
SUMMARY: UL FIRE TEST RESULTS INERGEN® FIRE EXTINGUISHING AGENT

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INTRODUCTION

Described in this paper are the fire extinguishment tests required by the UL interpretation and application of Underwriters Laboratories Standard 1058 as part of the listing process for clean agent fire extinguishant systems. These extinguishment tests conducted under “worst-case” conditions are conducted by fire equipment manufacturers under the direction and supervision of Underwriters Laboratories Incorporated (UL).

INERGEN extinguishing agent has passed all required fire tests including Class A and B fire extinguishment, nozzle area coverage, height coverage, hardware component and agent flow.

This paper summarizes these fire extinguishment testing requirements and reports the listing results for INERGEN fire extinguishing agent and suppression systems hardware (EX-4510).

BACKGROUND

Underwriters Laboratories (UL) Standard 1058, Halogenated Agent Extinguishing System Units contains the basic requirements for the construction and operation of halogenated agent fire extinguishing systems and automatic extinguisher units intended to be used in accordance with NFPA 12A Standard for Halon 1301 Fire Extinguishing Systems. UL-1058 covers component evaluation, system performance and fire extinguishment tests; and is currently being modified for use in evaluating both in-Kind and not in-Kind replacements for Halon 1301. Required fire extinguishment tests include nozzle area coverage, height coverage, Class A fires (wood crib), Class B fires (n-heptane), hardware components and agent flow.

EXTINGUISHMENT TESTS: CLASS A FIRES

Wood crib fire tests were conducted in a 10' x 10' x 12' high 1200 ft.³ (3 x 3 x 3.7 m – 4 m³) draft-free room provided with a means of observing the wood crib during the test. Adjustable vents on opposite walls near the floor and ceiling provided adequate ventilation during the fire's preburn. Three oxygen probes were located at the base, midsection and top side of the test enclosure to measure oxygen levels within the test enclosures. The oxygen level inside the test enclosure

was maintained at not less than 20% prior to initiation of the system discharge. The system piping arrangement provided the design minimum nozzle pressure. The test cylinder(s) were conditioned at 70 °F (21 °C) for 16 hours prior to the test. The tests were conducted at agent concentrations equal to extinguishing concentrations; hence agent concentrations did not include the 20% safety factor required by the NFPA. Discharge times, extinguishment times, and nozzle pressure were monitored and recorded.

Wood cribs consisted of four layers of six, trade size 2” x 2” x 18” long (5.1 x 5.1 x 45.7 cm) kiln-dried spruce or fir lumber having a moisture content between 9% and 13%. Alternate layers consisted of wood members placed at right angles to each other and the individual wood members were evenly spaced to form a square. Wood members were either stapled or nailed together.

Ignition of the wood crib was achieved by burning 1/4 gallon (.95 L) of commercial grade n-heptane in a square steel pan measuring 2.5 ft.² (.23 m²) in area; the crib was centered 12 inches (30.5 cm) above the top of the pan. The n-heptane was ignited and the wood crib exposed to the fuel fire for 3 to 3.5 minutes. The crib was then allowed to burn for an additional 2.5 to 3 minutes resulting in a total preburn of 6 minutes. The crib was then placed on a test stand, approximately 20 to 23 inches (50.8 – 58.4 cm) above the floor and positioned in the center of the enclosure. The enclosure was then sealed, ventilation equipment shut down, and the system discharge initiated. A soak period of 10 minutes from the end of system discharge was allowed before opening the test enclosure. The crib was then removed from the enclosure and observed. No combustion or re-ignition of the burned wood crib or free burning embers were permitted.

EXTINGUISHMENT TESTS: CLASS B FIRES

Class B fire extinguishment tests were conducted in a draft-free room measuring 10' x 10' x 12' high 1200 ft.³ (3 x 3 x 3.7 m – 4 m³), equipped with a means for observing the fire during the test. Adjustable vents were provided on opposite walls near the floor and ceiling to maintain adequate ventilation during the fire's preburn. Three oxygen probes were located at the base, midsection and top side of the test enclosure to

measure oxygen levels within the test enclosure. The oxygen level inside the test enclosure was maintained at not less than 20% prior to initiation of the system discharge. The system piping arrangement provided the design minimum nozzle pressure. The test cylinder(s) were conditioned at 70 °F (21 °C) for 16 hours prior to the test. Tests were performed with the agent concentrations equal to extinguishing concentrations; hence agent concentrations did not include the 20% safety factor required by the NFPA. Discharge and extinguishment times, and nozzle pressure were monitored and recorded.

The fuel source was contained in a 2.5 ft.² (.23 m²) steel pan, 6 inches deep located in the center of the enclosure. The test fuel was n-heptane. The test fuel consisted of a minimum 2 inch (5.1 cm) layer of the commercial grade fuel located 2 inches below the top edge of the pan (corresponding to 2 inches of free-board). The fuel was ignited and allowed a preburn of 30 seconds. The enclosure was then sealed, ventilation equipment shut down, and the system discharge initiated. The fire must be extinguished within 30 seconds after the end of the system discharge.

AREA COVERAGE TESTS

The test enclosure size is chosen by the manufacturer at the limits to be placed in the design manual. For INERGEN agent, the test enclosure consisted of a 32' x 32' x 8" high 683 ft.³ (9.8 x 9.8 x .2 cm – 19.3 m³) structure of commercial grade 3/8 inch plywood. Tests were performed using total flooding nozzles under conditions of minimum temperature and pressure. The test cylinder(s) were conditioned at the design minimum temperature for 16 hours prior to the test. The tests are conducted at agent concentrations equal to extinguishing concentrations. Agent concentrations do not include the 20% safety factor required by the NFPA.

Five three-inch diameter cans are used; each is at least 4 inches high (10.2 cm) filled with n-heptane to within 2 inches (5.1 cm) of the top edge are utilized. The cans are placed within 2 inches of the corners of the test enclosure and directly behind a baffle installed between the floor and ceiling in the center of the enclosure. The baffle is perpendicular to the direction of nozzle discharge and is 20% of the length or width of the enclosure. The n-heptane is ignited and allowed a 30 second preburn, after which the system discharge initiated. All five fires must be extinguished within 30 seconds from the end of system discharge.

HEIGHT COVERAGE TESTS

The test enclosure height is chosen by the manufacturer at the limits to be placed in the design manual.

For INERGEN agent, the height coverage tests were conducted in a draft-free room measuring 10' x 10' x 12' (3 x 3 x 3.7 m) equipped with a means for observing the fire during the test. Adjustable vents are provided on opposite walls near the floor and ceiling to maintain adequate ventilation during the fire's preburn. Three oxygen probes were located at the base, midsection and top side of the test enclosure to measure oxygen levels within the test enclosure. The oxygen level inside the test enclosure was maintained at not less than 20% prior to initiation of the system discharge. Tests were performed under conditions of minimum temperature and pressure. The test cylinder(s) were conditioned at the design minimum temperature for 16 hours prior to the test. The tests were conducted at agent concentrations equal to extinguishing concentrations; hence agent concentrations did not include the 20% safety factor required by the NFPA. Discharge and extinguishment times, and nozzle pressure were also monitored and recorded.

Four three-inch diameter cans (at least 4 inches (10.2 cm) high, filled with n-heptane to within 2 inches (5.1 cm) of the top edge of the can) are placed on the floor of the enclosure within 2 inches of the corners of the test enclosure. Four three-inch diameter cans filled with n-heptane are also located within 2 inches of the corners at a height of approximately 12 inches (30.5 cm) below the ceiling of the enclosure. The n-heptane is ignited and allowed a 30 second preburn after which the enclosure is sealed and the system discharge activated. All eight fires must be extinguished within 30 seconds of the end of system discharge.

Fire extinguishment tests currently required under the interpretation and application of UL Standard 1058 are summarized in Table 1.

EXTINGUISHING TEST RESULTS

INERGEN extinguishing agent has passed all of the fire tests required by UL interpretation and application of UL Standard 1058. The results of the Underwriters Laboratories fire testing employing the methods described within are outlined below.

Class A Fire Extinguishment Tests: Wood crib fires were extinguished at INERGEN agent concentrations of 31.5% by volume. Extinguishment was achieved at 2175 psi (14997 kPa) cylinder pressure with a nozzle pressure of 325 psi (2241 kPa).

Class B Fire Extinguishment Tests: Pan fires of n-heptane were extinguished at INERGEN agent concentrations of 31.5% by volume. Extinguishment was achieved at 2175 psi (14997 kPa) cylinder pressure with a nozzle pressure of 325 psi (2241 kPa).

Nozzle Area Coverage Tests: INERGEN agent concentration of 31.5% was determined at a hazard and agent temperature of 70 °F (21 °C) and a nozzle pressure of 325 psi (2241 kPa). All fires in the nozzle area coverage test were then extinguished within 30 seconds after the end of discharge with the same system configuration with the hazard at 70 °F (21 °C) and the cylinders conditioned to 32 °F (0 °C).

Height Coverage Tests: INERGEN agent concentration of 31.5% was determined at a hazard and agent temperature of 70 °F (21 °C) and a nozzle pressure of 325 psi (2241 kPa). All fires in the height coverage test were then extinguished within 30 seconds after the end of discharge with the same system configuration with the hazard at 70 °F (21 °C) and the cylinders conditioned to 32 °F (0 °C).

REVISED U.L. STANDARD 1058 FIRE TEST REQUIREMENTS

<u>TEST</u>	<u>TEST CONDITIONS</u>	<u>PASS/FAIL CRITERIA</u>	<u>TEST RESULTS</u>
CLASS A	10' x 10' x 12' enclosure (3 x 3 x 3.7 m) Minimum nozzle pressure (325 psi (2241 kPa)) Oxygen level not less than 20% 6 minute pre-burn Wood crib 18" x 18" x 6" (45.7 x 45.7 x 15.2 cm) 10 minute soak	Fire extinguished No re-ignition No free-burning embers	Passed at 31.5% by volume
CLASS B	10' x 10' x 12' enclosure (3 x 3 x 3.7 m) Minimum nozzle pressure (325 psi (2241 kPa)) Oxygen level not less than 20% 2.5 ft. ² pan (.23 m ²) 30 second pre-burn	Fire extinguished within 30 seconds after system discharge	Passed n-heptane at 31.5%
AREA COVERAGE	32' x 32' x 8" enclosure (9.9 x 9.8 x .2 cm) Minimum design temperature (32 °F (0 °C)) 3" n-heptane cans in corners and behind baffle 30 second pre-burn	All fires extinguished within 30 seconds after system discharge	Passed at 31.5% by volume
HEIGHT OF ENCLOSURE	10' x 10' x desired height (3x3 m) Minimum design temperature (32 °F (0 °C)) 3" (7.6 cm) n-heptane cans in all eight corners 30 second pre-burn	All fires extinguished within 30 seconds after system discharge	Passed for 12' (3.7 cm) ceiling at 31.5% by volume

TABLE 1

CONCLUSION

INERGEN extinguishing agent has proven to be a long term, people compatible, efficient and environment friendly replacement for Halon 1301 in total flooding applications. INERGEN agent has received the approval of governmental and industry regulatory agencies. Under the US EPA's SNAP program, INERGEN agent has been accepted for use in total flood applications either normally occupied or normally non-occupied with no restrictions or use conditions. INERGEN agent is also included in the NFPA 2001 standard entitled, "Clean Agent Extinguishing Systems." INERGEN agent has passed all the tests required for a suppression system listing by Underwriters Laboratories in interpretation and application of UL Standard 1058, including the extinguishment of Class A fires, Class B fires, nozzle area coverage, height coverage tests, hardware component and agent flow testing.

INERGEN extinguishing agent is the world's most widely accepted and utilized replacement agent for Halon 1301. In addition to successfully completing the required fire tests for an Underwriters Laboratories listing (EX-4510), INERGEN agent has also obtained numerous International approvals from governing bodies such as Ministries of Health, Worker Safety, Maritime, Environmental Affairs and Insurance authorities.

UNDERWRITERS LABORATORIES

REFERENCE NUMBERS:

FILE NUMBER: EX-4510

**PROJECT NUMBERS: 93NK 29232
92NK 04635
92NK 27530**

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