Analysis of water distribution efficiency from a sprinkler head

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Problem

- Examine use of water to determine nozzle efficiency
- Fixed Pressure (60 psi)
  - Droplet Size
  - Momentum
  - Distribution
- Based on design of nozzle with similar k-factors is one type of nozzle more efficient than another.
Birdcage Transformer Design

- Small k-factor
- Short throw
- Close proximity to the transformer
- Low pressure
- Excessive nozzles to protect the transformer (30-40)
Consequences
Modified Design Strategies
Manual Fire Nozzles
Manual Fire Nozzles
Modified Design Strategies
Nozzles to be examined

- Deflector plate nozzle
  - K-factor 7.2
  - 55.8 GPM (211.2 LPM)

- Rotor / cellar nozzle
  - K-factor 8.9
  - 68.9 GPM (260.8 LPM)
FM testing of nozzle

- FM testing indicated that
  - K-factor – Droplet Size
  - Orientation - Momentum
  - Response time – Fire Size

- Played greater role than design density

- Examine how nozzle design can affect
  - Momentum
  - Droplet size
  - Coverage
Characterization

- Droplet formation differs for each sprinkler arrangement (k-factor, pressure, type).
A spray nozzle is placed into the spray scanning system and detailed measurements of the spray are made using shadowgraphy, laser, and other diagnostic techniques. Depending on the nature of the nozzle (tines/slots or not) the characterization may vary in complexity.
Characterization

• Versatility of the testing apparatus and methodology allows for measurement optimization.
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Spray Distribution

Particle Size distribution

Particle velocity - Momentum
Droplet Size

- Dv0.5 = Volume Median Diameter (VMD)
- Drop size measured in terms of volume (or mass), with 50% of total volume of liquid sprayed drops with diameters larger than median value and 50% with smaller diameter.

- Rotor = 0.57 mm
- Deflector = 1.038 mm
Deflector Nozzle

![Graph showing downward momentum pressure and cumulative momentum flux vs. plane radius.]

Downward Momentum Pressure, $M^{**}$ (N/m$^2$)

Cumulative Momentum Flux (N)

Plane Radius, m

0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5

0 5 10 15 20

0 10 15

0 5 10 15

0 20 40 60
Rotating Nozzle

![Graph showing Downward Momentum Pressure and Cumulative Momentum Flux vs Plane Radius](image-url)
Spray Momentum Analysis

Rotating Nozzle
260.7 LPM @ 4.14 bar // 68.9 GPM @ 60 psi

Momentum Pressure (N/m²)

Tangent plane 0.35m below sprinkler.

Deflector Nozzle
210.9 LPM @ 4.14 bar // 55.8 GPM @ 60 psi

Tangent plane 0.35m below sprinkler.

Cumulative Momentum Flux (N)

Downward Momentum Pressure (N/m²)

Percentages based on maximum momentum possible from jet.
Deflector Nozzle

Momentum Pressure, $M_p$
Rotating Nozzle

Momentum Pressure, $M_p$

Pressure (N/m)
Deflector

Volume Flux (mm/min) vs. Plane Radius, m

Cumulative Volume Rate (LPM) vs. Plane Radius, m
Rotor

Volume Flux (mm/min)

Cumulative Volume Rate (LPM)

Plane Radius, m
Rotating Nozzle
260.7 LPM @ 4.14 bar // 68.9 GPM @ 60 psi

Tangent plane 0.35m below sprinkler.

Deflector Nozzle
210.9 LPM @ 4.14 bar // 55.8 GPM @ 60 psi

Tangent plane 0.35m below sprinkler.

Volume Flux (mm/min)
0 50 100 150 200 250 300 350 400 450 500

Accumulating Volume (LPM)

Volume Flux (mm/min)

Radius

Percentages based on total sprinkler flow rate.
Additional Information

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