



Interspersed Moderation: What Is Credible?

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Introduction

- All degrees of interspersed moderation must be evaluated.
- If a certain degree of interspersed moderation results in exceeding the license k_{eff} limit, it must be controlled.
- If ranges of interspersed moderation are determined not to be credible, those ranges do not need to be included in the criticality calculations.

Sources

- Fire Sprinklers
- Fire Hoses
- Fire-Fighting Foam
- Steam and Humidity
- Rain

Fire Sprinklers

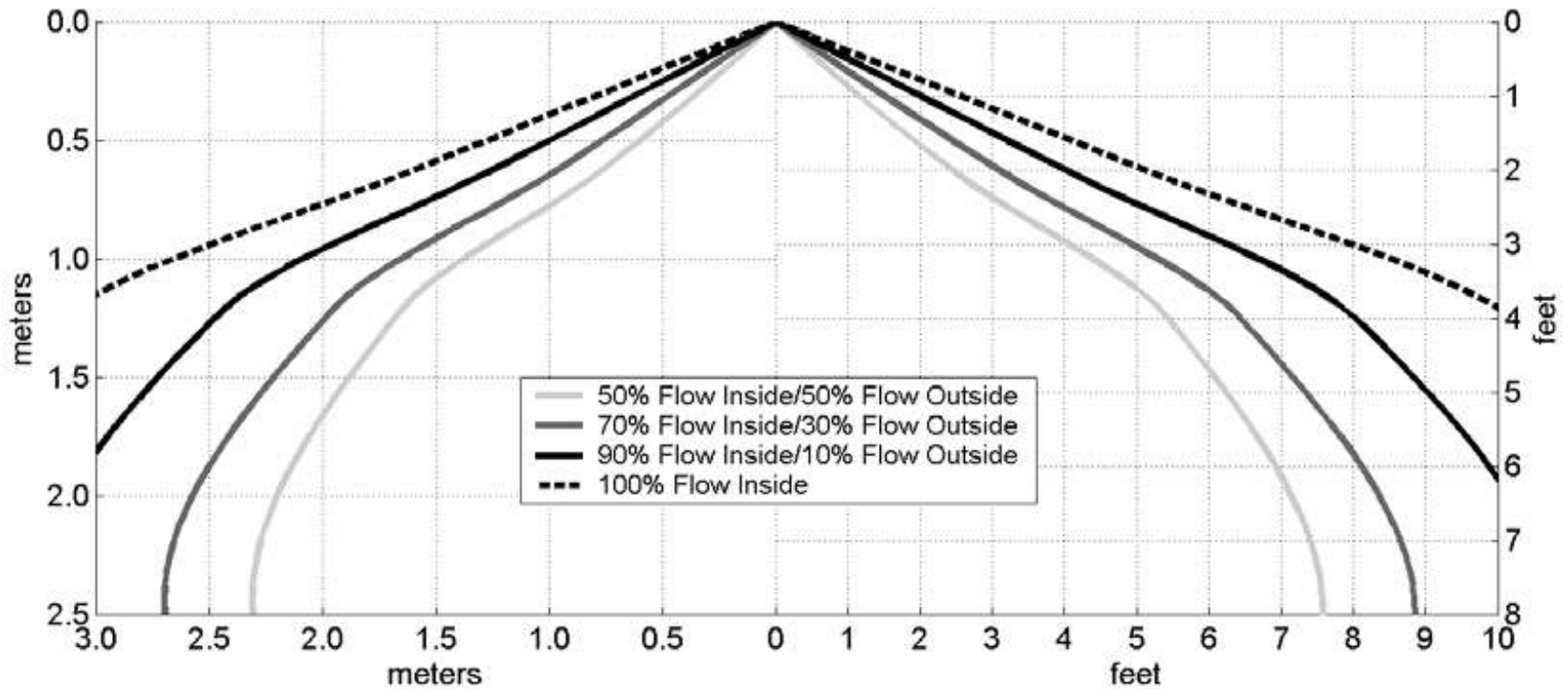
- Droplet Diameter

$$d_m = (0.86) \left(\frac{30}{P} \right)^{\frac{1}{3}}$$

- Droplet Velocity

$$V(h) = V_{\text{terminal}} (1 - e^{-bh})$$

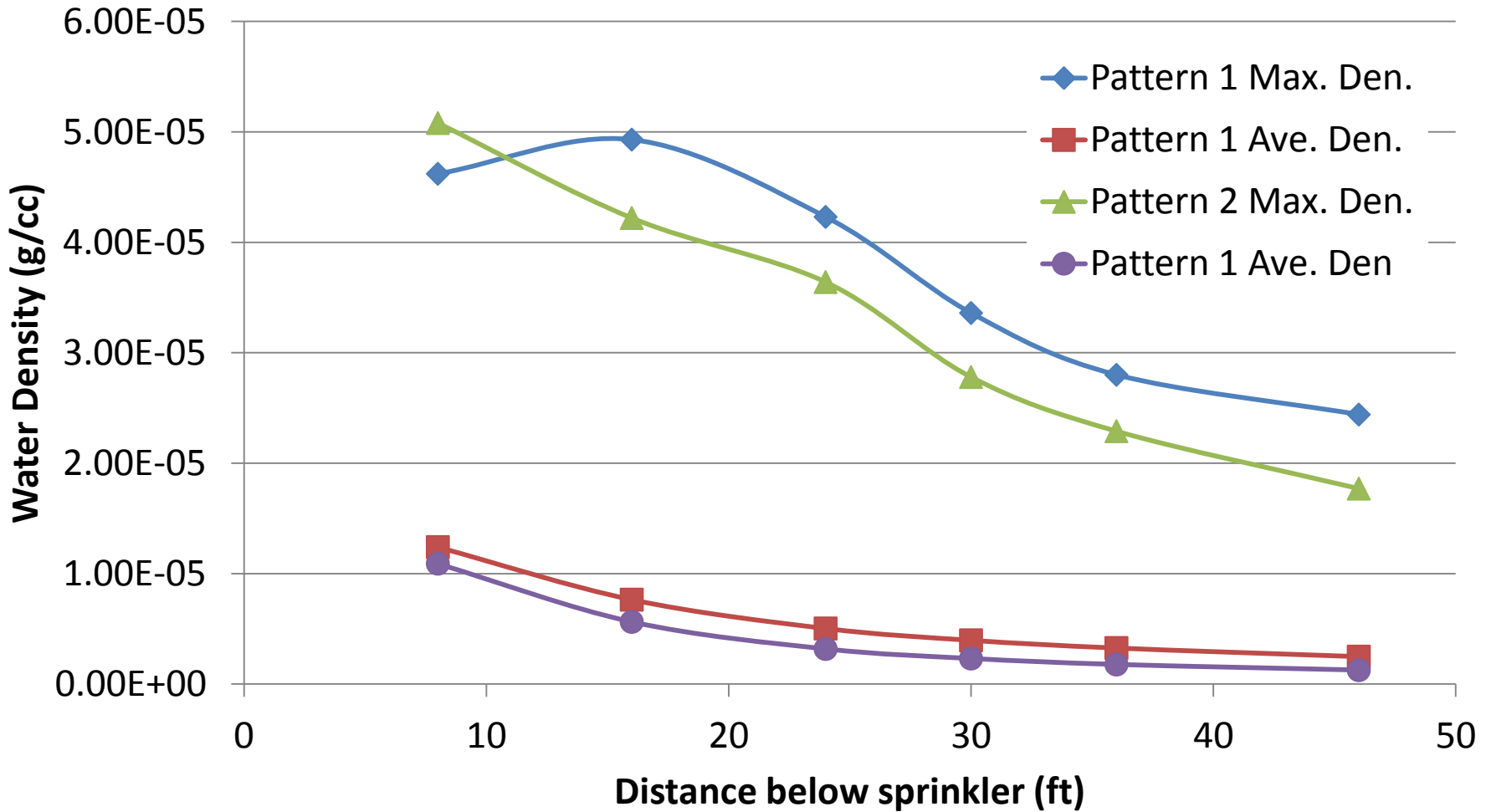
Sprinkler Spray Pattern



Modeling of Water Density

- The code incorporated the fitted velocity equations and the fitted spray distributions.
- A grid pattern is established over the area of interest.
- At each node location, the contribution of each sprinkler is calculated assuming:
 - no interference between sprinkler sprays,
 - no distortions for rising heat, and
 - no deflection from structures and equipment.

3 x 3 Array of Sprinkler on a 8 ft x 14 ft Pitch

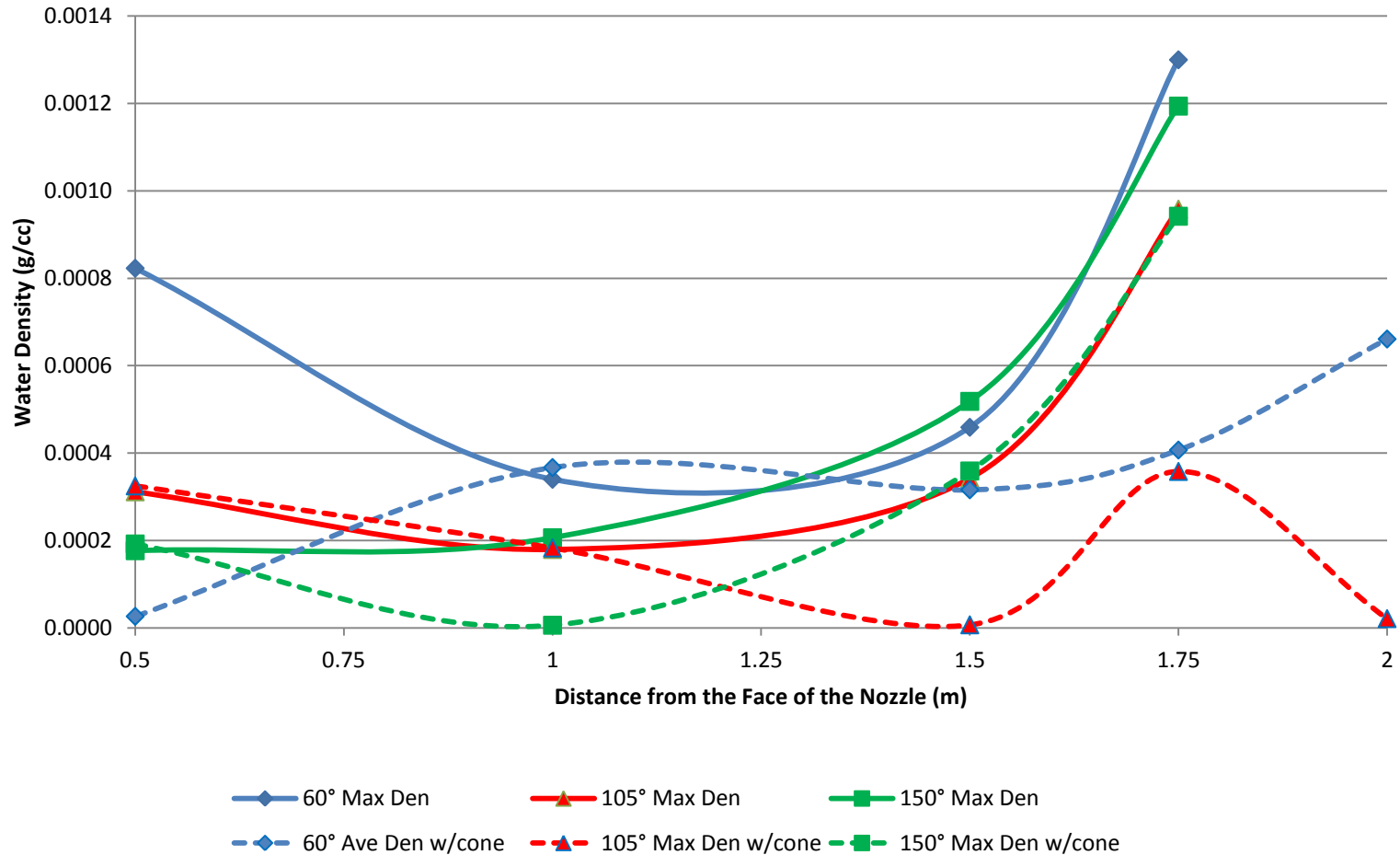


Fire Hose

- Typically 1½” diameter hose with a variable spray nozzle
- Flow rates from 26 to 225 gallons per minute
- Assume:
 - Droplet forms immediately
 - Drag on individual droplets
 - Nozzle horizontal and 1 meter above the ground

$$F_{\text{drag}} = \frac{1}{2} C_p \rho_{\text{air}} A V^2$$

Fire Hose Water Density Estimates



Fire Fighting Foams

- Low Expansion:
 - Expansion ratios up to 20:1. These are used effectively against Class B (flammable liquid) fires.
- Mid-Expansion:
 - Expansion ratios from 20:1 to 200:1. These can be used to suppress vaporization of hazardous chemicals.
- High Expansion:
 - Expansion ratios above 200:1. These are used for confined-space firefighting.

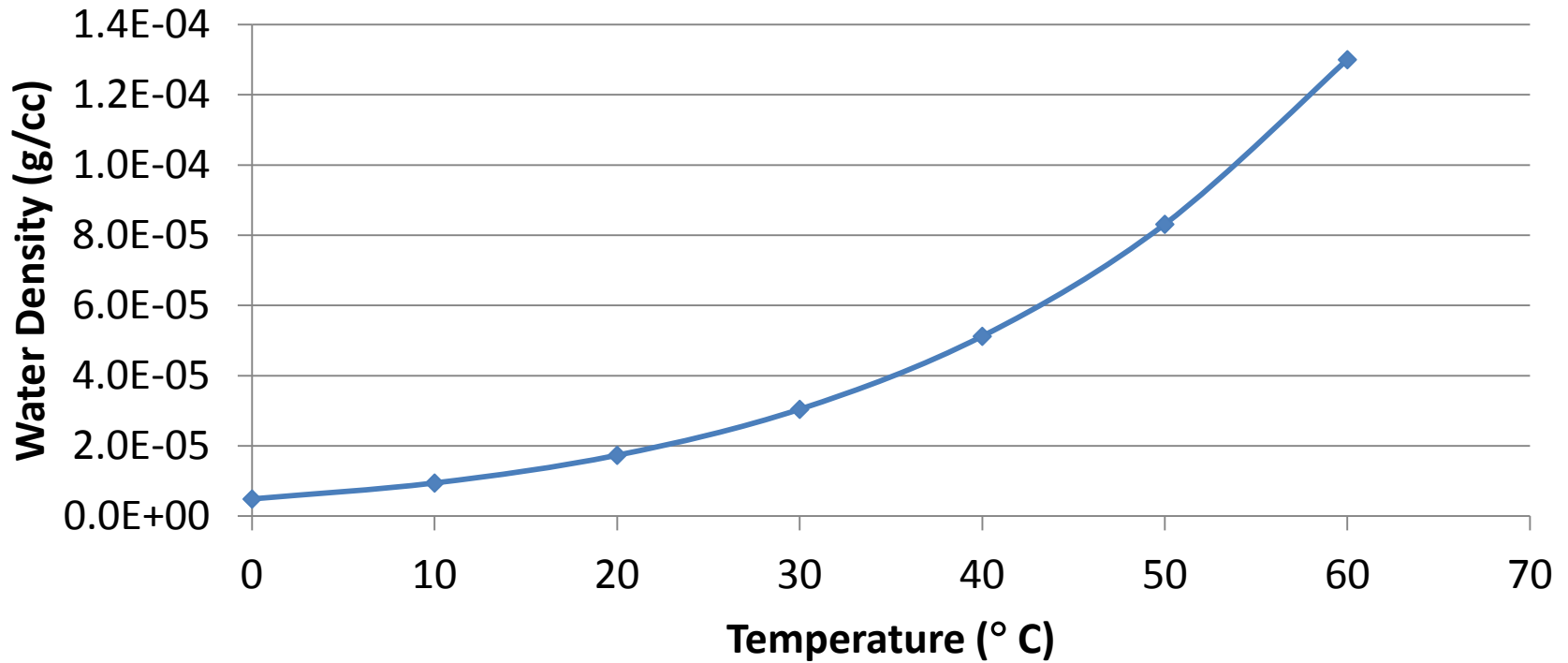
Fire Fighting Foam

- NOG-L Emergency Team carries low-expansion foam.
- Assisting departments have other types but only used with NOG-L approval.
- Not a significant source of moderation.

Steam and Humidity

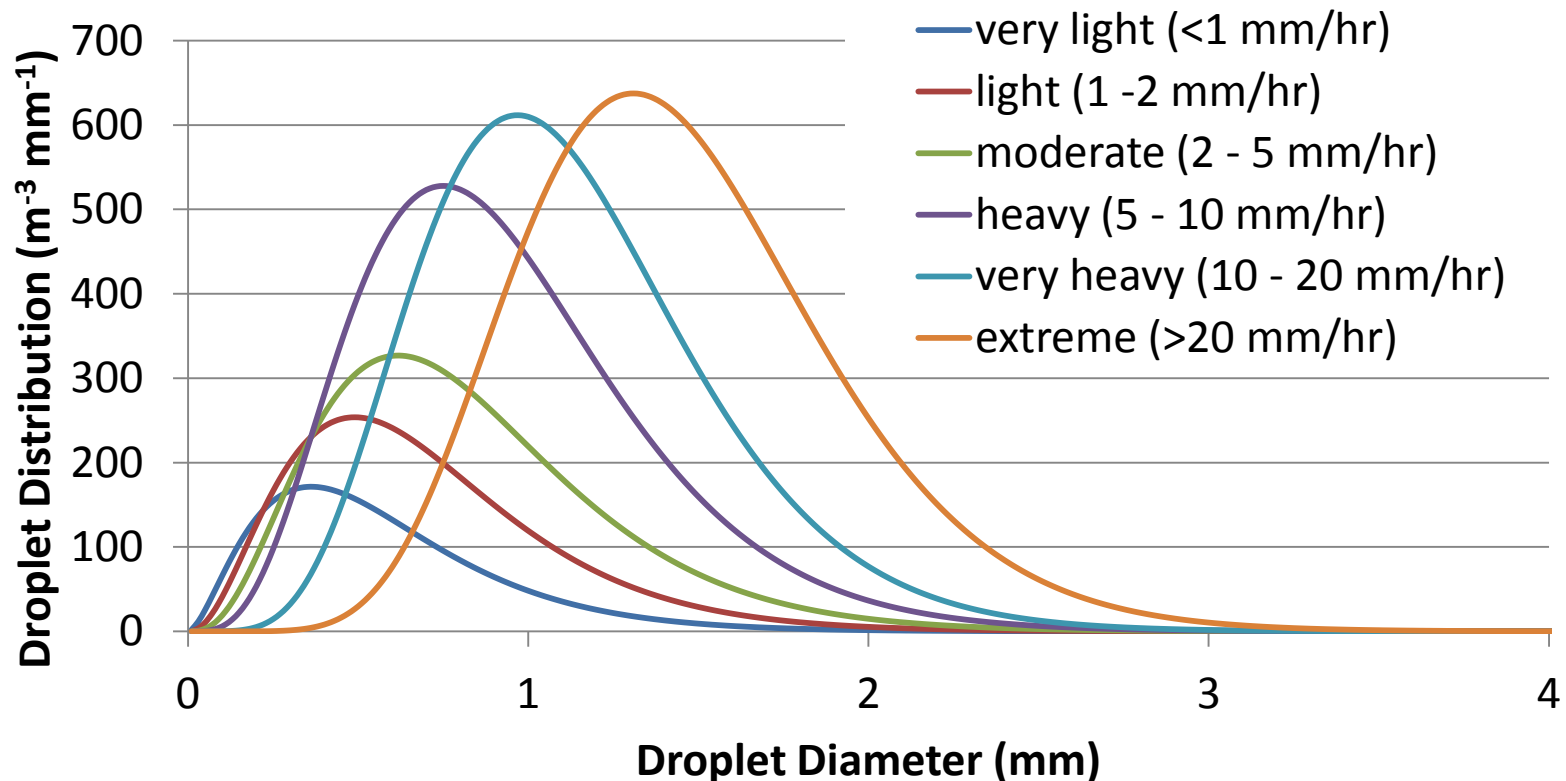
- Steam: 0.0006 g/cc at 100° C

Vapor Density



Rain

- Droplet size is typically modeled as a gamma function



Rain

- Extreme Rain: 1.5×10^{-5} g/cc for 10 inches/hour (or 254 mm/hr)
- Ordinary Hazard 2 Sprinkler is over 14 inches per hour.
- Fire Sprinkler bounds rain

Conclusions

- Sources:
 - ▶ Sprinklers: up to 0.0005 g/cc
 - ▶ Fire Hose: up to 0.001 g/cc
 - ▶ Fire Fighting Foam: only a source if High Expansion type
 - ▶ Steam: 0.0006 g/cc
 - ▶ Humidity: ~ 0.00003 g/cc
 - ▶ Rain: up to 0.0002 g/cc

Conclusion

Sources

