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Report to:
Carver Fire

Technical Opinion & Report (TO&R): ELSA Fire Protection System Used in Ignitable Liquid Applications

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1 OVERVIEW

This Technical Opinion & Report evaluates the ELSA fire suppression system in ignitable liquids applications. The ELSA system is a fire suppression system that uses cryogenic slurry of dry ice and liquid nitrogen to suppress fires caused by flammable/combustible (ignitable) liquids.

2 GENERAL

This report is prepared in accordance with IFC provisions for alternative materials and methods and evaluates equivalency with respect to life safety, property protection, fire spread, and fire department safety.

3 APPLICABLE CODES AND STANDARDS

- 2024 International Fire Code
- NFPA 13-2025 “Standard for the Installation of Sprinkler Systems”
- NFPA 30-2024 “Flammable and Combustible Liquids Code”

4 IGNITABLE FLUIDS FIRE PROBLEM

Ignitable liquids have historically been protected with AFFF (aqueous film-forming foam) water-foam suppression systems. The AFFF systems works very well to suppress ignitable liquid fires. However, AFFF contains PFAS and has been linked to health problems, and is extremely difficult and expensive to clean up after discharge.

Due to these reasons, AFFF has been banned in most developed countries. As a result, manufacturers have formulated an environmentally friendly fluorine-free foam suppression system to replace the AFFF systems. These fluorine-free systems are not nearly effective at suppressing ignitable liquid fires. End-users have been forced to replace their existing systems or decommission the systems to implement a less effective suppression system.

5 ELSA SYSTEM

5.1 General:

The ELSA system uses a mixture of two suppression agents: carbon dioxide and nitrogen. Nitrogen is stored as liquid nitrogen and solid CO_2 (dry ice) pellets are suspended in liquid nitrogen to form a cryogenic slurry (70% dry ice, 30% liquid nitrogen). The cryogenic slurry is approximately -324 °F. The liquid nitrogen keeps the dry ice pellets from fusing together. The primary extinguishment mechanism is cooling the ignitable liquid below it’s flashpoint and can no longer produce flammable vapors. A secondary mechanism is oxygen displacement.

The cryogenic slurry is discharged through hoses between 5-60 psi, depending on application, directly onto the liquid surface when activated. Upon discharge, the liquid nitrogen and dry ice mixture absorbs large amounts of heat and starts to form an ice film on the liquid surface. The slurry rapidly cools the fluid below the fluid’s flash point. The slurry is sprayed onto the liquid surface and expands approximately 800 times its volume at a temperature much colder than the surrounding air and displaces oxygen near the surfaces of the liquid slurry, effectively suppressing the fire. The dry ice and liquid nitrogen are natural substances and will eventually evaporate and leave behind no residue and relatively inexpensive cleanup.

The dry ice can reside intact after discharge, continuing to cool the liquid and displacing oxygen as it sublimes. Burnback would be highly unusual, if not impossible until the dry ice completely sublimates.

Complete coverage of the fluid surface is not completely required as the Carbon dioxide gas is heavier than air and will blanket the fuel surface limiting oxygen while the dry ice and nitrogen cool the liquid near the surrounding slurry below the flashpoint.

Wind affects are not as severe as other extinguishing systems because the cryogenic slurry is dense and is not as affected by the wind during application as much as other extinguishing fluids and gases. In addition, the dry ice is likely frozen to the fuel surface constantly cooling the liquid surface and renewing carbon dioxide gas if wind blows the carbon dioxide gas away.

Third-Party Research conducted by Rockwell and Reigelsperger at Eastern Kentucky University evaluate dry ice and gaseous CO2 as extinguishing agents on Class A and Class B fires [1]. It was determined that the primary method of extinguishment for Class B fires was determined to be the re-condensing of vaporized fuel into the liquid state (cooling).

5.2 Testing

The ELSA fire suppression system has been proven to suppress ignitable fluid fires in small -scale and real-scale testing.

5.2.1. Dry Ice Only:

- Carver Labs White Paper: A 25 ft diameter (490ft^2) pan was filled with 80 gallons of No. 2 Diesel Fuel. The #2 diesel fuel was ignited on top of a water layer. Wind speeds were between 12 and 15 miles per hour during testing. Dry Ice pellets only were deployed after 32 seconds of ignition when the entire surface of the liquid was flaming. 190 lbs of dry ice was applied in 1 minute 58 seconds, when the fire was 90% extinguished. The test met the UL 162 90% fire control limit.
- 2021 SERDP AFFF Challenge: Performed by Right Testing Labs. A seamless stainless steel cake pan was filled with tap water to a 1-inch depth. 500 ml of ethanol free gasoline was poured on the water. The pan was ignited and allowed to burn for 10 seconds to fully establish the flame pool. Dry ice pellets were poured down a ramp into the pool fire continuously for 5 to 10 seconds. The time to extinguish the fire from the start of pouring the dry ice pellets down the ramp ranged from 9.5 seconds to 19 seconds.

5.2.2. Liquid Nitrogen and Dry Ice:

- Full-Scale Diesel Fire Test-GPSTC: The test was performed at the Georgia Public Safety Training Center (GPSTC) in Forsyth, GA. A 25 ft diameter (490ft^2) pan was filled with 80 gallons of No. 2 Diesel Fuel. The #2 diesel fuel was ignited on top of a water layer. Wind speeds were less than 5 miles per hour during testing. The

ELSA system deployed a cryogenic slurry of liquid nitrogen and dry Ice pellets after 60 seconds of ignition when the entire surface of the liquid was flaming. The cryogenic slurry was discharged through a 1-inch discharge tube at 60 psi for 19 seconds delivering approximately 80 lb of dry-ice slurry. Full flame extinguishment was achieved in 19 seconds. The cryogenic slurry extinguished the fire 3 times faster using 60% less agent mass compared to prior tests using dry ice only. This proves that liquid nitrogen with dry ice slurry performs better than dry ice alone.

6 RISKS & LIMITATIONS

Introducing liquid nitrogen and dry ice inside an enclosed space will create overpressure inside any container causing structural damage and potential projectile hazards. Any container should have adequate overpressure protection.

In addition, an oxygen-deficiency hazard is created by the introduction of dry ice. In an enclosed space, the oxygen levels could reach the fatal range causing asphyxiation. The cryogenic slurry should not be introduced into an occupied space.

The cryogenic slurry should not be introduced to any space that is occupied as the cryogenic slurry can cause severe frostbite in seconds, and in extreme conditions could cause deep tissue necrosis or amputation.

7 PROFESSIONAL ENGINEERING OPINION

It is my professional opinion that the proposed ELSA system is superior to any other current fire suppression systems that are currently available to suppress ignitable liquid fires.

8 REFERENCES

[1] Scott Rockwell, Jason Reigelsperger “The Effect of Inert Gas Temperature Extinguishing Class A and B Fires”, International Symposium on Fire Investigation Science and Technology (ISFI 2014), page 561