DURATHERM
Heat Transfer Fluids

NEW SYSTEMS: OPERATION AND MAINTENANCE

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 is recommended before proceeding. Ensure all pipes, flanges, valves etc. are properly installed/tightened and valves are in their designated open/closed position before charging the system with fluid.
2. Inspect the system for any water that may have been introduced during construction, pressure testing etc. Check with the system manufacturer for any system-specific procedures but generally, opening low point drains and blowing nitrogen or dry air through the system is recommended to ensure the system is dry prior to filling. The use of moist/standard air is not recommended as is may introduce more water into the system.

Filling the System

Once the systems 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's 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. Close all 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 to its manual. Follow instructions for mechanical and air cooled seals – usually air needs to be removed. Your Duratherm fluid can often be used as 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 recommendations but in most cases, the fluid should be heated slowly – particularly up to 121°C to 149°C (250°F to 300°F) – to ensure any moisture can be vented safely and without causing undue pump cavitation.
4. Don't forget once the system has been started to take advantage of our complimentary fluid analysis program and send us a baseline sample. Doing so provides you with a start-up reference point that is invaluable in diagnosing any system fluid issues in the future.

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Heat Transfer Fluids

INITIATING A COLD SYSTEM START

A fluid at room temperature may have a viscosity as high 100 cSt but if the system is outdoors and the ambient temperature is below 0°C (32°F), 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 any System it is Important Follow These General Guidelines:

1. Ensure the fluid is warm enough to pump. Apply external heat as necessary.
2. Check the fluid level in the expansion tank to ensure it is at 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 104°C (220°F).
4. Once the fluid reaches 104°C (220°F) and is pumping smoothly without cavitation – a sign of water contamination, follow the manufacturer's recommendations to bring the system to operating temperature.

RETURNING A SYSTEM TO OPERATION

After an automatic shut down by the safety controls or an emergency stop, the fluid in the system may still be hot – above 93°C (200°F). Before restarting the system a few steps should be taken to ensure a safe return to operation.

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 or air pockets that may have possibly formed from the abrupt shut down are removed.
3. Start the burner and run at the low fire/flame setting until the flame is stabilized before turning to full fire.

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SAFELY SHUTTING DOWN YOUR SYSTEM

When shutting your system down, a few basic steps will help ensure that your system's thermal fluid isn't damaged in the process by unintended overheating.

During normal operation, your heat source will be cycling either on and off or from a low fire to a high fire in order to maintain your set-point temperature. Keep in mind too that within a short period of time the boiler tubes or electric element's chamber will become nearly as hot as the heat source itself. Therefore, it's important to remember that your heater is actually hotter than your output temperature and if the flow is stopped, there's a good chance it will quickly apply far more heat than the fluid can safely handle.

If a system is shut down without allowing the heat source and adjacent areas to cool before the fluid stops flowing around or through the heat source, it can become trapped and subsequently 'burn' or thermally degrade. For this reason it's important when shutting down any system to allow the fluid to cool below 121°C (250°F) before turning the pumps off. Using a heat exchanger or leaving your heater blower running will help speed up this cooling process.

UNDERSTANDING FACTORS THAT AFFECT THERMAL FLUIDS

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.

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 temperature. 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 is in contact with air. Once these areas are identified, during normal operation, measure the average fluid temperature in this area – usually the expansion tank or reservoir. If the fluid temperature is below 93°C (200°F) then the system should be sufficiently guarded against excessive oxidation. If however, the fluid temperature is above 93°C (200°F), there are a few options with respect to system design that should be considered to rectify the problem:

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 heated 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, consider moving it further away from the main system or look at the option of adding a nitrogen blanket to the tank to buffer the fluid from air contact.

One important note is that not all fluids are affected in the same way by oxidation. Having recognized oxidation as a major downfall to heat transfer fluids, all Duratherm thermal fluids contain an extensive additive system to combat oxidation. Be sure to check with your fluid supplier to ensure they have incorporated some protection against oxidation 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 temperature, sometimes resulting in a cracking or breaking of the fluids molecules. Beyond ensuring your fluid is properly specified for your equipment and temperature requirements, there are a few things to be aware of that can contribute to premature thermal degradation:

1. Start-up and shut down. We commonly see systems either heated up too fast or shut down abruptly without allowing the system some time to cool down first.

   During start-up, particularly with electrically heated systems, it's important for a few reasons to heat the system gradually. Incremental heating helps reduce the risk of thermal degradation but also ensures any moisture or vapors are safely vented from the system gradually without cavitating the pumps – or even worse, having a geyser of vapor and hot thermal fluid erupting from vent points.

   Shut down 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 be exposed to temperatures much higher than the fluid is rated for.
2. Another potential cause of thermal degradation is making physical modifications to the original 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 application 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 the system manufacturer, engineers and your fluid supplier to ensure your system will continue to safely operate within the original design parameters following the modifications or to make any operating adjustments with respect to the thermal fluid's capabilities.

UNDERSTANDING FLUID ANALYSIS

Duratherm's complimentary fluid analysis program will help to ensure your thermal fluid's in-service life is optimized for your specific application. Using the data from our analysis, we will be able to make recommendations as to a fluid's continued serviceability with the goal of helping to prevent possible future issues.

Generally there are two things that impact a fluid's life, oxidation and thermal degradation – indicators for which include flash point, viscosity and the Total Acid Number (TAN). What these are, why we analyze them and how they impact a fluid are explained below.

Definitions:

Oxidative Degradation: Oxidative degradation occurs when a fluid at over 93°C (200°F) comes in contact and reacts with air. The reaction causes an acid to form within the fluid that can continue to build-up over time. When the acid reaches its saturation point, 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.

Analysis:

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 overheated and is starting to degrade. As a fluid is thermally degraded, a lighter component is produced resulting in a reduction of the 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 may be an indication that a fluid has been thermally degraded by overheating.

TAN (Total Acid Number): Acids are formed when the fluid comes in contact with air (oxidation). We measure the TAN level to show the extent of which a fluid has been oxidized. The higher the number, the more oxidized and acidic the fluid has become.

Typically a new fluid has a TAN of less than 0.05. When fluid analysis indicates a TAN of 1.0, it is generally considered that it's time to change the thermal fluid.

HOW TO DEAL WITH WATER IN YOUR SYSTEM

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.

Proper storage of both full and partial drums of heat transfer fluid is very important. Drums should be sheltered or covered with bungs in place. If they must be kept outdoors, they should be stored on their sides to keep water (rain or snow) from collecting on the tops of the drums. It is also good practice to use dedicated pumps and transfer hoses for your heat transfer fluid to avoid any cross contamination of fluids, including water. Moisture can also be drawn into your system when operating in a humid environment. It should also be noted that if the tank fluid temperature is below the dew point, condensation can form within the expansion tank resulting in a build-up of water over time.

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 clearly seen if a sample is drawn from a low point while the system is not circulating. Although larger amounts of water will be visible to the naked eye, smaller amounts of water in the range of a few hundred ppm will not easily be seen but will still have the potential to cause operational issues.

Detection During Start-Up

If during the start-up process everything is fine until the fluid temperature reaches about 104°C (220°F), it is most likely that water, trapped within the system, is the cause of any problems at this point. 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 93°C (200°F) the pressure drops suddenly and the pump starts to shake from cavitation, you've most likely got water in your system. In some cases though, it's important to note that this may happen at much higher temperature if water is trapped deep down in a 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 warning signs. Although your system might be running above 100°C (212°F) – the boiling point of water – it is still 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 small amounts of water into the system over a period of time.

Safety

Caution should always be used when dealing with unintended water in your system. Water expands over 1000 times when turned to steam; if water is suddenly introduced to hot fluid, it will quickly vaporize into steam. The resulting steam expansion will displace an equivalent amount of fluid from the operating loop. This displacement can in turn force hot fluid from the loop, through the expansion tank or reservoir and out through the vent.

Removing Water

Larger amounts of water should be removed through system low points whenever possible. During startup however, it is possible to slowly heat the system toward 93°C – 104°C (200°F – 220°F) and coax small amounts of water out of the system as it turns to steam. If water evacuation persists, the temperature of the fluid in the expansion tank or reservoir can be elevated above 104°C to keep the escaping steam from condensing back into water.

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Heat Transfer Fluids

SYSTEM VENTING THROUGH THE EXPANSION TANK

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 and into 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 a 'after venting' sample for analysis.

MONITORING FOR LEAKS AND AVOIDING FIRES

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

Leaks can be obvious and clear hazards but they are not always evident. They can create potentially hazardous situations both in and around the equipment. 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, resolving the problem must be a priority – particularly with open cell insulation. Closed cell insulation is recommended for use in reactor jacket applications.

   Any thermal fluid that may become trapped within the insulation can oxidize. This reaction produces heat that 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 the oxidation reaction, the fluid can start to smolder – possibly leading to in an auto ignition type fire should air be introduced to the mix.

3. Mechanical 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 source of the smoke. Doing this will introduce air and could potentially result in an auto-ignition fire.

REGULARLY LOGGING PERFORMANCE DATA

Systems and thermal 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 quickly.

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.

STAYING SAFE AROUND HEAT TRANSFER FLUIDS

Most Duratherm fluids are considered non-toxic and non-hazardous and typically require very little in the way of special handling or personal protection. Please consult your thermal fluid's SDS for specific handling procedures but below are some general guidelines we recommend you follow:

1. Drums should be stored indoors and away from any heat sources. If they must be 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 the system while hot and/or circulating.

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

4. Be aware that heat transfer fluids expand in volume with temperature. Filling any system should be done 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, make sure it is done safely! Ideally, samples should be taken when the fluid is warm and circulating but if for some reason that is not possible, 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 vented materials should be safety collected in a suitable container. Be aware the vented materials can have very low flash points and should be handled and disposed of accordingly. Take appropriate precautions to avoid inhaling any vapors!