Recommendations

RC38

for frost protection measures for sprinklers

Fire Protection Association

InFiReS

LOSS PREVENTION RECOMMENDATIONS

These Recommendations are part of a series of insurer documents developed under the Insurers' Fire Research Strategy (InFiReS) Funding Scheme and published by the FPA. InFiReS membership comprises a group of UK insurers that actively support a number of expert working groups developing and promulgating best practice for the protection of property and business from loss due to fire and other risks. The technical expertise for the Recommendations is provided by the Technical Directorate of the FPA and experts from the Insurance Industry who together form the InFiReS Risk Control Steering Group.

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1 INTRODUCTION

1.1 Effects of frost

Unless sprinkler systems are within adequately heated buildings, measures will be required to prevent the water in the pipework, fittings, ancillary equipment and tanks freezing in cold weather. Freezing of water could result in two effects:

(a) damage to the pipework, fittings ancillary equipment, pumps or tanks, causing subsequent water leakage and property damage; and

(b) systems rendered inoperative due to ice blockage and hence not able to deliver water to control a fire.

1.2 Areas subject to freezing

Many industrial premises have areas which could be subject to freezing temperatures, for example:

(a) unheated or inadequately heated buildings;

(b) parts of heated buildings exposed to frost, such as ceiling voids or near open doors such as loading bays;

(c) chillers and cold rooms;

(d) external pipelines from a remote mains water supply or pumphouse to a sprinklered building;

(e) the pumphouse (BS EN 12845, Clause 10.9.2, requires that diesel engines be maintained above 5°C for ease for ease of starting);

(f) areas normally heated but temporarily unheated during out-of-work hours, weekends or winter holidays;

1.3 Main frost protection methods

The methods available for protecting areas and water-filled equipment from freezing are:

(a) maintaining adequate heating throughout the building (preferred option, where possible); or

(b) providing localised heating and/or trace heating and lagging to pipes, valves, tanks and ancillary equipment; or

(c) using a dry sprinkler pipe or alternate wet/dry sprinkler pipe installation; or

(d) using dry drop sprinklers.

2 SCOPE

These recommendations give specific measures for fitting electrical heating systems, including electrical trace-heating systems, the maintenance of such systems and the precautions to be taken to ensure that an effective heating system is in operation.

The recommendations apply only to installations in industrial and commercial premises in regions subject to a temperate climate.

3 TYPES OF SPRINKLER SYSTEMS

A sprinkler system comprises a means of providing a supply of water and distributing it to one or more arrays of sprinkler heads. A number of system arrangements may be used, depending upon the source of water and the type of installation. Water is obtained usually from the town main, either directly or via a water storage tank and pump(s), or occasionally from a river, canal or lake. There are four sprinkler installation types:

(a) wet sprinkler pipe installation, where all the sprinkler pipes remain charged with water at all times;

(b) dry sprinkler pipe installation, permanently charged with compressed air;

(c) alternate wet/dry sprinkler pipe installation, where the sprinkler pipes are charged with water throughout the summer, and compressed air during the winter;

(d) subsidiary dry or an alternate (wet and dry pipe) extension, which is part of a wet or alternate pipe installation. Sometimes referred to as 'tail-end' systems, the subsidiary dry or alternate valves are installed downstream of the main control valve set, allowing that part of the system which may be subjected to freezing temperatures to be charged with air either permanently or during winter months.

All of these are susceptible to frost damage, to a greater or lesser degree, and specific recommendations for each are given in these recommendations.

4 FROST PRECAUTIONS FOR SPRINKLER INSTALLATIONS

4.1 Wet sprinkler pipe installation

Five situations for the protection of wet sprinkler pipework against frost may apply:

- pipes in a building which is to be kept warm;
- pipes in cold areas of an otherwise warm building;
- pipes in an unheated building or outside buildings;
- pipes underground;
- main pipe runs in a warm building but the sprinkler heads in a cold area.

Recommendations for appropriate frost precautions for each of these situations are given below.

(a) Where the temperature throughout the building is to be maintained at 4°C or above at all times, frost-stat controls should be provided (section 7).

(b) Where sprinkler pipework inside HEATED buildings is exposed to frost, for example, range pipes in cold roof spaces or other concealed spaces, pipework in cold areas adjacent to large door openings, and any other vulnerable areas, such pipework (but not the sprinkler heads) should be trace-heated over the exposed length (section 8). N.B. Pipe lagging over the trace heating is bulky. It is essential that sprinkler heads are not obstructed by lagging or trace-heating cables; the trace-heating tapes should be affixed to the opposite side of the pipe to the sprinkler. It should also be noted that the increased diameter of the lagged pipework will increase the pipe shadow of upright sprinklers. Some pipework design changes may be necessary to overcome the possibility of lagging interfering with sprinklers. For example, it may be desirable to connect the sprinklers to the range pipe using rise or drop pipes.

(c) Where pipework within UNHEATED buildings or outside buildings may be exposed to frost, the pipework should be trace-heated over the exposed length (section 8).

(d) In temperate climate regions, underground pipework at depths of 750mm or more should not require additional protection from freezing. It may generally be assumed that the short vertical buried section of pipe below the point of emergence from the ground is kept adequately warm from above and below.

(e) Where the main wet sprinkler piping is adequately protected against frost, because of location in a warm area, but the sprinkler heads are located in an immediately adjacent cold area, dry upright or pendent sprinklers[1] may be used. This sprinkler has been designed for such situations and does not require frost protection over the rise or drop pipe or the sprinkler head, as the unit is dry until the sprinkler operates. It is important that an adequate length of the drop or rise pipe on a dry sprinkler is within the heated space to prevent freezing at the water-filled pipe end. Guidance is given in TB219, 'Sprinkler protection of cold stores'.

[1] Dry pendent sprinkler – Sprinkler and dry drop pipe with a valve at the head of the pipe, held closed by a device maintained in position by the sprinkler head valve.

Dry upright sprinkler – Sprinkler and dry rise pipe with a valve at the base of the pipe, held closed by a device maintained in position by the sprinkler head valve

4.2 Dry sprinkler pipe installation

The only part of a dry sprinkler pipe installation susceptible to freezing is from the main water supply point (floor level entry or wall entry), up to and including the dry pipe valve (the alarm valve separating the wet and dry sections). The 'wet' section comprises the supply pipe, main stop valve and the wet part of the dry pipe valve and test valves. Some dry pipe valves may have priming water above the sealing assembly, either to improve the water/air seal or to damp the valve action when the dry pipe valve opens. Dry pipe installations should only be used within artificially cold areas such as chillers and cold rooms.

4.2.1 *Wet section*

This section should be protected in one of the following ways:

(a) by siting within a local enclosure, maintained at all times at or above 4°C;

(b) by trace heating and lagging the pipe over the exposed length up to and including the valve, and above the valve up to the water prime level, including any ancillary piping (section 8). It should be noted that by trace heating the valve:

(i) access to the valve for maintenance purposes could be impeded;

(ii) during maintenance the trace heating could be damaged. For this reason, a purpose-made insulated box for the valve is often employed, which allows easy access.

4.2.2 *Dry section*

Weekly checks should establish that the intended 'dry' section is in fact dry, and that no water condensate from the air compressor has collected in the pipe. This involves opening all the water condensate drain valves in the dry section above the dry alarm valve. This can only be carried out when the temperature is above freezing. Where sprinkler pipework is located in an area where temperatures are permanently below freezing, it is essential that every effort is made to ensure that the pipework is dry before the installation is pressurised with gas (air or nitrogen) and that the pressurising gas is free of moisture. The only means available to check that there is no accumulation of frozen water or condensate may be to depressurise the pipework and internally inspect critical pipes. In the event of the pipework becoming charged with water (including after-fire conditions) it is likely that the pipework will need to be dismantled for drying out.

4.3 Alternate wet/dry sprinkler pipe installation

Alternate wet/dry sprinkler pipe installations are allowed in areas subject to climatic change and minimise the performance disadvantage when pipes are gas filled. Suitable arrangements must be in place to ensure that the sprinkler pipe installation is changed over for the respective season. Widely recognised dates for alternating the system in the United Kingdom are:

Water filled: 1 May to 1 October

Air filled: 1 October to 1 May though local variations may apply, in exposed or sheltered locations, or in the north or south of the country.

When alternate pipe sprinkler installations are changed from dry to wet in the spring it provides an opportunity to assess the reliability and performance of the dry pipe installation by opening the remote test valve and measuring the times to valve trip and water discharge through the remote test valve. If the dry pipe installation operating times are excessive, the control valve should be serviced and retested before being recommissioned in the autumn.

4.3.1 *Permanently wet section of the installation*

If an alternate wet/dry sprinkler pipe installation is operated correctly the only part susceptible to freezing is (as for a dry pipe installation) from the main water supply point (floor level entry or wall entry) up to the dry pipe valve. This 'wet' section should be protected in one of the following ways:

(a) by situating within a local enclosure, maintained at all times at or above a temperature of 4°C;

(b) by trace heating the pipe over the exposed length to and including the valve, and above the valve up to the water prime level, including any ancillary piping (see section 8). It should be noted that by trace heating the valve:

 (i) access to the valve for maintenance purposes could be impeded;

 (ii) during maintenance the trace heating could be damaged. For this reason, a purpose-made insulated box for the valve is often employed, which allows easy access.

4.3.2 *Wet/dry section of installation*

Before winter, the wet/dry sprinkler piping must be drained. Two factors which could prevent this being carried out effectively, and the precautions which should be taken, are:

(a) damage to piping, which could affect the falls designed into the original installation. Attention should be paid to adequate protection of pipes against fork lift truck damage. The annual drainage of the wet/dry installation should be accompanied by a full inspection of the piping, to ensure that no damage has occurred which could prevent complete drainage;

(b) Adverse drainage slope or trapped sections of piping (Figure1).

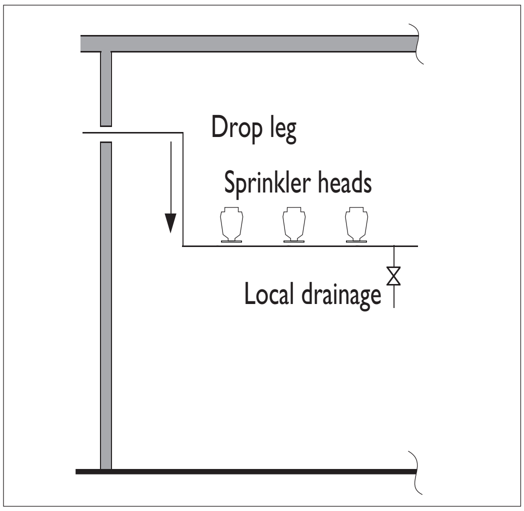

Figure 1. Adverse pipe drainage conditions

Where adverse slopes or trapped sections of pipework cannot be drained at the installation control valve drain, they should slope to the point of connection of a subsidiary drain valve.

Accurate documentation showing the location and number of all drain valves is essential.

The recommendations given in section 4.2.2 also apply.

4.3.3 *Pendent heads and drop pipes*

Where it is essential to use pendent sprinkler heads in dry pipe or alternate pipe systems, dry pendent sprinklers (see section 4.1(e)) should be used. It is important to prevent trapped volumes of water in pipework as this may result in freezing or leakage due to accelerated corrosion.

4.4 Wet sprinkler pipe installation, with subsidiary alternate pipe or dry pipe extensions

Subsidiary dry pipe or alternate pipe extensions to a wet pipe installation may be used to protect small areas requiring no more than 100 sprinklers, where there is a possibility of freezing.

(a) subsidiary alternate pipe extensions may be used in parts of the sprinklered building which are not adequately heated (example: loading bays);

(b) subsidiary dry-pipe extensions may be used where there is a continuous possibility of freezing (example: cold rooms and freezer cabinets).

4.5 Wet pipe installation protected by anti-freeze solution

BS EN 12845 (Clause 11.1.2.1) references the use of anti-freeze solution in sections of sprinkler systems where the sections do not exceed 20 sprinklers.[2]

5 FROST PRECAUTIONS FOR WATER SUPPLIES

5.1 Water supply pipework

(a) exposed water supply pipework above ground, that is, not inside permanently heated buildings, should be suitably lagged and trace-heated over the exposed length (section 8);

(b) below-ground pipework should be at a depth of 750mm or more.

5.2 Static water storage

Above-ground tanks comprise suction tanks[3], situated at ground level, pressure tanks and gravity tanks, elevated to a height above ground level. Underground tanks are normally constructed of concrete, with a concrete roof. Frost precautions should be taken as follows.

5.2.1 *Suction tanks*

The water storage tanks discussed in this section may be constructed from either GRP, suitably protected steel, or aluminium with a butyl liner. Storage volumes vary from, 5m³ to in excess of 1000m³ capacity, depending on the Hazard, protection required and whether the inflow has been taken into account in the determination of the volume required.

Water storage tanks should be fully covered by a tank roof, incorporating an inspection lid. In areas where severe weather conditions are anticipated, tanks should either be protected against freezing, or the normal water level increased by at least 1m depth and ice venting provided, see BS EN 12845, Clause 9.3.2.1. Where metal tanks are protected against freezing, consideration should also be given to measures that may be required to prevent corrosion.

Where water storage tanks may be susceptible to freezing, immersion heater(s) should be fitted adjacent to the ball float valve(s) to keep the ball float free of ice. This also prevents ice forming a complete seal across the water surface and allows the water level to fall as the water is pumped from beneath the ice covering. See section 9. During winter the operation of the immersion heater should be tested, if necessary using a switch that over-rides the immersion heater thermostat. See section 10(a).

The thermostats will require regular maintenance and this should be carried out in accordance with section 8.

5.2.1.1 Suction tank infill pipe and infill test line

All above-ground pipework to the suction tank and associated stop valves will normally be full of water and should be lagged and if necessary electrically trace-heated as described in section 8. For underground piping, see section 4.1(d).

The infill pipe line flow meter, which is used as a means of verifying the water supply pressure/flow characteristic, should be fitted with drain valves on any trapped sections of trim pipework and these should normally be empty and the drain valves left open. The flow meter supplier's instructions should be complied with.

5.2.1.2 Drain valve on storage tank

The drain valve on the storage tank should be lagged and if necessary trace-heated should it be exposed to freezing conditions. See section 8.

5.2.1.3 Gravity tanks

Similar considerations for heating apply as for suction tanks, above.

5.2.1.4 Pressure tanks

The pressure tank and house should be maintained at or above a temperature of 4°C.

5.2.1.5 Underground tanks

Underground tanks, covered with a thick concrete roof, are generally sufficiently protected against freezing due to their position and require no further frost precautions but the merits of each individual tank should be assessed.

5.3 Pump house

The pump house contains water pumps (electrically- or diesel-driven), priming tanks and pipework. Heating for the complete pump house is essential, as it is impractical to provide local heating for the pumps.

A frost-stat should be provided (see section 7), set to switch on the heating when the temperature falls below 4°C (or 10°C for diesel pumps). In the interests of economy of heat, it is common practice to locate the frost-stat inside the pump house and set to switch off the heating automatically once the temperature has risen a small amount, say to 7°C (or 13°C for diesel pumps). If such a system of control is used, careful attention should be paid to

[2] No detailed information has been provided in BS EN12845 or elsewhere in the *LPC Rules for automatic sprinkler installations* concerning the use of anti-freeze solutions to protect against freezing. Until such time as published guidance is available the supplier and user should take full responsibility for the design and maintenance of such frost protection methods.

[3] The sprinkler industry has traditionally used the term 'tanks' in the context of water storage. The water supply industry use the term 'cisterns'.

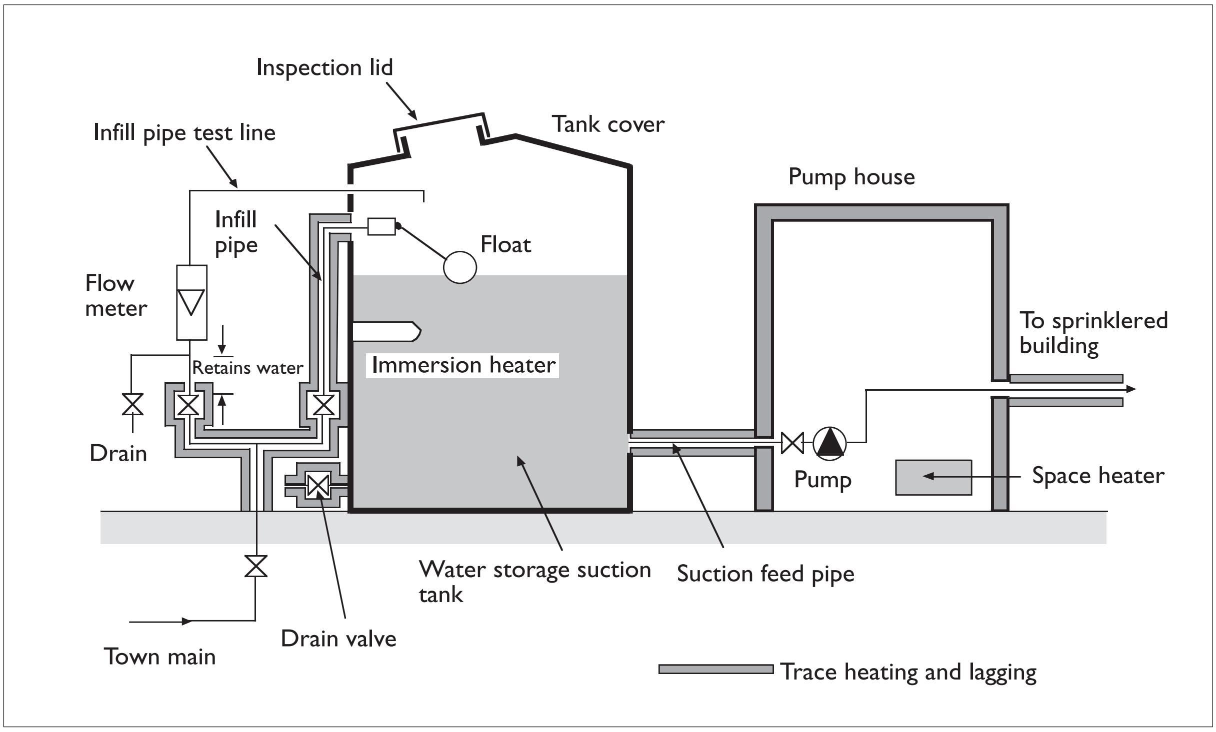

Figure 2. Schematic diagram of water storage suction tank and pump house

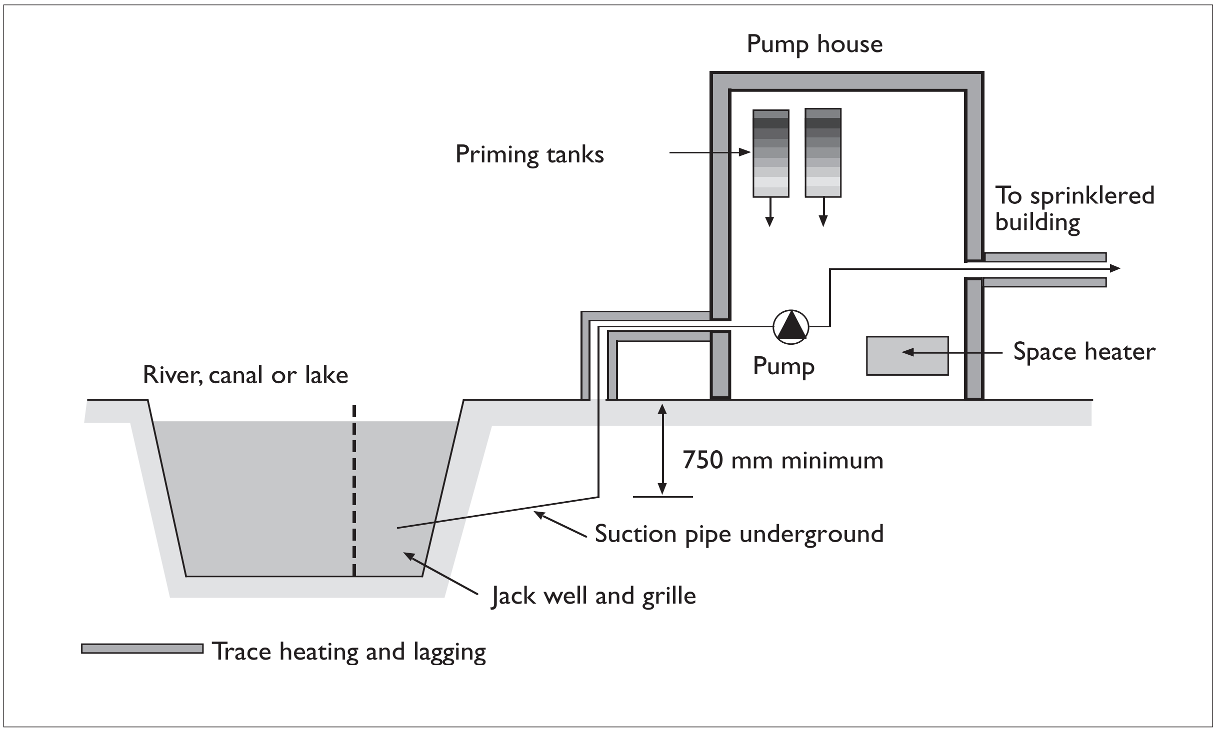

Figure 3. Schematic diagram of suction pipe from river, canal or lake

the possibility of a significant variation in temperature within the pump house, and in particular to the colder areas adjacent to the pump house ventilation louvres, which are provided for operational purposes.

(To prevent the wastage of power in heating pump houses with open louvres, it may be preferable to arrange that the louvres are only opened when the pumps start. Air for diesel pump aspiration can be taken directly from the open air.)

The choice of location of the frost-stat is most important and should take into account the above considerations; a frost-stat located at the coldest position gives the greatest protection against freezing.

Frost-stat adjustments should be in a locked box, with the key available only to responsible maintenance personnel. The frost-stat setting and operation should be checked annually. For reasons of reliability of supply, electric heaters are preferred to those using other fuels, unless the pump house can be reliably heated (even during factory shutdowns) by the master boiler plant. A minimum-reading air temperature thermometer should be provided in the pump house. If possible, electric remote monitoring of the pump house air temperature should be provided. For test purposes a frost-stat over-ride switch will be necessary. During winter weather the operation of the space heater should be tested weekly, if necessary by operating the frost-stat over-ride switch.

5.3.1 *Suction feed pipe from water storage tank to pump house (Figure 2)*

The suction feed pipe, with associated isolation valves, may be wholly above or partly below ground level and will require appropriate frost protection, as described in section 5.1.

5.3.2 *Suction pipe from river, canal, lake to pump house (Figure 3)*

The usual route for a suction pipe from a river, canal or lake is from a pipe entry at a depth of 1m or more below the water surface. The suction pipe passes underground, emerging close to (or inside) the pump house. There may be a section of pipe and associated stop valves above ground, for which frost protection should be as described in section 5.1.

5.4 Piping to sprinklered building (Figures 2, 3)

The piping from the pump house (or, if appropriate, directly from the town main) to the sprinklered building, above or below ground should be appropriately frost protected as described in section 5.1.

6 ELECTRICITY SUPPLIES

The electrical input to all the above frost protection systems should be fed from a reliable supply, independent of the general supplies to the factory or commercial unit, to ensure that supplies are not inadvertently switched off during holiday shutdowns and maintenance periods.

The electrical supplies to the various frost prevention areas should have indicator lights and ammeters (see section 10) to show that power is on. Where possible these should all be located on a single indicator board.

Site procedures should be devised and documented to ensure that power supplies are switched on before winter and off when the risk of frost has passed (see section 4.3).

Electrical protection of frost protection systems should follow the manufacturer's recommendations. The use of sensitive residual-current protection in addition to overcurrent and short-circuit protection is recommended to minimise damage in the case of short-circuits or other abuse of heaters.

7 ELECTRIC CONTROLS FOR HEATING SYSTEMS

Heating systems, including room heating and trace heating, are controlled using a combination of time-clock switches, thermostats and frost-stats.

A frost-stat is a thermostat used to over-ride any time-clock switch and turn on the heating system in the event of the air temperature falling to near freezing.

Once the heating has been turned on, it will often be controlled locally by a separate thermostat. The frost-stat is usually positioned outside or at the coldest part of the building, to turn on the heating as soon as possible.

Expert advice should be sought to decide whether the frost-stat is sited outdoors or indoors, depending on whether the coldest part of the building can be identified reliably.

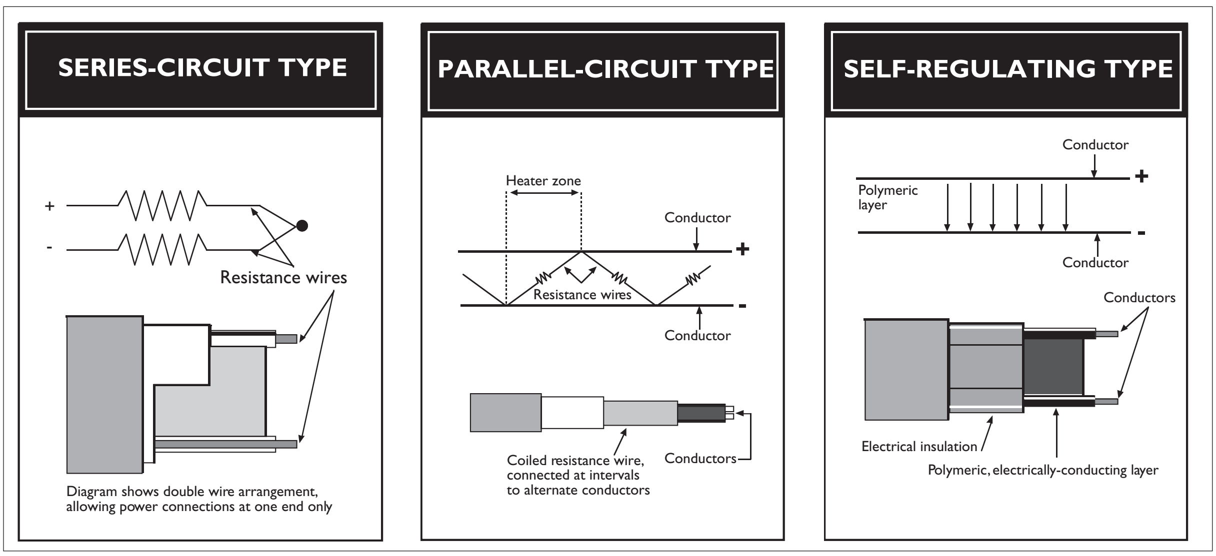

Figure 4. Features of the three main types of trace-heating tapes

NB. The frost-stats described for pump houses (section 5.3) and water storage tank heating (section 9) operate both as a frost-stat and thermostat for controlling the temperature.

8 TRACE HEATING AND LAGGING

8.1 Introduction

Trace heating comprises an electrically heated cable, suitably electrically insulated, taped along or wound around the pipes, valves and fittings. It is essential that the trace heating is covered with heat-insulating lagging, to a thickness as recommended by the trace-heating suppliers, and weather-protected in exposed positions.

8.2 Types of trace-heating systems

Three fundamentally different types of electrically heated cables are available and these are described below. Illustrations of each are given in Figure 4.

Any of the types of cables, if correctly installed, can be used to provide the required amount of heat and protect the sprinkler system from freezing but it is essential that the performance is monitored throughout the lifetime of the system.

The methods and extent to which this can be achieved vary widely for the three types and visual and audible alarms may be incorporated. Depending upon the size and importance of the system, the control and monitoring can be very simple or extremely complex, perhaps linked to the computer-controlled building management system.

8.2.1 *Series circuit heater*

In its simplest form, this consists of a single electrical resistance wire, run as a loop, with a mains voltage applied across the two ends. In this design the heat output is dependent upon the length of the wire and the voltage applied. Double wire cables are also used, in the form of a go and return element, and allow connections to be made at one end only.

The heat output is essentially uniform along the length of the wire and the temperature reached at each point is dependent upon the thermal-insulating properties of the lagging locally and the closeness of the coils of wire. The wires should not be overlapped, which could cause serious overheating.

Series-circuit trace heating is normally supplied as either:

(a) mineral-insulated cables, comprising resistive conductors surrounded by magnesium oxide electrical insulation, sheathed in metal (usually copper, cupro-nickel or stainless steel), or

(b) fixed-length, factory-terminated tapes, consisting of resistance wires or foils, sewn into a glass cloth carrier and covered with electrical insulation. Usually it has an outer metallic braiding.

8.2.1.1 Control

Series-circuit trace-heating systems are normally operated by a frost-stat (see section 7) so that the electric power is automatically switched ON when the temperature nears freezing point (usually at 4°C) and OFF when the temperature rises again (usually about 7°C). Control following switch-on is either based on measurement of the air temperature or the pipe temperature. For larger systems, control from the pipe temperature may be the more economical method.

8.2.1.2 Monitoring and testing

(a) Power supply. The presence of the electric power supply to the trace-heating cable may be indicated by a simple neon indicating light.

(b) Current flow. The actual passing of current through the trace-heating cable may be checked by an in-line return-path monitoring light, comprising essentially a light bulb in the return wire. If this light is not illuminated this provides a direct warning that no current is being passed. Additionally, an ammeter may be included in the circuit, which will give additional information that a problem has arisen if the current indicated is not the same as the original design value. It will be necessary to employ a thermostat bypass switch so that the system can be tested at any time.

(c) Temperature (over and under). It is possible, though unlikely, for over-temperature to occur and consideration should be given to the incorporation of temperature sensors along the pipe, especially if flammable materials are stored nearby. Provided that the lagging is not damaged, temperature changes of the pipe below the design value are unlikely and provisions for monitoring to detect under-temperature are not normally necessary.

8.2.2 *Parallel-circuit constant-wattage (zoned) heaters*

These are constructed from a single resistance wire element, wrapped or spiralled around two conductors which run the length of the heating tape or cable. The resistance wire is designed to make electrical contact with alternate conductors at predetermined intervals. A sequence of electrically parallel heating circuits is therefore formed along the length of the heating unit. Within the limits imposed by the maximum heating circuit length and minimum connection interval to the conductors, parallel-circuit heating tapes and cables may be cut to any convenient length. At a given mains voltage the power output per unit length is constant, regardless of the overall length of the heating unit. Flexible parallel-circuit units are available in either tape or cable form, electrically insulated in a variety of plastic/polymer materials.

8.2.2.1 Control

The control of parallel-circuit heaters is similar to that for series-circuit heaters, section 8.2.1.1.

8.2.2.2 Monitoring/testing

(a) Power supply. Monitoring as for series-circuit heaters.

(b) Current flow. As for the series-circuit, a return-path monitoring light and ammeter can be used to indicate that current is passing. However, because of the complex structure of the resistance wire circuitry, it is possible that one or more of the sections of the cable may fail, open-circuited, with little change to the current indication. Even a small change on the ammeter may signify a broken resistance wire. Should a change be observed, it may be necessary to use sophisticated voltage continuity monitoring equipment on the conductors in order to locate the problem area.

(c) Temperature.

Over-temperature; as for series circuit.

Under-temperature; There is a possibility of individual sections of heating tape failing and temperature monitoring at selected places may be appropriate.

8.2.3 *Self-regulating heating tapes*

These comprise two parallel conductors separated by a polymeric electrically conducting layer which has an unusual property that, with a constant voltage applied, the heat produced in the polymeric layer varies according to its temperature; when the temperature is low the heat produced is high and vice versa. A varying current thus passes through the polymeric layer from one conductor to the other. If such a material is fixed around a pipe, when the pipe temperature falls, the heat output of the trace heating rises. The overall result in a correctly designed installation is that the pipes are maintained at an essentially constant temperature, designed to be a few degrees above freezing, the system temperature being self-regulating. (In practice, due to the inherent characteristics of this type of trace heating, there will be some variation in pipe temperature with changes in the ambient temperature.) For this system the heating tape can be cut to any length as, at a fixed applied voltage and temperature, the heat output is constant per unit length.

8.2.3.1 Control

The electric power supply to self-regulating heaters is switched on by a frost-stat similarly to that for series-circuit heaters, section 8.2.1.1.

8.2.3.2 Monitoring/testing

(a) Power supply. Monitoring as for series circuit.

(b) Current flow. Because the current passed by the self-regulating heater depends upon the temperature of the polymeric layer, it is not possible to check satisfactorily by a simple measurement of current flow. A more satisfactory solution, where regular surveillance is undertaken, is to install a neon lamp end-of-line monitor across the ends of the conductors, in order to check electrical continuity. Otherwise a regular check should be incorporated in the maintenance schedule. This does not, however, give any indication that the heat output is correct.

Self-regulating heating tapes are reliable and long-lasting but there is a possibility that ageing of the polymeric layer and a consequent loss in performance could occur after an extended period if the heaters are exposed for any reason to temperatures beyond their ratings. The use of pipe-temperature sensors to indicate insufficient heating should be considered.

(c) Temperature (over and under). Over-temperature cannot occur with self-regulating heating tapes unless a short-circuit occurs. The maximum pipe temperature with frost-stat control will be related to the frost-stat switch-off temperature and the heater system selected. For under-temperature, see section 8.2.2.2 (b).

8.3 Selection of trace-heating systems

Any of the above systems can be tailored to provide frost protection to sprinkler systems. The choice of system should be made in relation to:

- initial cost/running cost/maintenance cost;
- effectiveness/close thermal contact of the cable with the pipe;
- reliability;
- robustness/durability;
- ease of functional checking;
- cost and ease of providing duplicate circuitry (see 8.4)
- ease of replacement/maintenance;
- resistance to faults causing overheating or fire;

- suitability for use in classified flammable areas.

Advice should be obtained from professional system designers as to which is the most appropriate for a particular installation. The main features and benefits of the three types may be summarised as follows:

(a) Series-circuit type

- constant power output;
- fixed length;
- simple;
- robust;
- particularly suited to long pipelines;
- any supply voltage;

(b) Parallel-circuit type

- constant power per ‘zone’;
- maximum circuit length 150m;
- cut from reel;
- easily terminated on site;
- no specialist tools required;

(c) self-regulating type.

- power output decreases/increases with temperature;
- any length;
- cut from reel;
- particularly suited for hazardous environments.

8.4 Duplication of heating elements

BS EN 12845, Clause 11.1.2.2, requires that there shall be duplicate heating elements to protect pipework. Each of the elements should be capable of maintaining the pipework at the minimum temperature and each trace-heating circuit should be separately switched and monitored.

8.5 Switching on the system

In common with other precautions for approaching winter, it will be necessary to ensure that a procedure for checking and switching on the main supply to the trace-heating system is instituted. In order to conserve electrical energy, it is not economical to leave the trace heating actually producing heat unless the ambient temperature is near to or below freezing. Even self-regulating systems consume some power. The normal procedure is therefore that power is actually switched to the system by a frost-stat, as described in the sections above. Regular checking that the frost-stat operates at the required temperature is most important.

8.6 Electrical safety and standards for trace heating

As with any electrical power circuit, precautions must be taken with all types of installations so that overheating and fire are prevented. In addition to the correct use of electrical overload protection devices, the use of residual current devices (RCDs) to trip the electrical supply in the event of an earth leakage fault is strongly advised. The use of outer metallic braiding on trace-heating cables will facilitate the early detection of electrical faults. Trace heating is a specialist subject and only reputable, competent installers should be used. The industry body (ref. 1) can give technical advice. The current standard to which trace-heating systems should be supplied is British Standard BS 6351 (ref. 2).

8.7 Installation in hazardous areas

In areas classified as hazardous because of the possible presence of flammable vapours, the electrical installation needs to be certified as suitable for use in such areas (ref. 3).

Resistance wire trace heating (series or parallel circuit) is not readily certifiable in this respect because of the possibility of hot-spots. The self-regulating tape is the only system known to have a rating for use in hazardous areas.

8.8 Lagging

Lagging systems for pipework are required to meet (Reaction to fire class) Euroclass A1 or A2[4] or equivalent. The advice of the supplier of the lagging systems should be sought about compliance with the Euroclass requirements and measures to prevent ingress of water or oils[5] into the lagging materials.

9 IMMERSION HEATER FOR STORAGE TANK FLOAT-OPERATED VALVES

Immersion heater(s) or other devices should be installed to prevent the water in the vicinity of the valve floats from freezing. The immersion heater should be of the type which will not burn out when exposed to air, when the water level in the tank is below the heater element level. The heater should be of the dual element type, each element being capable of independent operation, and the unit should be capable of being maintained without draining the tank.

[4] Euroclass A1 materials have the anticipated behaviour that they make no contribution to the fire. Typical insulation materials that may achieve such behaviour are mineral fibre and glass wool.

Euroclass A2 materials have the anticipated behaviour that make a limited contribution to the fire and do not result in flashover. Typical insulation materials that may exhibit such behaviour are faced mineral fibre and faced glass wool.

[5] Oil ingress into lagging materials may promote self heating and it is therefore important to avoid oil contamination. Any lagging which becomes contaminated should be replaced.

Custom and practice has been to install the immersion heater(s) below the ball valve, about 1m below normal surface level. The water temperature need not normally be controlled to close limits and it is common practice to control the heater by switching on and off as the air temperature falls below 4°C and rises above 7°C. A thermal cut-out would switch off the heater if the element temperature rises above 60°C, and on again when the temperature has fallen a few degrees below this. As a guide it is generally accepted that about 3kW total heat input is necessary for adequate protection against freezing. An immersion heater test switch should be installed.

10 OPERATION AND FUNCTIONAL TESTING OF ELECTRICAL CIRCUITS

Where systems are operated by a frost-stat (see section 7) it is essential that their correct operation is checked on a regular basis by over-riding the frost-stat, using a test switch. The frequency of these checks should be in accordance with the installer's instructions. Checks should include the following:

(a) Immersion heater in storage tank. By over-riding the frost-stat, using a test switch, it is possible to check that the immersion heater(s) passes the correct current, indicated on an ammeter.

(b) Electric space heater in pump house. By over-riding the frost-stat, using a test switch, it is possible to check that the electric space heater passes the correct current, indicated on an ammeter.

(c) Electric trace heating. For both series-type and parallel-type trace-heating systems it is possible, by over-riding the frost-stat, using a test switch, to check that the systems pass the correct current indicated on an ammeter. For the self-regulating type, the correct current cannot be checked but electrical continuity of the conductors should be checked. Details of the monitoring and testing of trace-heating systems are given in section 8. Test apparatus should be included in the installation to check as thoroughly as possible that the heating elements will in fact heat up correctly when called upon to do so. A suitable monitoring unit would include calibrated ammeters to show that the correct current is passing. The limitations and failure modes of the test system need to be fully evaluated when the system is first chosen.

11 MAINTENANCE

In addition to functional checks listed in BS EN 12845, section 20 and in TB203 a scheduled maintenance programme should be planned, to include, actions for trace-heating systems:

(a) inspection of the heating wire where possible;

(b) inspection of the lagging and replacing where damaged;

(c) servicing the temperature switches and control unit in accordance with the manufacturer's instructions.

REFERENCES

1. Electric Trace Heating Industry Council (ETHIC), PO Box 87, Stockport SK6 5WZ.
2. BS 6351: *Electric surface heating.*

   Part 1: 1983: *Specification for electric surface heating devices,* British Standards Institution.

   Part 2: 1983: *Guide to the design of electric surface heating systems,* British Standards Institution.

   Part 3: 1983: *Code of practice for the installation, testing and maintenance of electric surface heating systems,* British Standards Institution.
3. BS EN 60079: Part 14: *Electrical apparatus for explosive gas atmospheres. Electrical installations in hazardous areas (other than mines),* British Standards Institution.