

# Effects of Water Emulsion Fuels on NO<sub>x</sub> Formation

# Factors influencing NO<sub>x</sub> formation

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- Flame temperature
- Droplet flames (non-premixed diffusion flames)
- Fuel-bound nitrogen

# Fuel Factors – Emulsion Fuels

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- Water content
  - (Flame temperature influence)
- Water particle size
  - (Droplet flame influence)

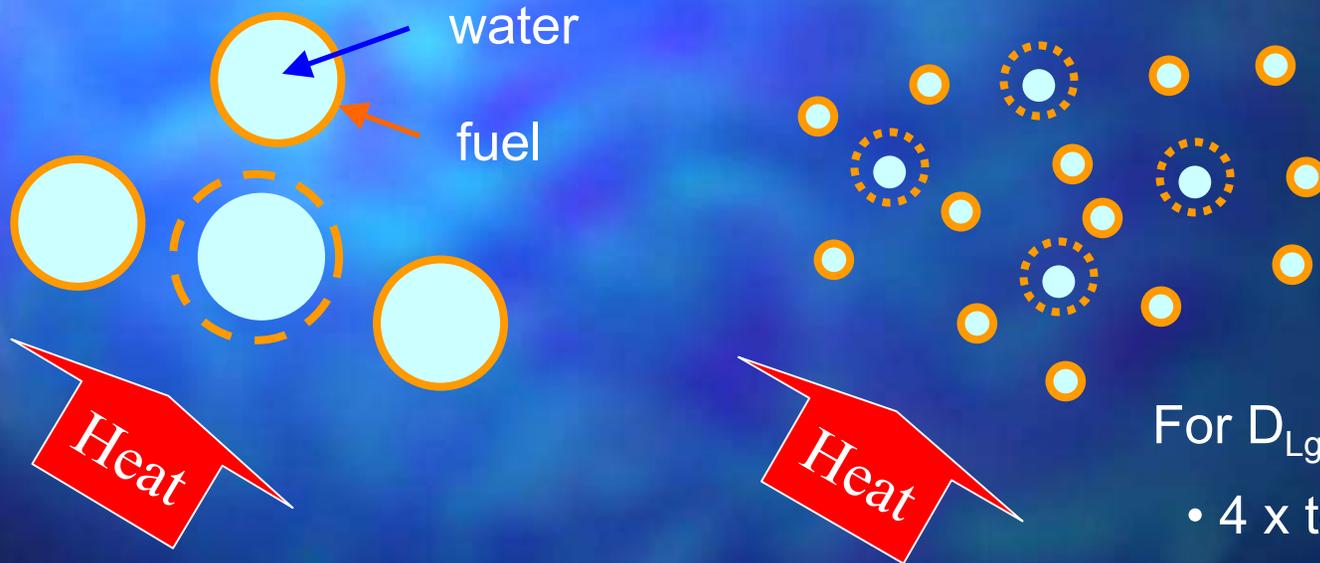
# Water Content

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- Passive constituent
- Absorbs energy
- Dilutes, hinders reaction
- Operability issues:
  - Starts, stops – problems at 25%
  - Corrosion potential
  - Instability potential

# Water Particle size

## ■ Secondary atomization efficiency



For  $D_{Lg} = 4 \times D_{Sm}$ :

- 4 x total surface area
- 64 x no. droplets

# Experimental controls

- Burners – (2) arrangements:
  - Standard flame retention (FR)
  - Combustion gas recirculation (CGR)
- Appliance:
  - 3-section, C.I. Boiler (N.A. style)
- Fuels:
  - (4) water contents
  - (2) water particle sizes (+ mix)

# Experimental fuels

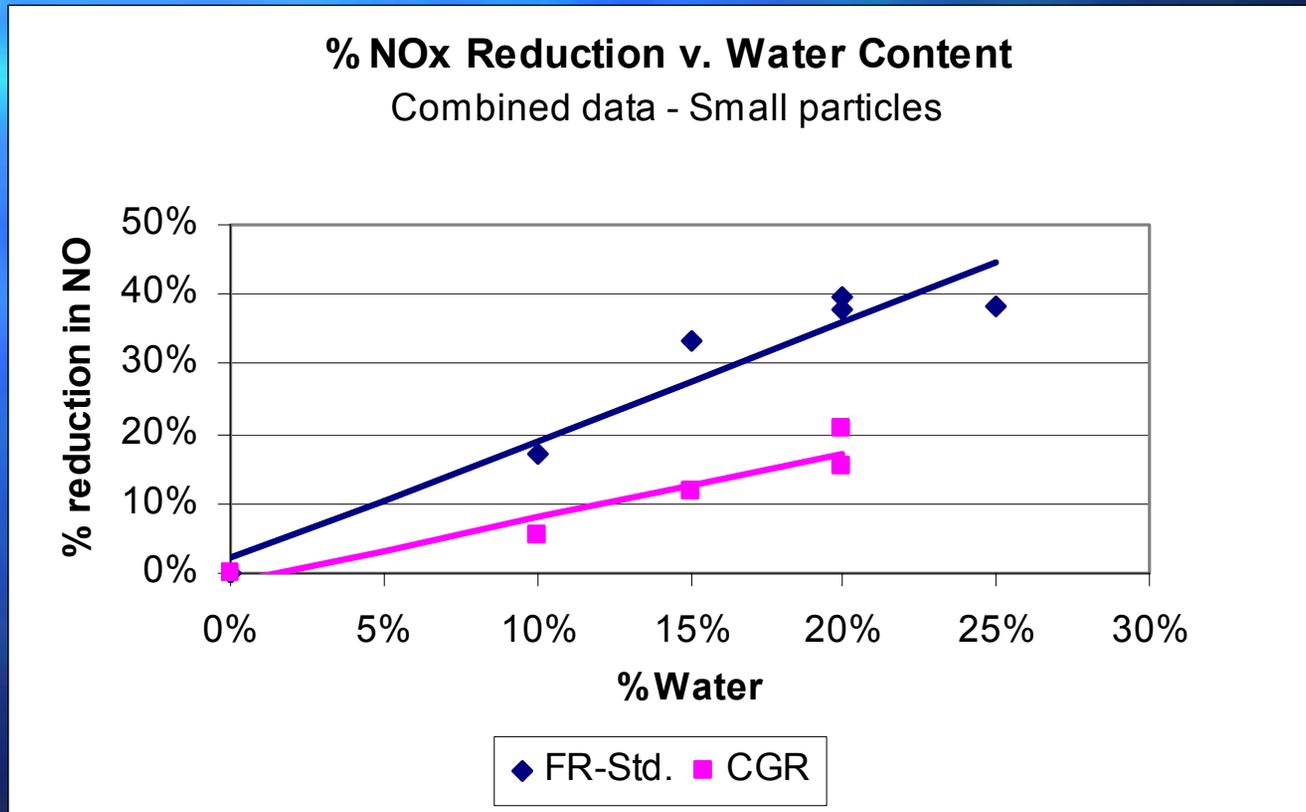
Experiment	Water Content	Particle Size	Base Fuel
Screening Experiment	- 10% - 20%	- Small	- No. 2 Fuel (Emul., Ref.)
Characterization Experiment	- 15% - 20% - 25%	- Small - Mixed - Large	- No. 2 Off-Hwy Diesel (Emul., Ref.) - No. 2 Fuel (Ref.)

# Responses

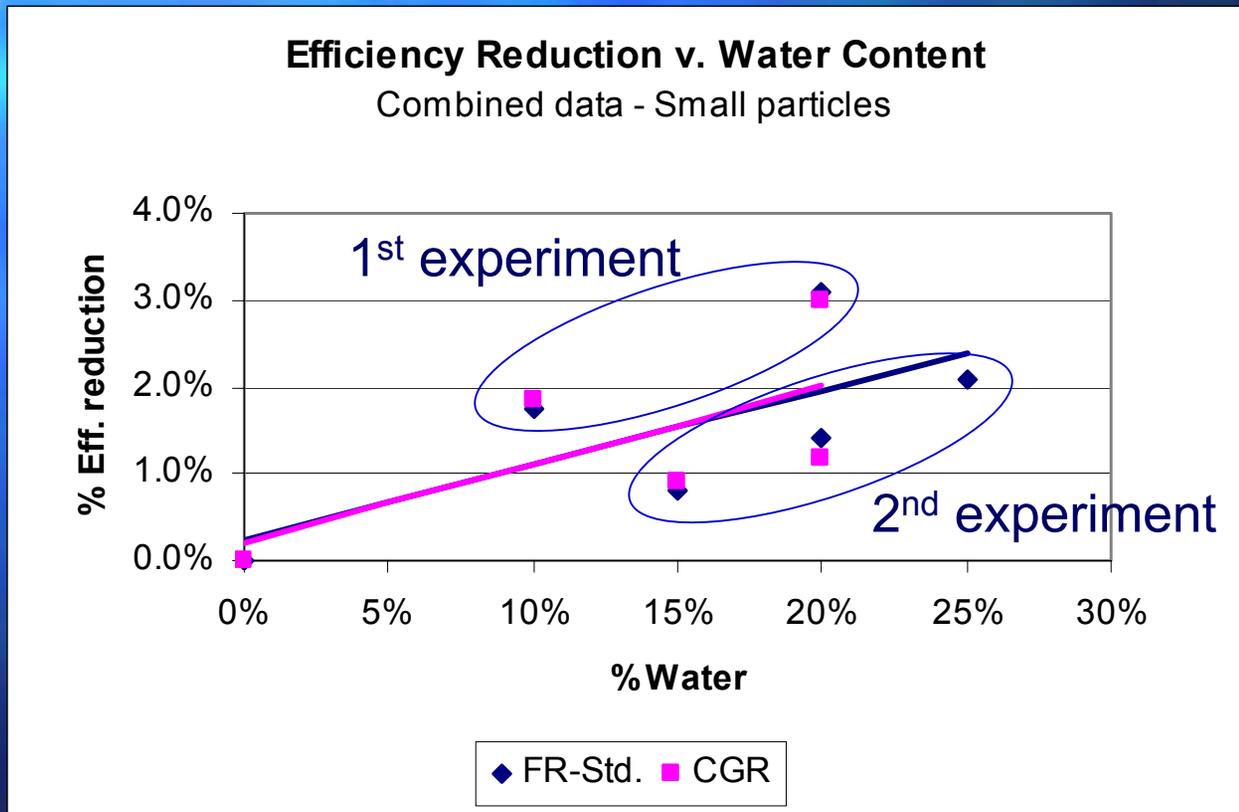
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- NO @ 3% O<sub>2</sub>
- Thermal efficiency (calculated)
- Chamber temperature (mean of (6) locations, 1.50 in. below crown)

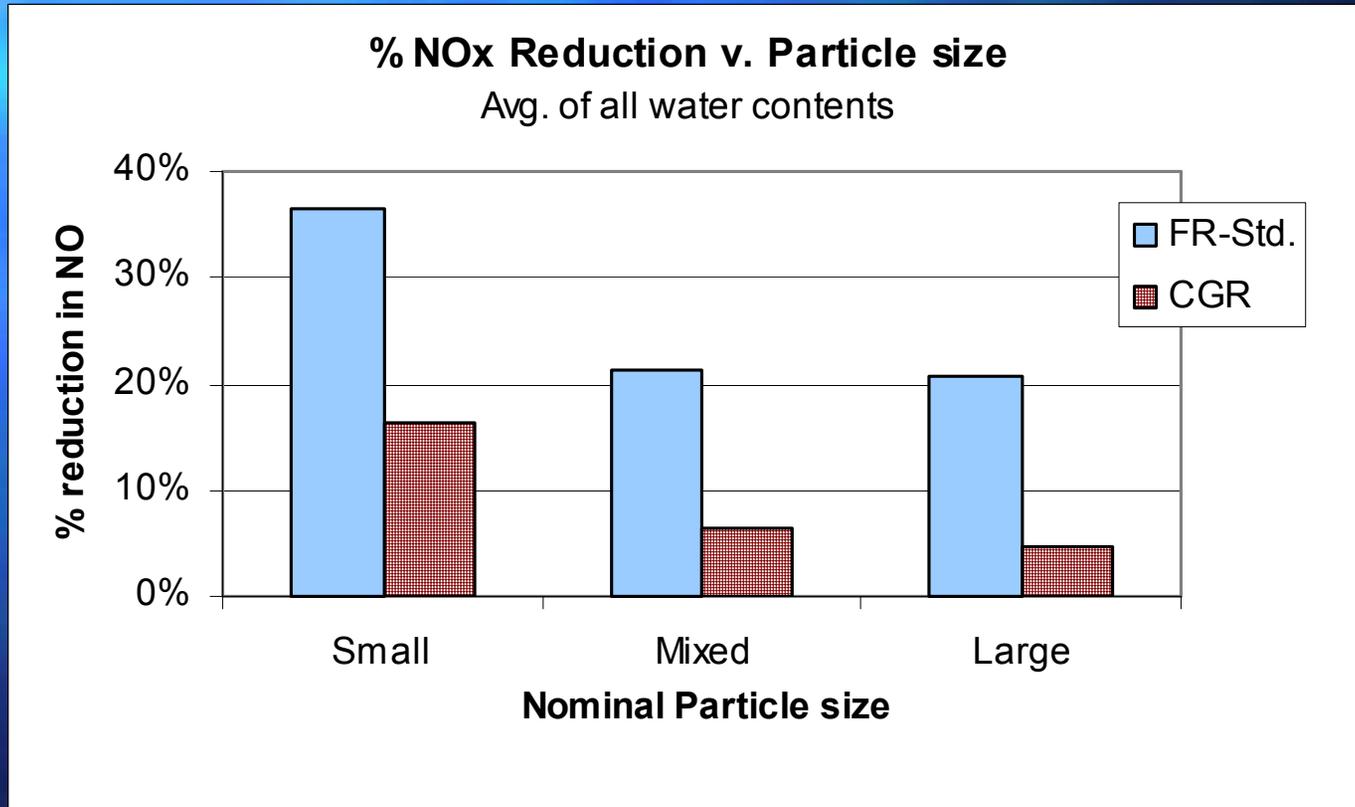
# Effect of Water Content - NOx reduction



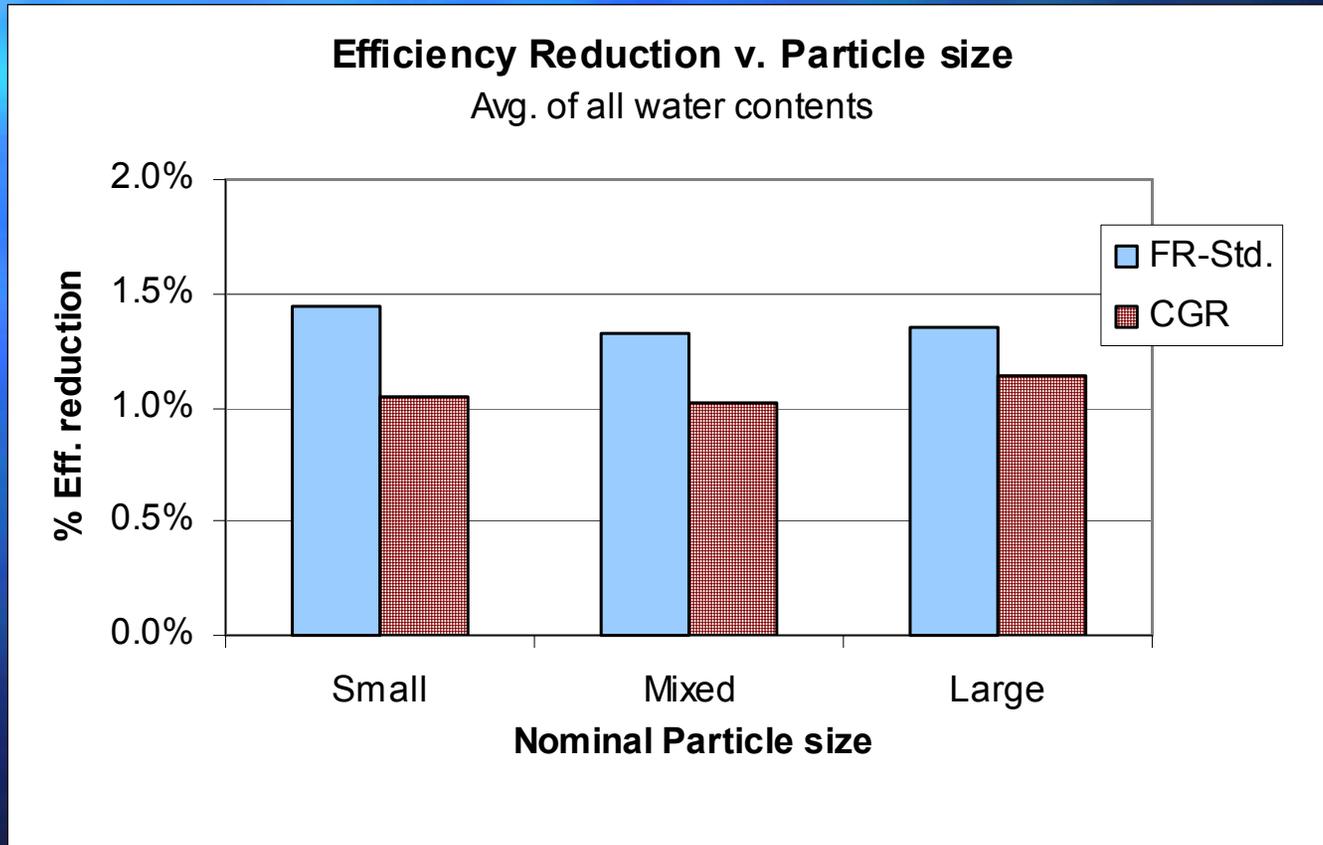
# Effect of Water Content - Thermal efficiency



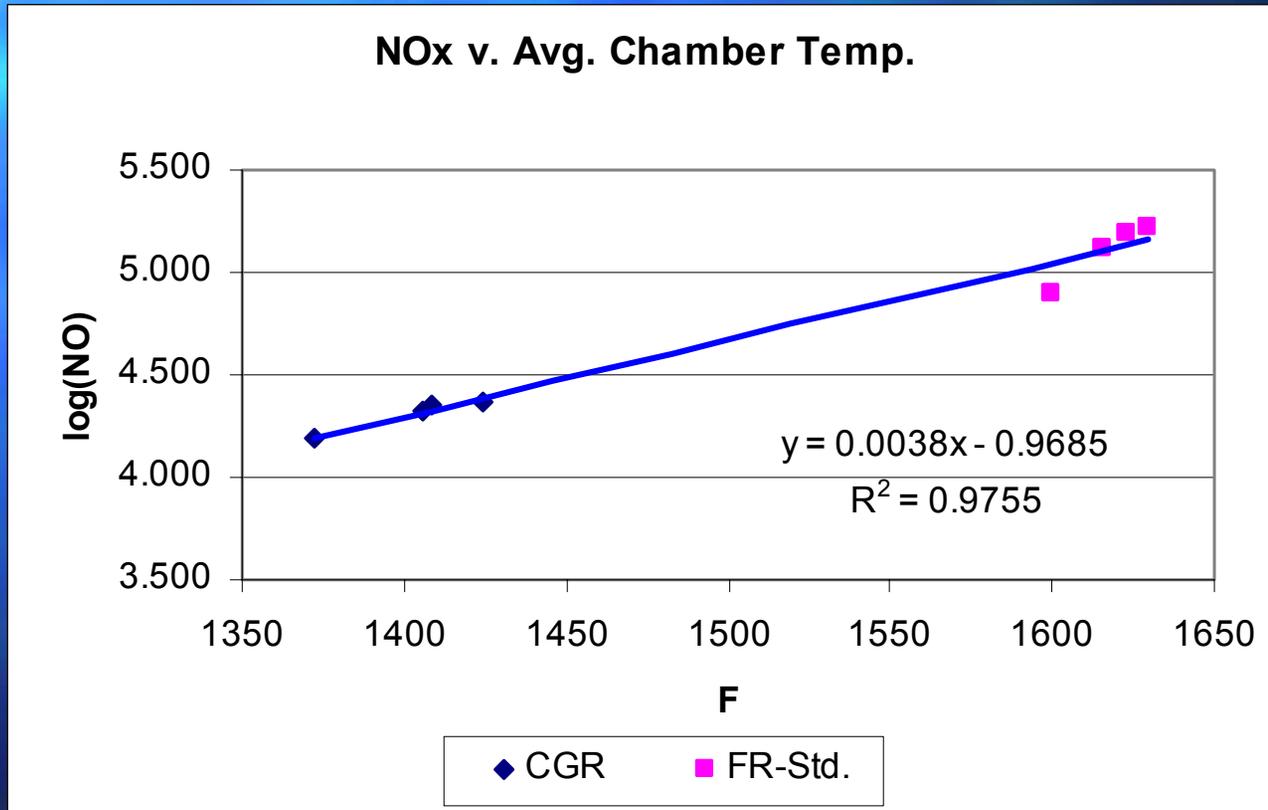
# Effect of Water Particle size - NOx reduction



# Effect of Water Particle Size - Thermal efficiency



# Chamber Temperatures



# Comparison of flames

Base  
fuel



10%  
water



20%  
water



# Summary – Water Emulsion effects

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- Water content to 20%:
  - 15-38% NO<sub>x</sub> reduction
  - 1-3% efficiency reduction
- Smaller particles:
  - Promotes higher NO<sub>x</sub> reduction
  - Little effect on efficiency reduction
- NO<sub>x</sub> reduction is a function of chamber (and flame) temperature