

A Fire Test Protocol for Off-Road Vehicle Fire Extinguishing Systems

**IWMA Conference
October 16 – 17, 2013
Paris, France**

Outline

- **Background**
- **Overview of the test protocol**
- **Evaluation of the test protocol**
- **Status**

Types of Off-Road Vehicles

dragline/power shovel



backhoe



bucket wheel excavator



bulldozer



compactor



crane



Types of Off-Road Vehicles

excavator



grader



loader



telescope handler



tractor



Fire Incidents



Fire Hazards

- **Internal or external fires**
- **Spray, pool or spill fires**
- **Exposures:**
 - Engine compartment ventilation up to 7 m³/s (15000 cfm).
 - Wind up to 6 m/s.
 - Hot surface temperature up to 600 °C.

SP Method 4912

- Evaluate extinguishing systems for engine compartments of transportation vehicles:
 - ✓ consider pool and spray fire hazards.
 - ✓ consider re-ignition propensity caused by hot surface .
 - ✓ ventilation up to 3 m³/s (6400 cfm).
 - ✓ does not consider external fires.



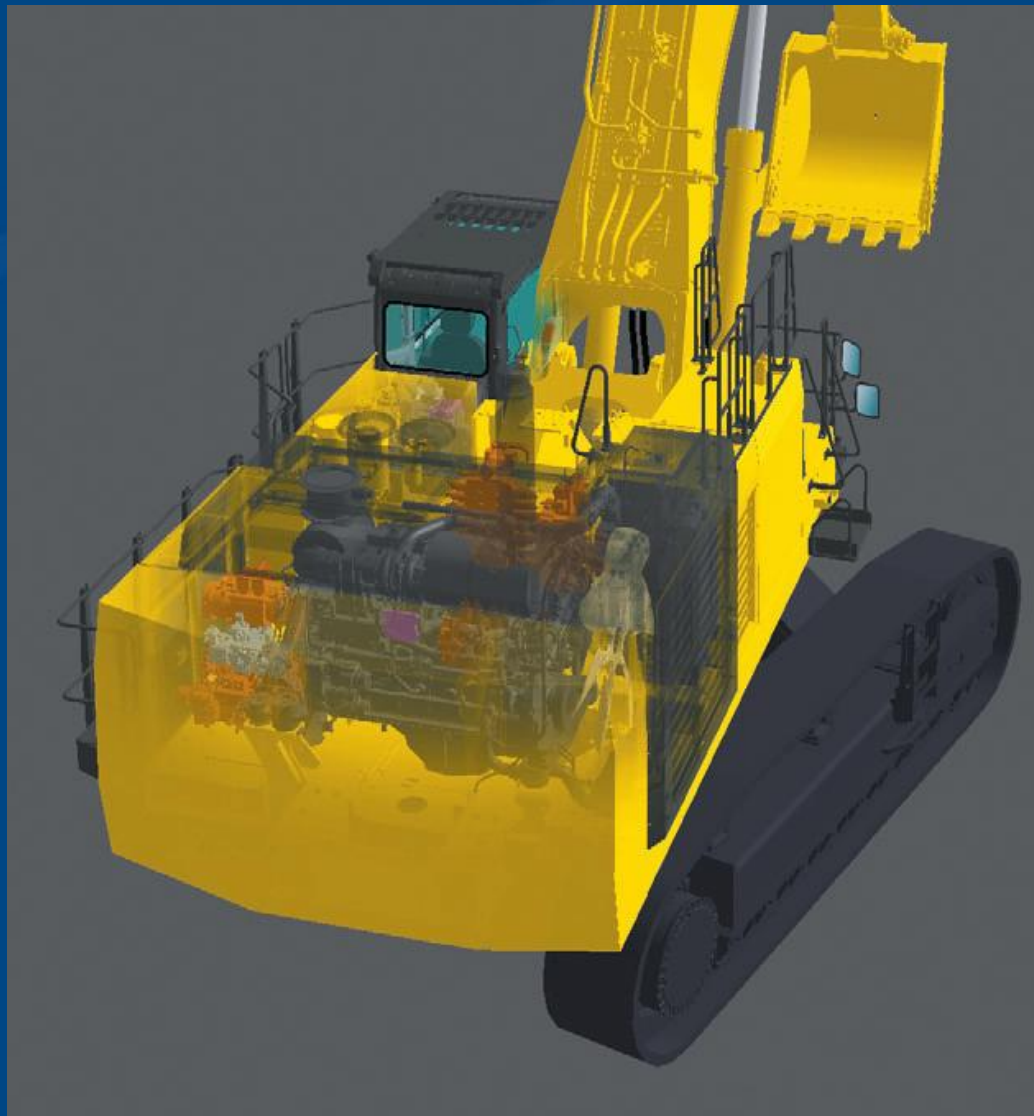
Proposed Approach for Off-Road Vehicles



A two-pronged approach:

- **Engine compartment test facility – to evaluate pre-engineered systems for the typical engine compartment of large off-road vehicles.**
- **Single nozzle test facilities – to evaluate a single nozzle’s fire extinguishing capability => provide flexibility for configuring customized systems for internal or external fires, based on a vehicle’s specific conditions, such as configuration, size, fire hazard, and fire shielding.**

Typical Engine Compartment Configuration



Engine Compartment Mock-up

Compartment: 2.50 x 1.50 x 1.00 m high

Engine block: 2.11 x 1.15 x 0.70 m high

Exhaust manifolds: 73 mm in diameter

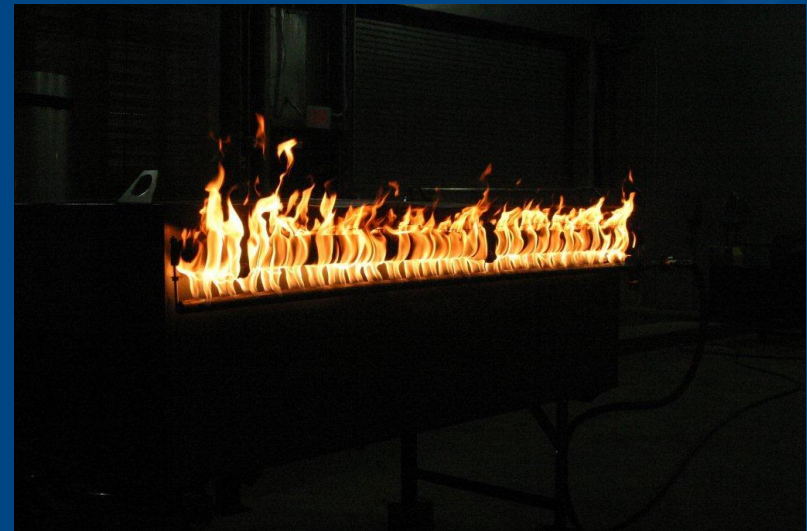
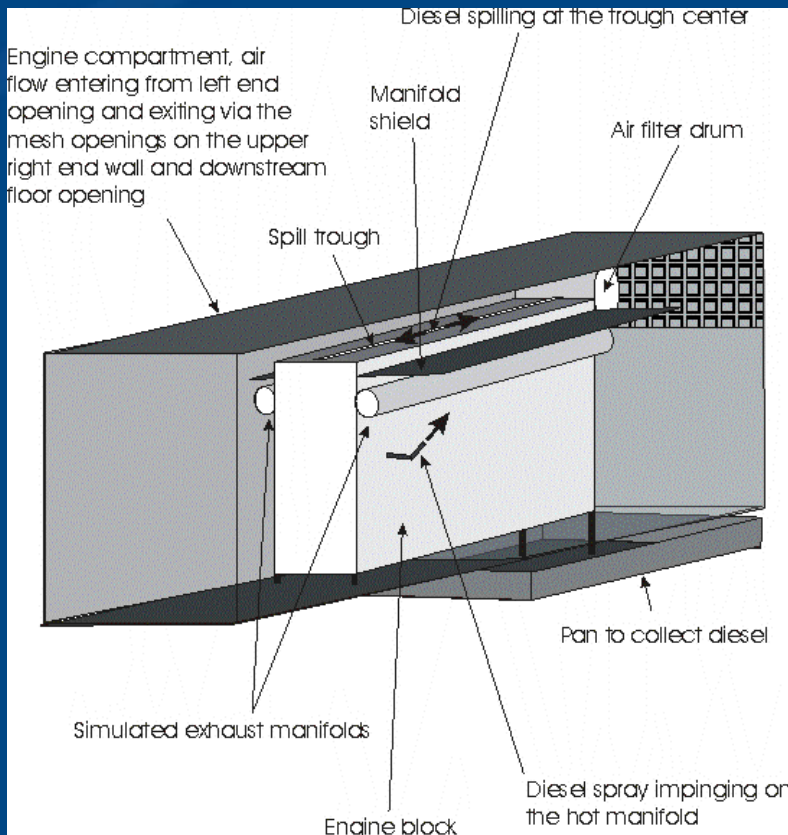
Exhaust manifold shield: 0.10 m wide

Air filter drum: 0.15 m diameter

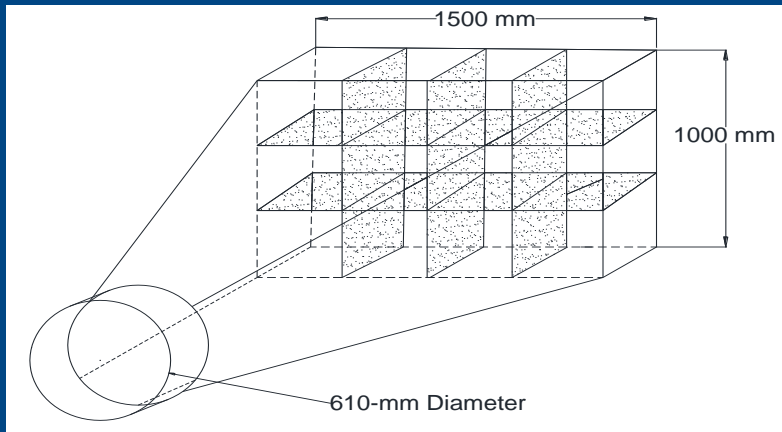
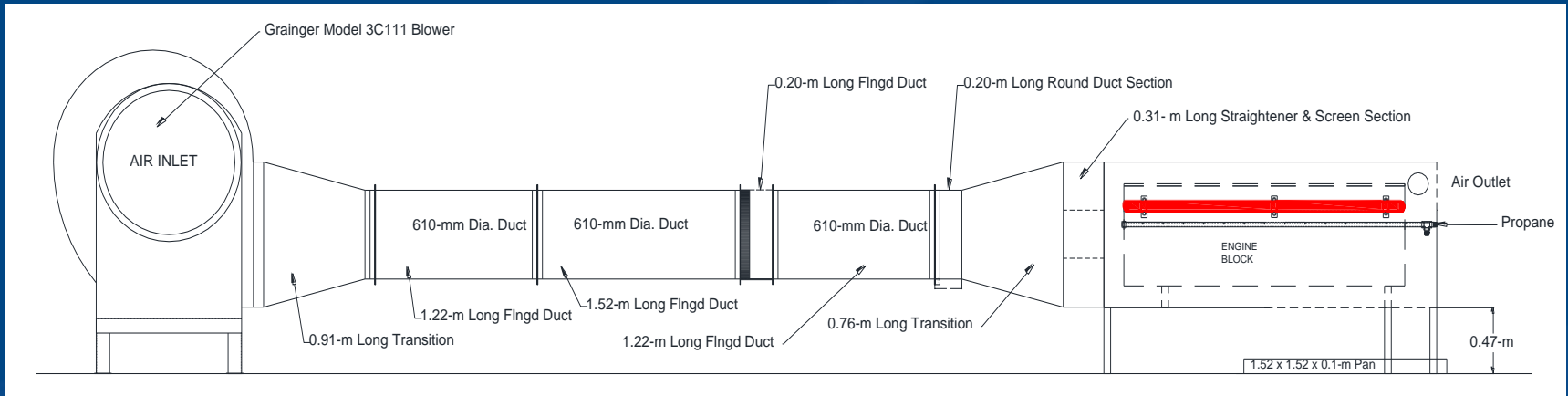
Pan: 1.52 x 1.52 x 0.10 m high

Hazard conditions:

- Diesel injection/release rate: 1 liter/min
- Ventilation rate: 7.5 m³/s (16000 cfm)
- Exhaust manifold temperature: 600 °C

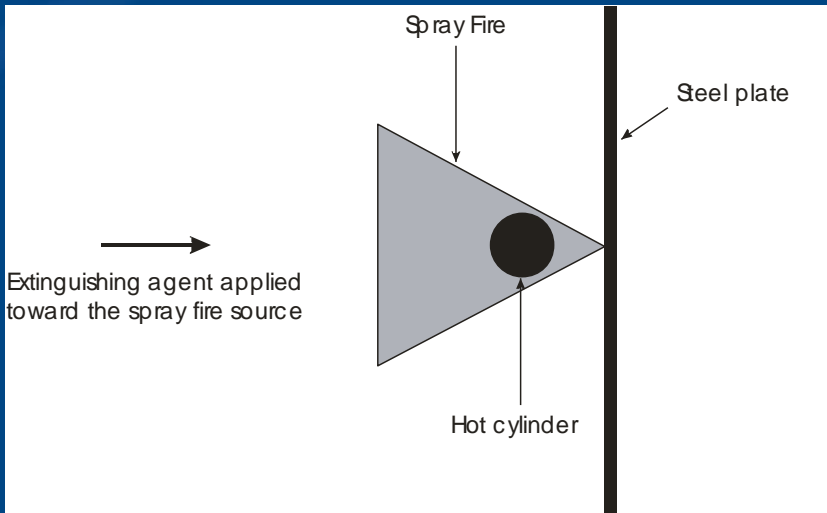


Engine Compartment Test Facility



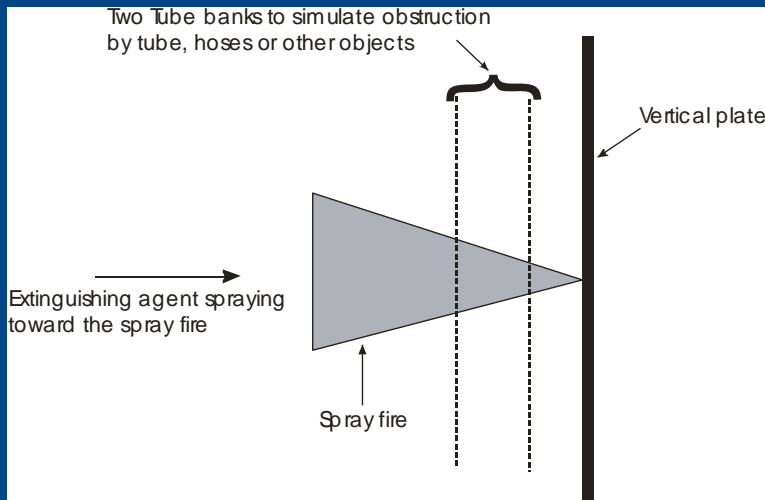
Single Nozzle Scenario 1 – A Spray Fire Partially Obstructed by a Hot Cylindrical Object

Pipe OD: 75 mm
Pipe-wall distance: 90 mm
Pipe temperature: 600 °C
Diesel spray rate: 1 lpm
Nominal maximum wind speed: 6 m/s



Single Nozzle Scenario 2 – A Spray Fire Obstructed by Banks of Cylindrical Objects

- Pipe OD: 75 mm
- Pipe separation in each bank: 30 mm
- Each pipe bank dimension: 1200 x 1200 mm
- Inner pipe bank to wall: 75 mm
- Outer pipe bank to wall: 180 mm
- Diesel spray rate: 1 lpm
- Nominal maximum wind speed: 6 m/s



Single Nozzle Scenario 3 – A Vertical Spill Fire Partially Obstructed by a Hot Cylindrical Object

Pipe OD: 75 mm

Pipe-wall distance: 75 mm

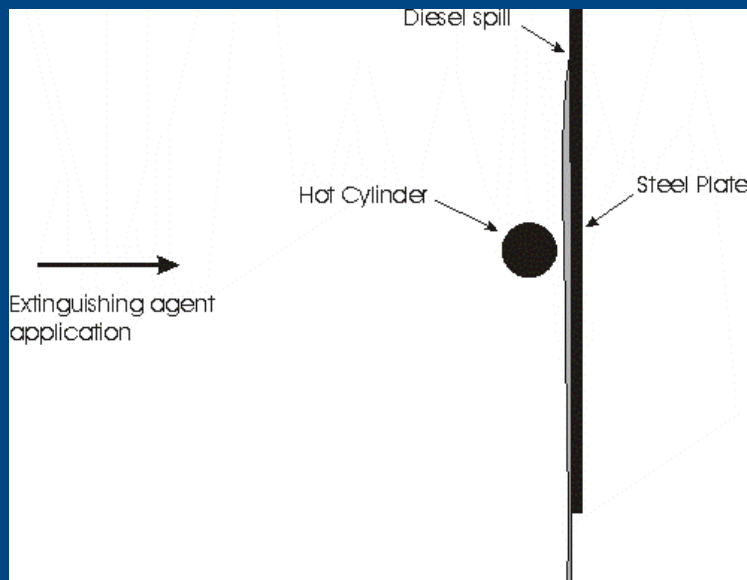
Pipe temperature: 600 °C

Spill opening: 6.5 x 150 mm wide

Spill opening elevation: 610 mm above pipe centerline

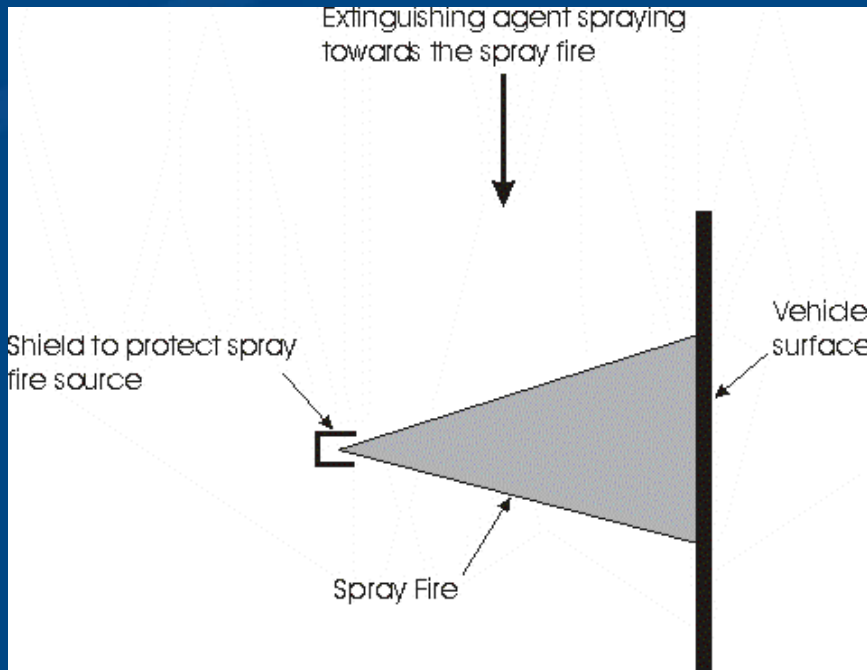
Diesel spill rate: 1 lpm

Nominal maximum wind speed: 6 m/s



Single Nozzle Scenario 4 – A Spray Fire Impinging on a Vertical Wall

Diesel spray rate: 1 lpm
Diesel spray nozzle to wall: 510 mm
Nominal maximum wind speed: 6 m/s



Single Nozzle Scenario 5 – A Pool Fire Partially Obstructed Below a Large Object

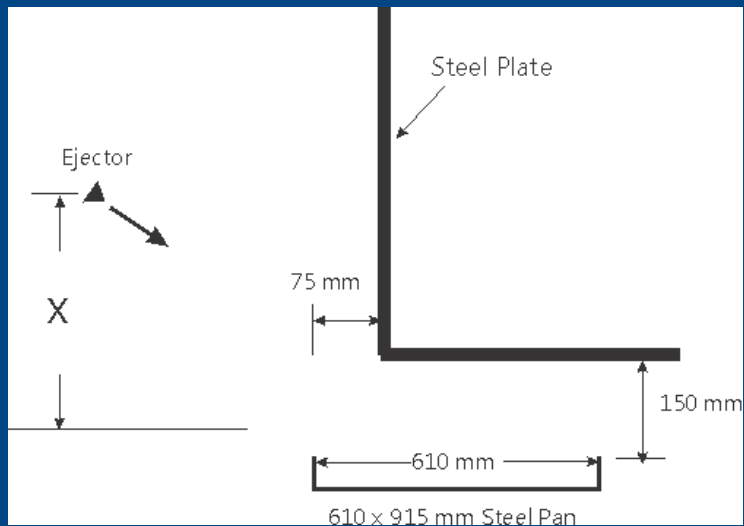
Fuel: Diesel

Pan dimension: 610 x 915 mm long

Pan to horizontal raised floor: 150 mm

Pan offset from vertical wall: 75 mm

Nominal maximum wind speed: 6 m/s



Single Nozzle Scenario 6 – A Partially Obstructed Pool Fire in Open Space

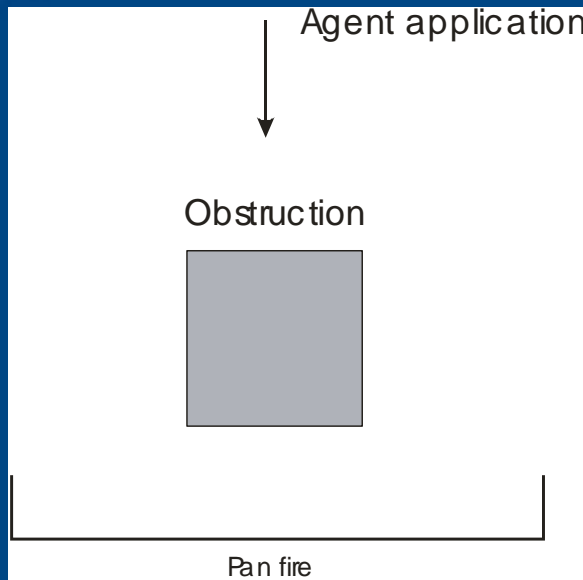
Fuel: Diesel

Pan diameter: 915 mm

Obstruction: 355 mm dia. x 480 mm tall

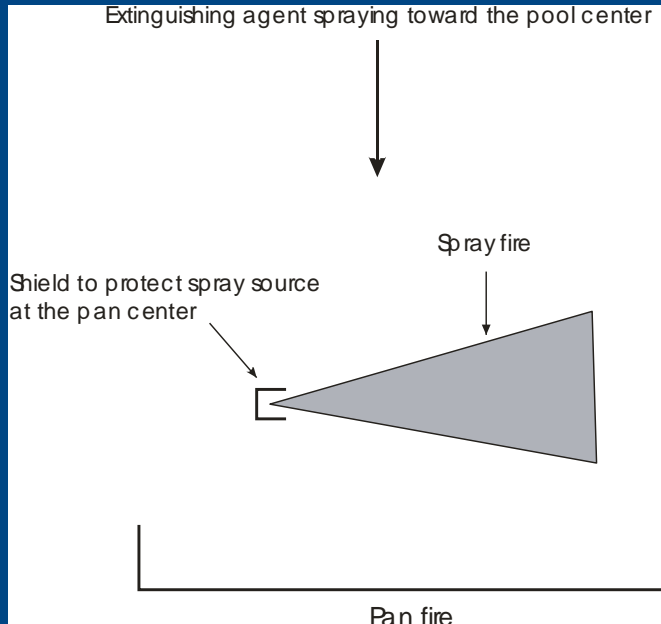
Obstruction above pan: 75 mm

Nominal maximum wind speed: 6 m/s



Single Nozzle Scenario 7 – A Combined Spray and Pool Fire

Pan diameter: 915 mm
Diesel spray rate: 1 lpm
Diesel spray nozzle elevation above pan: 305 mm
Diesel spray nozzle from pan edge: 230 mm
Nominal maximum wind speed: 6 m/s



Protocol Evaluation with Three Extinguishing Agents

- Water mist – 40% potassium acetate ($\text{CH}_3\text{CO}_2\text{K}$)
- Foam – 3 % AFFF, 8:1 expansion ratio
- Monoammonium phosphate ($\text{NH}_4\text{H}_2\text{PO}_4$)

Results - Engine Compartment Fires

Agent	Spray Fire	Spill Fire
8:1 3% AFFF	No	Yes
Water mist with 40% Potassium Acetate	Yes	<u>Yes</u>
Monoammonium phosphate	Yes	No

Note: Yes/No is determined if the fire was extinguished in the agent discharge period.

Single Nozzle Test Results

Fire Scenario	Extinguishing Agents		
	8:1 3% AFFF	Water mist with 40% Potassium Acetate	Monoammonium Phosphate
Spray fire obstructed by hot cylinder	No	Yes	No
Spray fire obstructed by pipe banks	No	Yes	Yes
Spill fire obstructed by hot cylinder	Yes	Yes	Yes
Spray fire impinging on vertical wall	No	Yes	No
Obstructed corner pool fire	Yes	Yes	Yes
Obstructed open pool fire	Yes	Yes	No
Combined spray and pool fire	No Test	Yes	No

Approval Standard for Off-Road Vehicle Protection

FM Approvals Class 5970: Off-Road Vehicle Protection Systems

- **8/31/13 – Completion of draft standard for 1st internal review**
- **10/31/13 – Revised draft standard sent for external comments**
- **12/31/13 – Revised draft standard sent for 2nd internal review**
- **2/28/14 – Revised draft standard for final approval**
- **3/31/14 – Publish the approval standard**

Questions?