EUROPEAN FIRE SPRINKLER NETWORK

A European Fire Safety Coalition

Anti-Freeze in Sprinkler Systems

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Introduction

Anti-freeze is more widely used in sprinkler systems in the United States than in Europe, where areas at risk of freezing are usually protected by dry pipe sprinkler systems or by dry sprinklers. In the United States it has been common practice to mix water and anti-freeze in wet pipe sprinkler systems, in particular in homes at risk of freezing.

The two types of anti-freeze used, glycerine (flashpoint 160°C) and propylene glycol (flashpoint 105°C) can ignite if heated. Various definitions for combustible liquids are in use: in Europe a combustible liquid is defined as one with a closed cup flashpoint above 60°C[1]; in the United States it is defined as one with a closed cup flashpoint between 38°C and 93°C. However, the flash point does not provide a measure of the fire hazard when heated, such as when anti-freeze is discharged from a sprinkler system onto a fire. When sufficiently diluted with water, the solution will not produce an ignitable concentration of anti-freeze vapour when exposed to a fire. At the same time the freezing temperature of the water is lowered. However, if not mixed properly parts of the system may contain the anti-freeze at a higher concentration than intended, sufficient such that when sprayed from a sprinkler onto a fire it could ignite and contribute to a large fire. Sadly this has happened on more than one occasion.

Whether a specific concentration of anti-freeze will catch fire depends upon its evaporation rate, which in turn depends upon the rate of heat release from the fire and the surface area of the solution (itself inversely proportional to the water droplet size).

Since anti-freeze is used in Europe, if less often than in the United States, the European Fire Sprinkler Network has published this short position paper to summarise the latest knowledge and give some practical recommendations.

Research

The Fire Protection Research Foundation, FPRF, published a report in November 2012[2]. The report considers the potential for ignition of anti-freeze solutions released from spray sprinklers. The FPRF had previously investigated residential sprinklers and not found ignition when a 50% solution of glycerine was exposed to a 1.4 MW fire. However, solutions of 55% glycerine and 45% propylene glycol did ignite when discharged from residential sprinklers and exposed to a 1.4 MW fire. This type if testing was repeated with spray sprinklers. 1.4 MW was judged to be a reasonable worst case residential fire to which a sprinkler might be exposed. However, spray sprinklers are installed in industrial and storage applications where they are likely to experience larger fires at activation. When a 50% solution of glycerine was exposed to a 3 MW fire, ignition of the sprinkler discharge occurred. The rapid, large-scale combustion of the sprinkler spray could over-pressurise the space. Larger k-factor sprinklers

[1] Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:EN:PDF

[2] Antifreeze solutions supplied through spray sprinklers
http://www.nfpa.org/assets/files/Research%20Foundation/RFAntifreezeSolutionsThroughSpraySprinklersFinal.pdf

discharge more anti-freeze solution so the resulting fire from the sprinkler spray can be larger. The testing also showed that the potential for the sprinkler spray to ignite generally increased with inlet pressure to the sprinkler. At higher pressures the average droplet size in the discharge spray is smaller and the total surface area of the anti-freeze solution is larger.

Results from the residential sprinkler tests showed that a 50% glycerine solution has a similar ignition propensity to a 40% solution of propylene glycol.

The results of this research were used to update the relevant NFPA standards. The European sprinkler system design, installation and maintenance standard, EN 12845, has not yet been updated to reflect this new knowledge about the safe limits of anti-freeze concentration.

New Residential Sprinkler Systems (NFPA 13D and 13R)

Given that a 50% concentration of glycerine and 40% concentration of propylene glycol do not lead to ignition from a 1.4 MW fire, which is as large a fire as a domestic sprinkler system is likely to experience, NFPA 13D now permits anti-freeze concentrations to 48% glycerine and 38% propylene glycol in new domestic sprinkler systems, where acceptable to the authority having jurisdiction (AHJ). The solutions must be factory pre-mixed. Other anti-freeze solutions may be used if they are listed. At present factory pre-mix solutions and listed anti-freeze solutions are not available so anti-freeze cannot be used in new domestic sprinkler systems in the United States. NFPA 13R only permits listed anti-freeze solutions.

Existing Residential Sprinkler Systems (NFPA 13D and 13R)

If the anti-freeze concentration in an existing residential sprinkler system is above 50% glycerine or 40% propylene glycol it must be replaced. NFPA 13D allows existing domestic sprinkler systems to use anti-freeze at up to 50% glycerine or 40% propylene glycol. Existing residential sprinkler systems with concentrations up to 38% glycerine or 30% propylene glycol are permitted providing the concentration is verified using samples from two locations. Existing residential sprinkler systems with concentrations above 38% glycerine or 30% propylene glycol (but no higher than 50% and 40% respectively) are permitted based upon a deterministic risk assessment conducted by someone approved by the AHJ. This assessment is expected to use the research results and other factors identified in NFPA 25. By 2022 the anti-freeze solution must be replaced with a listed anti-freeze solution.

Residential Sprinkler Systems (European guidance)

CEN is drafting a standard for residential and domestic sprinkler systems. It will include guidance on the use of anti-freeze. Meanwhile VdS has published a design guideline for residential sprinkler systems, VdS 2896. It does not permit the use of anti-freeze.

Commercial/Industrial Sprinkler Systems (NFPA 13)

New systems must use an anti-freeze that is non-ignitable. NFPA 13 also allows glycerine to 48% and propylene glycol to 38% in new, non-residential sprinkler systems. However, it

must be factory pre-mixed and listed. Since listed, factory pre-mix solutions are not available anti-freeze cannot generally be used today in new commercial or industrial sprinkler systems in the United States.

Commercial/Industrial Sprinkler Systems (VdS)

In Germany, VdS permits the use of pre-mixed propylene glycol anti-freeze solutions to a general temperature limit of -20°C (at 38% concentration) and under additional conditions to -30°C. A solution of propylene glycol is not as good as water for extinguishing fire. For this reason EN 12845 and VdS limit the volume of propylene glycol solution in the sprinkler system by imposing a limit of 20 sprinklers for sections of the system filled with a propylene glycol solution and a further limit of 100 sprinklers for all the anti-freeze sections. Furthermore, for propylene glycol anti-freeze solutions, VdS requires pure water to be discharged from the most remote sprinkler within four minutes, or within one minute for temperatures below -20°C.

For sodium-chloride anti-freeze solutions down to -20°C, VdS does not limit the size of the system to 100 sprinklers, nor is there a maximum time until pure water is discharged from the most remote sprinkler. A limit of four minutes until pure water is discharged from the most remote sprinkler only applies for temperatures below -20°C.

The anti-freeze solution has a higher viscosity than pure water and it is important to make the hydraulic calculations using the solution viscosity at the lowest system operating temperature. Measures, such as an expansion tank, must be taken to prevent excessive system pressures due to expansion on the anti-freeze. Each year a sample of the solution must be tested by the pre-mix manufacturer. The feed of make-up solution into the system should be downstream of the alarm valve to minimise losses and the risk of contamination of the water supply. In Germany, sprinkler systems using anti-freeze may not be connected to the mains; in other European countries this is allowed with enhanced backflow prevention.

VdS only permits the use of approved anti-freeze agents. The complete approval and test procedure is given in VdS 2369en.

VdS prohibits the use of galvanised pipe and components in anti-freeze systems. Foam concentrate or other additives must also not be used. The manufacturer must supply a list of common materials that are compatible with the anti-freeze. In particular an installer using CPVC should ensure that the anti-freeze is compatible with this material.

Existing Commercial/Industrial Sprinkler Systems (NFPA 13)

If the anti-freeze concentration in an existing commercial or industrial sprinkler system is above 50% glycerine or 40% propylene glycol it must be replaced. Existing sprinkler systems with concentrations up to 38% glycerine or 30% propylene glycol are permitted providing the concentration is verified using samples from two locations. Existing commercial or industrial sprinkler systems with concentrations above 38% glycerine or 30% propylene glycol (but no higher than 50% and 40% respectively) are permitted based upon an approved deterministic risk assessment. This assessment is expected to use the research results and other factors

identified in NFPA 25. By 2022 the anti-freeze solution must be replaced with a listed anti-freeze solution.

Other Options

There are a number of alternative to anti-freeze:

- Dry pipe systems
- Insulation
- Trace heating of the pipe
- Dry sprinklers
- Pre-action systems

The Future (NFPA 13)

It is likely that listed anti-freeze solutions for sprinkler systems will become available. However, NFPA 25 requires the listed solution in a sprinkler system to be tested annually at two locations for its concentration, a time-consuming and potentially costly process. New, less dangerous forms of anti-freeze may be developed but this will not be straightforward. Salt solutions have been tried in the past but they caused corrosion and leaks. They are being tried again in Germany, with additional measures to prevent corrosion. Meanwhile dry pipe systems will continue to be popular in Europe, although they are not without problems, exhibiting faster corrosion than wet pipe systems and with the risk of an ice plug if any water from the initial hydrostatic test is not fully drained.