Water Mist Extinguishment of Exhaust Duct Fires

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Exhaust ducts in industrial occupancies

- Food processing
- Semiconductor fabrication
- Pharmaceutical production
- Metal processing
- Power generation
- Paper and pulp production
- Textile
- Chemical processing
- Spray painting
- ....
Advantages of Water Mist Protection

- Better spray dispersion in ventilated tight space
- Less water runoff
- Effective for flame extinction to extinguish fire quickly in ventilated ducts
- Easier nozzle installation in ducts
Outline

• Test fires
• Evaluation of fire extinguishment in 0.3-m duct
  – Test facility
  – Water mist protection
  – Fire test results
• Evaluation of fire extinguishment in 0.61-m duct
  – Test facility
  – Water mist protection
  – Fire test results
• Conclusions
Test Fires

- Simulate fires fueled by combustible deposits on duct’s inside surface
- Use propane as the surrogate fuel

<table>
<thead>
<tr>
<th>Duct Diameter (m)</th>
<th>Freeburn Fire Heat Release Rate (kW)</th>
<th>Propane Release Rate (liter/min)</th>
<th>Duct Length for Propane Release (mm)</th>
<th>Exhaust Air Velocity (m/s)</th>
<th>Volumetric Air Flow Rate at Duct Entrance (m³/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
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<td>590</td>
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</tbody>
</table>
0.3-m Duct Test Facility – Horizontal Orientation

- Stainless steel ductwork
- Blower
- Bypass
- Flow conditioning screen

- Two water mist application locations at 3 m apart
- Propane-release plenum
- Viewport
- Drain
0.3-m Duct Test Facility – Vertical Orientation
0.3-m Duct Test Facility - Instrumentation

- Duct wall temperature
- Gas temperature
- Gas velocity at duct opening
- Propane release rate
- Nozzle operating pressure
- Total water mist discharge rate
0.3-m Duct Test Facility – Horizontal Orientation

Duct insulated to simulate the thermal response of 0.3-m diameter combustible ducts made of:

- Fiber Reinforced Plastic (FRP)
- Polypropylene (PP)
- Fiberglass
- PVC
0.3-m Duct Test Facility – Vertical Orientation
Water Mist Protection for 0.3-m Duct Tests

• Targeted water mist concentration: 300 cc/m³ or higher

• Water mist application
  – Spacing for the water mist application: 3 m
  – Water mist concentration provided from the upstream application
    √ 471 cc/m³ at midpoint between the two application locations
    √ 303 cc/m³ right before the downstream application location

• Volume-median droplet size: 77 µm
## Horizontal 0.3-m Duct Test Results

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<thead>
<tr>
<th>Freeburn Fire Heat Release Rate (kW)</th>
<th>Air Ventilation Rate (m³/min)</th>
<th>Propane Release Location</th>
<th>Preburn Time (s)</th>
<th>Number of Tests</th>
<th>Fire Extinguished ?</th>
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<tbody>
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A Horizontal 0.3-m Duct Test Video

- Fire size: 475 kW
- Fire origin: Midpoint between upstream and downstream water mist applications
Horizontal 0.3-m Duct Tests with an Increased Water Mist Concentration

- Water mist concentration at the downstream fire location: 395 cc/m³
- Volume-median droplet diameter: 88 µm

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- Tests also showed that, with same protection, fire in the vertical duct could be extinguished similarly as in the horizontal duct.
Duct Wall Temperature – 0.3-m Duct Tests

• Measurement: Not higher than 200°C.

• Protection applicable to ducts made of steel, fiber-reinforced plastic and fiberglass, but not for polypropylene and PVC due to the lower softening temperature.
0.61-m Duct Test Facility – Horizontal Orientation

- Stainless steel ductwork
- Blower
- Bypass
- Flow conditioning screen

- Two nozzle locations 3.3 m apart
- Three propane-release plenums
- Viewport
- Drain
0.61-m Duct Test Facility – Vertical Orientation
0.61-m Duct Test Facility - Instrumentation

- Duct wall temperature
- Gas temperature
- Gas velocities before test section and at duct opening
- Propane release rate
- Nozzle operating pressure
- Total water mist discharge rate
**Test Conditions and Results – Horizontal 0.61-m Duct**

- Water mist concentration at midpoint between the upstream and downstream application locations: 422 cc/m³
- Volume-median droplet diameter: 115 µm

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- Similar test results were obtained for fire situated in the vertical duct.
Duct Wall Temperature – 0.61-m duct Tests

- 15-s preburn: Peak temperature not higher than 195°C
- 30-s preburn: Peak temperature up to 320°C

To protect FRP and fiberglass ducts, a preburn time not longer than 15 s is recommended.
Conclusions

• Water mist is capable of extinguishing exhaust duct fires with a water mist concentration of 300 cc/m³ or higher.

• Besides steel ducts, water mist protection is applicable to combustible ducts made of FRP and fiberglass.

• A preburn time not longer than 15 s is recommended for the protection of FRP and fiberglass ducts.
Thank you!

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