Fire Sprinkler International 2022 – Antifreeze Solutions in Fire Sprinkler Systems

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Presenter

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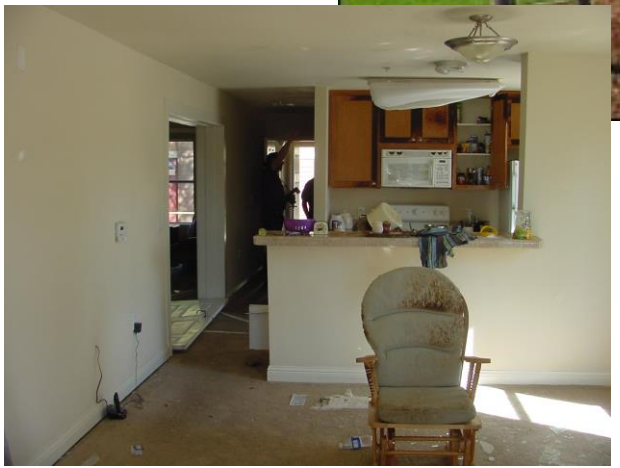
Overview of Topics

- History of antifreeze and NFPA standards
- Legacy solution research
- Recent UL research
- Current listing requirements 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 in 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.

Legacy Solution Research

- Fire test data summary for residential sprinklers discharging antifreeze mixtures, Underwriters Laboratories Inc., May 26, 2010
- Antifreeze Systems in Home Fire Sprinkler Systems — Literature Review and Research Plan, Fire Protection Research Foundation, June 2010.
- Antifreeze Systems in Home Fire Sprinkler Systems — Phase II Final Report, Fire Protection Research Foundation, December 2010.
- Antifreeze Solutions Supplied through Spray Sprinklers — Final Report, Fire Protection Research Foundation, November 2012.

Legacy Solution Research

Scope (see A.5.3.4.4.1(2) of NFPA 25 for summary)

- **Potential for ignition and substantial contribution to fire of origin**
  - Residential sprinklers (small flammable liquid and cooking oil fires)
  - Residential sprinklers (nominal 1.4 MW exposure)
  - Spray sprinklers (nominal 3.0 MW exposure)
  - *No tests with <50% glycerin and <40% propylene glycol*

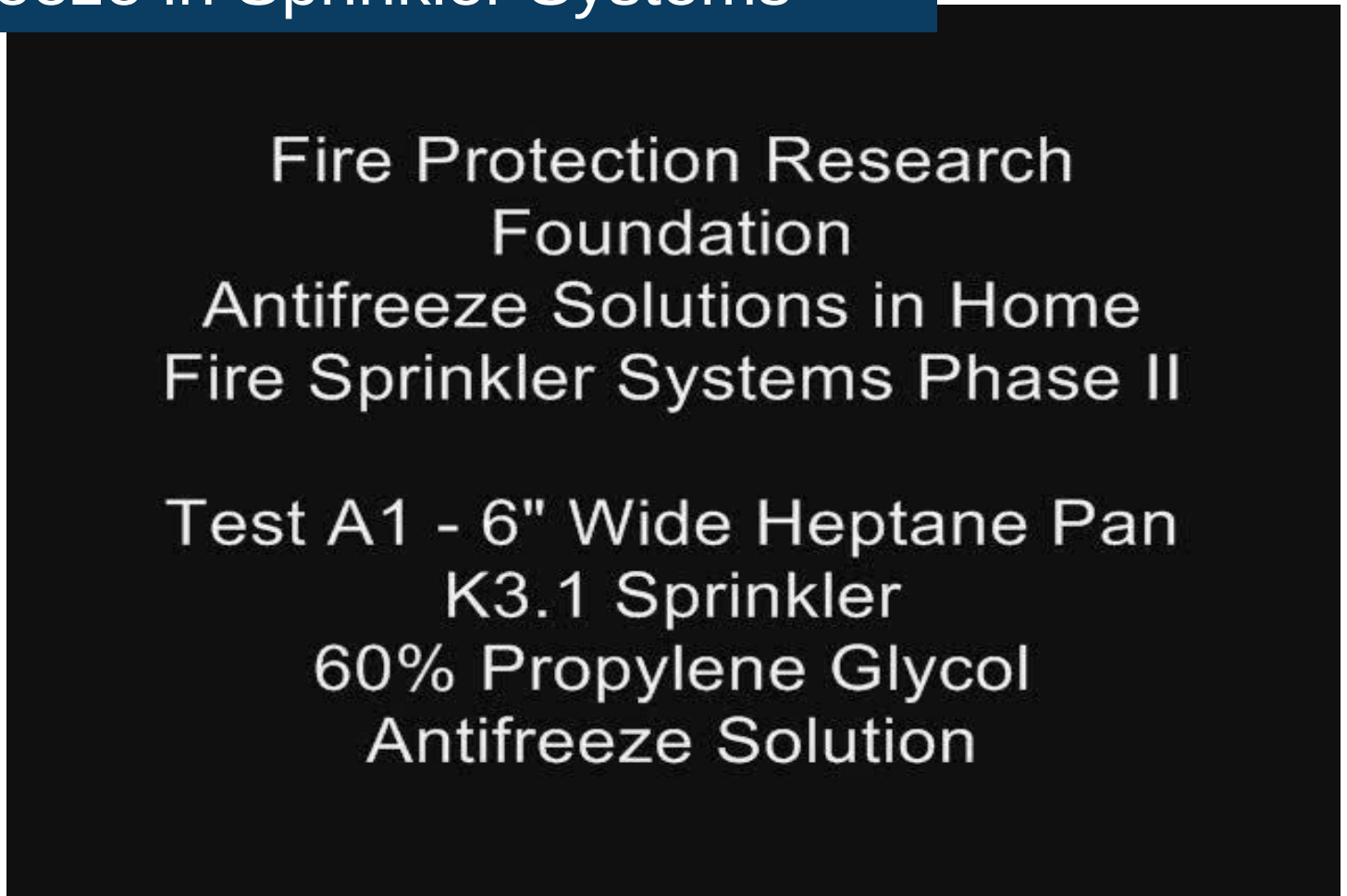
- **Firefighting effectiveness**
  - Residential sprinklers (20 tests using actual furniture and simulated furniture arrangements)
  - *No tests conducted with spray sprinklers for light or ordinary occupancy applications*

Legacy Solution Research – Antifreeze Ignition

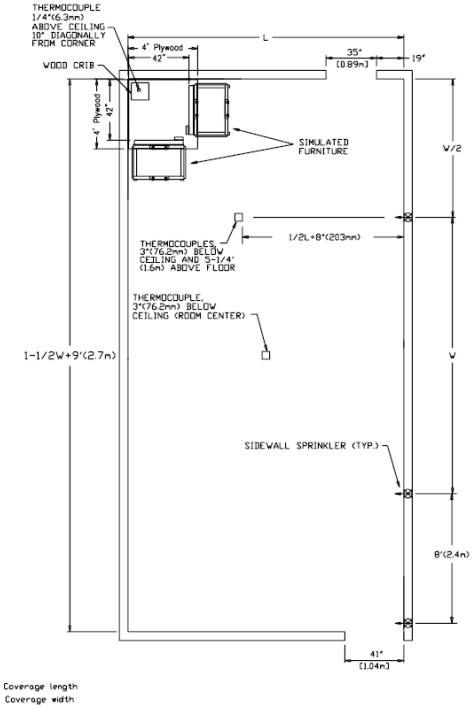
Fire test parameters

- **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 (44) Residential
- **Sprinkler Pressure:** 10 - 80 psig (69 – 550 kPa)
- **Nominal HRR of Fire:** 500 kW
- **Sprinkler to Pan Distance:** 5 ft. (1.5 m)

Antifreeze in Sprinkler Systems



Legacy Research – Residential Fire Tests



Scope – A total 20 firefighting effectiveness tests using 50 percent glycerin, 40 percent propylene glycol and water

Results – Both 50% glycerin and 40% propylene glycol results were comparable to water

UL 2901 – Antifreeze Solutions

Test	UL Acceptance Criteria Listed Antifreeze Solutions	Test Details	Test Results			
			38% Glycerin	50% Glycerin	30% Propylene Glycol	40% Propylene Glycol
Fire Fighting Effectiveness - Residential Dwelling Units	Temperature acceptance criteria and not more than 2 operated sprinklers	Test 1 – Nominal K=4.9 (70) Pendent Residential Sprinkler, Low Flow	Compliant based upon 50% test results	Compliant	Compliant based upon 40% test results	Compliant
		Test 2 – Nominal K=4.9 (70) Pendent Residential Sprinkler, 100 psig (690 kPa)	Compliant based upon 50% test results	Compliant at 80 and 150 psig (550 and 1030 kPa)	Not Tested - Assumed Compliant based upon glycerin test results	Not Tested - Assumed Compliant based upon glycerin test results
		Test 3 – Nominal K=4.2 (60) Sidewall Residential Sprinkler, Low Flow	Compliant based upon 50% test results	Compliant	Not Tested - Assumed Compliant based upon glycerin test results	Not Tested - Assumed Compliant based upon glycerin test results
		Test 4 – Nominal K=4.2 (60) Sidewall Residential Sprinkler, 100 psig (690 kPa)	Compliant based upon 50% test results	Compliant at 80 and 150 psig (550 and 1030 kPa)	Not Tested - Assumed Compliant based upon glycerin test results	Not Tested - Assumed Compliant based upon glycerin test results

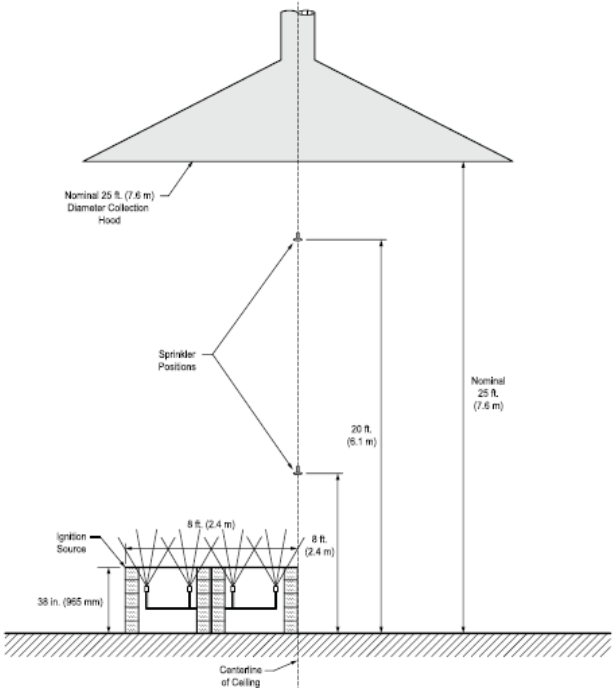
ANSI/CAN/UL 2901 – Antifreeze Solutions

Summary

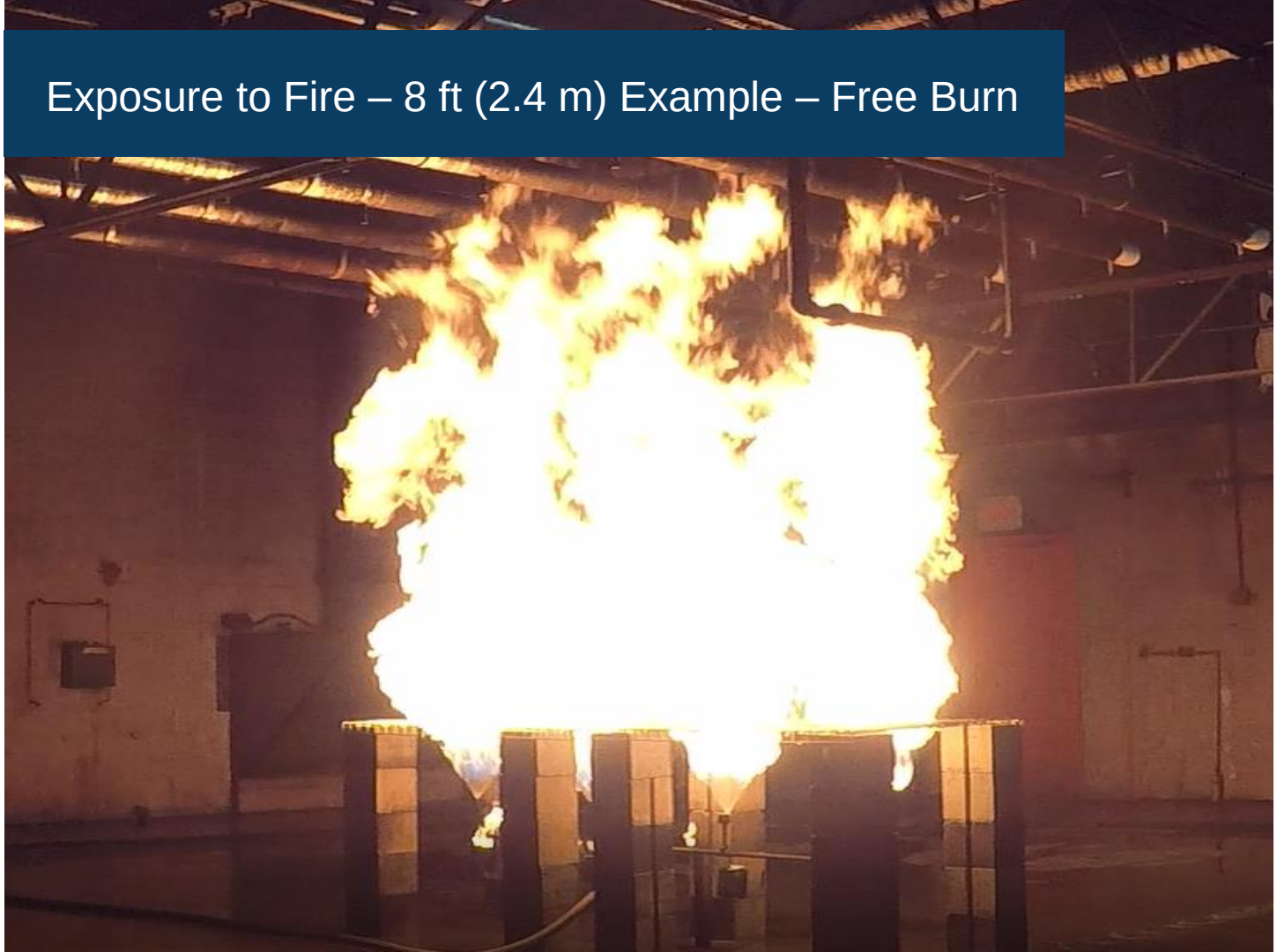
1. Solution characteristics & stability
2. Conductivity and galvanic action potential
3. Material compatibility testing
4. Toxicity
5. Fire performance
   - **Exposure to fire**
   - **Firefighting effectiveness**
6. Resistance to leakage
7. Manufacturing and production control
8. Installation instructions

UL 2901 – Exposure to Fire (Contribution)

Figure 17.2
Details of Fire Exposure Test Arrangement



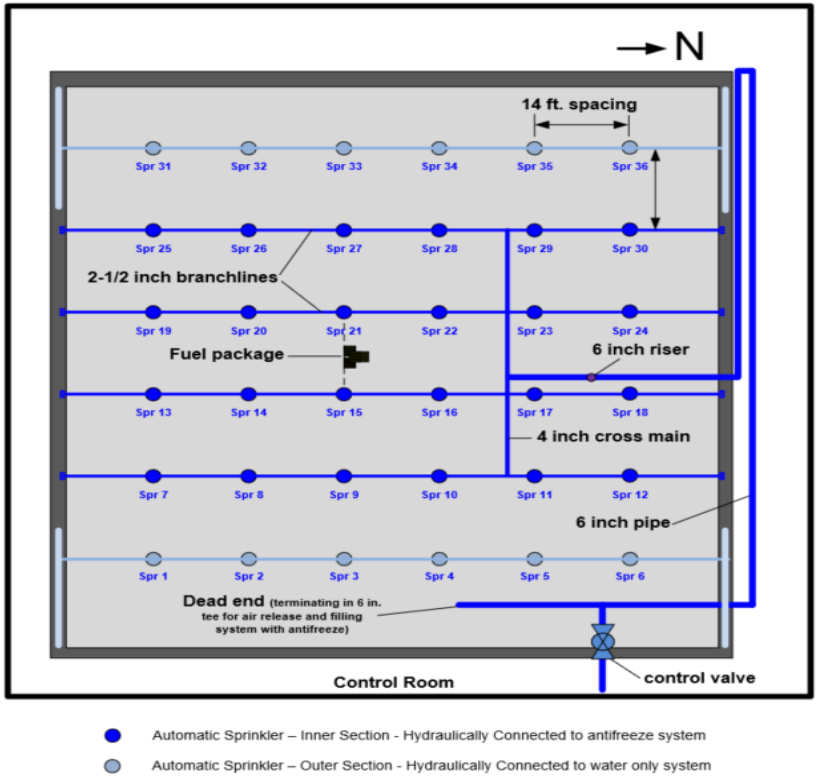
Exposure to Fire – 8 ft (2.4 m) Example – Free Burn



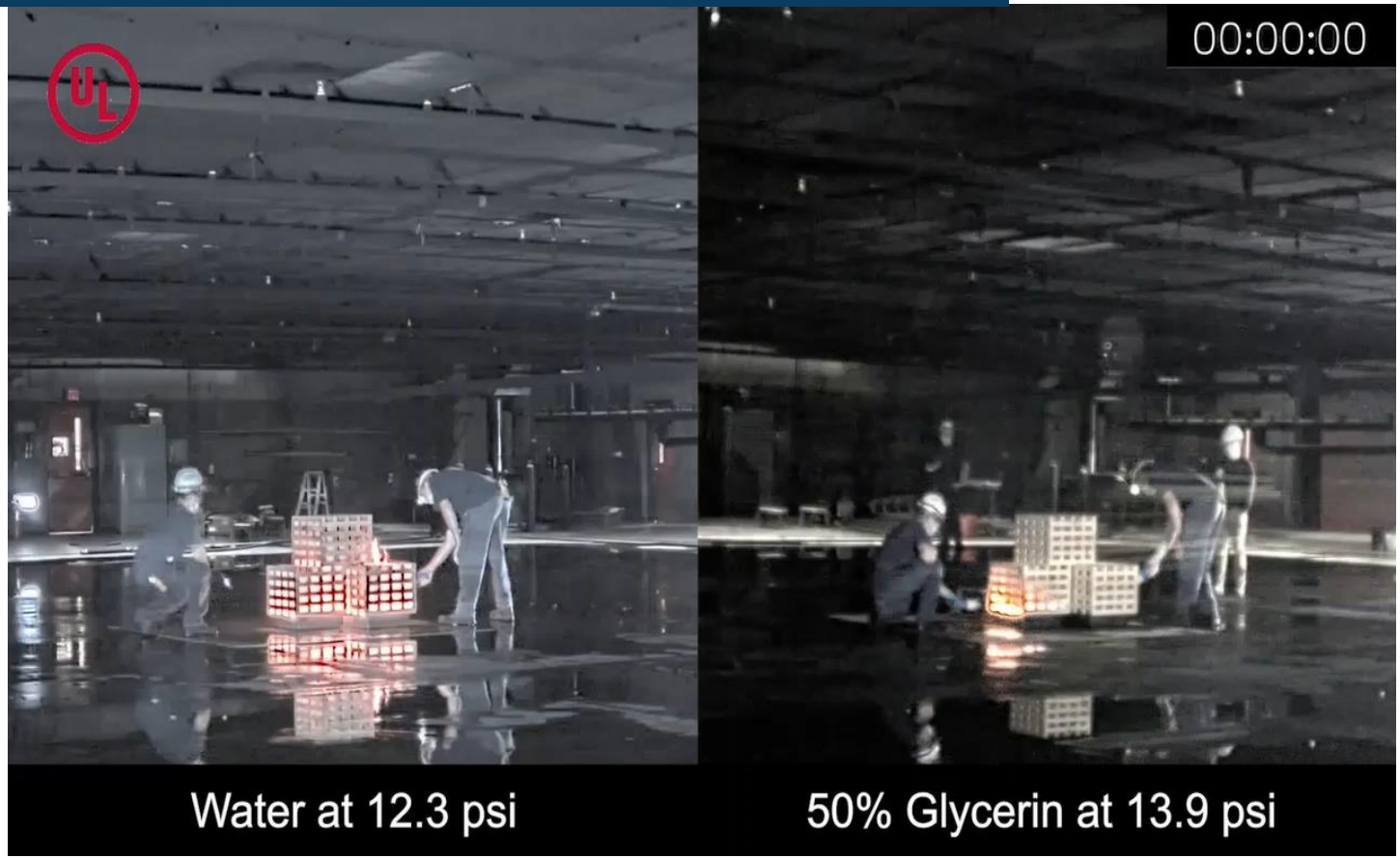
UL 2901 – Exposure to Fire

UL Acceptance Criteria Listed Antifreeze Solutions	Test Details	Test Results			
		38% Glycerin	50% Glycerin	30% Propylene Glycol	40% Propylene Glycol
Not more than a 40 percent increase above the maximum running 15 s average total heat release rate for the nominal 3,000 kW base fire	Test 1 – Nominal K=4.2 (60) SSP, 8 ft (2.4 m) ceiling	Compliant – 24.0% increase	Noncompliant- 84.1 % increase	Compliant - 18.4% increase	Not tested – Assumed Noncompliant based upon 50% glycerin test results
	Test 2 – Nominal K=4.2 (60) SSP, 20 ft (6.1 m) ceiling	Compliant - 26.9% increase	Noncompliant- >230%* increase	Compliant - 8.5% increase	Not tested – Assumed Noncompliant based upon 50% glycerin test results
	Test 3 – Nominal K=8 (115) SSP, 8 ft (2.4 m) ceiling	Compliant - 24.1% increase	Compliant- 28.6 % increase	Compliant - 12.9% increase	Not tested – Assumed Compliant based upon 50% glycerin test results
	Test 4 – Nominal K=8 (115) SSP, 20 ft (6.1 m) ceiling	Compliant - 13.7% increase	Noncompliant - >230%* increase	Compliant - 13.8% increase	Not tested – Assumed Noncompliant based upon 50% glycerin test results

Recent UL Research – Light Hazard Occupancy



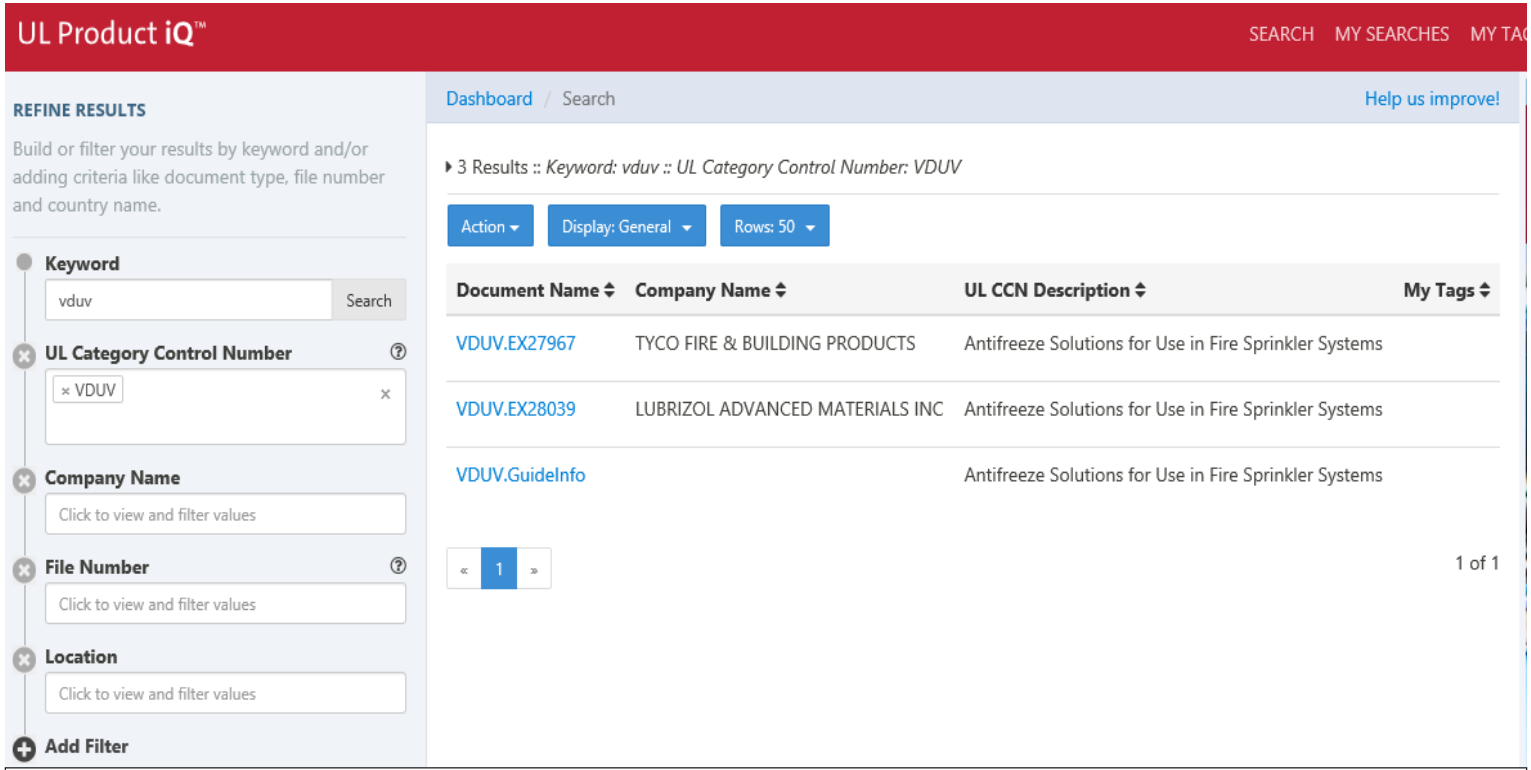
Video Comparison of Water and 50% Glycerin



UL 2901 – Light Hazard Testing Results

UL Acceptance Criteria Listed Antifreeze Solutions	Test Details	Test Results	
		50% Glycerin	Water
Not more than 10 operated sprinklers	Nominal K5.6 (80) SSU 14 ft. by 14 ft. (4.3 m by 4.3 m) spacing 12.3 psig (85 kPa)	Noncompliant - 12 Operated Sprinklers	Wet System - 4 Operated Sprinklers Dry System - 10 Operated Sprinklers
Not more than 4 operated sprinklers	Nominal K5.6 (80) SSU 14 ft. by 14 ft. (4.3 m by 4.3 m) spacing 24 psig (165 kPa)	Noncompliant - 7 Operated Sprinklers	Wet System - 2 Operated Sprinklers

Product iQ™ Database



https://productiq.ulprospector.com

Example limitations

Use Temp Range	Application	Max Volume of Antifreeze in Sprinkler System
-##° F to 150° F (-##° C to 66° C)	NFPA 13D [1]	≤500 gal (1893L); in accordance with NFPA 13D design criteria
	NFPA 13R – Residential Only (including corridors, garages that serve only a single dwelling unit, and compartmented Ordinary Hazard areas ≤500 ft^2) (46.5 m^2) [1] Where NFPA 13R requires the use of NFPA 13 design criteria, refer to the NFPA 13 applications and volume limitations.	≤500 gal (1893L); in accordance with NFPA 13R design criteria Where NFPA 13 design criteria is required in areas of an NFPA 13R Occupancy, such as an attic, use the applicable volume limitation for the hazard area for NFPA 13.
	NFPA 13 - Light Hazard [1]	≤200 gal (757 L); in accordance with NFPA 13 design criteria or >200 gal (757 L) to ≤500 gal (1893L); in accordance with NFPA 13 using the dry system hydraulic design criteria, where the system hydraulics are designed as a dry system even though the system is filled with antifreeze.
	NFPA 13 – Ordinary Hazard Groups 1 & 2 [1]	≤40 gal (151 L), in accordance with NFPA 13 design criteria or >40 gal (151 L) to ≤375 gal (1420 L), in accordance with NFPA 13 using the dry system hydraulic design criteria, where the system hydraulics are designed as a dry system even though the system is filled with antifreeze.
	NFPA 13 – Storage [1]	40 gal (151 L); in accordance with NFPA 13 design criteria

Requirements for Hydraulic Design

- The viscosity of the antifreeze solution at use temperatures shall be considered in the hydraulic design for all systems using antifreeze.
- Hydraulic design and pipe sizing shall be determined using both the Darcy-Weisbach and Hazen-Williams approved hydraulic calculations.
- Because of the density of antifreeze, the K-factor shall be adjusted, and the friction loss shall be considered in the system design.

Thank You

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