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Heat transfer system safety: Comparing the effectiveness of batch venting and a light-ends removal kit (LERK)

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ABSTRACT

Heat transfer fluids (HTF) should be analysed at least once per year to determine the extent of thermal degradation. Under normal operating conditions, mineral-based HTFs will thermally degrade and the bonds between hydrocarbons break to form shorter-chain hydrocarbons known as "light-ends". These light-ends accumulate in a HTF system and present a future potential fire risk. Light-ends can be removed from a HTF system via a batch vent or installation of a temporary or permanently installed light-ends removal kit (LERK). Data was collected prior to and following batch venting or installation of a LERK. The main study parameter was closed flash temperature as open flash temperature and fire point did not change considerably. Analysis showed that both methods increased closed flash temperature in excess of 130 °C three months after the intervention, so both methods were deemed effective. Data showed that the percentage change achieved with the LERK, compared to batch venting, was 2-fold higher at three months and 10-fold higher at 6 months. The duration of effect was longer with the LERK with closed flash temperature being stable and consistently above 130 °C for 50 months after being permanently installed. This case highlights the effectiveness of a permanently fitted LERK which is effective for the longer-term control of closed flash temperature. However, mobile LERKs could be an option for manufacturers looking to manage closed flash temperature on a shorter-term basis or as an alternative to batch venting.

1. Introduction

In the UK there is estimated to be 4000 systems using a heat transfer fluid (HTF; e.g., water, mineral-based HTFs) to transfer heat energy to process equipment [1]. The continued operation of mineral-based HTF systems depends on the condition of the HTF being sustained for as long as possible as they are known to thermally degrade over time. For this very reason, manufacturers recommend that a HTF is sampled at least once annually if a HTF operates close to its upper operating temperature or every other year if it is operating more than 20 °C below its upper operating temperature [2]. Some insurers also stipulate annual HTF sampling [3]. HTF sampling and analysis enables the assessment of oxidative state and to

Abbreviations: HTF, heat transfer fluid; LERK, light-ends removal kit

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determine the presence of foreign contaminants such as water [4,5]. The formation of short-chained hydrocarbons or "light-ends" is a by-product of thermal degradation and form when long-chained hydrocarbons start to thermally degrade.

Over time all HTFs start to thermally degrade when operating at high temperature and this is likely to lead to losses in efficiency, potential pump failure, an increased flammability risk all of which may cause system downtime and increased costs [6]. Light-ends are one aspect of HTF degradation and can be monitored by routine laboratory testing of open and closed flash temperatures [4,5]. Flash temperature represents the proportion of flammable decomposition products or light-ends in a HTF and an increase in light-ends is denoted by a decrease in flash temperature. A decrease in flash temperature represents an increasing future potential fire risk [5]. This is because light-ends have lower boiling and ignition temperatures. Laboratory testing is used to assess flash temperatures. A small sample of the HTF is gradually heated and exposing a naked flame to assess the temperature the HTF flashes [5]. This is conducted in the laboratory according to internationally testing standards (i.e., ASTM D92 and D93).

Any HTF system in Europe that operates above the flash temperature of the HTF will need to manage the potential fire risk in-line with ATEX Directive 99/92/EC (ATEX 137 or ATEX Workplace Directive) and ATEX Directive 94/9/EC (ATEX 95 or ATEX Equipment Directive). In the UK Directive 99/92/EC was put into effect through regulations 7 and 11 of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). Maintaining the condition of a HTF falls under these Directives and regulations as HTFs with a low flash temperature are a future potential fire risk.

Two methods commonly utilised to manage flash temperature are batch venting and installation of a LERK [7]. These methods remove or prevent light-ends building-up in a HTF. Batch venting, which is not suitable for every system, involves heating the expansion tank to raise the temperature of the circulating HTF and to vaporise the light-ends from the HTF system. In contrast, a LERK is commonly installed as a permanent installation and works by distillation and continuous removal of light-ends from the HTF and the HTF system [7].

The objective of this research was to determine the effectiveness of batch venting and a LERK in the management of flash temperatures (reflective of light-ends accumulation) in a HTF. Analysis focused on open and closed flash temperatures and fire temperature. These parameters were recorded prior to and following batch venting and installation of a LERK. Their effectiveness was assessed in terms of the magnitude of change achieved a the duration of the change achieved.

2. Experimental methods

2.1. Number of systems assessed

Five systems had been batch vented and form the basis of experimental analysis. All systems contained Globaltherm™ M, which is a mineral-based HTF. A light-end removal kit (LERK) can be used to control light-end formation in a HTF. Data obtained following batch venting was compared with that following the installation of a LERK [7].

From the multiple samples taken was possible to assess changes against time and to assess changes prior to and following a system intervention to control flash point temperatures.

2.2. How was the HTF sampled?

All systems were sampled whilst the HTF was operational and this means the system was in full operation at the time the HTF was sampled. This is performed using a custom designed sampling device (please see [5,7]) that isolates the sampled HTF so it is not exposed to air. This stops light-ends vaporising from the HTF and ensures that a true representative sample of the HTF is obtained.

2.3. What HTF parameters are analysed in the laboratory?

Once the sampled HTF has cooled to ambient temperature, the characteristics of the HTF were analysed in the laboratory according to ISO14001 and ISO17025 [7]. The characteristics analysed in this case are summarised in Table 1.

2.4. How the condition of a mineral-based HTF was rated?

The parameters in Table 1 were assigned one of four ratings based on pre-defined criteria. These ratings are outlined in Table 2.

2.5. Equipment for managing decreases in HTF flash temperatures

2.5.1. Batch venting

It is important to mention that batch venting is not suitable for every system and that the expansion tank is heat rated to deal with elevations in temperatures. If the customer is unsure, they should obtain advice from an expert.

Batch venting involves heating the expansion tank to raise the temperature of the circulating HTF and to vaporise the light-ends form the HTF system. The volume of HTF that is heated is managed by opening the valves on the purge line into the expansion tank and allowing the HTF to flow into the expansion tank. At elevated temperature, the rate of oxidation is