System Components" for more information.

Add to this large metal dimensional change from thermal expansion and contraction, and leak prevention becomes critical. The "Components" bulletin details proper pipe, flanges, insulation, packing, gasketing and sealants, among others.

DRAINING YOUR SYSTEM

Bring the oil temperature up to about 225°F, and circulate the fluid until you are assured of thorough mixing. At this temperature the fluid will be less viscous, and many solids will be suspended. Thoroughly drain using valves at the system's low points. As the fluid drains, observe what comes out. If you see chunks of carbon and other solids, you should consider flushing with the heat transfer fluid you intend to use. Call us for additional information.

Note: It a system is heavily fouled, it is recommended to consider cleaners other than water-based types. Water is difficult to remove, and can cause pump cavitation and system upsets.

CHARGING YOUR SYSTEM

Connect a small positive-displacement pump to a low-point drain near pump suction. A convenient place to fill is the blowdown valve which is often located on the strainer. The strainer is usually located upstream of pump suction. Bottom-filling will substantially reduce the entrainment of air, a common cause of pump cavitation. Bottom-filling allows the system to vent normally as the fluid enters.

Consider purging the system with inert gas prior to charging. Inert gas forces the air out, and can assist with the removal of water vapor as well. And once the system is brought up to temperature, inert gas bubbles will not contribute to fluid oxidation.

PREVENTING OXIDATION

Organic heat transfer fluids, whether natural or synthetic, will oxidize in contact with air. Oxidation can begin as low as 250°F, and will double with every 20°F rise in bulk fluid temperature. Oxidation will cause the fluid to thicken and to become acidic and sludgy. And the fluid can become more susceptible to thermal degradation.

If your system is not equipped with a cold-seal tank, and the temperature of the fluid in the expansion tank runs hotter than 200°F, we strongly suggest you consider blanketing the tank with inert gas. Nitrogen is inexpensive and readily available. We suggest that you purge the system with inert gas prior to charging. This, coupled with the inert gas blanket will not only protect the fluid against oxidation, but will assist in keeping contamination and water vapor out.

Note: If your system employs a deaerator/cold-seal expansion tank, insulate the deaerator portion only, leaving the remainder bare.

COLD WEATHER DELIVERIES

During shipment, air bubbles can become entrained in the fluid. If the cold fluid is immediately pumped into the system, the air bubbles can cause pump cavitation. It's best that the fluid be as near room temperature as possible prior to charging the system. You might store the drums in a warm room, or employ drum warmers to bring the fluid up to room temperature. The warmer the fluid, the more easily it will pump into your system.

FINAL NOTES

1. Cleanliness: By removing mill scale, quench oils, protective lacquer coatings and weld flux, spatter and slag from each section of pipe, each component and all fittings before they are installed; and by thoroughly cleaning and drying the heater and all users before installation, you can avoid many problems later on.

2. Filtration: Before start-up, check and clean all filters and strainers. It's best to pull the filter or strainer several times just after start-up to make sure that it's clean and not restricting flow. Matter stuck in the filter can be an indication of trouble, and can help you avoid a potentially serious problem. If the strainer is to be mounted near a control valve, we suggest it be installed on the inlet side of the valve. This will help keep the valve free from matter that could cause improper valve operation.

3. Fluid Analysis: Periodic analysis of your fluid can help pick up glitches before they become serious problems.

TUNING YOUR SYSTEM

Maintaining your thermal fluid system's design flow rate is critical for system performance. Quantitative output can be provided by flowmeters, but for a simpler and less costly method of tuning a system, users should consider the installation of pressure gauges.

While pressure gauges don't provide the data for actual flow calculations, they can track valuable information for troubleshooting. For example, should a Y-strainer become blocked, a compound pressure/vacuum gauge installed on the pump suction will identify it before it becomes a major problem. Similarly, a malfunctioning control valve can be readily detected by pressure gauges installed on the inlet and outlet lines of a heat user. Pressure gauges can also be used for certain functions which are vital to overall system performance. For example, if there is more than one user on a loop, a 3-way control valve mounted on the bypass leg can equalize the user pressure drop.

Pressure gauges should be located at the end of the supply header, the beginning of the return header, at the heater inlet and outlet, at pump suction and discharge, and also before and after every heat user (between the control valve and the user).

Pressure gauges should always be installed with enough connecting tubing to dissipate heat. Moreover to make sure the gauge can be easily removed for maintenance or purging of solids, the installation of a block valve is necessary as well.

THERMAL FLUID PROPERTIES EXPLAINED: DEBUNKING THE RHETORIC

THERE IS a lot of confusion and misinformation about what makes one heat transfer fluid better or more efficient than another. And once the salesman begins to brag about how his or her fluid's conductivity will reduce degradation or the low density makes for low pressure drop, you may as well get the shovel out and start cleaning up. Here below are items to help you debunk the rhetoric regarding thermal fluid properties.

1. DEBUNKING THE RHETORIC

Comparing 1 or 2 properties of fluids can be very misleading. For example, low viscosity improves heat transfer but low density reduces it. High thermal conductivity makes water efficient but most non-aqueous fluids have very low conductivity. The only way to compare thermal performance of 2 fluids is to calculate the fluid heat transfer coefficient (also known as the inside film coefficient) using some variation of the Seider-Tate equation. The way the math works in this equation, Viscosity has the most influence on heat transfer, followed by Density, Specific Heat and least of all Thermal Conductivity.

2. THE RED HERRING: VAPOR PRESSURE DEBUNKED

At some point in any project involving a new thermal fluid system, somebody will decide that vapor pressure is an important property that should be considered in fluid selection. There will be talk of pump cavitation along with a nitrogen blanket on the expansion tank with the extra costs for high-pressure components. All of these issues will quickly be reinforced by the thermal-fluid salesman with (you guessed it) the lowest vapor pressure.

What can be confusing is that some aromatic-based fluids have higher vapor pressure and coincidentally require more exotic sealing on pumps and valves because of VOC issues. What cuts through the confusion is that all fluid manufacturers specify Schedule 40 seamless piping, 300# flanges and some type of graphite gaskets. On the equipment side, most suppliers build their expansion tanks to ASME code regardless of the fluid chosen. So the bottom line is that vapor pressure has little effect on the overall cost of a heat transfer system.

One point that does require extra attention—don't confuse "smoke" with vapor pressure. Most thermal-fluid leaks are due to seepage through gaskets, pump seals, valve stems, etc. Regarding such seepage, what will have more of an effect than vapor pressure is whether the fluid is also a good solvent—such as many aromatic-based fluids (which, again coincidentally, typically have higher vapor pressures).

3. MINIMUM RECOMMENDED OPERATING TEMPERATURE

There really is no standard definition for the recommended operating temperature range for heat transfer fluids. The Minimum Recommended Temperature is a perfect example. Sometimes the "Minimum Pumpable Temperature" (@ 2000 cps) and the "Pour Point" are given as the minimum temperature. Ignore both of them - the fluid is way too viscous at those temperatures to be pumped with anything short of a piston pump (and when was the last time anybody used one of those on a thermal fluid system?)

There are actually two aspects to the low-temperature limit:

How cold a startup will the fluid handle? All fluids get more viscous with decreasing temperature. High viscosity reduces the heat transfer rate as well as the pumpability, both of which influence how fast the system can be brought up to temperature. If you anticipate extremely cold weather around your installation, you may want to specify a gear pump, which will move almost any viscosity. Centrifugal pumps are much more widely used so it makes more sense to use their limitations as a general guideline for cold start-ups. A properly specified centrifugal pump (correct horsepower and impeller size for normal operation) can handle a maximum viscosity of about 400 cps. So unless you heat-trace the lines, the lowest startup temperature of a fluid is where the fluid viscosity is in the 300 to 400 cps range.

If the fluid will be used for cooling as well as heating, what is the lowest fluid temperature that the fluid can handle? In the heat transfer world, it is a long way from the cold startup temperature to the minimum viscosity where a fluid will actually transfer heat. Just like the maximum film temperature of the fluid (more on that next time), the fluid film coefficient at the surface of the heat exchanger will determine how well the fluid works. For most equipment, the maximum design viscosity is around 20 cps. So this sets the lowest operating temperature.

4. MAXIMUM FLUID TEMPERATURE

If the temperature of the fluid film exceeds the maximum recommended, the fluid will degrade. For an explanation, click here.

5. THE DIFFERENCES BETWEEN LUBE OILS AND HEAT TRANSFER OILS

Keep a look out for claims and properties that indicate a product is not formulated exclusively for heat transfer. For more, click here.

6. THERMAL OIL TESTING VS. LUBE OIL TESTING

Lube-oil standards are much different than thermal-oil standards. To find out how, click here.

7. COLOR

Impurities can give oil a yellow color. For more on color issues, click here.

MORE ABOUT PARATHERM

- A Full Range of Heat Transfer Fluids
- Immersion Engineering: Service with Art and Science
- Fast and Available Supply