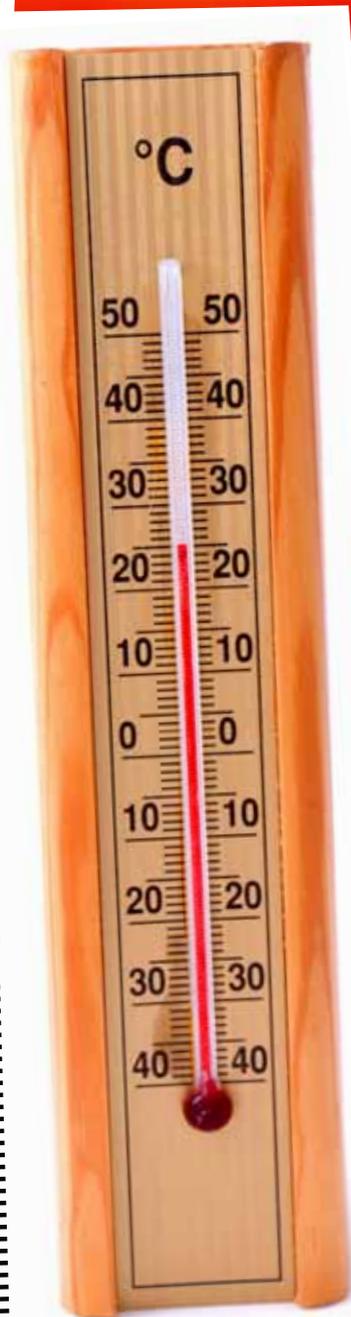


**RYAN RITZ, PARATHERM CORPORATION, USA, DESCRIBES THE APPLICATIONS, OPERATIONS AND MAINTENANCE OF THERMAL FLUID SYSTEMS IN GAS PROCESSING.**

# LIQUID HEAT



**A** growing number of natural gas processing facilities are utilising thermal fluid heating systems throughout various stages of the gas treatment process. Thermal fluids, also commonly known as heat transfer fluids or hot oils, are an attractive alternative to traditional heating methods such as high pressure steam, fired reboilers and direct heaters.

The most conventional application where thermal fluid is used as a heating medium is in the reboiling stage for regeneration of liquid amine. The concern of accelerated degradation of the amine as it passes through the stripper/reboiler creates the need for precise temperature control and efficient heat transfer. While the stripping of  $H_2S$  and  $CO_2$  impurities from rich amine can be achieved at relatively low bulk liquid temperatures, flaws in system design or disruptions in operating parameters can create elevated film temperatures that may ultimately lead to thermal breakdown of amine. This becomes an even greater probability with the use of direct fired reboilers where uniform temperature control and localised overheating are inherent problems.

Thermal fluid systems are less commonly used to heat the dry gas used in the regeneration or dehydration beds and molecular sieves. In these applications the technology also offers distinct advantages over high pressure steam and direct heating. Regeneration gas typically needs to be heated to 450 – 500 °F to effectively vaporise the accumulated moisture in the saturated adsorbent. When using a direct fired heater or high pressure steam system, the pressures required to achieve this heat demand introduces increased safety and operational concerns and requires specially designed high pressure coils and equipment.

The use of a thermal fluid in an indirect heating loop to achieve temperature control in both of these regeneration processes offers numerous advantages in operation, maintenance and safety. The irony is that those very advantages, which largely increase work efficiencies through reducing inspection, oversight and operator attention, may result in the thermal fluid system being neglected in routine maintenance because of the extensive and multi staged operations that occur at natural gas processing facilities.

Once an issue with the fluid does arise, it has the potential to become a costly and time consuming problem that may require a total system shut down and significant losses in production.

There are a number of simple practices that can be followed to maximise the effectiveness of a system utilising thermal fluid as the heating medium. The following information aims to provide the reader with key points to follow when implementing, operating and maintaining a thermal fluid heating system in a gas processing plant.

## Fluid selection

The decision to use a thermal fluid system is influenced by the advantages that these systems present, such as higher efficiency, better product yield and relatively low maintenance demand. To further fine tune that decision, a number of important factors come into play when considering the proper heat transfer fluid to use for a particular



**Figure 1.** Viscosity, consistency and colour of fluid will vary with age and use conditions; dark colouration does not necessarily reflect poor fluid condition, so although visual inspection can provide clues, it is always best to verify with lab analysis.

operation. Thermal fluids (heat transfer fluids and hot oils) are generally categorised as either highly refined petroleum based oils, synthetic hydrocarbons or silicone oils. In choosing which type of oil to use, consideration should be given to the advantages and disadvantages that each offers in factors such as:

- Temperature limitations.
- Initial price.
- Thermal efficiency.
- Operating demands.
- Life expectancy/thermal stability.
- Environmental friendliness.
- Safety.

Generally speaking, options should be limited to the fluids that offer the best thermal efficiency across the entire range of required operating temperatures for the particular process.

In selecting a thermal fluid for the reboiler stage in amine regeneration, superior heat transfer efficiency below the 350 °F bulk fluid temperature is critical. The typical bulk temperature desired for the rich amine in this step is at or below 260 °F. Efficient heat transfer at the heated surface in the reboiler is critical to prevent degradation of the rich amine at the liquid film layer. Thermal fluids with a relatively low viscosity typically display higher heat transfer coefficients at moderate temperatures (<350 °F bulk fluid temperature is considered moderate for high temperature fluids) and will offer the best protection against overheating the amine due to inefficient heat transfer at the heated surface. Using a less viscous, more efficient fluid could also allow for a lower set point at the thermal fluid heater outlet to achieve the same desired bulk amine temperature. The lower the delta-T across the heated surface between the thermal fluid and the amine, the less of a chance for overheating at the film layer.

If selecting a fluid for heating regeneration gas in the dehydration stage, thermal stability and upper operating temperature will become more important factors to consider. An upper bulk operating temperature of at least 600 °F is ideal for this process. When operating at such high temperatures, thermal stability, or the resistance to thermal degradation, of the fluid should be evaluated. Generally speaking, oils with basic molecular structures, unnecessary additive packages and/or unrefined impurities will be less thermally stable and will degrade at a much faster rate over time at high temperatures.

While thermal efficiency and high temperature capability/stability are commonly used as primary criteria for selecting a heat transfer fluid, there are a number of other factors that become

important under specific circumstances. If the plant is located in a cold weather climate, the minimum start up temperature of the fluid becomes a crucial consideration. Plants in compliance with environmental restrictions will need to consider a non-toxic or biodegradable product. There is a wide range of thermal fluid options that can satisfy any combination of required specifications to a certain extent, with price and availability being obvious factors as fluid needs become more specialised. With so many options, it is important to avoid multipurpose oils, lubricating oils, hydraulic fluids and any other product not specifically designed for use as a thermal fluid, as these can cause significant damage to a system. The safest bet is to select a fluid from a reputable supplier that is backed up by strong technical support, fluid analysis capabilities and an established relationship with the relevant equipment manufacturer.

## Effective operation

While the control of a thermal fluid system during normal operation is relatively straightforward, there are certain steps that should be followed to prolong the life of the fluid and prevent disruptive maintenance problems from occurring when least expected. Fluid degradation occurs gradually over time and, when overlooked, can lead to any number of costly setbacks. The primary culprit for this degradation is improper operation of the system in the form of faulty equipment, inherent design flaws and/or ill advised operating practices. The combination of having a basic education on how the system is meant to operate and adhering to periodic monitoring of key components is the primary defence against continuous fluid degradation.

The two basic controls an operator has over the thermal fluid system are the heater outlet temperature and the fluid flow. In theory, this is an easy process without much potential for disturbance or error; in practice, there are a number of additional factors that can occur throughout the system to complicate things and adversely affect the performance of the fluid. As the fluid degrades over time, these complications tend to escalate undetected until it is too late. To prevent this from happening, it is necessary to understand how the fluid degrades, where the degradation originates and how the operation of the system can be altered to avoid the problem. There are two primary ways in which thermal fluids degrade: oxidation and overheating.

## Oxidation

Oxidation occurs when hot fluid is in continuous contact with a fresh supply of oxygen from the air. As the fluid oxidises, it begins



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to produce acids and will eventually lead to increased fluid viscosity and sludge formation. The source of oxidation is the system expansion tank (reservoir), which is vented to atmosphere. Under normal operating conditions, the temperature of the fluid in the expansion tank should never exceed 200 °F. 'Warm up' or 'boil out' valves that direct flow of hot oil directly into the expansion tank are designed to be used only for the removal of moisture in the system and should always remain closed during normal operation. Certain operating conditions or system design features can make elevated temperatures in the expansion tank difficult to control. Under these circumstances, blanketing the headspace in the expansion tank with an inert gas such as nitrogen is strongly suggested.

## Overheating

Overheating occurs when a fluid is exposed to film temperatures that exceed the manufacturer's maximum recommended limit. This exposure at the inside walls of the heater tube causes the fluid molecules to break down or crack. Severely cracking the fluid can result in decreased heat capacity, excess low boilers, pump cavitation and eventually the formation of solid carbon particles.

Overheating can be caused by improper control of heat input (flame impingement, controller inconsistencies, power failures, ill advised start up and shut down practices) and/or reduction in flow rate through the heater. As flow rate decreases, the fluid becomes less turbulent and will not effectively transfer heat from the walls of the heater tube to the bulk of the fluid. The result is continually and dramatically increasing film temperature that will severely degrade the fluid. As the degradation continues, the problem is compounded by decreased heat transfer capability and carbon fouling on the heated surfaces. Low flow can be a result of plugged strainers or lines, inadequate fluid volume, faulty or improperly configured bypass valves and circulating pump problems.

Being aware of these paths to degradation, how to detect them before they progress too far and what to do to correct the underlying problems will allow operating personnel to run efficient heating processes with minimal downtime and maintenance problems.

Periodic monitoring of the key components of the thermal fluid system is essential to this goal. Normal operating values, such as heater set point; actual outlet and return temperatures; pressure readings at key locations (pump suction, feed/return differential, etc); exhaust stack temperature; and expansion tank temperature, should be recorded and any discrepancies should be evaluated. Any drastic changes in these performance criteria can often be traced back to an issue that may lead to degradation. Any out of the ordinary sounds, visual leaks or evidence of smoke or vapour may be key indicators of a problem that can be easily fixed if noticed early enough. These basic monitoring steps, in conjunction with a good routine maintenance plan, go a long way in prolonging the life of the fluid and keeping the system up and running.

## Routine maintenance

Natural gas processing is a multi staged operation in which the thermal fluid heating units are often overlooked in the grand scheme of things. It is widely accepted that thermal fluids offer the distinct advantage of requiring relatively minimal

maintenance when compared to steam and direct heat methods. While this may be true, a routine maintenance schedule is still a crucial factor in the long term operation of thermal fluid systems.

Periodic analysis of the fluid is the most fundamental aspect of any routine maintenance plan for a thermal fluid system. Proper testing of the fluid not only indicates the current condition, but it also establishes a history of the system and can raise red flags for problems that will eventually damage both the fluid and the system.

As recommended by all thermal fluid and equipment manufacturers, a professional analysis of the fluid should be conducted at least annually. The analysis should be specific to the operating criteria that are unique to thermal fluids, and should not be substituted by common lubrication oil testing. A combination of visual inspection, laboratory testing and professional evaluation of the results is essential for capturing all of the information necessary for an effective analysis. Just as important as the frequency and specific type of testing is the proper collection of the fluid sample. The sample should be taken at a minimum temperature of 180 °F from an active section of the system and protected from any contamination. This ensures that the sample is providing an accurate representation of the bulk operating fluid within the system.

There are three basic laboratory tests that should be run to accurately determine the condition of a thermal fluid sample. Total acid number (ASTM D-664) is the most telling and directly relevant test. This measures the level of acids present in the fluid as a result of oxidation. These acids are the raw material responsible for the formation of sludge, fluid 'gelling' and system cold spots: the higher the acid number, the greater the extent of oxidation.

Kinematic viscosity (ASTM D-445) is a measurement of how easily a fluid flows at a certain temperature (40 °C being the most common test temperature). Fluids with extremely high viscosities will typically display poor heat transfer efficiency and may also cause problems with low temperature start up. Significant increases or decreases in fluid viscosity over time are strong indicators of thermal degradation or the possibility of contamination. Finally, the distillation range (ASTM D-2887) can be used to track changes in the make up of the fluid over time to determine whether a fluid has degraded or been contaminated. When analysed by an expert, the results of these tests, especially when conducted at routine intervals, can be interpreted to identify degradation problems as well as the likely source of the degradation.

## Conclusion

Thermal fluid systems can be utilised as efficient, safe and low maintenance alternatives to high pressure steam and direct heating systems. By following a few simple steps to monitor the key components of the system and by keeping up on basic routine maintenance practices, a thermal fluid user can benefit from uniform, precise temperature control of key regeneration stages in the processing of natural gas. Taking the time to understand the equipment and how to properly maintain the fluid will not only extend the operating life but also ensure more efficient, reliable production capabilities for many years. 