DURATHERM
Heat Transfer Fluids

UNDERSTANDING THERMAL 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 thereby increasing its viscosity. A more viscous fluid will be more difficult to pump, have poorer heat transfer characteristics and will have an increased chance of forming coke within the system. 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 effect is exponential and can impact the fluid life in systems not utilizing oxidation reducing measures such as nitrogen blanketing the expansion tank.

In layman's terms, oxidation occurs when hot fluid is exposed to air. Signs of fluid oxidation become evident with the formation of sludge within the system – most notably 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. The TAN will increase as fluids experience oxidative degradation and will promote sludge and resin formation within the system. TAN values above the range of 1.0 to 1.2 mg KOH/g are usually cause for concern. It is important to note that with smaller, less efficient draining systems, these acids can remain behind and contaminate any new fluids added to the system. It is extremely important – especially if the TAN number is greater than 1.0 – to ensure maximum evacuation of the spent fluid prior to refilling.

Thermal Degradation

Thermal degradation or thermal cracking is the breaking of carbon–carbon bonds in the fluid molecules by heat in excess of the fluid's recommended maximum bulk temperature 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, these two types of degradation products are known as "low boilers" and "high boilers".

Low Boilers

The presence of low boilers is evident with a measured decrease in the flash point and viscosity of the thermal fluid as well as an increase in vapor pressure. The increased vapor pressure can affect overall system efficiency and can cause pump cavitation leading to premature failure. The reduction in the flash point could also be cause for serious safety and operating concerns.

High Boilers

If thermal degradation occurs at extreme temperatures – usually greater than 400°C (752°F), the overall effect is it not only leads to the breakdown of the carbon-carbon bonds but it also causes the hydrogen atoms to separate from their carbon atoms – leading to the formation of coke. High boilers result in an increase in the viscosity of the fluid for 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's terms, thermal degradation is the result of 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. Along with the creation of these lighter components, the overall flash point, fire point and auto ignition temperatures of the fluid will be reduced to possibly unsafe levels.

Flash Point

The flash point is important from the viewpoint of safety; however, it is not a concern unless it falls significantly from new specifications. It is quite common for heat transfer systems to be operated at temperatures above the flash point of the fluid.