SUPDET 2019

Antifreeze Solutions in Fire Sprinkler Systems

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Overview of Topics

• History of Antifreeze and NFPA Standards

• Antifreeze Evaluation Requirements

• Current Listing and Limitations
Fire and Explosion in an Apartment Complex Protected by a NFPA 13 Sprinkler System

General Details of Fire Occurrence

- Fire and explosion occurred in the first floor apartment of a 12-unit complex on August 2009.
- Sprinkler system was supplied with glycerin antifreeze.
- Fire involving a skillet containing cooking oil and onions originated on the range top.
Antifreeze in Sprinkler Systems

Background on the Use of Antifreeze in Sprinkler Systems

➢ Most common antifreeze solutions historically used were propylene glycol and glycerin which were referenced in NFPA 13 since at least the 1952 edition of the standard.

➢ Maximum concentration permitted for the glycerin solution was a 70%/30% mix and for propylene glycol it was a 60%/40% mix.
Antifreeze in Sprinkler Systems

Fire Test Parameters

• Test Configuration: Residential Sprinkler Discharging onto Fire Source

• Liquid Discharged: 60% PG/40% Water Mixture

• Fire Source: 6 in. (15 cm) Wide by 8 ft. (2.4 m) Long Pan of Heptane

• Sprinkler Type: Nominal K=3.1 Residential

• Sprinkler Pressure: 10 - 80 psig (69 – 552 kPa)

• Nominal HRR of Fire: 500 kW

• Sprinkler to Pan Distance: 5 ft. (1.5 m)
Antifreeze in Sprinkler Systems

Fire Protection Research Foundation

Antifreeze Solutions in Home Fire Sprinkler Systems Phase II

Test A1 - 6" Wide Heptane Pan
K3.1 Sprinkler
60% Propylene Glycol Antifreeze Solution
Historical Timeline

- **May 2010**: UL issues Research Report
- **June**: UL sponsored research initiated
- **July**: FPRF initiates Research on residential sprinklers
- **Aug**: FPRF research testing on residential sprinklers conducted at UL
- **Dec**: Interim FPRF Report Issued
- **March 2011**: NFPA issues 1st public notice
- **Aug 2010**: TIAs for NFPA 13, 13D, 13R banning glycerin & PG in new residential installations become effective
- **Aug 2011**: Interim FPRF Report Issued
- **March 2012**: New TIAs for NFPA 13, 13D, 13R and 25 permitting limited antifreeze concentrations become effective
- **Aug 25, 2010**: New TIAs for NFPA 13, 13D, 13R and 25 permitting limited antifreeze concentrations become effective
- **March 21, 2011**: FPRF research on spray sprinklers conducted at UL

The timeline shows the progression of research and regulatory changes related to residential sprinkler systems, including the issuance of reports and the implementation of new regulations.
Status of Requirements in NFPA Standards

NFPA 13
- New systems are required to use listed antifreeze solutions.
- Exception for ESFR sprinklers for use a premixed propylene glycol solution or a specific application

NFPA 13R
- New systems are required to use listed antifreeze solutions.

NFPA 13D
- New systems are generally required to use listed antifreeze solutions except as noted below.
- New systems are permitted to use up to 38% premixed propylene glycol or 48% premixed glycerin in a limited portion of the building if the AHJ determines that no other option can be used (See 9.2.2.2).
- Existing systems are limited to 40% propylene glycol and 50% glycerin.
Status of Requirements in NFPA Standards

NFPA 25 (Existing Systems for NFPA 13 & 13R Installations)

1. Systems installed prior to September 12, 2012 are limited to 40% propylene glycol and 50% glycerin.

2. Systems having greater than 30% propylene glycol and 38% glycerin are required to have a deterministic risk assessment prepared by a qualified person approved by the AHJ to justify the use at the higher concentrations.

3. Listed antifreeze solutions are required after September 30, 2022.
350 lb. (159 kg) Wood Crib Testing

00:30 prior to sprinkler discharge
Comparison Data – Traditional Antifreeze vs. Water
350 lb. (159 kg) Wood Crib Fire

Test Time (minutes)

Ceiling Temperature (Deg. F)

Control Temperature
30% Propylene Glycol 70% Water
38% Glycerin 62% Water
Water

Transitioned to water
UL – Development of Requirements

Standards Development Organization
- Manage standards
- ANSI Accredited

Certification Organization
- Independent Third Party
- Ensure public safety remains a focus with standards development and maintenance
- ANSI Accredited
UL 2901

Outline of Investigation for Antifreeze Solutions for Use in Fire Sprinkler Systems

1.1 This Outline of Investigation covers requirements for the performance of antifreeze solutions for fire sprinkler systems.

1.2 These solutions are intended for use in wet pipe sprinkler systems subject to freezing for installation in accordance with the manufacturer’s design and installation instructions and the Standard for Installation of Automatic Sprinkler Systems, NFPA 13; and inspected, tested and maintained in accordance with the Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems, NFPA 25.
UL 2901 – Antifreeze Solutions

Issue 2: Nov. 15, 2018 – (Issue 1 published in Dec. 2013)

Summary
1. Solution Characterization & Stability of Solutions
2. Conductivity
3. Material Compatibility Testing
4. Toxicity
5. Fire Performance
6. Manufacturing and Production Control
7. Installation Instructions
**UL 2901 - Characterization Tests**

Conducted on As-Received Sample:

<table>
<thead>
<tr>
<th>Test description</th>
<th>Test standard reference</th>
<th>Antifreeze samples</th>
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</thead>
<tbody>
<tr>
<td>Pour Point</td>
<td>ASTM D97, Standard Test Method for Pour Point of Petroleum Products</td>
<td>Each Formulation, each concentration</td>
</tr>
<tr>
<td>Viscosity</td>
<td>ASTM D2983, Standard Test Method for Low-Temperature Viscosity of Lubricants Measured by Brookfield Viscometer or NFPA 18A for ultra low viscosity ranges</td>
<td>Each Formulation, most concentrated</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>ASTM D1429, Standard Test Methods for Specific Gravity of Water and Brine</td>
<td>Each Formulation, each concentration</td>
</tr>
<tr>
<td>pH</td>
<td>ASTM D1293, Standard Test Methods for pH of Water</td>
<td>Each Formulation, most concentrated</td>
</tr>
</tbody>
</table>
UL 2901 – Stability Tests

High Ambient Temperature Stability
• Conditioned for 90 days @ 150°F (70°C)

Temperature Cycling Stability
• 40 cycles between manufacturers temperature use limitations
  • Max temp at least 150°F (66°C)

Characterization tests conducted post conditioning
• Assessed for amount of change from “As Received” Sample
UL 2901 – Electrical Conductivity

Electrical Conductivity ≤ 2200 µSiemens/cm²

• ASTM D1125 – Standard Test Methods for Electrical Conductivity and Resistivity of Water

Early Research Included Discharge Over Mock Kitchen

• Showed increased leakage current with higher conductivity
UL 2901 – Electrical Conductivity

Solution discharged onto representative energized equipment
UL 2901 – Electrical Conductivity

Conductivity Review of Water Provided by Public Water Supplies
• Some higher levels in certain areas, Southwestern US

UL Research - Electrical Shock Hazard Assessment
• Research on water with varying conductivity levels
• Impact on skin resistivity

Conclusion: Increase Conductivity Limit to 7000 µSiemens/cm²
UL 2901 – Corrosion Rate

Solution Tested at Minimum and Maximum Concentrations
• No corrosion in excess of 1.0 mils/year for the following:
  • ASTM A108, Grade 1010 steel;
  • ASTM B16, H02 (Half Hard) brass;
  • Type 304 stainless steel; and
  • Additional representative metallic materials and platings

Test coupons exposed to the solution
• Method and corrosion rate according to NFPA 18A
UL 2901 – Pit Depth Corrosion

Solution Tested at Minimum and Maximum Concentrations According to ASTM G31 – Standard Guide for Laboratory Immersion Corrosion Testing of Metals

- ASTM A108, Grade 1010 steel;
- ASTM B16, H02 (Half Hard) brass;
- Type 304 stainless steel; and
- Additional representative metallic materials and platings

Test coupons exposed to the solution

- Shall not cause pit corrosion depth in excess of a C-1 rating according to ASTM G46 - Standard Practice for Examination of Pitting Corrosion
UL 2901 – Stress Corrosion

Solution at Minimum and Maximum Concentrations
U-Bend Stress-Corrosion Test Specimens (ASTM G30)

- Steel (ASTM A108, Grade 1010), Brass (ASTM B16, H02), Stainless Steel (Type 304)
- Additional representative metallic materials

Test coupons exposed to the solution for 30 days @ 120°F (49°C)

- Shall not cause stress cracking – viewed at 25X with magnifying instrument
UL 2901 – Impact of Galvanic Action


- ASTM A108, Grade 1010 steel;
- ASTM B16, H02 (Half Hard) brass;
- Type 304 stainless steel; and
- Additional representative metallic materials and platings

Immerse combinations of metals in solution at 70°F (21°C) and measure voltage with potentiometer

- Compared to combinations in solution with conductivity of 1000 µSiemens/cm²
UL 2901 – Exposure to Elastomeric Materials

Solution Tested at Maximum Concentration for 30 days @ 150°F (66°C) according to UL 157 – Standard for Gaskets and Seals

- Natural Rubber;
- EPDM;
- BUNA-N;
- Styrene Butadiene Rubber (SBR); and
- Additional representative elastomeric materials referenced in the manufacturer’s instructions

Requirements
- At least 60% of original tensile strength and elongation
- Volume change not more than -1% to +25%
- Maximum loss of weight of 10%
UL 2901 – Compatibility with Polymeric Materials

Polymeric Materials Indicated in Manufacturer’s Instructions

CPVC and PEX Piping Pressurized for 1000 hours with Solution
• Per UL 1821 – Standard for Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service

Tensile Strength Specimens
• Immersed in solution for 30, 60, and 90 days at 189°F (87°C)
  ➢ Shall not reduce tensile strength more than 30%
Coatings with a Scribed X Immersed in Solution Tested at Maximum Concentration for 90 days @ 150°F (66°C)

- Representative coatings referenced in the manufacturer’s instructions

Requirements

- No Disbondment
- No Blistering
- No Corrosion Outside Scribed Area
UL 2901 – Toxicity

Toxicological Assessment for Potential Routes of Exposure
• Dermal contact, ocular, ingestion, and inhalation

Assessment Scenarios
• Release into potable water system through backflow at 5000/1 dilution
• Release into occupied space w/ 98% of discharge having droplet sizes greater than 200 µm
• Release into occupied space w/ operation of relief valve
• Release into the natural environment
Discharge of Most Concentrated Solution Over Heptane Spray Fire

- Shall not cause a heat release rate increase greater than 40%

Test Details

- Solution discharged through standard spray pendent sprinklers w/ K-factor of 4.2 and 8.0 gpm/(psig)$^{1/2}$
- Fire source – line-burner w/ 4 spray nozzles to discharge heptane at 1.6 gpm (6.0 L/min) resulting in a fire having a nominal total heat release rate of 3,000 kW
UL 2901 – Exposure to Fire (Contribution)

Figure 17.1
Diagram of Heptane Spray Burner Assembly

Plan View

- 2 ft. (610 mm) on center (typical)
- 12 in. (305 mm)
- 18 1/2 in. (400 mm)
- 37 in. (940 mm)

Front Elevation View
(not showing metal grating for clarity)

- 18 in. (457 mm)
- 24 in. (610 mm)

Side Elevation View
(showing metal grating with cinder block supports)

- 38 in. (965 mm)
UL 2901 – Exposure to Fire (Contribution)

Four Test Conditions

Table 17.1
Test Conditions

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Nominal Sprinkler K-factor gpm/(psig)^{1/2}</th>
<th>Sprinkler Elevation Above the Floor feet</th>
<th>Sprinkler Inlet Test Pressure Range psig</th>
<th>Sprinkler Inlet Test Pressure Range (kPa)</th>
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<tbody>
<tr>
<td>1</td>
<td>4.2</td>
<td>8</td>
<td>10 – 150</td>
<td>(69 – 1034)</td>
</tr>
<tr>
<td>2</td>
<td>4.2</td>
<td>20</td>
<td>10 – 150</td>
<td>(69 – 1034)</td>
</tr>
<tr>
<td>3</td>
<td>8.0</td>
<td>8</td>
<td>10 – 100</td>
<td>(69 – 690)</td>
</tr>
<tr>
<td>4</td>
<td>8.0</td>
<td>20</td>
<td>10 – 100</td>
<td>(69 – 690)</td>
</tr>
</tbody>
</table>

Sprinkler Inlet Pressure is Increased Across Designated Range

- 10 psig (6.9 kPa) increments for 10 second dwell times at each pressure
Figure 17.2
Details of Fire Exposure Test Arrangement

Nominal 25 ft. (7.6 m)
Diameter Collection Hood

Sprinkler Positions

Nominal 25 ft. (7.6 m)

20 ft. (6.1 m)

Ignition Source

6 ft. (2.4 m)
8 ft. (2.4 m)

38 in. (965 mm)

Contour of Ceiling
Exposure to Fire – 8ft Example – Free Burn
UL 2901 – Fire Fighting Effectiveness (FFE)

Residential Dwelling Units
- UL 1626 - Residential Sprinklers for Fire Protection Service
  - NFPA 13D Applications
  - NFPA 13R Dwelling Units
  - 40 gal limitation for LH, OH1, OH2, Storage

Light Hazard/OH Group 1&2
- UL 199 – Automatic Sprinklers for Fire Protection Service
  - 350 lb Wood Crib Test

Other Applications
- Storage, Attics, Combustible Concealed Spaces, etc.
- Ongoing Development
UL 2901 – FFE – Residential Dwelling Units

Based on UL 1626 – Residential Sprinklers
- Test room configured based upon rated sprinkler coverage of 16’ x 16’ (4.9 m x 4.9 m)

- In-line with FPRF Research Approach

- Four test configurations
  - Recessed residential pendent, low pressure
    - $K=4.9 \times 1.4\text{ times min rated flow } 1^{\text{st}}\text{ head, rated flow for 2 heads}$
  - Recessed residential pendent, $K=4.9 \times 100\text{ psi (690 kPa)}$
  - Recessed residential horizontal sidewall, low pressure
    - $K=4.2 \times 1.4\text{ times min rated flow } 1^{\text{st}}\text{ head, rated flow for 2 heads}$
  - Recessed residential horizontal sidewall, $K=4.2 \times 100\text{ psi (690 kPa)}$
UL 1626 - Recessed Pendent Sprinkler
UL 1626 Acceptance Criteria

A Maximum of 2 Sprinklers are Allowed to Operate

Maximum Temperatures @ Specified Locations

- Max temp 3” (76 mm) below ceiling shall not exceed 600°F (316°C)
- Max temp 5-1/4 feet (1.6 m) above floor shall not exceed 200°F (93°C)
- The temp at 5-1/4 feet (1.6 m) above the floor shall not exceed 130°F (54°C) for more than any continuous 2-minute period
- Max ceiling material temperature ¼” (6.4 mm) behind the finished ceiling surface shall not exceed 500°F (260°C)
Recessed Horizontal Side Wall Sprinkler
UL 2901 – FFE – LH/OH1/OH2

Based on UL 199 – 350 lb Wood Crib Test
• Most Concentrated Solution
• Solution First 10 min
• Followed w/ Water

Acceptance Criteria
• Weight loss of crib ≤ 20%
• Ceiling Temp Limit Control
  • Within 5 minutes
  • Duration of test
UL 2901 – Viscosity at Temperature Limitations

Each Concentration of Antifreeze is Evaluated
• Temperature ranges in the manufacturer’s instructions
• Samples conditioned for 16 hours at specified temperature

Viscosities Measured Using ASTM D2983
• Standard Test Method for Low-Temperature Viscosity of Lubricants Measured by Brookfield Viscometer.

Shall Correspond to the Manufacturer’s Published Viscosities
UL 2901 – Resistance To Leakage

Pipe Assemblies Filled and Pressurized w/ Antifreeze Solution

• Metallic assembly contains 5 nominal K=5.6 orifice sprinklers
  • Utilizes grooved couplings, grooved fittings, threaded fittings, and a shut-off valve.

• CPVC Pipe assembly w/ non-threaded gasket seals

• Pressurized for 30 days @ 350 psi (2413 kPa)
  • Checked weekly and at end of time frame for leakage
Manufacturing and Production Control

Production Control Program
• Manufacturer shall have a program in place to demonstrate ongoing compliance with UL requirements

Formulation Control
• Each batch shall be tested to verify the consistency of the formulation.
  • Active ingredients, concentration, characteristics, etc.
UL 2901 – Installation Instructions

Manufacturer is Required to Provide Installation Instructions

Some Examples of Content in the Instructions
• Materials the antifreeze is acceptable for use with
• Temperature limitations
• Antifreeze properties and characteristics
• Method for hydraulic calculations
• Safe handling procedures
• Information on verifying proper concentration in the field
UL 2901 – UL Surveillance Program

Ongoing verification of compliance with the requirements of UL 2901

Inspections
• Periodic inspections - at least quarterly
• Selection of samples for testing
• Review of batch testing of product at the manufacturing site

Testing
• Periodic testing through of samples selected during inspection at UL
UL Product iQ Database

REFINE RESULTS
Build or filter your results by keyword and/or adding criteria like document type, file number and country name.

Keyword
VDUV

UL Category Control Number
Click to view and filter values

Company Name
Click to view and filter values

File Number
Click to view and filter values

Country Name
Click to view and filter values

Add Filter
# Current Certifications

<table>
<thead>
<tr>
<th>Tyco Fire &amp; Building Products</th>
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<th>Application</th>
<th>Max Volume</th>
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<td><strong>Use Temp Range</strong></td>
<td><strong>Dsg</strong></td>
<td><strong>LFP Antifreeze</strong>*</td>
<td><strong>-10°F to 150°F (-23°C to 66°C)</strong></td>
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<td>NFPA 13R - Occupancies with Dwelling Units Only</td>
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<td>NFPA 13R - Mixed Use Occupancies</td>
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<td>NFPA 13 - Light Hazard</td>
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<td>NFPA 13 - Ordinary Hazard Groups 1 &amp; 2</td>
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<td>NFPA 13 - Storage</td>
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</tr>
<tr>
<td>40 gal</td>
<td>40 gal</td>
<td>40 gal</td>
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</table>

*The antifreeze solution is intended to be installed in accordance with the manufacturer's instructions.*
Antifreeze Next Steps

New Submittals
• Continued Activity and Interest From Manufacturers

Transition to ANSI Standard
• Formed STP and Passed Ballot
• Currently Pending Publication
Thank You

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