Preparation and Startup of New Systems

This document is offered as a general guideline to starting a new or freshly filled system. Please follow proper safety procedures and consult your system manufacturer for specifics on your system and what steps need to be taken to ensure a smooth and safe start up.

System Preparation

1. A general inspection of the system before proceeding is recommended. Ensure all pipes, flanges, valves etc. are properly installed/tightened and valves are in their designated open/closed position for charging the system with fluid.

2. Inspect system for any water that may have been introduced during construction, pressure testing etc. Check with your system manufacturer for specific procedures but opening low point drains and blowing nitrogen or dry air (moist/standard air could introduce more water) through the system is generally recommended to ensure the system is dry.

Filling the System

Once the system's integrity has been checked and all water removed it's time to start filling the system.

1. Consider the ambient/fluid temperature and its affect on the fluid's viscosity to ensure adequate pumps are available to start charging the system with fluid. Consult your specific Duratherm fluid property chart for its viscosity at your specific fill temperature.

2. Open all high point vents and valves to the various system 'users'.

3. Filling the system should be done through the lowest point in the system in order to prevent air pockets - this is generally at the pump level and in some cases the system pump may be appropriate for filling the system. Otherwise a portable, high velocity pump or truck mounted pump (if bulk delivered) can be used to fill the system.

4. Fill the system slowly, closing bleed vents as the fluid level reaches them.

5. Filling is generally complete when the system's expansion tank reaches a point just above the low level switch - check with your system manufacturer to be sure of desired expansion tank levels. Should you overfill the expansion tank, drain back an appropriate amount of fluid keeping in mind that the fluid expands as it's heated.

6. Should your system utilize an inert gas (usually nitrogen) on the expansion tank please consult your system manufacturer for proper procedures for initializing its use. Generally speaking, Duratherm fluids do not require more than a low pressure nitrogen pad to help reduce oxidation.

Starting the System

1. First ensure your system pump is set up in accordance with its manual. Follow instructions for mechanical and air-cooled seals (usually air needs to be removed). Your Duratherm fluid can often be used at the barrier fluid if required.

2. Consult your system manufacturer's manual for specifics but assuming the system is in a ready state to be started follow the specific instructions for your system. This will typically include a pump and boiler test/check.

3. When the system is pumping, leak-free and circulating properly, again follow your manufacturer's recommendation but in most cases the fluid should be heated slowly, particularly up to 250° to 300°F to ensure any moisture can be vented safely and without causing undue pump cavitation.

4. Once the system has been started, don't forget to take advantage of our complimentary fluid analysis program and send us a baseline sample.

Startup of Cold Systems

A fluid at room temperature may have a viscosity as high 100Cst but if the system is outdoors and the ambient temperature is below 32°F (O°C), the viscosity could be 1000 cSt or higher.

While a fluid at these viscosities is easily pumpable, it is not yet ready for full heat. Your heater is designed to apply heat at a set rate according to a fluid's flow or velocity. When a fluid hasn't achieved the ideal viscosity its flow or velocity will not be sufficient for the heat source. Basically, the fluid will be too thick to allow for efficient flow. If a heater is allowed to fully fire during these periods it will most likely overheat and thermally degrade the fluid. The fluid will simply move too slow past the heater and absorb too much heat.

Therefore when starting up any system it is important follow these general guidelines.

1. Ensure the fluid is warm enough to pump. Apply external heat as necessary.
2. Ensure the expansion tank has the minimum recommended fluid level for a system start (usually 1/4 to 1/3 full).
3. Start the burner on the low fire setting, circulate at full flow and slowly raise the temperature until the fluid reaches 220°F
4. Once the fluid reaches 220°F and is pumping smoothly without cavitation (a sign of water contamination), follow the manufacturer's recommendation for a full fire heat up.

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Restarting a System After an Automatic Shutdown

After an automatic shut down by the safety controls or emergency stop the fluid should still be hot (above 200°F) but before restarting the system a few steps should be taken.

1. Identify the cause of the shut down and rectify the condition or malfunction that caused it.

2. Run the pump without the heater and circulate the fluid through the system for a number of passes to ensure any vapor/air pockets possibly formed from an abrupt stop are removed.

3. Start the burner at the low fire/flame setting until the flame is stabilized before turning to full fire.

System Shutdown

When shutting your system down a few basic steps will help ensure that no damage from overheating is inflicted on your thermal fluid.

During the course of normal operation your heat source (boiler, furnace, electric heater) will be cycling either on/off or from a low fire to a high fire in order to maintain your set-point temperature. Within a short period of time the heater tubing or vessel will become nearly as hot as the heat source itself and is actually much hotter than your output temperature. The actual temperature at the impingement point of the heater in most cases will be even higher than that of the recommended maximum fluid or film temperature for your fluid.

If a system is shutdown abruptly without allowing the heat source and adjacent areas to cool when the fluid ceases to flow, it will become trapped and subsequently 'burn' or thermally degrade. Therefore when shutting down any system it is important to simply allow the fluid to cool below 250°F (121°C) before shutting down the pump.

The use of a heat exchanger or leaving your heater blower running will help expedite cooling the fluid temperature to under 250°F (121°C).

Understanding Fluid Degradation

Oxidative Degradation (Most common)

The scientific definition of oxidative degradation is the reaction of oxygen (in air) with the fluid by a free radical mechanism to form larger molecules which end up as polymers or solids. These thicken the fluid increasing its viscosity. A more viscous fluid will be more difficult to pump, have poorer heat transfer characteristics as well as an increased chance of coke formation. Oxidation is also accompanied by an increase in the acidity (TAN) of the fluid. As with most chemical reactions, oxidation occurs more rapidly as the temperature is increased. At room temperature the reaction rate is hardly measurable. However, at elevated temperatures the affect is exponential and can impact the fluid life in systems not utilizing oxidation reducing measures such as nitrogen blanketing the expansion tank.

In layman terms oxidation occurs when hot fluid comes in contact with air. Signs of fluid oxidation are seen most evident as sludge formation within the system especially in low flow areas such as reservoirs or expansion tanks. Total Acid Number (n/t-H) or TAN is the common measurement of oxidative degradation degradation.

Thermal Degradation

Thermal degradation or thermal cracking is the breaking of carbon - carbon bonds in the fluid molecules by heat in excess of the fluids recommended maximum bulk or film temperture. The reaction may either stop at that point, in which case smaller molecules than previously existed are formed, or, the fragments may react with each other to form polymeric molecules larger than previously existed in the fluid. In heat transfer terminology, the two types of degradation products are known as “low boilers” and “high boilers”.

Low Boilers

The effect of the low boilers is to decrease the flash point and viscosity of the fluid as well as to increase its vapor pressure. The increased vapor pressure can affect overall system efficiency and can cause pump cavitation. The reduction in the flash point could also be cause for safety concerns.

High Boilers

If thermal degradation occurs at extreme temperatures greater than 400°C (752°F), the effect is not only to break carbon - carbon bonds but to separate hydrogen atoms from carbon atoms and form coke. The effect of the high boilers is to increase the viscosity of the fluid as long as they remain in solution. However, once their solubility limit is exceeded, they begin to form solids which can foul the heat transfer surfaces. In this case, fouling of the heat transfer surfaces is very rapid and the system will soon cease to operate.

In layman terms, thermal degradation is overheating the oil past its boiling point. As the fluid boils, much like water, it produces a lighter component in the form of vapors. Excessive overheating or cracking can cause reduced viscosity as well as pose safety concerns with the creation of the lighter components which in turn reduces the overall flash point, fire point and autoignition temperatures.

Avoiding Oxidation And Thermal Degradation

Oxidation

Weak points with respect to oxidation can easily be identified by looking for any point in the system where the fluid contacts air. Once these points are identified, during normal operation measure the average fluid temperature in this area (usually expansion tank or reservoir). If the fluid temperature is below 200°F the system should be sufficiently guarded against excessive oxidation. If however, the fluid temperature is above 200°F there are a few quick steps that might help.

1. If the system does not have an external expansion tank or fluid reservoir, consider adding one. Generally placing a reservoir of 'cold' fluid at the point of air contact will significantly reduce oxidation.

2. If the system has an external reservoir but is running hot, examine the flow path. If the fluid is flowing through the reservoir consider plumbing it so that the reservoir is "T'd" into the system and not part of the circulation loop.

3. If the expansion tank is not part of the circulation loop but is still running hot you can consider moving it further away from the main system or add a nitrogen blanket to buffer the fluid from air contact.

One important note is that not all fluids are affected the same by oxidation. Recognizing oxidation as a major downfall to heat transfer fluids all Duratherm fluids contain an extensive additive system to combat oxidation. Check with your fluid supplier to ensure they have incorporated some protection in their fluid, particularly if your system is open to the atmosphere.

Thermal Degradation

Thermal Degradation happens when a fluid is heated past its recommend bulk or skin temperatures sometimes resulting in a cracking or breaking of the fluids molecules. Beyond ensuring your fluid is properly spec'd for your equipment and temperature requirements there are a few things to be aware of that can contribute to thermal degradation.

1. Start up and shut down. We commonly see systems either heated up too fast or shut down without cooling first.

During startup, particularly with electrically heated systems its important, for a few reasons to heat the system gradually. This not only helps reduce the risk of thermal degradation but also ensures any moisture or vapors are vented from the system gradually without cavitating the pumps or even worse having a geyser of vapor and fluid erupting from vent points.

Shutdown is equally important, again particularly with electrically heated systems. If a system is not allowed to cool before stopping fluid circulation fluid can become trapped in the heater/boiler and will likely see temperatures much higher than the fluid is rated for.

2. Another potential cause of thermal degradation is modifying system design. A well engineered system will utilize the heat transfer fluid as efficiently as possible without wasting valuable energy/fuel. This means that pumps, valves, heater watt densities, user loads etc. are all engineered to work in harmony. However, as systems age or needs change it is likely that some aspect of the system will need to be changed, modified or removed. If this is the case work closely with system manufacturers, engineers and fluid suppliers to ensure you will remain within the parameters of the systems original design or that compensations are allowed for with respect to the fluids capabilities.

Fluid Analysis

Duratherm's complimentary fluid analysis program will help ensure maximum fluid life for your specific application. The analysis, will allow us to make recommendations on a fluid's continued serviceability and help prevent possible issues.

Generally there are two things that impact a fluid's life: oxidation and thermal degradation, the indicators for which include flash point, viscosity and TAN (total acid number).

What these are, why we analyze them and how they affect a fluid are explained below.

Oxidative Degradation: Oxidative degradation occurs when a fluid at over 200°F comes in contact with air. This reaction causes a formation of an acid within the fluid. When the acid reaches its saturation point in the fluid it drops out in the form of sludge.

Thermal Degradation (overheating or thermal cracking): Thermal degradation occurs when the fluid is heated past its maximum bulk temperature.

Flash point: Flash point is basically the temperature at which the vapors from a fluid will ignite if in the presence of an ignition source.

A decrease in the flash point may be an indicator that the fluid has been thermally degraded. As a fluid is thermally degraded a lighter component is produced which reduces the overall flash point.

Viscosity: Viscosity is a measurement of a fluid's resistance to flow, sometimes considered its thickness. An increase in viscosity can indicate fluid degradation by oxidation. A decrease in viscosity can indicate that a fluid has been thermally degraded.

TAN (total acid number): Acids are formed when the fluid comes in contact with air (oxidation). We measure the TAN (acid) level to show the extent to which a fluid has been oxidized. The higher the TAN the more the fluid has been oxidized.

Typically a new fluid has a TAN of less than 0.05. When a fluid reaches a TAN of 1.0 it is generally considered time for a fluid change.

Dealing with Water Contamination

Precautions

Water should never be used to pressure test a system. Heat exchangers utilizing a water side should be inspected regularly and monitored for leaks.

Heat transfer drum storage should be covered but if they must be kept outdoors they should be stored on their sides to keep water (rain) from collecting on the tops of the drums. It is also good practice to dedicate pumps and transfer hoses for your heat transfer fluid to avoid any contamination, including water. Moisture can also be drawn in from humid outside air. It should also be noted that if the tank fluid temperature is below the dew point, condensation can form within the expansion tank

Detection Before Start-Up

Fortunately most common heat transfer fluids are not water soluble and will, if significant amounts of water are present, form a distinct layer that can be seen if a sample is drawn from a low point while the system is not circulating. While this will provide a clear observation of larger amounts of water, a few hundred ppm of water would not easily be seen but could still cause operational issues.

Detection During Start-Up

If during the start-up of a system everything is fine until the temperature reaches about 220°F water could be the cause. As you heat up your system the fluid thins out and it's normal to see a decrease in the pump discharge pressure. However, if at around 200°F the pressure drops suddenly and the pump starts to shake from cavitation, you've most likely got water in your system.

Detection During Operation

Oftentimes trace amounts of water (a few hundred ppm) can show up as fluctuations in pump pressure or as small disruptions or cavitation of the pump. Do not ignore these signs. Although your system might be above 212°F (or above the boiling point of water) it is possible to have water trapped in low lying areas or dead legs that will break free at random times. A leaky heat exchanger could also be introducing water into the system a small amount at a time.

Safety

Caution should always be used when dealing with water. Water expands over 1000 times when turned to steam; if water is suddenly introduced to hot fluid, the steam expansion will displace an equivalent amount of fluid. This displacement can in turn force hot fluid through the expansion tank or reservoir and out through the vent.

Removing Water

Larger amounts of water can and should be removed through system low points whenever possible. During start-up however, it is possible to slowly heat the system toward 200°F - 220°F and coax small amounts of water out as it turns to steam. If water evacuation persists, the expansion tank or reservoir fluid temperature can be elevated above 220°F to keep the escaping steam from condensing into water.

System Venting

A system's expansion tank will usually vent minor insolubles or light ends during the course of normal operation. However, from time to time it may be necessary to remove excessive amounts of water, contaminants or degradation by-products by routing a portion of the hot system fluid through the expansion tank.

General instructions are below but consult your system manufacturer for detailed instructions and before you get started take a system sample to be submitted as a 'before' venting sample.

1. Determine if your system has two legs from the main loop to the expansion tank and identify the valve positions - one should be open and one closed during normal operation

2. Open the normally closed leg to allow fluid to flow through the expansion tank.

3. If your system has a nitrogen blanket turn it off and open any vents or pressure relief valves so the expansion tank vents freely to atmosphere but to a collection vessel.

4. Empty or mark the level in the collection vessel.

5. Monitor material collection in the collection vessel on a regular basis (hourly, daily etc. depending on volume and volatility of material venting).

6. Once the vent material flow ceases submit another 'after' sample for analysis.

Monitoring Leaks and Avoiding Fires

When a system leaks it could result in a few potentially hazardous scenarios. Systems should be inspected routinely for leaks and repaired as soon as possible. Flanges, pump seals, rotary unions, instrument lines etc. should be monitored regularly and addressed as required.

Leaks can be obvious and clear hazards but they are not always evident and can pose potentially hazardous situations. Here are a few examples:

1. The fluid drips on to a hot surface or open ignition source where it could potentially ignite.

2. If a fluid leaks and collects within the system’s pipe/reactor jacket insulation it is of particular concern particularly with open cell insulation (it is recommended to use closed cell insulation). If the fluid becomes trapped within the insulation, the fluid can oxidize. This process produces heat which remains trapped between the process piping or reactor jacket and the insulation. As the fluid continues to degrade, its fire safety points are reduced and compounded with the heat created from its degradation, the fluid can start to smolder which could result in an auto ignition type fire should air be introduced to the mix.

3. Mechanbical Seals (pump seals or rotary unions) will almost inevitably leak at some point and while the temporary (or sometimes long term) solution would be to install a catch pan, this is not a permanent fix. Any fluid collecting or pooling around hot surfaces is potentially an ignition source and should be attended to quickly.

** It is extremely important to remember that should any part of your heat transfer system start to leak or smoke that you approach it with caution and have proper fire extinguishing media close at hand, particularly if you see smoldering insulation. Instinctively workers will often cut away the insulation to investigate the smoke which introduces air and potentially could cause an auto-ignition fire.*

Monitoring and Logging Data

Systems and fluids generally operate trouble-free for many years but if a problem does arise having data history on such things as pressure differential across boilers, boiler output temperatures, flow rates, pressure readings at users, amp draw on pumps etc. can be invaluable in troubleshooting a problem.

Once a system is operating properly start a log of all available data points. These logs should be updated frequently within the first few months of commissioning a system but once everything is operating consistently, quarterly logs at a minimum should be maintained.

Safe Handling of Heat Transfer Fluids

Most Duratherm fluids are considered non-toxic and non-hazardous and typically require little special handling or personal protection. Please consult your specific MSDS but below are some general guidelines.

1. Drums should be stored indoors and away from any heat sources. If stored outside always keep drums on their sides to avoid water penetration.

2. Consult your system manufacturer for safe instructions on filling or topping up systems while hot and/or circulating.

3. Do not share drum pumps, hoses or containers with lubricants or other fluids to avoid contamination.

4. Be aware that heat transfer fluids expand with temperature, fill systems slowly, a little at a time to avoid overflow.

5. When handling hot fluid for any reason use common protective measures to avoid burns.

6. When taking a fluid sample ensure it is done safely, (Ideally, samples should be taken when the fluid is warm and circulating.If it's necessary, take a sample at a cooler temperature to ensure personal safety).

7. Monitor systems for leaks and rectify problems quickly, both for personal safety and to reduce fire hazards.

8. If a system has a vent, the vent materials should be safety collected in a suitable container. Be aware the vent materials can have very low flash points and should be handled and disposed of accordingly. Do not breathe vapors!