Water Mist Extinguishment of Ignitable Liquid Storage Fires in Cutoff Rooms

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September 25, 2025

Outline

- Background and objectives
- Test setup
  - Cutoff room – liquid storage occupancy
- Fire test results
- Summary and conclusion
- Recommendations

Background

- Ignitable liquids (IL) pose high fire protection challenge
  - Readily ignitable, high heat release rate, spread rapidly, difficult to extinguish
- Sprinklers with large droplets are ineffective for LFP liquids
  - Required water demand is high
  - Storage type and height are highly restricted
  - Post-fire water treatment is costly
- Water mist has shown effective in extinguishing ignitable liquid fires
  - Fast droplet vaporization

Objectives

- Demonstrate efficacy of water mist extinguishment
  - Ignitable liquid storage fires in cutoff rooms with a door opening
  - Fill current protection gap:
    - Water-immiscible liquids with a low flash point (< 93°C)
    - Stored in plastic or glass containers (3.8 - 24.6 liters)
    - Cartoned or uncartoned in rack storage
- Achieve primary IL protection in cutoff rooms
  - No need for drainage and foam

Test Setup - Commodities

- Heptane
  - 3.8-L plastic container selected
    - Free-burn test, more susceptible to fire breach
  - One carton (4 containers, 2×2, 38×38×43 cm)
  - One-pallet load (3×3×3, 27 cartons)

3.8-L glass and HDPE plastic containers

108 containers

Test Setup - Commodities

- Heptane
  - 19-L plastic container
  - One-pallet load (4×4×3, 48 containers)

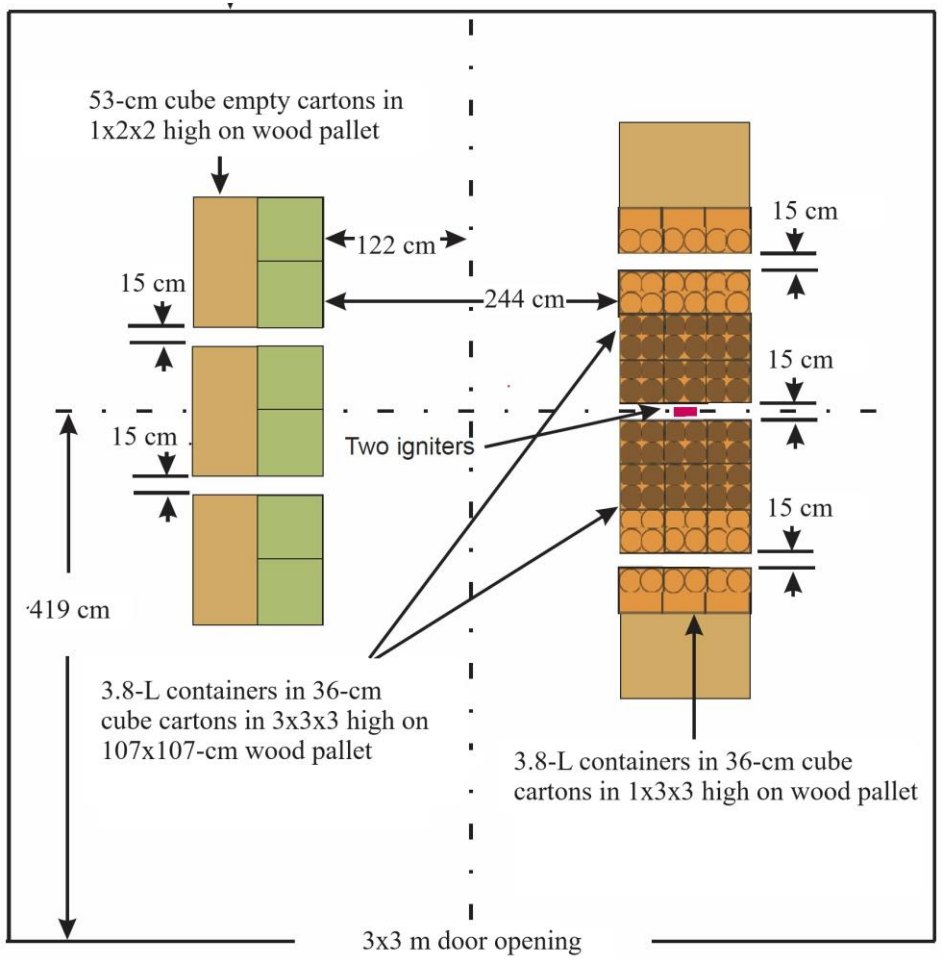
19-L HDPE container
28x28x26 cm, 1.28 kg

48 containers

Test Setup – Enclosure

Enclosure 7.6×7.6×7.6 m, door 3×3 m

Test Setup – Rack Storage, 2-, 3- or 4-tiers, each 1.5-m H



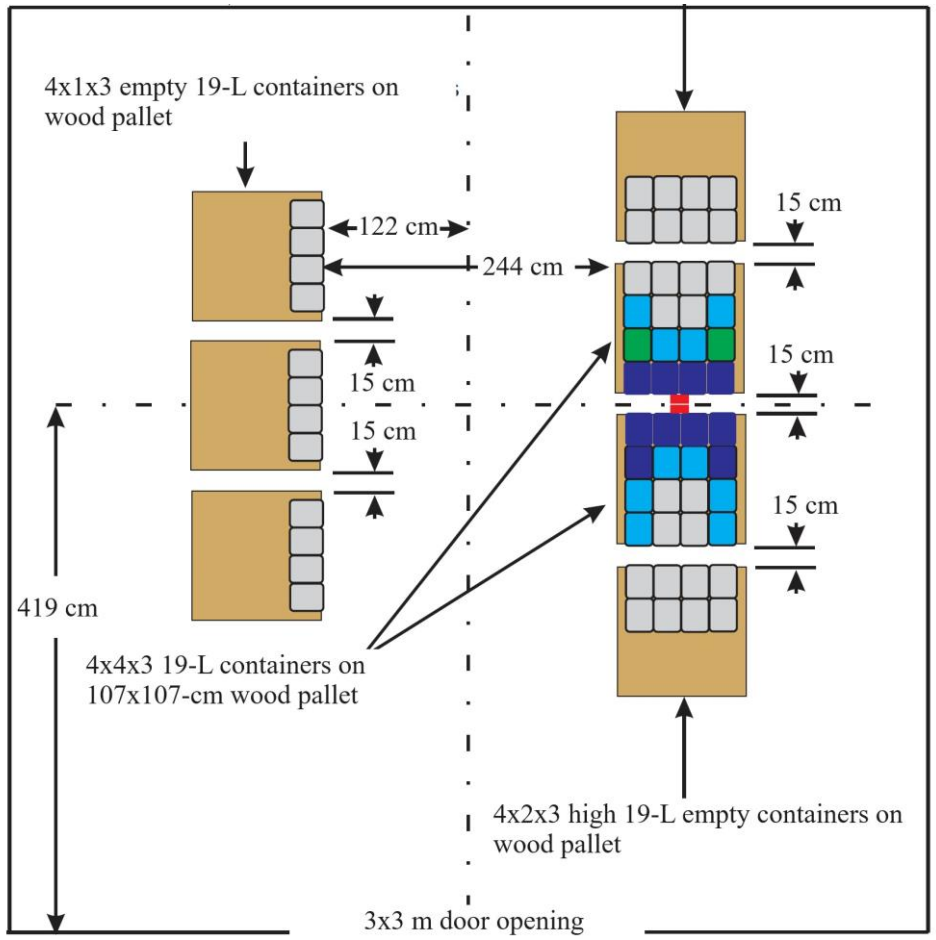
Plan view of 1st-tier fuel-array for cartoned 3.8-L containers

Target

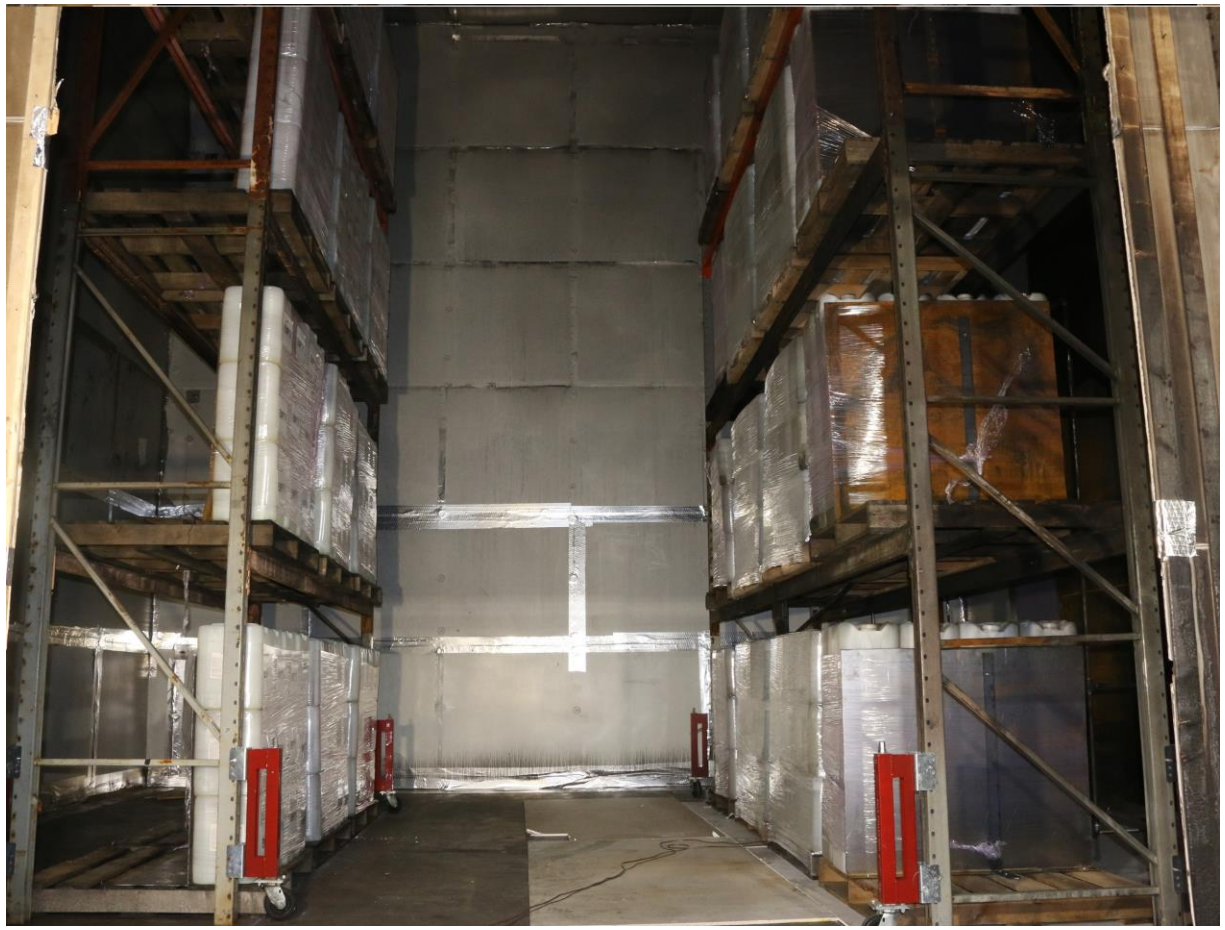
Main array with igniter

3.8-L containers, 4-tier rack storage

Test Setup – Rack Storage, 2-, 3- or 4-tiers



Plan view of 1st-tier fuel-array for 19-L containers

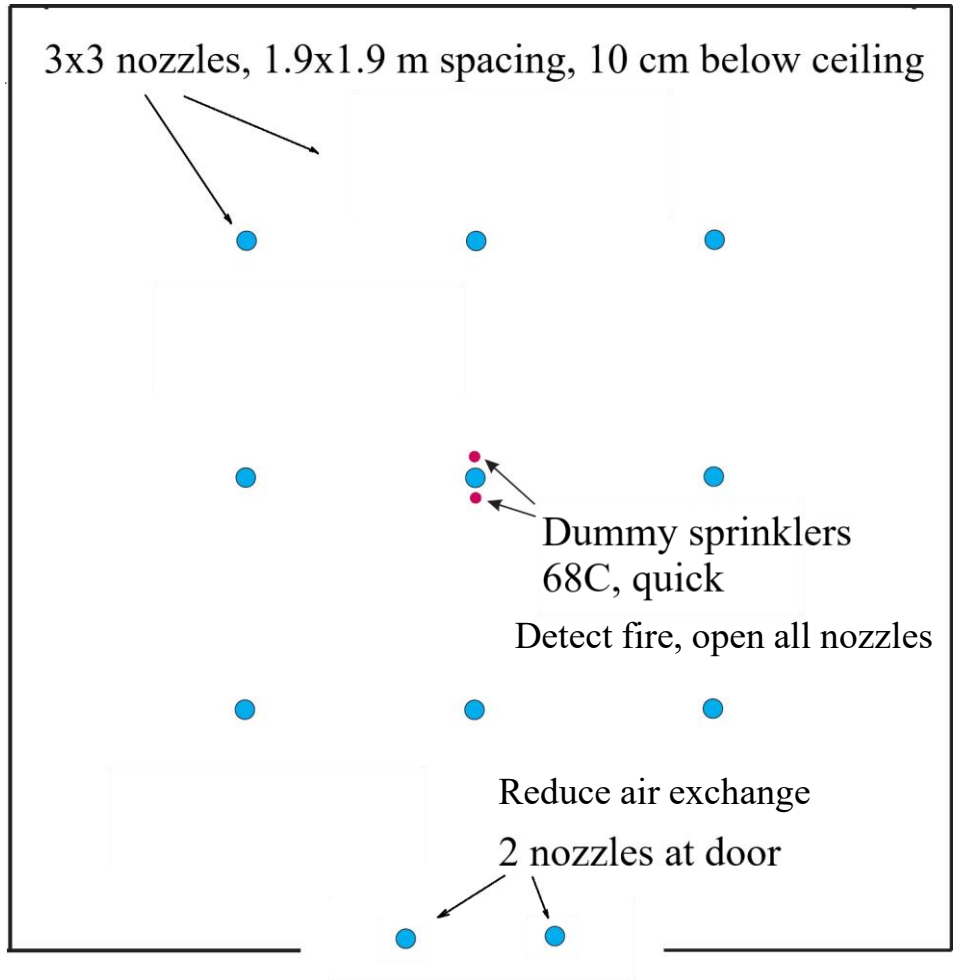


19-L containers, 4-tier rack storage

Test Setup – Water Mist Protection

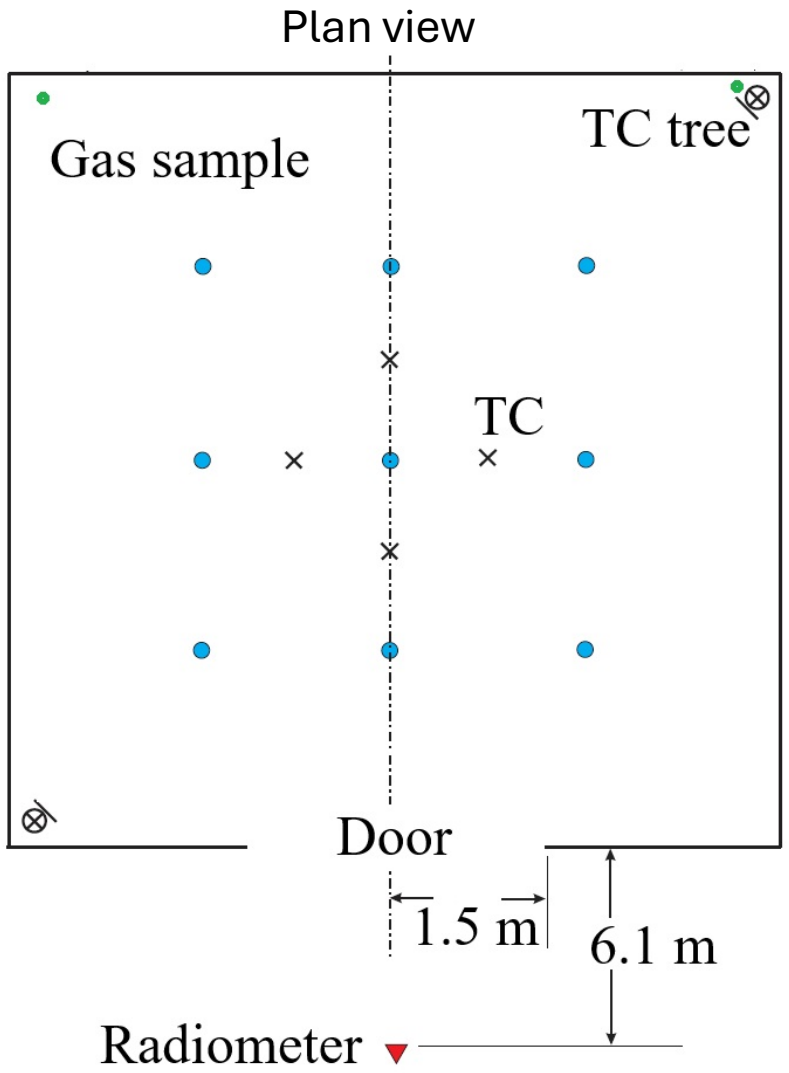
Nozzle (prototype)
150 µm at 60 bar
34 liter/min
Stokes number: 1.2

Plan view



Applied water density 5.3 mm/min

Test Setup – Instrumentation

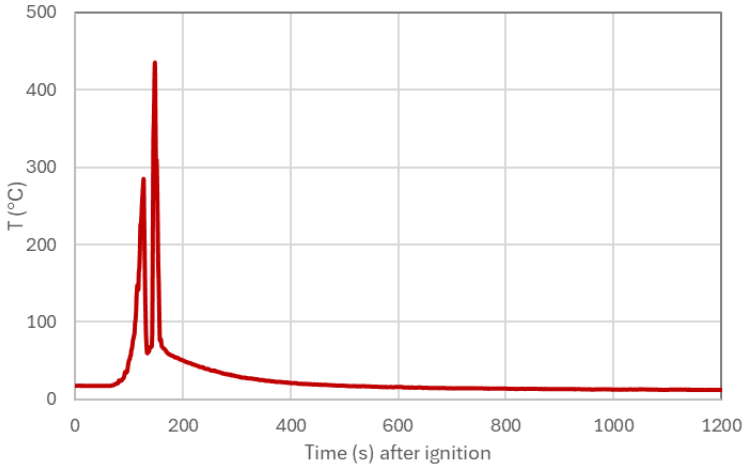


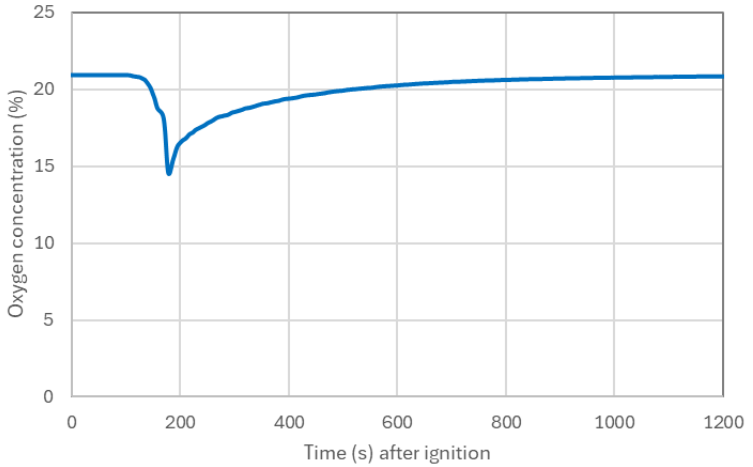
Fire Tests and Results

- Eight tests conducted for rack storage up to four tiers high
  - First four for heptane in cartoned 3.8-L HDPE containers
  - Subsequent four for heptane in uncartoned 19-L HDPE containers
- Test results showed water mist could extinguish all above fires
  - Rack storage tiers: 2, 3, and 4

Fire Test Results

4-tiers rack storage, cartoned 3.8-L containers (video 1:30 after ignition)





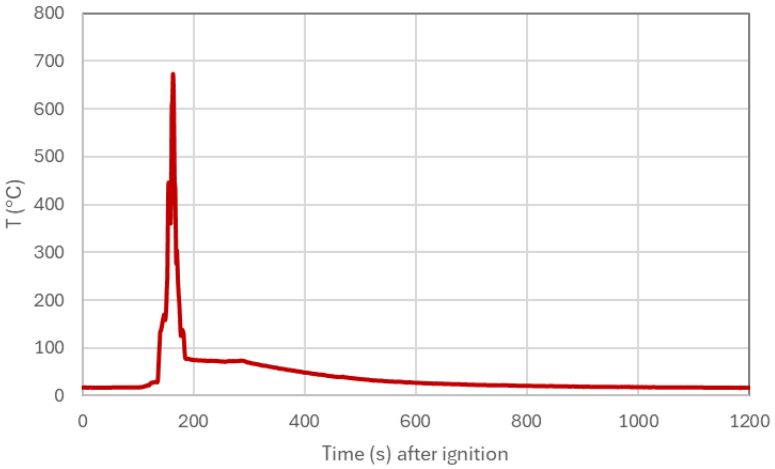
Fire Test Results - Damage

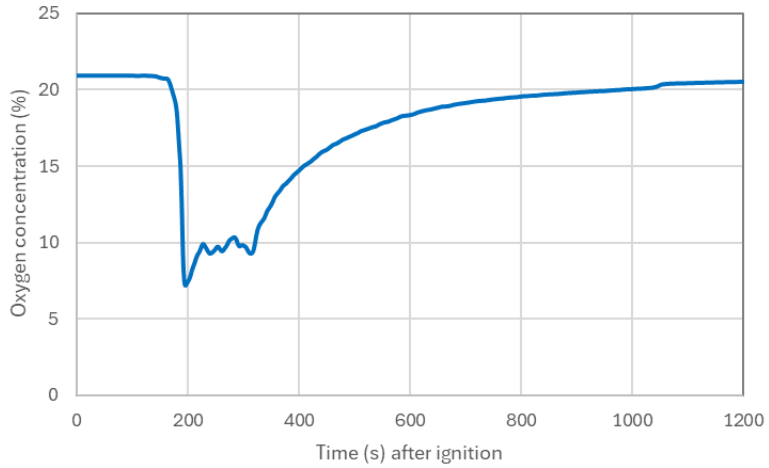
Target

Main fuel array, 4-tiers
28 containers breached

Fire Test Results

4-tiers rack storage, uncartoned 19-L containers (video 2:00 after ignition)





Fire Test Results - Damage

Target

Main fuel array, 4-tiers
49 containers breached

Summary and Conclusion

- Water mist can effectively extinguish ignitable liquid fires in cutoff rooms
  - Water-immiscible liquids with flash points less than 93°C
  - Stored in plastic or glass containers from 3.8 to 24.6 L
  - Rack storages up to four tiers high in test enclosure
  - Enclosure: 7.6×7.6×7.6-m high
  - One door: 3×3-m high
  - Require install downward mist spray at door

Recommendations

- Develop FM Approval test protocol for water mist systems
  - Enclosure volume in increment of 250 m^3
  - Door centered in one wall and not smaller than 3×3-m high
  - Main fuel array centered in enclosure, no more than 1.8 m from door
  - Fire tests conducted at the lowest and highest storage height
  - Flexible parameters for individual mist systems
    - Fuel array length with enough container breach area
    - Nozzle layout and spacing
    - Spray properties (e.g., spray pattern and droplet size), water application density

Thank you.
Any questions?

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