BULLETIN

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Fire and Explosion Hazards of Thermal Oil Systems

Background

The Southern Ontario Chapter of the Society of Fire Protection Engineers (SFPE) hosted a luncheon meeting in November 1998 on the fire and explosion hazards of heat transfer systems, commonly known as thermal oil systems. The guest speaker, John Valiulis, from the Standards Division of Factory Mutual Research Corporation (FMRC), is responsible for FM data sheet 7-99 Heat Transfer by Organic and Synthetic Fluids.

This bulletin is a summary (not a complete guide) of the hazards associated with thermal oil systems and the major fire protection methods described in this presentation.

Application

Heat transfer systems are used in various industries to heat process equipment, ranging from small melting pots and die casters in metalworking occupancies to large composite panel presses used to make particle board or oriented strand board in woodworking occupancies. Sometimes, these systems are used to heat the building as well.

High flash point oils, synthetic or organic, are the heat transfer fluid (HTF). The oil is heated above its flash point in a heat exchanger or boiler, and circulated in closed-loop piping to the process equipment via primary and secondary loops. The volume of HTF can range from several hundred gallons to thousands of gallons.

Hazard analysis

Thermal oil systems are **a severe fire hazard** because of the large volume of high temperature combustible oil circulating through the plant. This hot oil is easily ignited if accidentally released and there is a large volume of oil available to fuel the fire.

Factory Mutual (FM) fire loss experience involving thermal oil systems in the last 15 years is US$157 M (physical damage and business interruption) from 69 incidents, which translates into an average loss of almost $2.3 M per incident. Statistically, however, the majority of the losses fall between $100,000 and $1 million. Closer to home, in 1997 an oriented strand board (OSB) plant in northern Ontario burned down because of a thermal oil fire, resulting in an estimated loss over $60 M (Cdn) in physical damage and business interruption.
To a lesser extent, thermal oil systems can also present an explosion hazard if the oil is released in the form of a fine mist that has an explosion potential similar to a dust cloud. In the last 15 years, FM's explosion loss experience involving thermal oil systems is US$3.6 M from four incidents, averaging $900,000 per incident.

Keep in mind that the above loss statistics may not necessarily be representative of general industry loss experience as the level of physical protection at plants insured in the Factory Mutual system may be higher than average because of the need to meet highly protected risk (HPR) requirements.

Loss prevention strategies

The three key elements of any prevention strategy are *Isolate, Contain and Drain*.

Isolation refers to the HTF heater/boiler room, which should be cut-off from the plant by a minimum one-hour fire wall. A detached heater building is even better.

Containment means keeping the thermal oil in the pipes and limiting the extent of a leak or spill.

Piping should be in floor trenches rather than overhead in the plant. Threaded pipe fittings should not be used. Pipe insulation should be non-absorbent at possible leakage points. All access

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openings/ports in pipes and equipment should be tightly sealed. Smaller expansion tanks (less than 250 gallons) should have secondary containment. Pressure relief valves should be piped to a safe outdoor location or blowdown tank.

System operating and emergency interlocks are also an part of containment. The HTF heater/boiler should have the following alarms, interlocked to shut down the heater firing: low oil flow; high outlet oil pressure or temperature; low outlet oil pressure; and low fluid level in the expansion tank. In an emergency, system pumps should be shut down to stop oil circulation (exception: hog fuel-fired HTF boilers), safety shut-off valves should isolate all secondary loops from the primary loop and shut-off valves should subdivide large primary loops. Valve operation should be automatic, based on sprinkler water flow alarm, heat detection or low system pressure.

Drainage refers to emergency drainage of the piping and equipment – in the event of a fire – to limit the amount of thermal oil that can contribute to the fire. Large expansion tanks (over 250 gallons) should have a remotely operable emergency drain to a safe location. If the boiler is not equipped with a fixed extinguishing system, the HTF heater/boiler should be arranged to drain through an emergency cooler in the event of a fire in the combustion chamber.

General fire protection features are also important. Sprinkler protection should be provided in the heater/boiler room and in all areas with thermal oil piping and equipment. Factory Mutual recommends a density of 0.25 gpm/sq.ft. over 3,000 sq.ft., using high temperature (286 F) rated sprinklers, designed for a large flammable liquid fire.

Pits below large panel board presses (e.g. particle board, OSB, etc.) should also be sprinklered, preferably with a deluge system. Some other HPR property insurers, such as Industrial Risks Insurers (IRI), recommend foam/ water deluge sprinklers in press pits. Factory Mutual does not recommend this measure, but it has decided to do fire testing in a simulated press pit to assess the effectiveness of foam protection. It is hoped they will eventually upgrade their press pit protection requirements as foam/water protection is generally considered to be superior to straight water protection.

Critical HTF heater/boiler combustion chambers should have an automatic, fixed extinguishing system (gaseous agent such as carbon dioxide), plus interlocks to shut down the burner fuel supply, air fans and dampers.

Conclusion

An in-house study completed by a HTF manufacturer revealed that system maintenance was the primary cause in about 50% of the fires, 25% resulted from system design, and 25% were the product of incorrect system operation. Clearly, proper maintenance and testing of the system, plus good operating procedures, will reduce the probability of an incident. When accidents happen, the above safety features and fire protection systems can help prevent or minimize the effect of an incident.

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