Fire-Resistant Test Parameters Explained

Overview

The resistance to ignition and burning, termed fire-resistance in the hydraulic fluids field, is measured using a variety of methods. The techniques developed include laboratory testing methods, as well as simulations for possible industrial crisis situations. When it comes to the testing methods it is not always clear what the parameters used actually mean or how to interpret the results of the tests.

The following will explain the parameters used, and how to interpret the results of six tests used to measure fire resistance in hydraulic fluids, and most frequently included on product Technical Data Sheets. The tests to be discussed are:

- Fire triangle
- Lower/higher flammability limits
- Flash-and fire point
- Auto Ignition point
- Heat capacity
- Heat of combustion

Fire Triangle and Flammability Limits

The **fire triangles** or **combustion triangles** or "fire diamond" are simple models for understanding the necessary ingredients for most fires. The triangle illustrates the three elements a fire needs to ignite: heat, fuel, and an oxidizing agent (usually oxygen).

Source : Quaker Houghton

If any one of the parameters stated - Oxygen, Fuel or Heat - is missing, a fire will not occur. Additionally, if any one of these parameters is removed the fire will extinguish.

Upper and lower flammability limits or explosive levels are the well-defined boundaries between which mixtures of dispersed combustible materials (gaseous or vaporized fuels and some dusts) and oxygen will combust. Combustion can range in violence from deflagration through detonation depending on the ratio vapors to air.

The level of these parameters can also determine if a fire takes place. Not only is sufficient energy in the form of heat or a spark needed before a fire can start, but also the ratio of fuel (as vapor!) to oxygen has to be within the upper and lower flammability limits to be able to get an ignition. Too little fuel vapor or too much fuel vapor is the difference between no fire at all or an explosion.

Flash and Fire Point

The **flash point** of a fuel is the lowest temperature at which a particular organic compound gives off sufficient vapor to ignite in air, when exposed to an open flame.

The **fire point** of a fuel is the lowest temperature at which a particular organic compound gives off sufficient vapor to burn for at least 5 seconds after ignition by an open flame.

When hydraulic fluids are tested for fire resistance by Factory Mutual, the fire point is particularly important, since it is a key parameter in the equation used to calculate the Spray Flammability Parameter (SFP) [1].

1) The SFP is calculated using the formula :

$$SFP_{normalized} = 11.02 \times 10^{6} \times \frac{Q_{ch}}{\rho_f q_{cr} m_f}$$ Of which $q_{cr} = \alpha \times \sigma \times T_{f,}^{4}$ where T_f is the Fire point.

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The results of the flash point test has no impact on the fire-resistant classification made by Factory Mutual. However, to explain the flash point further, consider a practice situation where two polyol ester based fluids with flash points of 250°C/ 482°F and 310°C/ 590°F respectively come into contact with a hot surface around open sparks or fire. If the hot surface has a temperature between 250°C/ 482°F and 310°C/ 590°F, the fluid with the lower flash point might give a flash, but will not continue to burn.

If the hot surface is outside of the 250°C/ 482°F and 310°C/ 590°F range the fire-resistant behavior will be comparable for both fluids.

Auto Ignition Temperature, Heat Capacity and Heat of Combustion

The **auto ignition temperature (AIT)** of a substance is the lowest temperature at which it spontaneously ignites in normal atmosphere without an external source of ignition, such as a flame or spark.

The **specific heat (heat capacity)** is the amount of heat/ energy needed to raise the temperature of one gram of mass by 1 kelvin.

The **heat of combustion** is the amount of heat released during the combustion of a specified amount of a substance.

How are these parameters useful when comparing a Mineral Oil with QUINTOLUBRIC® 888?

PROPERTY	MINERAL OIL	QUINTOLUBRIC® 888 HFDU	UNIT
Auto Ignition Temperature	300 572	460 860	°C °F
Specific Heat	1.7 - 1.8	2.06	J/g.K
Heat of Combustion	43	38	KJ/g

The driving force is the relative low auto ignition temperature of mineral oil in combination with a relative low specific heat and high heat of combustion.

1. The auto ignition point of mineral oil is much lower than that of QUINTOLUBRIC® 888.
2. The specific heat shows that you need 10-15% less energy to heat mineral oil based lubricants.
3. The heat of combustion of a mineral oil based hydraulic fluid is typically about 43-44 kJ/g, whereas an HFDu, polyol ester fire-resistant hydraulic fluid has a heat of combustion of about 38 kJ/g. So chemically an HFDu fluid generates 10-15% less heat during combustion.

Purely on physical facts it can be stated

- Less energy is needed to heat mineral oil based lubricants to reach the temperature needed to auto ignite (which is already relatively low)
- The relative high heat of combustion of mineral oil based lubricants acts as a catalyst to the process and causes the mineral oil to keep itself burning

This effect is very well demonstrated in a pool fire comparing a mineral oil based hydraulic fluid and a HFDu polyol ester based hydraulic fluid.

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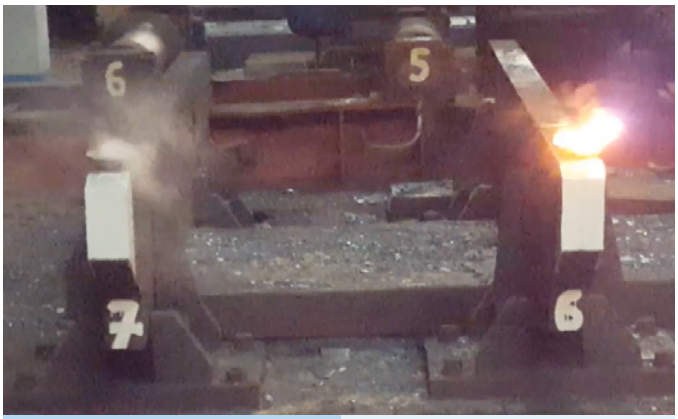
QUINTOLUBRIC®	mineral oil based hydraulic fluid

A red hot piece of iron is placed into a pool of QUINTOLUBRIC® fire-resistant hydraulic fluid, and a pool of mineral oil based hydraulic fluid.



QUINTOLUBRIC®	mineral oil based hydraulic fluid

After **53 seconds QUINTOLUBRIC® self-extinguishes** and **stops burning**. The mineral oil based hydraulic fluid continues to burn.

QUINTOLUBRIC®	mineral oil based hydraulic fluid

The **mineral oil continues to burn for over 1 hour** until all the mineral oil is gone, and **only black tar and stained iron remain.**

In general for TMP (Trimethylolpropane) -trioleate (polyol ester) based HFDu's the **auto ignition temperature (AIT)** will be in the range of 420-460°C/ 788-860°F. A high or low flash point or fire point does not have an impact on the AIT thus its performance in the pool test. The same principle is valid for burning fluid falling from for instance a red hot blank and falling on the ground. The more base fluid there is, the more likely to continue burning and igniting the greasy surrounding, where the polyol ester based fluid will self-extinguish and stop the event.

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