RISCAuthority

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RC26: Recommendations for thermal fluid heating systems

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Contents

Summary of Key Points

The table below summarises the key points of the document.

Safety of the system	• All systems should be designed, installed, used and maintained in accordance with the manufacturer's recommendations. (5.3.1)
Serious problems during start-up	• Since the system will be operating above the boiling point of water this water must be removed from the system safely. (5.3.6)
The use of flammable thermal heating fluids	• Containers of spare fluid should be stored, handled and used in accordance with RISCAuthority Recommendations RC56. (5.3.10)
Impact on the safety of the workplace	• An effective fire safety management regime should be observed, including training of the operators of the system. (5.3.12)
Location	• The equipment should be located in a detached non-combustible building at least 10m from other buildings or plant. Vapour state boilers should be enclosed by a blast proof four-hour rated fire resistant wall. Fluid systems with a volume of up to 1900 litres should be located in a two-hour rated enclosure and those with a greater volume in a four-hour enclosure. (5.4.1)
Environmental protection	• The height of the chimney above the roof should be sufficient to prevent down-draughts. (5.4.9)
The use of toxic fluids	• Where thermal heating fluids are toxic, double walled, closed loop heat exchangers should be installed. (5.5.8)
Production of over pressure	• One or more safety valves or bursting discs should be provided to prevent the pressure exceeding the maximum permissible working pressure. (5.5.9)
Design of pipe work	• Hot oil transfer pipe work should be carefully designed and constructed of materials compatible with the thermal fluid. (5.6.2)
Leakage of fluid	• The system should be constructed of a primary loop with secondary loops that may be isolated with three way diverter valves. (5.6.5)
The use of pumps	• Pumps should have a flexible stainless steel connection on the suction side, to absorb any mechanical stress, vibration or movement. (5.8.2)

Symbols used in this guide

Good practice

Bad practice

Discussion topic

FAQ Frequently asked question

1 Introduction

FAQ

How hot is the thermal heating fluid? (See Introduction and Figure 4)

Thermal fluids are used for heating applications in various industrial processes where temperatures are required that are above those which can be obtained by steam heating at reasonable pressures, or as an alternative to electrical or other form of heating. The systems may be used for many processes such as for heating tanks, reaction vessels, ovens, moulds, dies or calendar rolls.

The nature of the thermal fluid heating system employed will vary considerably, ranging from a small self-contained package heater supplying a single item of process plant such as a press, to extensive pipework based systems supplying the heating requirements of a major industrial environment. The systems may run at very low pressures but at temperatures up to 150°C in the case of water/glycol systems, 300°C for organic thermal oils and 400°C for some synthetic fluids. A typical layout is shown in Figure 1.

Many fluids employed in these systems are flammable and are often operated at temperatures above their flashpoint. Leaks can therefore produce a potentially flammable mist and present a significant fire and explosion hazard. Accordingly, careful attention must be made to the design, installation, operation and maintenance of these installations.

2 Scope

What actions should be taken to protect the business if the thermal fluid system fails?

What should we do in the event of a leak of fluid?

These recommendations apply to the design, installation and operation of thermal fluid heating systems in relation to both liquid phase and vapour phase applications, and are intended to provide background information for insurers, property owners, specifiers and fire safety managers regarding the fire hazards that these installations may introduce into the workplace and the measures that should be taken to mitigate these. Other health and safety issues that may arise from the use of these systems are outside the scope of this document.

Although thermal fluid systems may be used as heat exchangers in commercial refrigeration and solar heating plant, this guidance is concerned solely with high temperature industrial heating applications.

3 Synopsis

Thermal fluid transfer systems are not just simple services but can be complex process plants in their own right. These recommendations outline the fire hazards associated with this type of plant and the actions that should be taken to mitigate the risks. In all cases the plant should be operated and maintained only by trained personnel.

4 Definitions

Hartford Loop

A Hartford Loop is an arrangement of piping installed between a heated vessel (originally a steam boiler) and its gravity-return piping in a vapour phase system. The end of the header drops vertically below the vessel's liquid level and connects into the bottom of the vessel in order to retain the liquid contents and thus prevent an explosion. (A **Gifford Loop** is a variation of the Hartford loop that provides additional benefits.)

Pour point

The lowest temperature at which a fluid will flow under specified conditions.

FAQ

What is thermal heating fluid?

Thermal fluid

A fluid used to transport heat between two or more pieces of equipment, normally from a heater or vaporiser to a vessel or other apparatus which requires heating, by means of pipework.

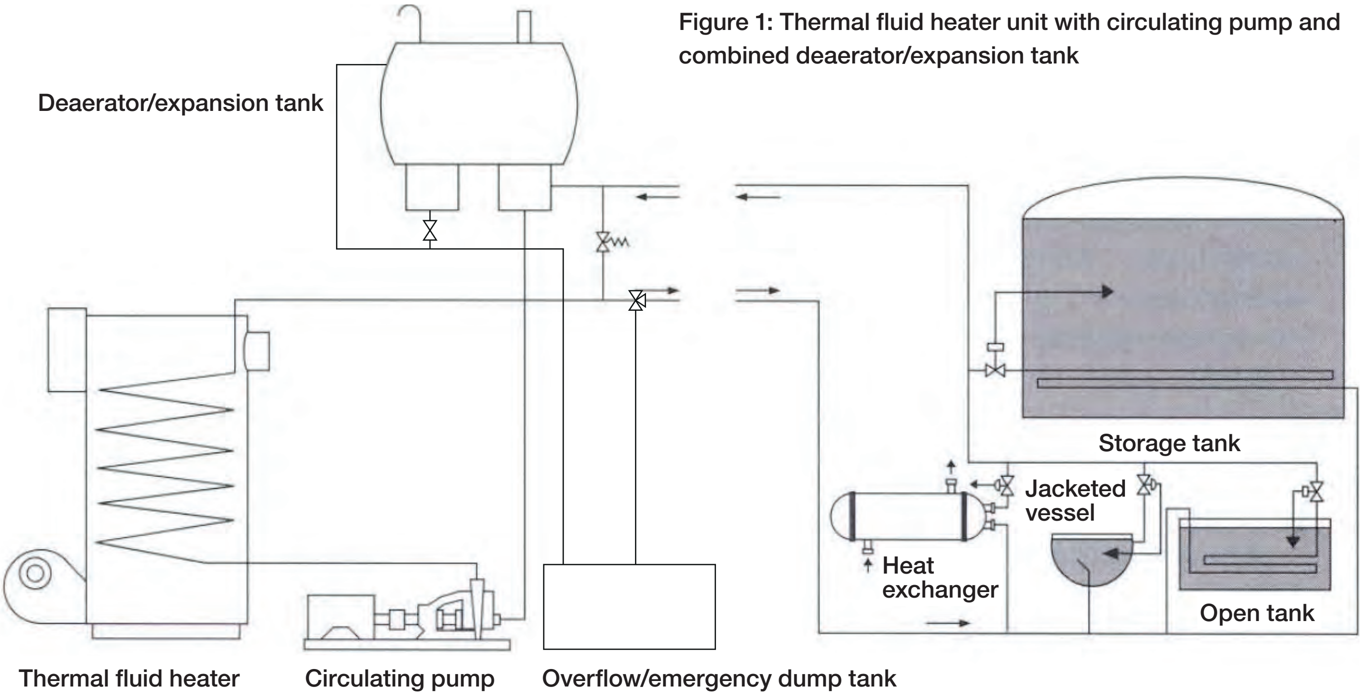
Liquid phase system

An indirect heating system in which a thermal fluid is used throughout the system in its liquid state, either below its ambient boiling point or above this temperature where boiling is suppressed by pressure. (A comparison of liquid and vapour phase installations is set out in Figure 2.)

Vapour phase system

An indirect heating system in which a thermal fluid is used in the form of a hot vapour. This has the advantage of providing more heat per unit weight of the medium than a liquid phase heater, and has less working volume. It can also can give a more uniform or precise heating effect than a liquid phase system.

Figure 1: Thermal fluid heater unit with circulating pump and combined deaerator/expansion tank



5 Recommendations

5.1 Compliance with fire safety

5.1.1 A suitable and sufficient fire risk assessment should be undertaken by a competent person for all premises to which the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) applies (refs 1-5). Where they are installed, this assessment should include consideration of the fire hazards associated with a thermal fluid heating system.

5.1.2 The potential hazards associated with a thermal fluid heating system should be considered when undertaking assessments in compliance with the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR (as amended 2015) (ref. 6). DSEAR assessments should be undertaken by a competent person.

5.1.3 The risk assessments undertaken in compliance with the Regulatory Reform (Fire Safety) Order and DSEAR should be reviewed regularly. An annual review is appropriate where thermal fluid heating systems are installed.

5.1.4 Risk assessments should also be subject to periodic review at the time when any changes to the process, the layout of the equipment, the type of fluid used or changes to the temperatures associated with a fluid heating system are being considered.

5.2 Business continuity

5.2.1 Even a small fire can have a disproportionate effect on a business if it occurs in a critical area. The use of a thermal fluid heating system increases the hazard of an operation and must be carefully managed to avoid unnecessary disruption to the efficient functioning of the business.

5.2.2 All businesses should take steps to maintain the continuity of their operations by making a suitable emergency plan. Guidance for this is set out in *Business resilience: A guide to protecting your business and its people* (ref 8). The emergency plan should address the implications of a fire, flood or other perceived disaster on all facets of the business model. It should indicate the lines of communication that should be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of replacement equipment.

5.2.3 With regard to thermal fluid heating systems the emergency plan should evaluate recovery actions in the event of a loss of a pump or heater as well as the loss of the capability to provide thermal oil to the heating process. The location of temporary heaters and the ability to connect them quickly to the system should also be highlighted.

5.2.4 Tabletop exercises should be held periodically to test the effectiveness and suitability of the emergency plans.

5.2.5 Consideration may be given to applying commercially available computer programs, such as the ROBUST software (Resilient Business Software Toolkit) that is available free of charge (ref 9), or similar product, to develop and check the adequacy of the plan.

5.3 Fire safety management

5.3.1 All systems should be designed, installed, used and maintained in accordance with the manufacturer's recommendations.

5.3.2 The response by fire and rescue services to 999/112 calls and signals routed via fire alarm monitoring organisations varies widely throughout the UK, and differs from day to night-time. Fire safety managers should refer to the relevant fire and rescue service to make themselves aware of the levels of response in the areas in which their premises are located and consider this information when undertaking and reviewing their fire risk assessments.

5.3.3 Site plans should be available for the emergency services; these should show the locations of the thermal fluid heating plant and the layout of the pipe runs. Details of the emergency shutdown procedures should also be available together with the locations of any emergency shut off and/or dump valves or flammable liquid stores.

5.3.4 The use of thermal fluid systems to provide heating for the workplace should be avoided.

5.3.5 No combustible materials should be sited within 1m of the heating equipment or its associated pumps, valves, pipes or flues. This is to prevent the spread of fire and to provide adequate clearance between the equipment and the walls and ceilings to allow periodic maintenance to be undertaken. (See also section 5.4.4 regarding pipework and flues passing through roofs or combustible elements of construction, including composite panels with combustible cores.)

5.3.6 Start-up and shut-down are the times when serious problems can occur. This is especially true when the system has been drained for maintenance and either the thermal fluid recharged or new fluid added. Water is soluble to a small degree in most heat transfer fluids and drums of new fluid may also absorb some water during storage. Since the system will be operating above the boiling point of water it is essential that this water is removed from the system safely. The system must therefore be warmed up slowly under no-load conditions. As the liquid temperature in the system approaches 100°C the water will start to boil off creating a characteristic crackling sound known as the 'chip pan' effect. It is essential that the water is allowed to boil off slowly since the steam generated can cause the header tank and other components to overpressure if heated too quickly.

5.3.7 When a system is refilled, provision should be made to bleed all gas out of the system so as to prevent air locks. Suitable small bore bleed valves and lines should be provided at high points in the system as the presence of air locks may result in potential damage to pumps and overheating of furnace tubes.

5.3.8 In a well designed installation topping up of thermal heating fluid should not be a routine exercise as the system will be effectively sealed with only minor losses such as those due to degradation of the fluid. If regular topping up is necessary the cause should be established and rectified.

5.3.9 Topping up of fluid should be undertaken by the maintenance engineers or trained personnel as if the process is not undertaken correctly, the thermal shock from cold fluid can result in severe damage to the system.

Storage of spare fluid

5.3.10 Where the thermal fluid in use is flammable, containers of spare product should be stored in accordance with the requirements of RISCAuthority RC 56: *Fire safety in the storage, handling and use of highly flammable and flammable liquids: storage in containers other than external fixed tanks* (ref 10).

5.3.11 Drums should be stored bung uppermost, and any horizontal drums chocked against rolling. Suitable bunding should be provided, the catchment area should incorporate an impervious sill or low bund, at least 150mm high, and must have a capacity of not less than 110% of the contents of the largest container in the bund or 25% of their aggregate storage capacity, whichever is greater. Containers should be kept dry (see 5.3.6) and care must be taken to avoid water ingress into the bund.

Training

5.3.12 Operators of thermal heating systems should be trained on all aspects of the installation, including emergency procedures. They should undergo refresher training annually. Where such specialist training is undertaken it may be advisable to involve the manufacturers.

5.3.13 Operators should be made aware that there is a very narrow operating range between efficient operation and the temperature at which degradation of the fluid can decrease the wall life of the furnace tubes. This may be as little as 20-30°C.

Unattended processes

5.3.14 In commercial premises where thermal fluid heating processes are in routine use, the fire hazards and thus the threat to the business are increased if a process is allowed to continue unattended. If it is intended that a process is to be left operating without staff in attendance then a specific risk assessment for the process should be undertaken and appropriate control measures introduced. Further information regarding unattended processes is set out in RC42: *Recommendations for fire safety of unattended processes* (ref 7).

Figure 2: Liquid versus vapour phase systems

Liquid phase	Vapour phase
Wide operating temperature range, lower operating pressure	Heat transfer at constant temperature (temperature is controlled by pressure)
Lower heat losses	Higher heat losses
Fast temperature response	Slower temperature response
Low thermal degradation	Higher thermal degradation
Narrow bore piping	Wider bore piping
Larger heat exchangers	Smaller heat exchangers

5.4 Location and construction

5.4.1 In the case of large installations the heating unit and associated equipment should be located in a detached non-combustible building at least 10m from other buildings or plant. Vapour state boilers should be enclosed by a blast proof four-hour rated fire resistant wall. Fluid systems with a volume of up to 1900 litres should be located in a two-hour rated enclosure and those with a greater volume in a four-hour enclosure.

5.4.2 Piping and equipment carrying the thermal heating fluid should not be exposed to temperatures below the pour point of the fluid. Where this is not practicable, exposed piping and equipment should be insulated and/or trace heated to ensure that the temperature remains above the pour point.

5.4.3 Floors should be suitably dished or curbed to prevent the escape of any leaking oil from the compartment. Where it is necessary for drains to be located in the area they should be provided with interceptors of sufficient capacity to prevent pollution.

5.4.4 Where pipework carrying thermal heating fluid or a flue pipe serving a solid fuel, gas or oil-burning heater passes through a roof or combustible element of construction, a proprietary sleeve system should be installed around it to provide a degree of fire rating, usually between two and four hours fire resistance in terms of integrity and insulation, as agreed with the insurer. Alternatively, the combustible element should be cut back and a proprietary collar and minimum of 150mm of non-combustible material, such as mineral wool insulation, be installed around the flue or pipe in the intervening space up to the combustible element.

5.4.5 For oil and gas-fired equipment, adequate ventilation should be provided for combustion and normal cooling purposes. The ventilation inlet should not be so sited that there would be a risk of flammable vapours or dusts being drawn into the compartment.

5.4.6 Some heaters may be fuelled with sawdust, wood bark, or other biomass materials. In these cases specialist advice should be sought regarding the form of construction of the heater and appropriate fixed fire suppression systems. The latter should be in accordance with the manufacturer's requirements and recognised standards.

5.4.7 Flue gas temperature monitors should be fitted in chimneys and flues. A high temperature monitor should raise an alarm to the main control panel and to a manned area; a second, higher temperature monitor should shut off the fuel supply to the heater.

5.4.8 Flues or chimneys should be substantially constructed of non-combustible materials capable of withstanding the flue gas temperatures to which they may be subjected. They should be adequately supported and fixed and external elements should be capable of withstanding the maximum expected wind loads.

5.4.9 The height of the chimney above the roof should be sufficient to prevent down-draughts.

5.4.10 All ductwork, including exhaust flues, should be constructed of galvanised or stainless steel, with seamless components properly connected to prevent leakage of smoke and vapours. The ductwork should be designed so as to minimise the introduction of bends and horizontal runs where there could be a build up of condensates. Joints should be sealed wherever possible.

5.4.11 The base of the flue or chimney should incorporate an inspection panel and a drain to prevent water or condensate entering the heater.

5.5 Control systems

5.5.1 Remote shut-off valves for the fuel supply should be provided both outside the area housing the thermal heating fluid plant and at the process being heated to enable safe close down in an emergency. Oil pumps can remain operating but should also be able to be safely shut-down when leaks are detected.

5.5.2 For oil fired equipment, safety controls and procedures should be as described in RISCAuthority RC9: *Oil-fired heating installations* (ref 11). Similar measures should be taken in the case of gas fuelled plant. In particular, automatic interlocks should be provided to:

- delay ignition until the furnace chamber and flue have been purged of any flammable mixture.
- cut off the fuel supply should the flame be extinguished for any reason.

5.5.3 Gas and oil burners should be fitted with two self checking flame failure devices to minimise the potential for an explosion within the furnace caused by late ignition. Other control systems should be provided in accordance with the standards to which the system is to comply (for example NFPA 87 - see Further Reading list below).

5.5.4 In addition, interlocks should be fitted to prevent the heating system starting or continuing to run unless the circulating pumps are operating.

5.5.5 Both the flow and return fluid pressures should be monitored automatically, and any imbalance should result in automatic shutdown, since this indicates a leak has occurred somewhere in the system.

5.5.6 Monitoring devices should be installed:

- **On fluid inlets:** High pressure and low flow alarms.
- **On fluid outlets:** High temperature alarms.
- **On the heater outlet:** High temperature and pressure alarms interlocked with the heating source so that an alarm is given should an abnormally high temperature or pressure be registered. Triggering of a second monitor set at a higher temperature should result in automatic shutdown of the fuel source to the heater or vaporiser. (It must be ensured that the upper temperature interlock operates below the manufacturer’s maximum recommended bulk fluid temperature.)
- **On the tanks:** Low level fluid alarm.
- Other monitoring devices should include high stack temperature, low fluid system pressure and low liquid level in the vaporiser/heater alarms and interlocks to shut down the vaporiser or heater and divert the fluid to a storage tank away from the secondary loops

5.5.7 The monitoring devices referred to in paragraph 5.5.6 should provide an alarm to give operators an opportunity to correct the problem before conditions reach an unsafe level.

5.5.8 Where thermal heating fluids are toxic, double walled, closed loop heat exchangers should be installed.

5.5.9 One or more safety valves or bursting discs should be provided to prevent the pressure exceeding the maximum permissible working pressure, and should be fixed directly on, or as close as practicable to, the heater or vaporiser. On operation they should discharge liquid and/or vapour to a safe area. Care should be taken to avoid environmental pollution.

5.5.10 Rate of flow and pressure sustaining valve(s) should be installed to provide safety relief for an isolated heater; alternatively, a separate relief valve should be fitted between the last system isolating valve and the heater. Without either of these arrangements a heater with high residual heat could, when isolated, generate excessive pressure internally with the prospect of failure and internal leakage.

5.5.11 Manual emergency stop valves should be provided at safe locations in process areas to allow operators to shut down the thermal fluid supply where an incident has occurred. An emergency stop should also be provided outside the area housing the fluid heating equipment. Relevant operators should be trained in the use of the stop valves and associated emergency response.

5.5.12 For vapour phase systems where condensate is returned by gravity to any point below the safe working liquid level of the vaporiser, a vacuum breaking loop (such as a Hartford or Gifford Loop) should be fitted on the condensate return line to prevent liquid being forced or drawn below the minimum safe level of the tank.

5.6 Pipework

5.6.1 Pipework systems must incorporate proper provision for expansion, be adequately supported and sloped for efficient drainage.

5.6.2 Hot oil transfer pipework and connecting unions must be constructed of materials suitable for the thermal fluid that is to be used. Pipes should be welded; screwed connections are not considered suitable for this purpose. Flanges at heater and process terminals should be fitted with capture covers to prevent oil spray in the event of a leak. Where jointing materials have to be used they should be applied as thinly as practicable. All pipework should be fitted in accordance with the instructions provided by the supplier of the equipment.

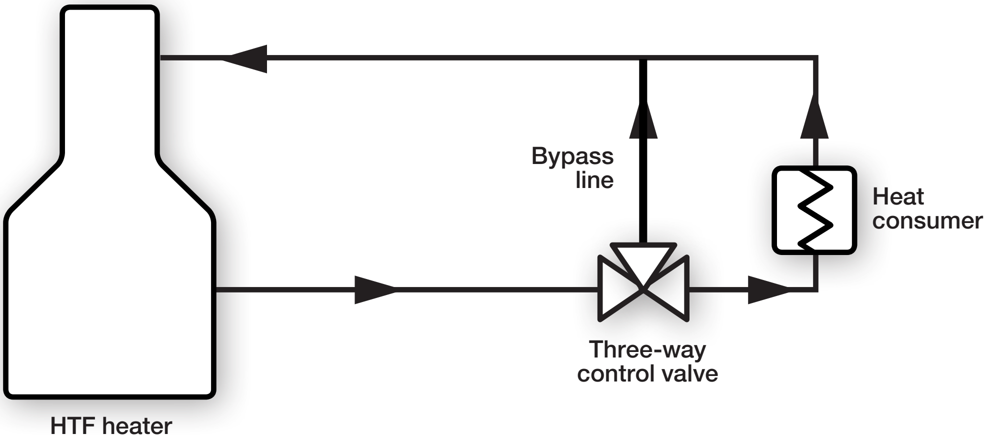
5.6.3 Where possible, all hot work on the thermal heating system should be avoided (see 5.11.5). When welding of pipework is unavoidable, all welding should be undertaken by competent welders and in compliance with the terms of a hot work permit scheme. Further information regarding hot work permits is set out in RISCAuthority Recommendation RC 7: (ref 12)

5.6.4 Following maintenance or when the temperature of the fluid has fallen below the pour point, the fluid should not be heated by the direct application of a flame to the pipework. General space heating, steam heating or temporary trace heating should be employed.

5.6.5 Safety shut-off valves or 3-way divert valves should be provided to isolate each secondary circulation loop from the primary loop running into and out of the heater or vaporiser to allow processes not involved in a malfunction or leak to continue uninterrupted (see Figure 3).

5.6.6 In large installations additional shut-off valves should be installed within loops to minimise the volume of a potential leak. Such additional valves may also be installed to protect business critical or valuable equipment. Additional shut-off valves should only be installed following the advice of the manufacturer or installer of the equipment as in some cases fluid circulation is required to allow the plant to shut down safely.

Figure 3: Flow control by three-way divert valve and bypass



5.7 Tanks

Expansion tanks

5.7.1 Liquid phase systems should be provided with an expansion tank, which may be either at atmospheric pressure or, where the liquid is being used above its normal boiling point, pressurised with air, nitrogen or carbon dioxide.

5.7.2 The expansion tank should be located at the highest point of the system to ensure that all the pipework and apparatus is completely filled with liquid and that the risk of pump cavitation is minimised.

5.7.3 The expansion tank should be located so that any leak of fluid will not come into contact with the heater, vaporiser or other hot surface.

5.7.4 The expansion tank should be sized so that its effective volume is at least 30% greater than the expansion volume of the system's total liquid content at the maximum permissible working temperature.

5.7.5 The level of liquid in the expansion tank should be monitored and should it fall below the manufacturer's recommended minimum level, shut-off of the plant should be triggered automatically. The lock out facility should only be capable of being reset manually.

5.7.6 The expansion tank should be provided with desiccant or other means to reduce the ingress of moisture into the fluid.

Storage tanks

5.7.7 For liquid systems not operating under pressure, a cold seal tank is required in order to minimise losses from the system and also to compensate for any changes in level such as those due to thermal expansion.

5.7.8 The storage tank should be located where it will not be exposed to fire.

5.7.9 In addition to the storage tank a tank capable of taking the total system contents at its maximum expansion volume should be provided at low level in order that the liquid can be drained by gravity for maintenance work. It some cases this may also be used as a 'dump tank' if there is a serious problem with the system to prevent loss of the thermal fluid. The construction of the tank should be suitable for receiving hot fluid and where this option is followed the provision of a cooling coil should be considered to reduce vaporisation. These 'dump tanks' should be bunded and located outside the heater room in a safe location away from other important equipment.

5.7.10 A quick-acting remote control valve should be fitted in order to achieve fast emptying of the system in the event of an emergency.

FAQ

What sort of lagging can be used on thermal fluid systems?

5.7.11 If the storage tank is fitted with a heater to warm the liquid before returning it to the system after maintenance, a safety valve should be fitted, discharging to a safe place.

5.7.12 Vent valves should be provided at the high points of the system to remove air or, where there is positive flow in one direction, valves should be fitted at the end of the flow path.

5.7.13 The discharge should be fed away from all sources of ignition and can be piped through the expansion tank or to a common vent condenser, from where the condensed liquid can be returned to the storage tank.

5.7.14 Any vent condenser should be protected against over pressure in the event of failure of its cooling system.

5.7.15 Vents should be provided on the storage and expansion tanks and, in these cases, the vent pipe should rise continuously and terminate outside the building in a catchment area or other safe place.

5.7.16 Vents should be kept free of obstruction.

5.8 Pumps

5.8.1 Glands and packing materials should be adequate to withstand the hot fluid temperatures involved, and compatible with the metals and fluids present.

5.8.2 Pumps should have a flexible stainless steel connection on the suction side, to absorb any mechanical stress, vibration or movement.

5.8.3 Pumps are also vulnerable to thermal stresses from the expansion and contraction of the pipework. The pipework should be designed to minimise this stress throughout the foreseeable cycle of operating conditions, allowing for times when the system is shut down and cold.

5.8.4 Where the fluid may be vulnerable to freezing during shut down or maintenance operations, trace heating should be installed to pumps and vent and relief lines.

5.8.5 Pumps should have double seals, with a drain between, which should be piped to a closed container in a safe area. Where necessary seal cooling may be necessary with the coolant being circulated through a cooler.

5.8.6 Water cooled pumps should be fitted with a device arranged to shut off the burners in the event of low water flow.

5.8.7 Although pumped systems offer higher heat transfer and greater flexibility and thus are now almost universally installed, not every thermal heating system has a pump. Natural convection systems may be used but these tend to be limited to low heat transfer rates because of the flow limitations. The main advantage of a natural convection system is that without a pump there is less risk of leakage from the system. In order for a natural convection system to function effectively, the height between the furnace and the process vessel should be maximised and the length of the pipework minimised. The pipe diameter must also be as large as possible to maximise the flow.

5.9 Insulation

5.9.1 Lagging should be of non-combustible, non-absorbant, closed cell material suitable for the temperature employed. If non-combustible fibrous material, such as glass fibre or mineral wool, is used, it should be covered by an outer cladding of reflective metal.

5.9.2 Lagging should not be applied to:

- pumps, flanges, valves and fittings since these are sources of possible leaks and need to be accessible for maintenance and inspection.
- the expansion tank, or to the buffer section of any deaerator. Where a combined deaerator and expansion tank is installed, only the deaerator section should be insulated.

5.9.3 Uninsulated pumps, flanges, vessel sections, expansion tanks etc should be positioned safely or be shielded to prevent burns or other personnel injury.

5.9.4 If completely enclosed, shielding on tanks should be provided with bottom holes to allow any leaking fluid to drain out and be quickly noticed.

5.9.5 On new installations, lagging should not be applied until the installation has had at least 50 hours operation at its maximum rating so as to expose any leaks caused by faulty workmanship, thermal expansion, and bedding down.

5.10 Electrical equipment and wiring

5.10.1 Electrical equipment and wiring should be designed, installed and maintained to BS 7671 (ref 13).

5.10.2 Electrical equipment and wiring should be suitable for the high temperatures likely to be found near the heater and vaporiser.

5.10.3 Electrical equipment and wiring should be segregated or protected so as to avoid the dangers arising from exposure to thermal fluid pipelines and consequently the effects of heat or leaking fluids, Thermal fluid pipe runs and electrical services should be routed independently.

5.10.4 Where electrical cables are exposed to the possibility of mechanical damage, suitable cables should be selected or mechanical protection provided.

5.10.5 Metal pipework, boilers and other equipment should be earth-bonded to dissipate the build-up of any static electricity generated by the flow of the thermal fluid, as well as for the effectiveness of fusing or other protective safety devices.

5.11 Maintenance

5.11.1 Use of a fluid over a period of time may result in degradation which can result in loss of thermal efficiency, increased flammability, cavitation, mechanical failure and system down time with its associated costs. The entire system should therefore be serviced and maintained in accordance with the manufacturer's instructions. During this process particular attention should be given to the correct working of safety devices and cutouts.

5.11.2 When recharging it is essential that all traces of the old fluid are removed prior to recharging with fresh fluid; failure to do so can lead to premature degradation of the new fluid.

5.11.3 Because of the propensity for thermal fluids to leak, all pipework systems and associated lagging should be checked visually every week with particular attention being paid to identify any leaks in the heater plant room and piping in loft areas or other concealed spaces. In the case of any signs of leakage the spill response plan should be implemented. Leaks should be rectified and contaminated lagging replaced. This is of particular importance because the fluid degrades over a period of time and the autoignition temperature of the products eventually falls below the system operating temperature, potentially leading to the occurrence of fires.

5.11.4 The thermal fluid should be sampled and tested at intervals as determined by the manufacturer or supplier of the product but at least every twelve months. Tests should determine the levels of impurities in the samples and their degree of thermal degradation.

5.11.5 Where possible, all hot work on the thermal heating system should be avoided. Where hot work is unavoidable, it should be undertaken in accordance with a permit to work system as outlined in RISCAuthority Recommendations RC7 (ref 12).

5.11.6 Before any unavoidable hot work, such as welding or cutting, is carried out on the system, it should be thoroughly drained and purged. During such work a continuous purge of nitrogen or carbon dioxide should be passed through the pipework or apparatus.

5.11.7 When maintenance is complete, the system should be cleansed of all potential contaminants. In particular, weld spatter, pickling acid and water can all cause problems if trapped within the system. Weld spatter and other solid materials can cause rapid wear on pumps as well as internal erosion of pipework.

5.12 Fire protection

5.12.1 Thermal fluid heating plant should be protected by automatic fire detection and alarm (AFD) installations designed, installed, commissioned and maintained by an engineer with certification from an independent UKAS accredited third party certification body. The installation should be to a recognised category of installation in accordance with BS 5839-1 (ref 14) as determined by a fire risk assessment.

5.12.2 The automatic fire detection and alarm system should be monitored either on-site or by an off-site alarm receiving centre with certification from an independent UKAS accredited third party certification body and operating in accordance with BS EN 50518 (ref 15).

5.12.3 The fire detection and alarm system should be periodically serviced and maintained in accordance with BS 5839-1 (ref 14) by a competent engineer with certification from an independent UKAS accredited third party certification body.

5.12.4 Consideration should be given to water spray or automatic sprinkler protection for thermal fluid heating plant. Sprinkler systems should be installed and maintained in accordance with the requirements of the *LPC Rules for automatic sprinkler installations incorporating BS EN 12845* (ref 16) or other recognised standard.

5.12.5 An appropriate number of fire extinguishers, of a type suitable for extinguishing fires in nearby materials should be provided in the vicinity of all areas in which thermal heating fluid plant is located or through which these services run. All extinguishers should be approved and certificated by an independent, third-party accredited certification body. The extinguishers should be provided in easily accessible positions as set out in BS 5306-8 (ref. 16) and maintained in accordance with BS 5306-3 (ref 18).

Figure 4: Thermal transfer fluids

Product	Type of system	Application
Alkylated aromatic formulations	Thermally stable, used in closed loop system liquid phase heating systems up to 280°C	Asphalt plants, plastic production, gas processing plant
Mineral oil based fluids	High flash/fire point for use in closed loop heat transfer systems up to 310°C	Thermal oil heated laundries, Asphalt plants and terminals, chemical processing
Partially hydrogenated terphenyl based fluid	Closed loop liquid phase heating to 340°C	Gas processing, chemical processes, waste oil recovery
Synthetic oils	Closed loop thermal oil systems to 260°C	Die temperature control units, extruders
Water and glycol/water based systems (50/50 or 60/40 glycol to water)	Pressurised (low pressure) systems incorporating antifreeze agents (such as glycol)	Solar heating systems

The choice of a thermal heating fluid will depend on the process requirements. Many of the available thermal heating fluids are blends of components rather than pure substances and thus the properties of the product selected should be obtained from the supplier.

Thermal heating fluids have relatively high coefficients of thermal expansion and adequate provision for this should be made in the design of the system. The fluids are non-corrosive but corrosion problems may be introduced by contaminants such as cleaning fluids left in the installation prior to commissioning or leakage of a process fluid into the system.

Hot thermal fluids are liable to oxidation when coming into contact with air. This is especially important where vented expansion tanks are in use. In these cases any vapours that are produced by the heat transfer fluid will react with air to produce acids. These acids in time are themselves subject to thermal degradation. The result is that the thermal fluid becomes thicker and darker and its heat transfer capabilities decrease rapidly.

The thicker, oxidised fluid becomes more difficult to pump and susceptible to overheating. The overheated fluid eventually breaks down to form an acidic, carbonaceous sludge that precipitates out and bakes on to the internal surfaces of the equipment. Regular maintenance is therefore critical.

Care should be taken not to overheat the fluid as to do so will result in a degradation of the fluid and thermal cracking. This results in the production of short chain molecules which may reduce the flashpoint as well as being boiled off as flammable vapour. In addition long chain molecules may be produced which increase the viscosity of the fluid, reducing the heat transfer properties, damaging pumps and again leading to the production of tarry deposits.

6 Checklist

		Yes	No	N/A	Action required	Due date	Sign on completion
6.1	**Compliance with fire safety legislation (section 5.1)**						
6.1.1	Has a suitable and sufficient fire risk assessment been undertaken by a competent person in compliance with the Regulatory Reform (Fire Safety) Order 2005 or equivalent legislation in Scotland and Northern Ireland? (5.1.1)						
6.1.2	Have the potential hazards associated with thermal fluid heating systems been considered when undertaking assessments in compliance with the Dangerous Substances and Explosive Atmospheres Regulations? (5.1.2)						
6.1.3	Are the risk assessments undertaken in compliance with the Regulatory Reform (Fire Safety) Order and DSEAR reviewed regularly? (5.1.3)						
6.1.4	Are the risk assessments subject to periodic review, including at the time when any changes to the process, the layout of the equipment, change of fluid type or changes to the temperature associated with a fluid heating system are being considered? (5.1.4)						
6.2	**Business continuity (section 5.2)**						
6.2.1	Is the use of the thermal fluid heating system carefully managed to avoid unnecessary disruption to the efficient functioning of the business? (5.2.1)						
6.2.3	Does the emergency plan address the implications of a fire, flood or other perceived disaster on all facets of the business model and does it indicate the lines of communication to be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of replacement equipment? (5.2.2)						
6.2.4	Does the emergency plan evaluate recovery actions in the event of a loss of a pump or heater as well as the loss of capability to provide thermal oil to the heating process? (5.2.3)						
6.2.5	Are tabletop exercises held periodically to test the effectiveness and suitability of the emergency plans? (5.2.4)						
6.2.6	Is consideration given to applying commercially available computer programs, such as the ROBUST software to develop and check the adequacy of the emergency plan? (5.2.5)						
6.3	**Fire safety management (section 5.3)**						
6.3.1	Are all systems designed, installed, used and maintained in accordance with the manufacturer's recommendations? (5.3.1)						
6.3.2	Has the fire safety manager contacted the fire and rescue service to become aware of the level of response in the areas in which the premises are located so as to be able to consider this information when undertaking and reviewing fire risk assessments? (5.3.2)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.3.3	Are site plans available for the emergency services showing the location of the thermal fluid heating plant and the layout of the pipe runs? (5.3.3)						
6.3.4	Has the use of a thermal fluid system to provide heating for the workplace been avoided? (5.3.4)						
6.3.5	Is the area within 1m of the heating equipment or its associated pipes and flues clear of combustible materials? (5.3.5)						
6.3.6	Is the thermal fluid heating system warmed up slowly under no-load conditions? (5.3.6)						
6.3.7	When a system is refilled, is provision made to bleed all gas out of the system using suitable small bore bleed valves and lines located at high points in the system? (5.3.7)						
6.3.8	If regular topping up is necessary is the cause established and rectified? (5.3.8)						
6.3.9	Is topping up of fluid only undertaken by the maintenance engineers or trained personnel? (5.3.9)						
6.3.10	Are containers of spare flammable fluid stored in accordance with the requirements of RISCAuthority Recommendations RC56? (5.3.10)						
6.3.11	Are drums stored bung uppermost in a suitable bund, with any horizontal drums chocked against rolling? (5.3.14)						
6.3.12	Are operators of thermal heating systems trained in all aspects of the installation, including emergency procedures? (5.3.15)						
6.3.13	Are operators made aware that there is a very narrow range between efficient operating temperature and the temperature at which degradation of the fluid can decrease the wall life of the furnace tubes? (5.3.13)						
6.3.14	If it is intended that a process is to be left operating without staff in attendance has a specific risk assessment for the process been undertaken and appropriate control measures introduced? (5.3.14)						
6.4	**Location and construction (section 5.4)**						
6.4.1	In the case of large installations is the heating unit and associated equipment located in a detached non-combustible building at least 10m from other buildings or plant? (5.4.1)						
6.4.2	Are measures taken to ensure that the piping and equipment carrying the thermal heating fluid are not exposed to temperatures below the pour point of the fluid? (5.4.2)						
6.4.3	Are floors suitably dished or curbed to prevent the escape of any leaking oil from the compartment? (5.4.3)						
6.4.4	Where it is necessary for drains to be located in the area, are they provided with interceptors of sufficient capacity to prevent pollution? (5.4.3)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.4.5	Where a flue pipe serving a solid fuel, gas or oil-burning heater passes through a roof or combustible element of construction, is a proprietary sleeve system installed around it to provide a degree of fire rating, usually between two and four hours fire resistance in terms of integrity and insulation, as agreed with the insurer? (5.4.4)						
6.4.6	For oil and gas-fired equipment, is adequate ventilation provided for combustion and normal cooling purposes? (5.4.5)						
6.4.7	Are flue gas temperature monitors fitted in chimneys and flues with a high temperature monitor raising an alarm to the main control panel and to a manned area and also a second, higher temperature monitor to shut off the fuel supply to the heater? (5.4.7)						
6.4.8	Are flues or chimneys substantially constructed of non-combustible materials capable of withstanding the flue gas temperatures to which they may be subjected? (5.4.8)						
6.4.9	Is the height of the chimney above the roof sufficient to prevent down-draughts? (5.4.9)						
6.4.10	Is all ductwork, including exhaust flues, constructed of galvanised or stainless steel, with seamless components properly connected to prevent leakage of smoke and vapours? (5.4.10)						
6.4.11	Does the base of the flue or chimney incorporate an inspection panel and a drain to prevent water or condensate entering the heater? (5..4.11)						
6.5	**Control systems (section 5.5)**						
6.5.1	Are remote shut-off valves for the fuel supply provided both outside the area housing the thermal heating fluid plant and at the process being heated to enable safe close down in an emergency? (5.5.1)						
6.5.2	For oil fired equipment, are safety controls and procedures as described in RISCAuthority Recommendations RC9? (5.5.2)						
6.5.3	Are automatic interlocks provided to delay ignition until the furnace chamber and flue have been purged of any flammable mixture and to cut off the fuel supply should the flame be extinguished for any reason? (5.5.2)						
6.5.4	Are gas and oil burners fitted with two self checking flame failure devices to minimise the potential for an explosion within the furnace caused by late ignition? (5.5.3)						
6.5.5	Are interlocks fitted to prevent the heating system starting or continuing to run unless the circulating pumps are operating? (5.5.4)						
6.5.6	Are both the flow and return fluid pressures monitored automatically with any imbalance resulting in automatic shutdown? (5.5.5)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.5.7	Are monitoring devices installed as follows: (5.5.6) • On fluid inlets: High pressure and low flow alarms? • On fluid outlets: High temperature alarms? • On the heater outlet: High temperature and pressure alarms interlocked with the heating source so that an alarm is given should an abnormally high temperature or pressure be registered. Triggering of a second monitor set at a higher temperature should result in automatic shutdown of the fuel source to the heater or vaporiser? • On the tanks: Low level fluid alarm?						
6.5.8	Do the monitoring devices referred to in paragraph 5.5.6 provide an alarm to give operators an opportunity to correct the problem before conditions reach an unsafe level? (5.5.7)						
6.5.9	Where thermal heating fluids are toxic are double walled, closed loop heat exchangers installed? (5.5.8)						
6.5.10	Are one or more safety valves or bursting discs provided in suitable locations to prevent the pressure exceeding the maximum permissible working pressure? (5.5.9)						
6.5.11	Are rate of flow and pressure sustaining valve(s) installed to provide safety relief for an isolated heater? (5.5.10)						
6.5.12	For vapour phase systems where condensate is returned by gravity to a point below the safe working liquid level of the vaporiser is a vacuum breaking loop (such as a Hartford or Gifford Loop) fitted for safety? (5.5.11)						
6.6	**Pipework (section 5.6)**						
6.6.1	Do pipework systems incorporate proper provision for expansion and are they adequately supported and sloped for efficient drainage? (5.6.1)						
6.6.2	Are hot oil transfer pipework and connecting unions constructed of materials suitable for the thermal fluid that is to be used? (5.6.2)						
6.6.3	Is hot work on the thermal heating system avoided? (5.6.3)						
6.6.4	Following maintenance or when the temperature of the fluid has fallen below the pour point, are staff aware that the fluid should not be heated by the direct application of a flame to the pipework? (5.6.4)						
6.6.5	Are safety shut-off valves or 3-way divert valves provided to isolate each secondary circulation loop from the primary loop running into and out of the heater or vaporiser to allow processes not involved in a malfunction or leak to continue uninterrupted? (5.6.5)						
6.6.6	In large installations are additional shut-off valves installed within loops to minimise the volume of a potential leak? (5.6.6)						

6.7	Tanks (section 5.7)	Yes	No	N/A	Action required	Due date	Sign on completion
6.7.1	Are liquid phase systems provided with an expansion tank? (5.7.1)						
6.7.2	Is the expansion tank located at the highest point of the system to ensure that all the pipework and apparatus is completely filled with liquid and that the risk of pump cavitation is minimised? (5.7.2)						
6.7.3	Is the expansion tank located so that any leak of fluid will not come into contact with the heater, vaporiser or other hot surface? (5.7.3)						
6.7.4	Is the expansion tank sized so that its effective volume is at least 30% greater than the expansion volume of the system's total liquid content at the maximum permissible working temperature? (5.7.4)						
6.7.5	Is the level of liquid in the expansion tank monitored and should it fall below the manufacturer's recommended minimum level is shutting off of the plant triggered automatically? (5.7.5)						
6.7.6	Is the expansion tank provided with desiccant or other means to reduce the ingress of moisture into the fluid? (5.7.6)						
6.7.7	For liquid systems not operating under pressure, is a cold seal tank provided in order to minimise losses from the system and compensate for any changes in level such as those due to thermal expansion? (5.7.7)						
6.7.8	Is the storage tank located where it will not be exposed to fire? (5.7.8)						
6.7.9	In addition to the storage tank is a tank capable of taking the total system contents at its maximum expansion volume provided at low level in order that the liquid can be drained by gravity for maintenance work? (5.7.9)						
6.7.10	Is a quick-acting remote control valve fitted in order to achieve fast emptying of the system in the event of an emergency? (5.7.10)						
6.7.11	If the storage tank is fitted with a heater to warm the liquid before returning it to the system after maintenance, is a safety valve fitted, discharging to a safe place? (5.7.11)						
6.7.12	Are vent valves provided at the high points of the system to remove air (or where there is positive flow in one direction, are valves fitted at the end of the flow path)? (5.7.12)						
6.7.13	Is the discharge fed away from all sources of ignition and may be piped through the expansion tank or to a common vent condenser, from where the condensed liquid can be returned to the storage tank? (5.7.13)						
6.7.14	Are vent condensers protected against over pressure in the event of failure of their cooling systems? (5.7.14)						
6.7.15	Are vents provided on the storage and expansion tanks and, in these cases, does the vent pipe rise continuously and terminate outside the building in a catchment area or other safe place? (5.7.15)						
6.7.16	Are vents kept free of obstruction? (5.7.16)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.8	**Pumps (section 5.8)**						
6.8.1	Are glands and packing materials adequate to withstand the hot fluid temperatures involved, and compatible with the metals and fluids present? (5.8.1)						
6.8.2	Do pumps have a flexible stainless steel connection on the suction side, to absorb any mechanical stress, vibration or movement? (5.8.2)						
6.8.3	Is the pipework designed to minimise the thermal stresses from expansion and contraction throughout the foreseeable cycle of operating conditions, allowing for times when the system is shut down and cold? (5.8.3)						
6.8.4	Where the fluid may be vulnerable to freezing during shutdown or maintenance operations is trace heating installed to pumps and vent and relief lines? (5.8.4)						
6.8.5	Do pumps have double seals, with a drain between which is piped to a closed container in a safe area? (Where necessary is seal cooling provided?) (5.8.4)						
6.8.6	Are water cooled pumps fitted with a device arranged to shut off the burners in the event of low water flow? (5.8.5)						
6.8.7	In order for a natural convection system to function effectively, is the height between the furnace and the process vessel maximised and the length of the pipework minimised? (5.8.6)						
6.9	**Insulation (section 5.9)**						
6.9.1	Is lagging non-combustible, non-absorbent and suitable for the temperature employed? (5.9.1)						
6.9.2	Is lagging absent from the following? (5.9.2) • pumps, flanges, valves and fittings to allow them to be accessible for maintenance and inspection? • the expansion tank, or to the buffer section of any deaerator?						
6.9.3	Are uninsulated pumps, flanges, vessel sections and expansion tanks positioned or suitably shielded to prevent burns or other personnel injury? (5.9.3)						
6.9.4	If completely enclosed, is shielding on tanks provided with bottom holes to allow any leaking fluid to drain out and be quickly noticed? (5.9.4)						
6.9.5	On new installations, is lagging not applied until the installation has had at least 50 hours operation at its maximum rating so as to expose any leaks caused by faulty workmanship, thermal expansion, and bedding down? (5.9.5)						
6.10	**Electrical equipment and wiring (section 5.10)**						
6.10.1	Is electrical equipment and wiring designed, installed and maintained to BS 7671? (5.10.1)						
6.10.2	Is the electrical equipment and wiring suitable for the high temperatures likely to be found near the heater and vaporiser? (5.10.2)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.10.3	Is electrical equipment and wiring segregated or protected so as to avoid the dangers arising from exposure to the effects of heat or leaking fluids? (5.10.3)						
6.10.4	Where electrical cables are exposed to the possibility of mechanical damage, are suitable cables selected or is mechanical protection provided? (5.10.4)						
6.10.5	Are metal pipework, boilers and other equipment earth-bonded? (5.10.5)						
6.11	**Maintenance (section 5.11)**						
6.11.1	Is the entire system serviced and maintained in accordance with the manufacturer's instructions with particular attention being given to the correct working of safety devices and cut-outs? (5.11.1)						
6.11.2	When recharging are all traces of the old fluid removed prior to recharging with fresh fluid? (5.11.2)						
6.11.3	Are all pipework systems and associated lagging examined at least every six months? (5.11.3)						
6.11.4	Is the thermal fluid sampled and tested at intervals as determined by the manufacturer or supplier of the product but at least annually? (5.11.4)						
6.11.5	Is all hot work on the thermal heating system avoided wherever possible? (5.11.5)						
6.11.6	Before any unavoidable hot work is carried out on the system, is it thoroughly drained and continuously purged with nitrogen or carbon dioxide during the period of work? (5.11.6)						
6.11.7	When maintenance is complete, is the system cleansed of all potential contaminants? (5.11.7)						
6.12	**Fire protection (section 5.12)**						
6.12.1	Is the thermal fluid heating plant protected by an automatic fire detection and alarm installation designed, installed, commissioned and maintained by an engineer with certification from an independent UKAS accredited third party certification body? (5.12.1)						
6.12.2	Is the installation to a recognised category of installation in accordance with BS 5839-1 as determined by a risk assessment? (5.12.1)						
6.12.3	Is the automatic fire detection and alarm system monitored either on-site or by an off-site alarm receiving centre with certification from an independent UKAS accredited third party certification body and operating in accordance with BS 5979? (5.12.2)						
6.12.4	Is the installation periodically serviced and maintained in accordance with BS 5839-1 by a competent engineer with certification from an independent UKAS accredited third party certification body? (5.12.3)						
6.12.5	Has consideration been given to water spray or automatic sprinkler protection for thermal fluid heating plant? (5.12.4)						
6.12.6	Have sprinkler systems been installed and maintained in accordance with the requirements of the *LPC Rules for automatic sprinkler installations incorporating BS EN 12845*? (5.12.4)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.12.7	Have an appropriate number of fire extinguishers, of a type suitable for extinguishing fires in nearby materials been provided in the vicinity of all areas in which thermal heating fluid plant is located or through which these services run? (5.12.5)						
6.12.8	Have the extinguishers been sited in easily accessible positions as set out in BS5306-8 and are they being mainmtained in accordance with BS5306-3? (5.12.5)						

References

1. Regulatory Reform (Fire Safety) Order 2005, SI 2005 No 1541, The Stationery Office.
2. The Fire (Scotland) Act 2005, asp 5, The Stationery Office.
3. Fire Safety (Scotland) Regulations 2006, Scottish SI 2006 No 456, The Stationery Office.
4. Fire and Rescue Services (Northern Ireland) Order 2006, SI 2006 No 1254 (NI9), The Stationery Office.
5. Fire Safety Regulations (Northern Ireland) 2010, SI 2010 No 325 (NI), The Stationery Office.
6. Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), 2002, SI 2002 No 2776 (as amended in 2015), The Stationery Office.
7. RC42: *Recommendations for fire safety of unattended processes*, 2011, Fire Protection Association.
8. *Business resilience: A guide to protecting your business and its people*, 2005, Fire Protection Association.
9. The ROBUST software (Resilient Business Software Toolkit) may be found at https://robust.riscauthority.co.uk
10. RC56: *Recommendations for fire safety in the storage, handling and use of highly flammable and flammable liquids: storage in containers other than external fixed tanks*.
11. RC9: *Recommendations for oil-fired heating installations*, 2011, Fire Protection Association.
12. RC7: *Recommendations for hot work*, 2012, Fire Protection Association.
13. BS 7671: 2008 + A3: 2015: *Requirements for electrical installations*. IET Wiring Regulations, British Standards Institution.
14. BS 5839-1: 2017: *Fire detection and alarm systems for buildings. Code of practice for system design, installation, commissioning and maintenance of systems in non-domestic premises*, British Standards Institution.
15. BS EN 50518-3: 2013: *Monitoring and alarm receiving centre. Procedure and requirements for operation*, British Standards Institution.
16. LPC *Rules for automatic sprinkler installations incorporating BS EN 12845: Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance*, British Standards Institution, 2015, Fire Protection Association.
17. BS 5306-8: 2012: *Fire extinguishing installations and equipment on premises. Selection and positioning of portable fire extinguishers. Code of practice*, British Standards Institution.
18. BS 5306-3: 2017: *Fire extinguishing installations and equipment on premises. Commissioning and maintenance of portable fire extinguishers. Code of practice*, British Standards Institution.

Further reading

- *Heat transfer by organic and synthetic fluids: Property Loss Prevention Sheet* 7-99: 2014: FM Global.
- NFPA 87: *Standard for Fluid heaters*, 2018, National Fire Protection Association (USA).

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