APEX CFM-56 Particle Emissions: Concentrations and Size Distributions

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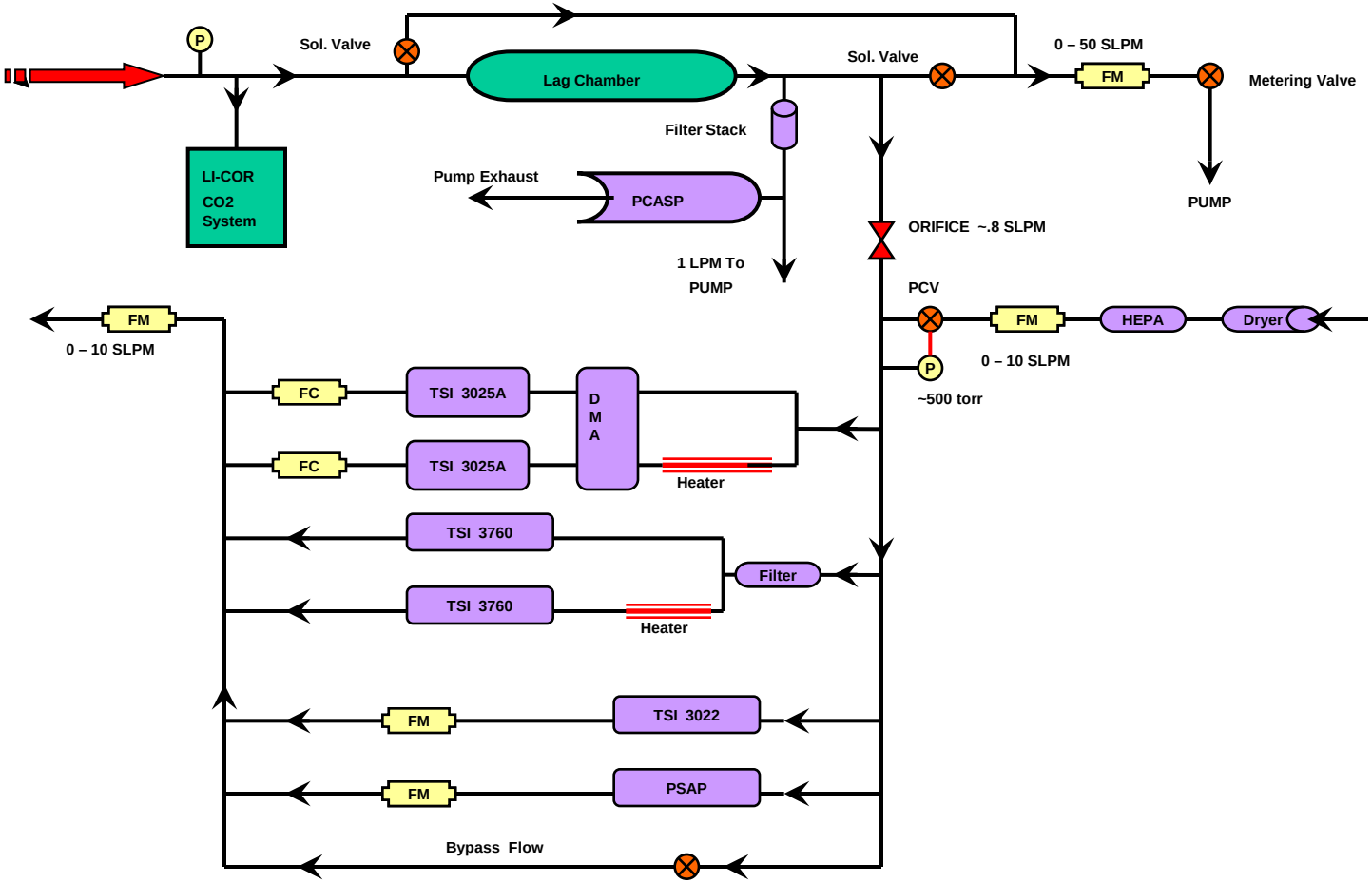
LaRC Project Objectives

- Characterize commercial aircraft particle physical properties (number densities, size, mass and volatility) as a function of engine power
- Examine the impact of fuel sulfur upon secondary aerosol formation
- Investigate the relationship between fuel aromatic content and EC/OC emissions
- Observe the evolution of particle concentrations and characteristics as the exhaust plume ages

LaRC Instruments



Derived Aerosol Parameters

Number Emission Index

$$NEI = (\Delta X/\Delta CO2) * EI[CO2] * M_{air}/(\rho * M_{co2})$$

Geometric Mean Diameter

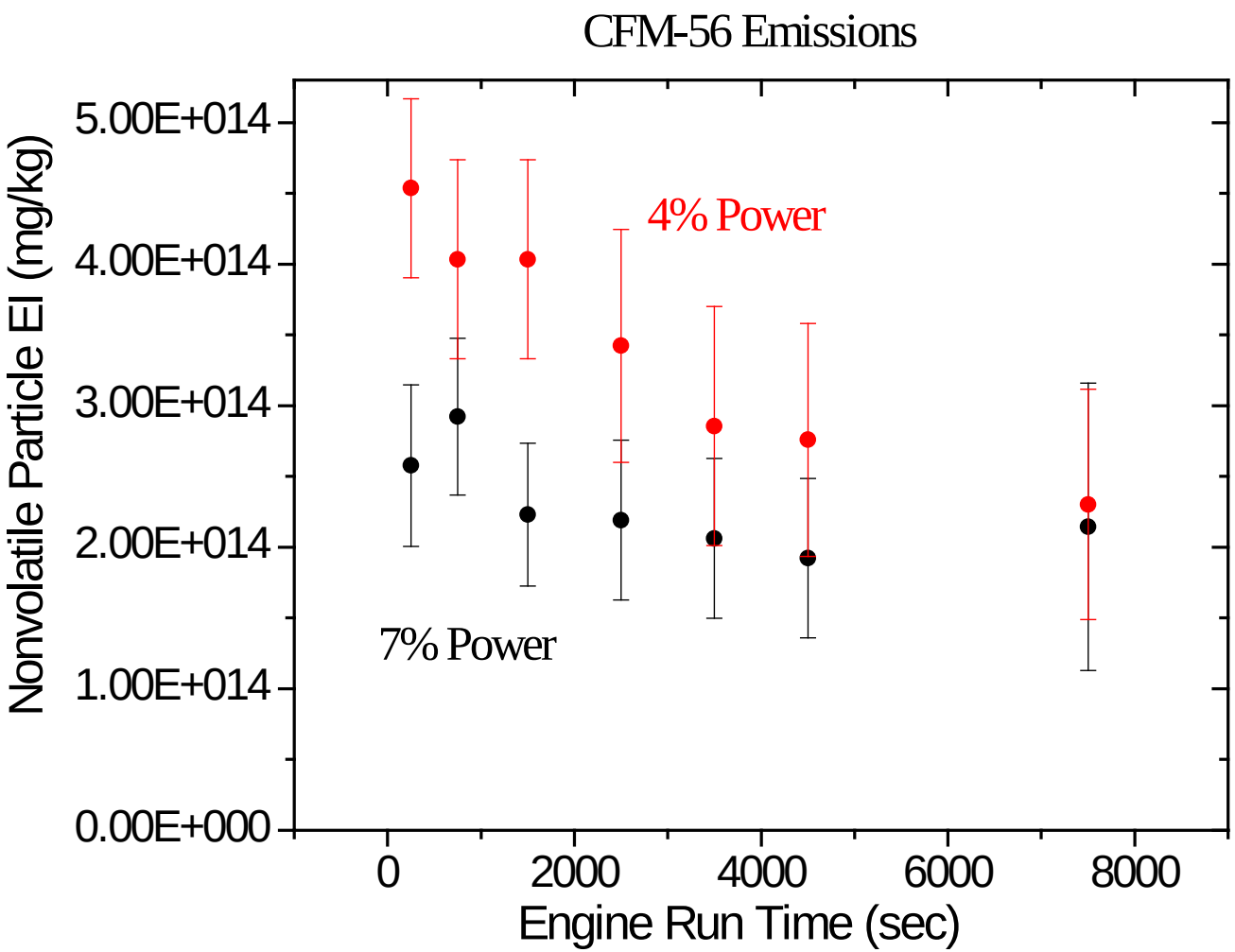
$$GMD = EXP\{\Sigma\, n_i * \ln(Dp_i)/\Sigma\, n_i\}$$

Geometric Standard Deviation

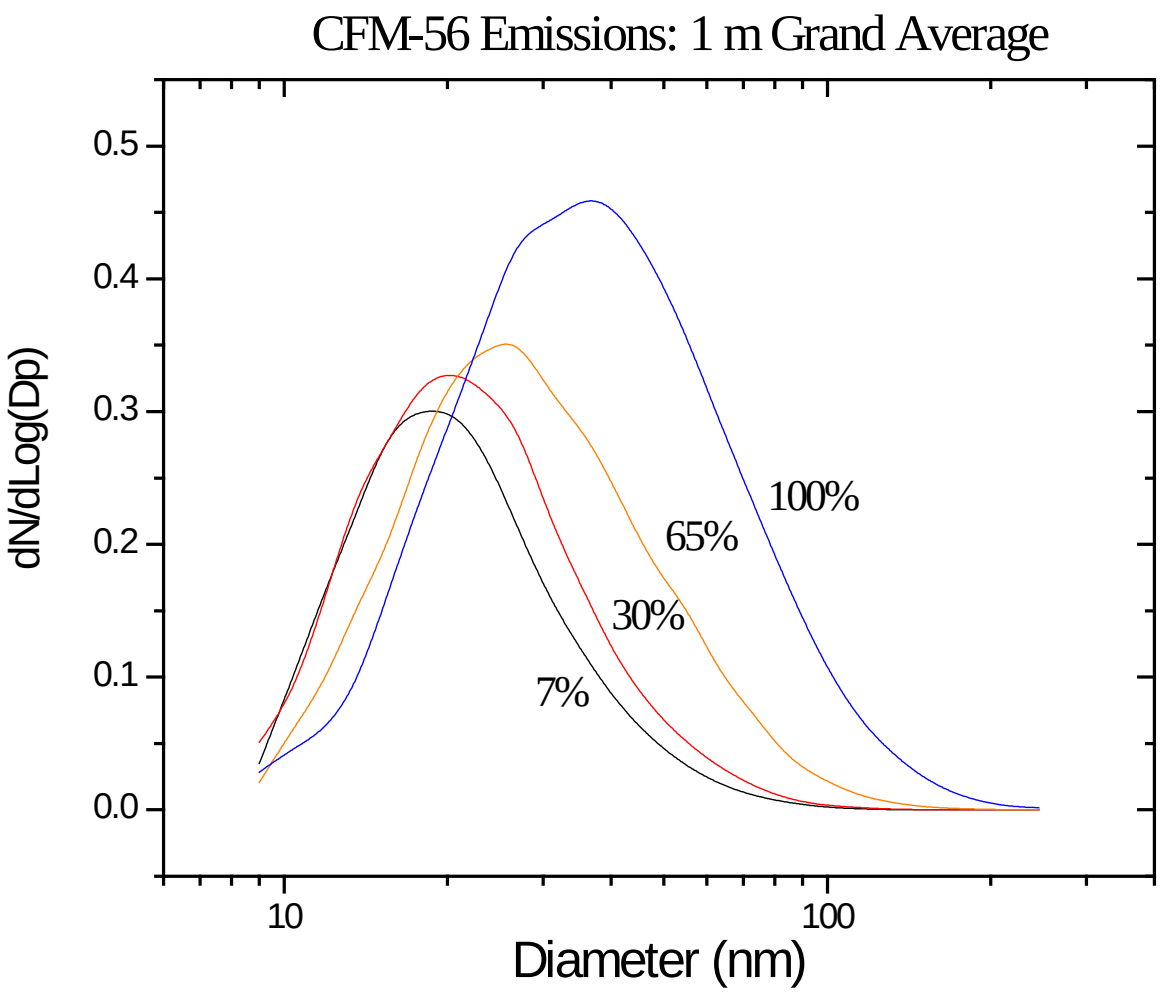
$$\sigma_g = EXP\{[\Sigma\, n_i * (\ln(Dp_i) - \ln(GMD))^2]/(N-1)\}^{0.5}$$

Home, Sweet Home

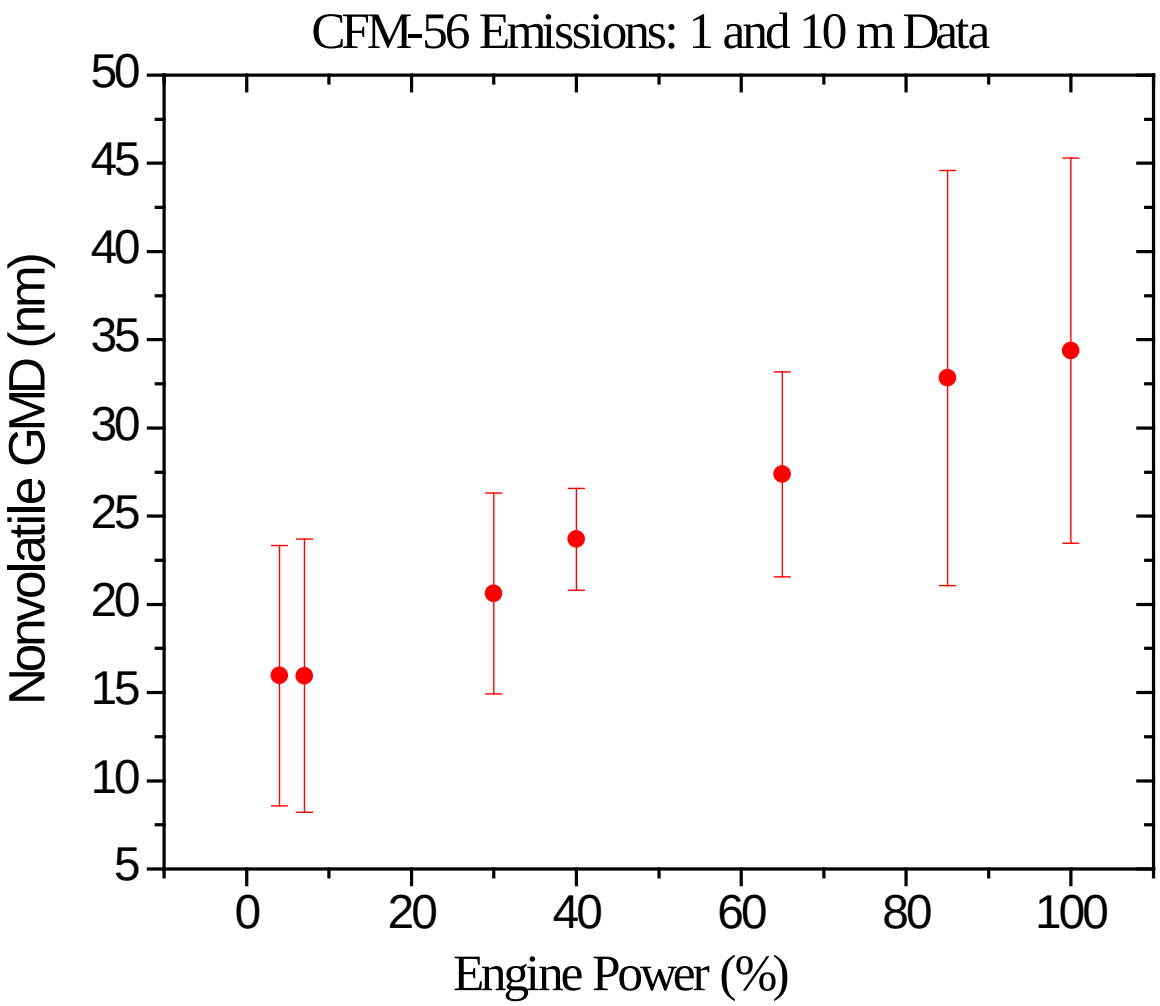
Number EI: Run-time Dependence



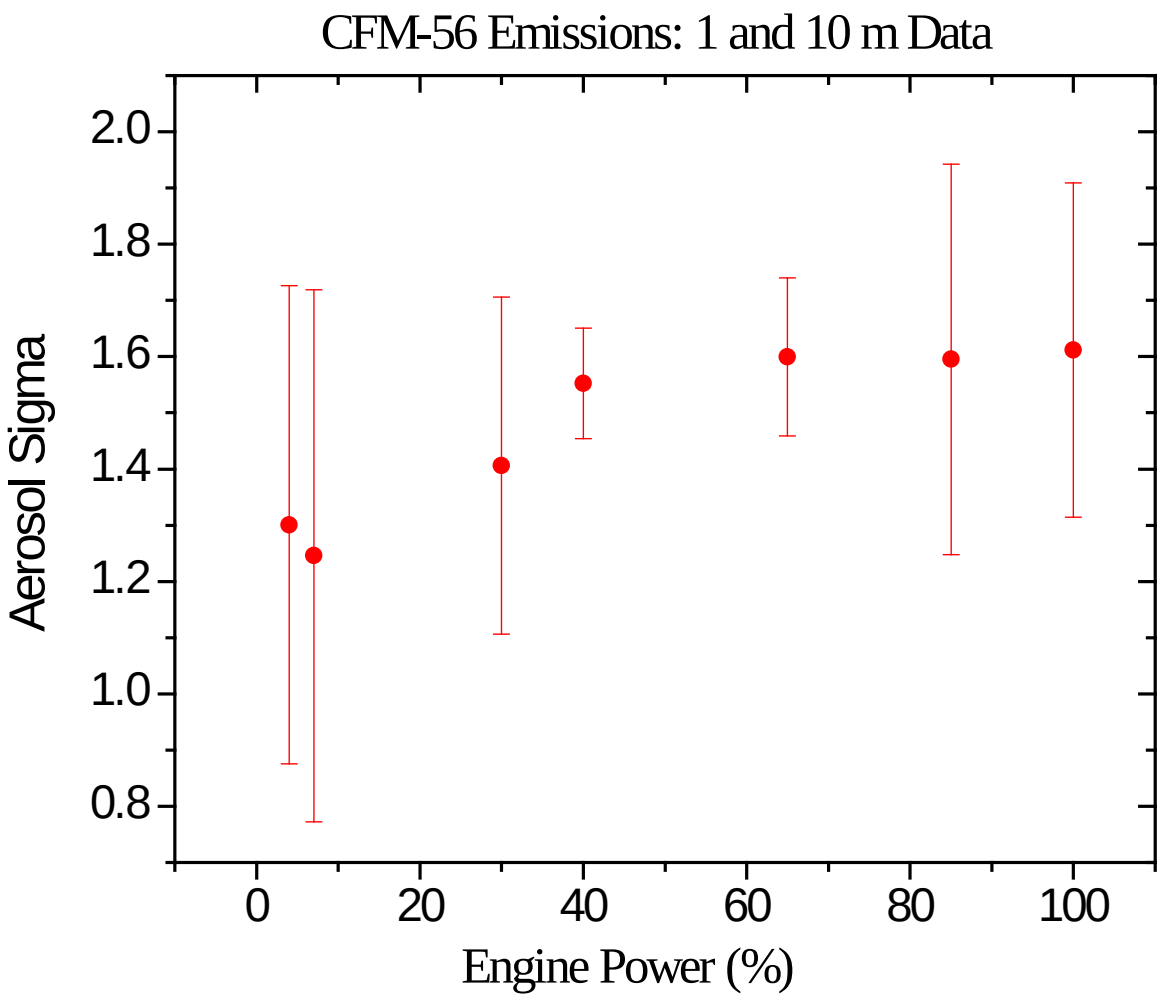
Particle Size Distribution at 1 m



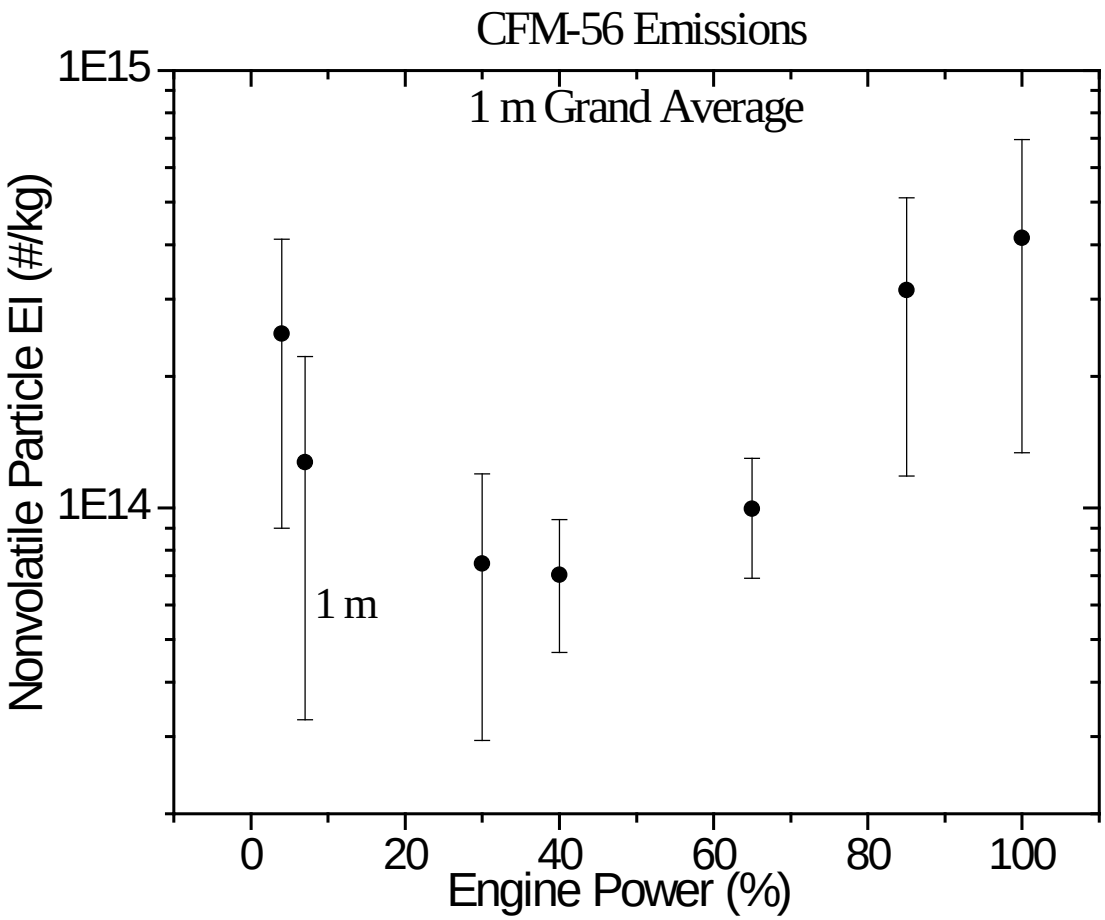
Geometric Mean of Size Distribution



Standard Deviation of Size Distribution



Number Emission Indices



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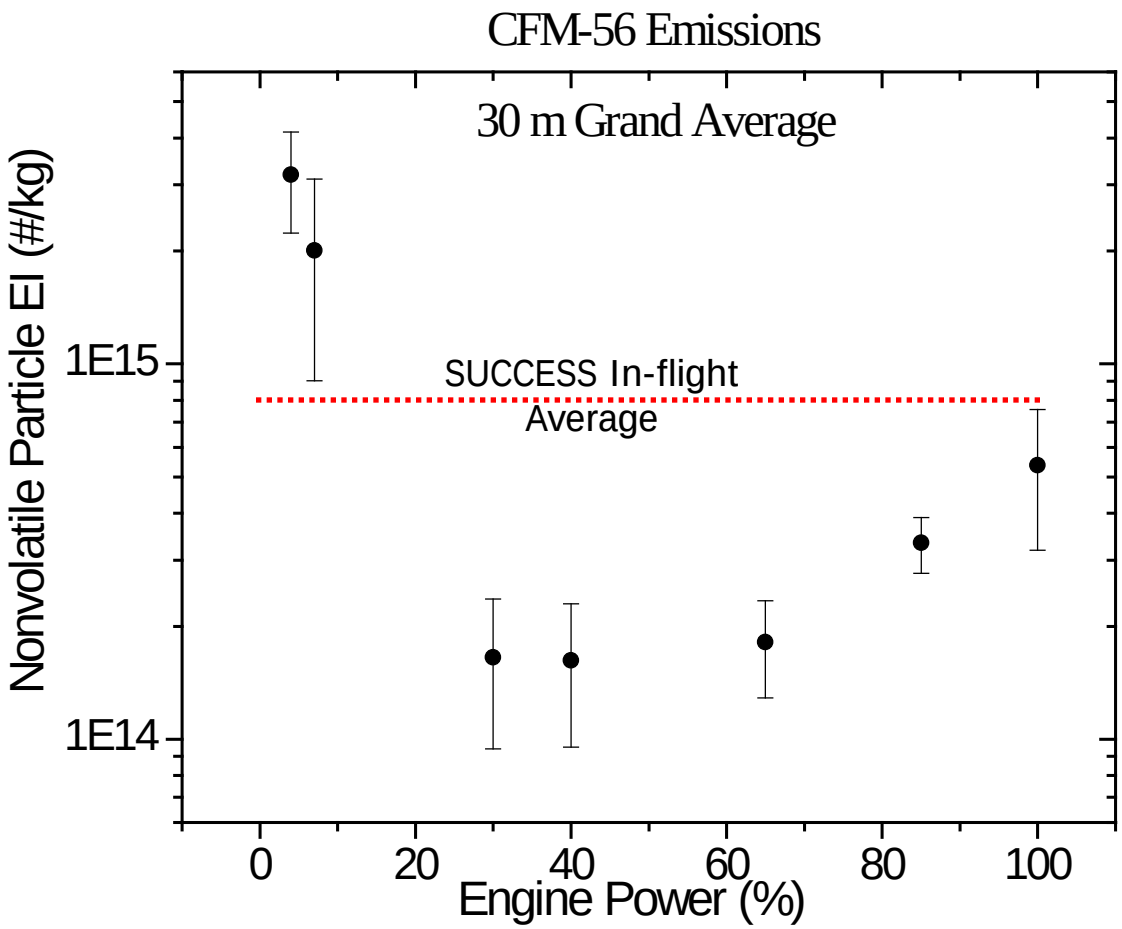
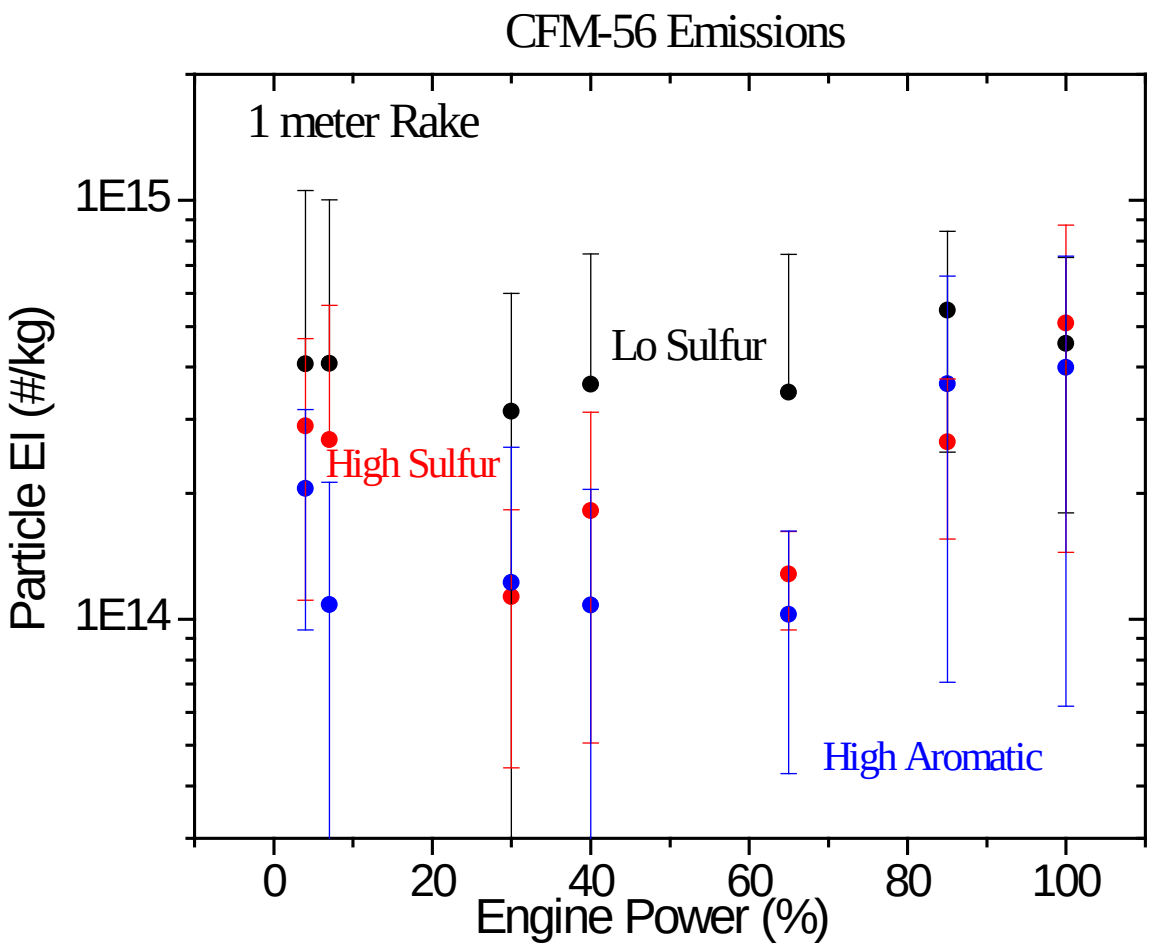


Fuel Dependence of Emission Indices



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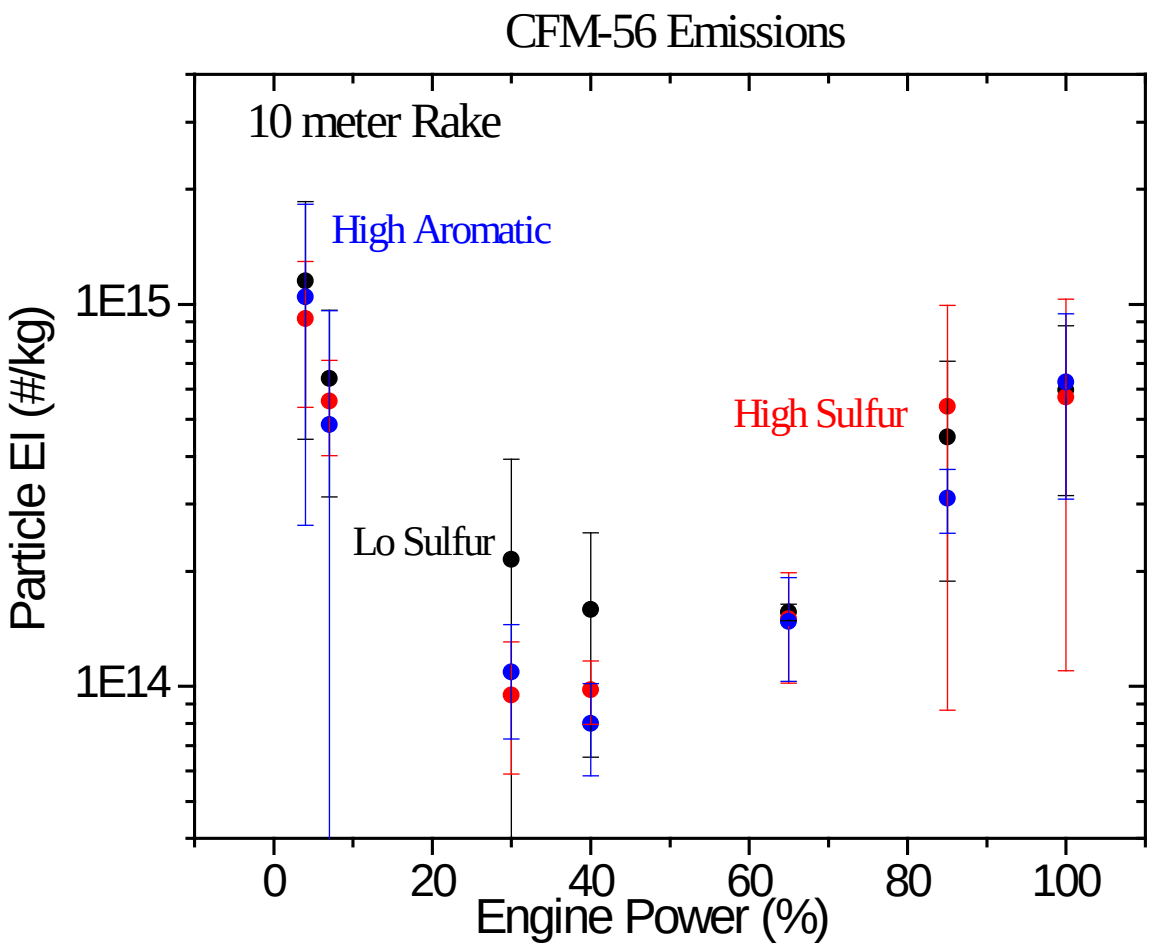

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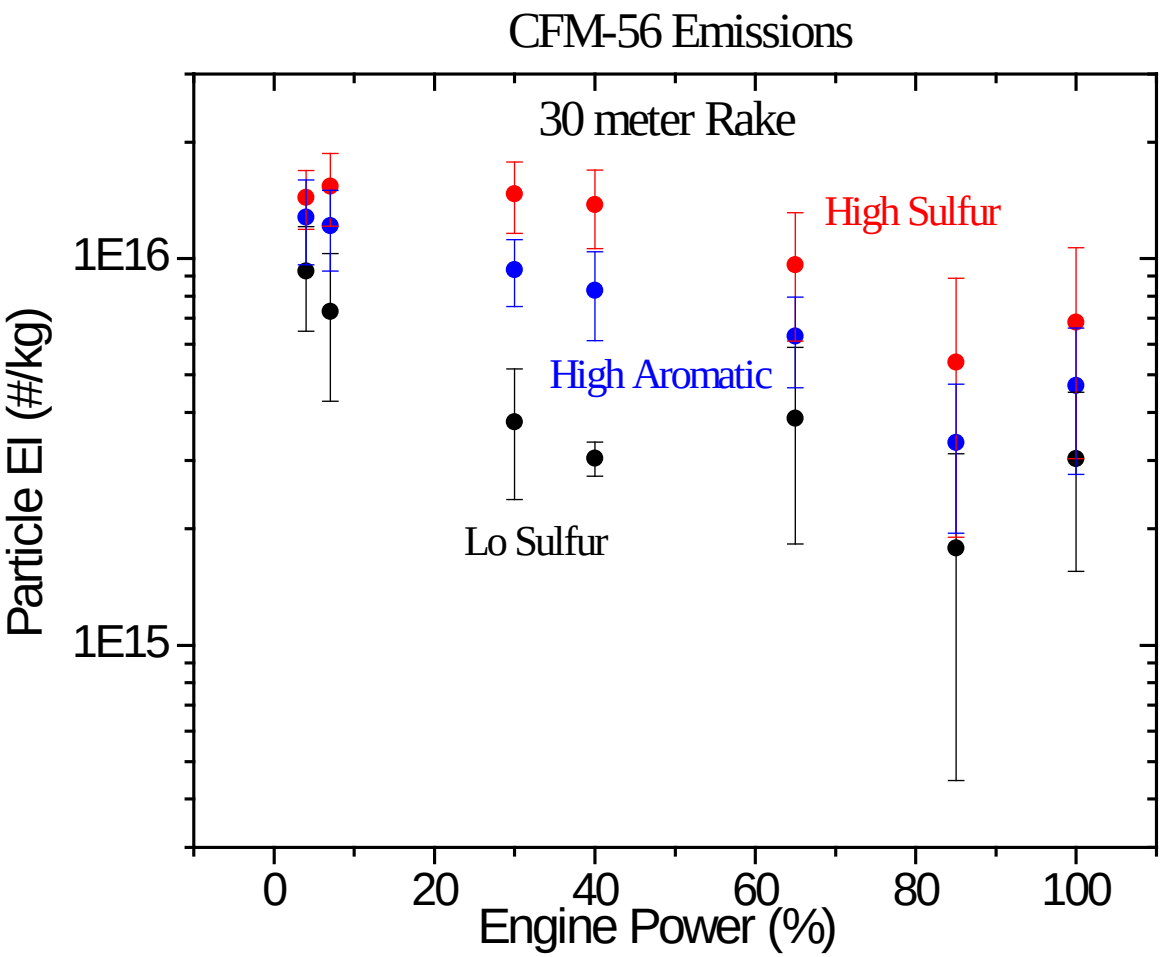
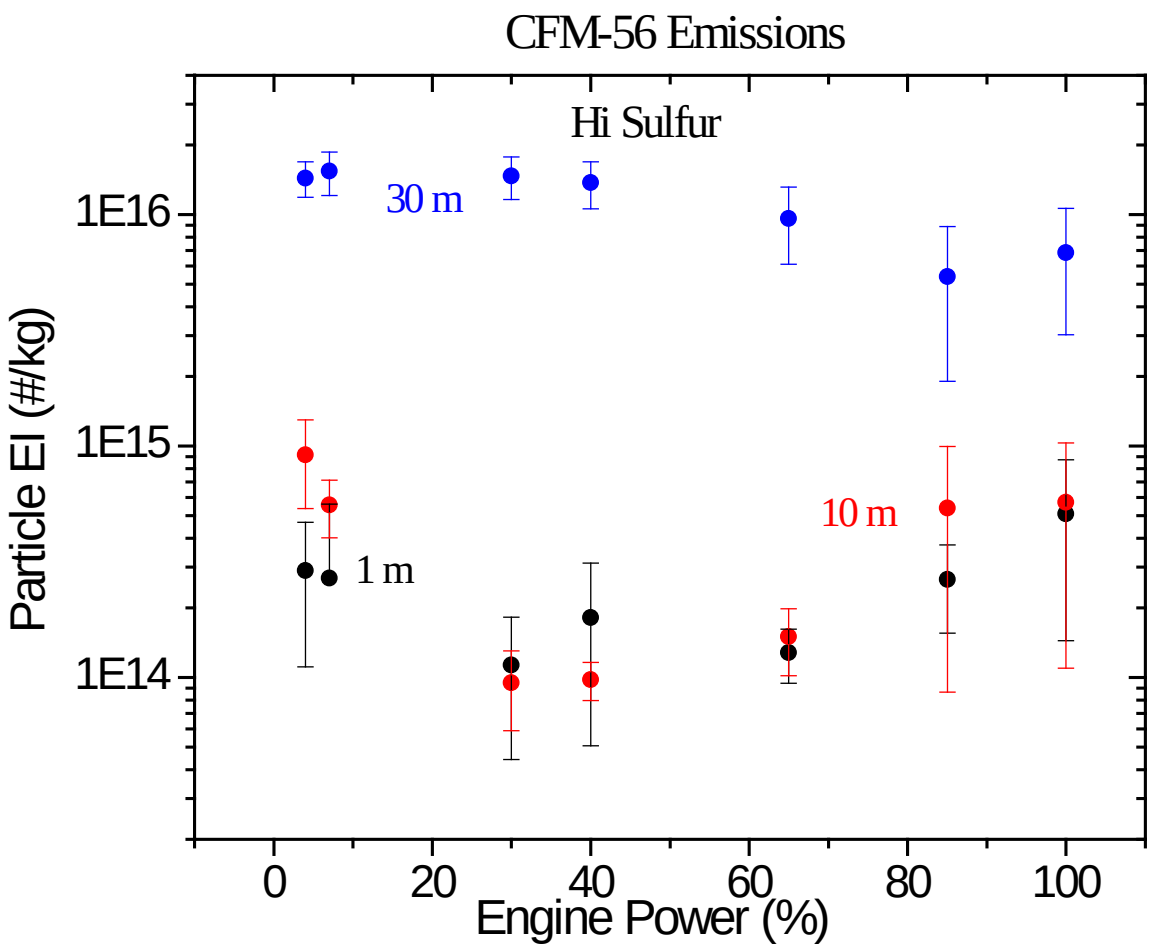


Number EI: Age Dependence



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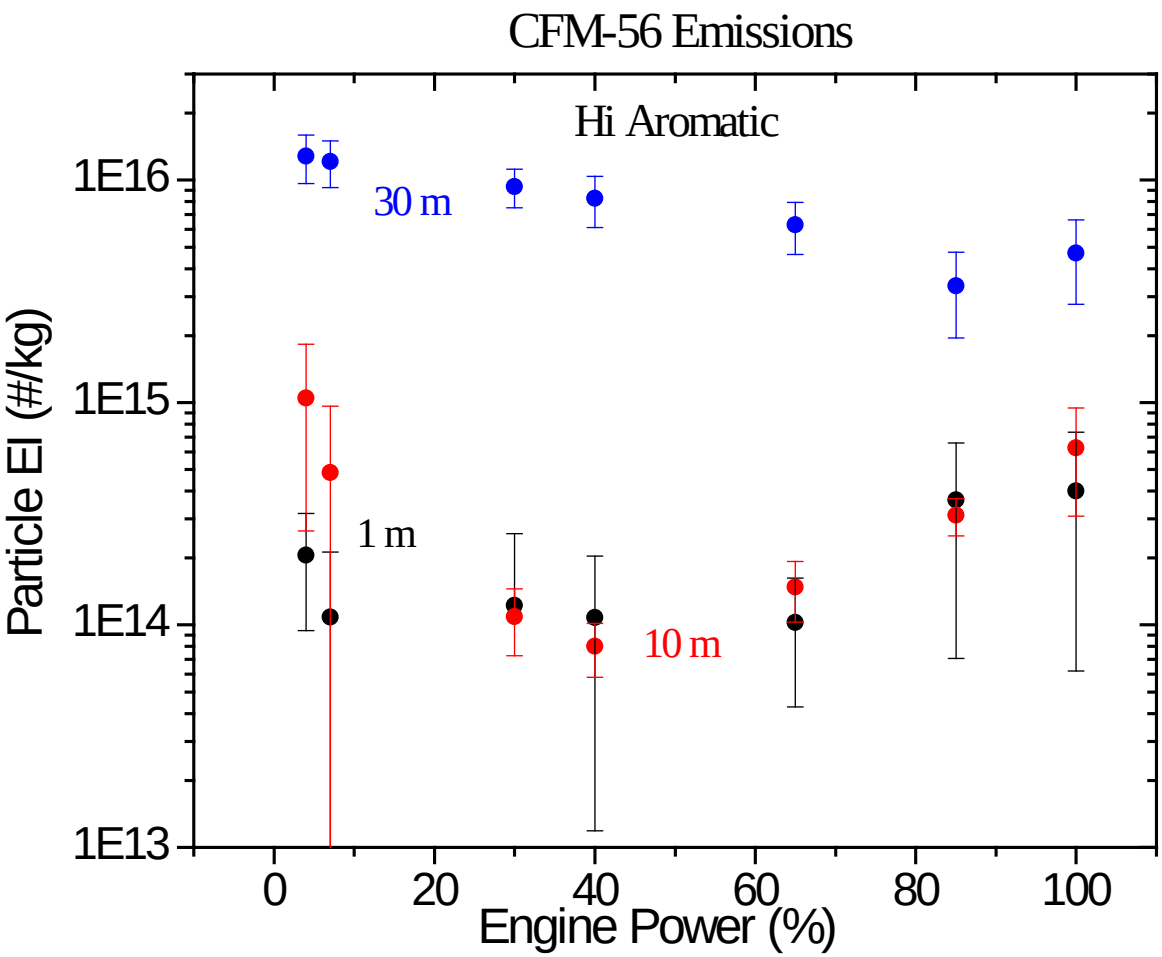

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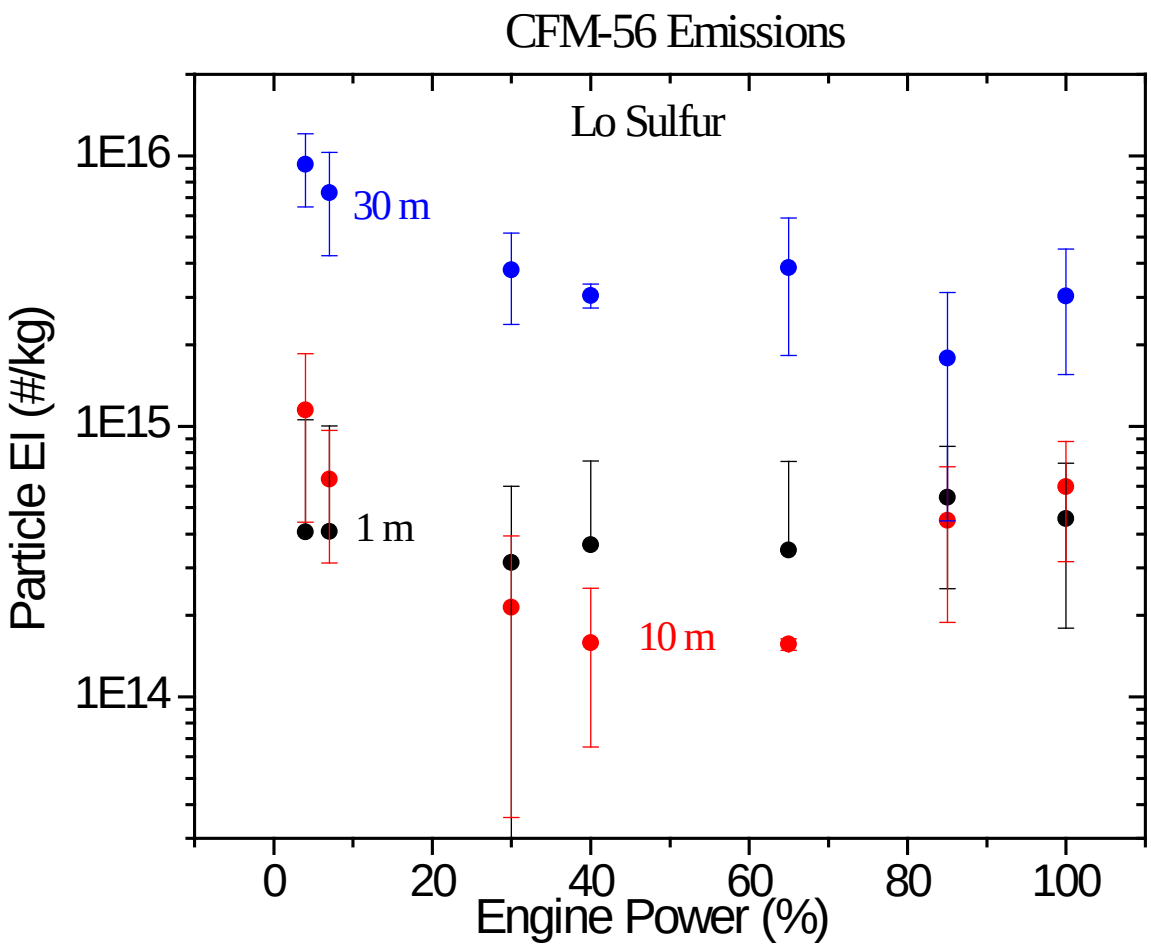
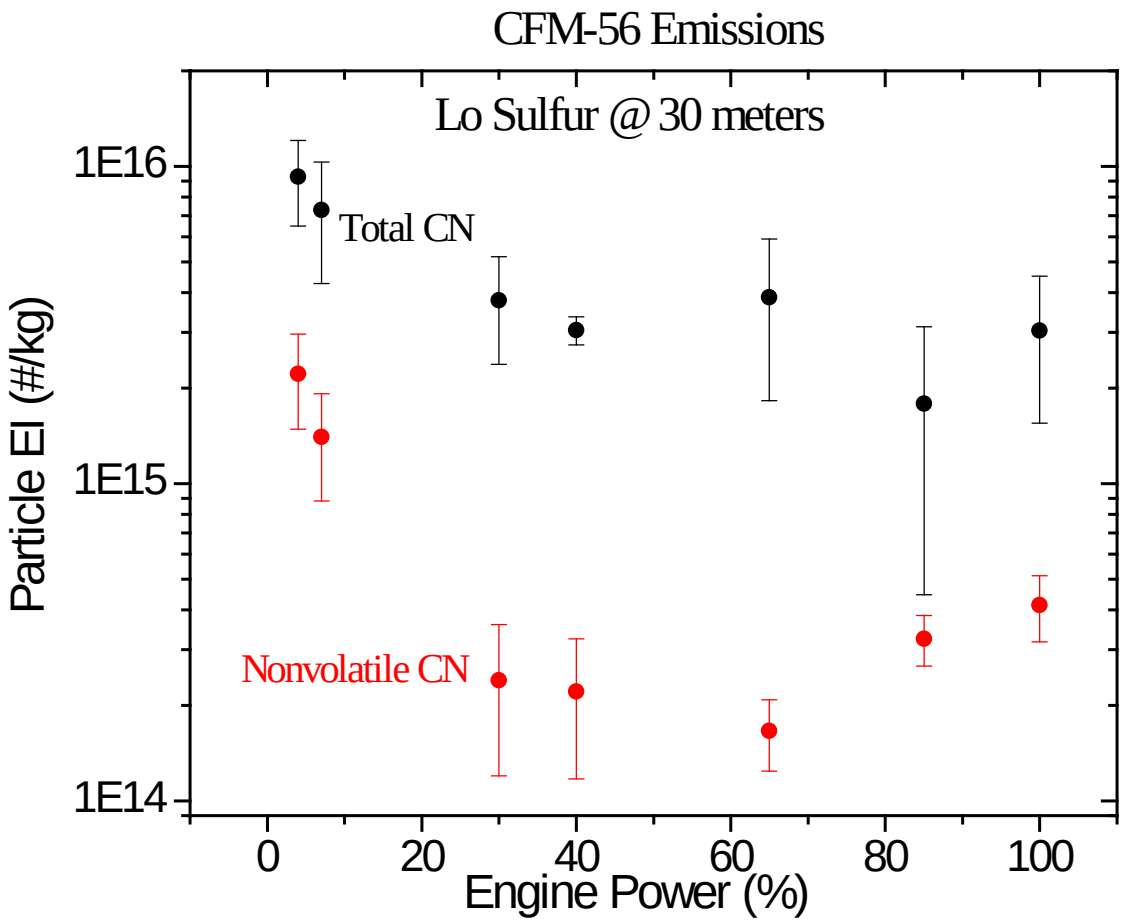


Fractional Volatility of Emissions



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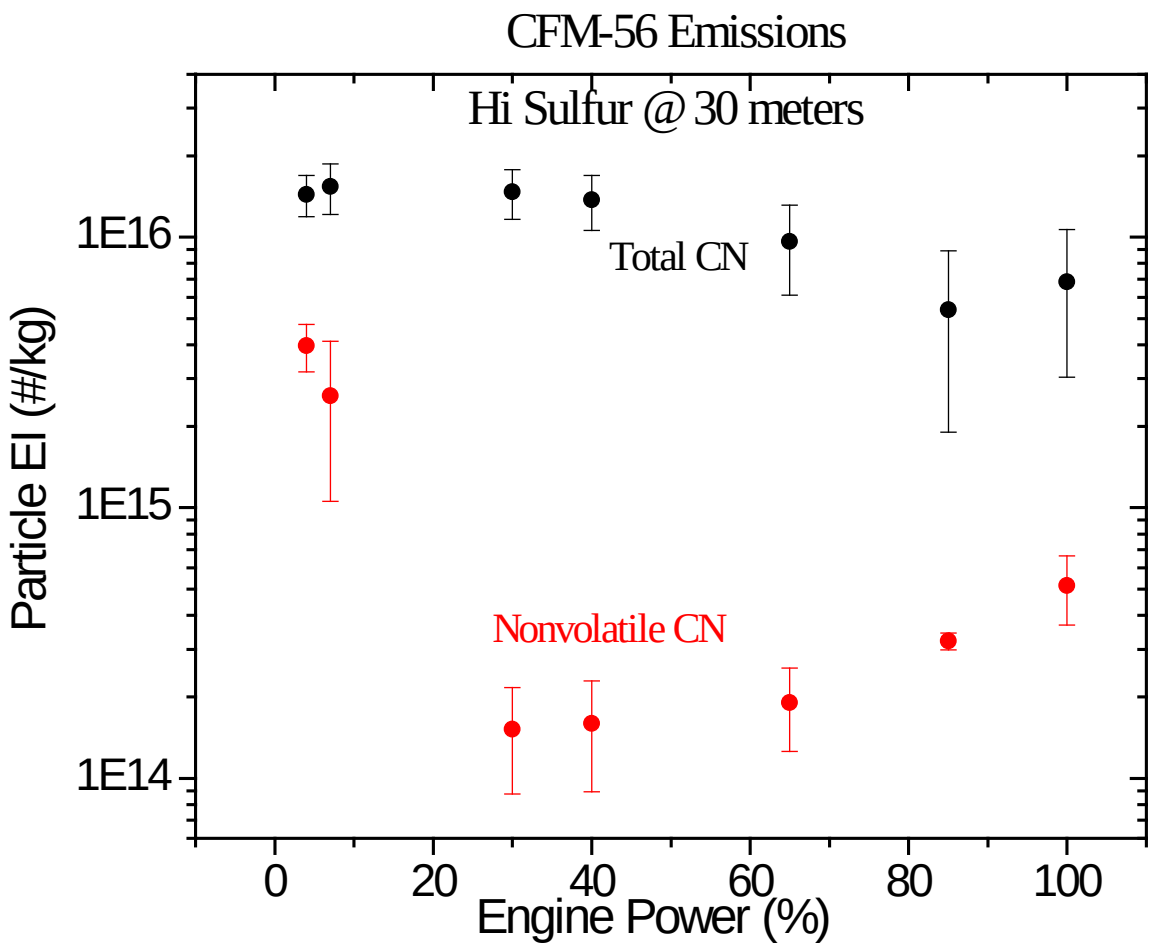

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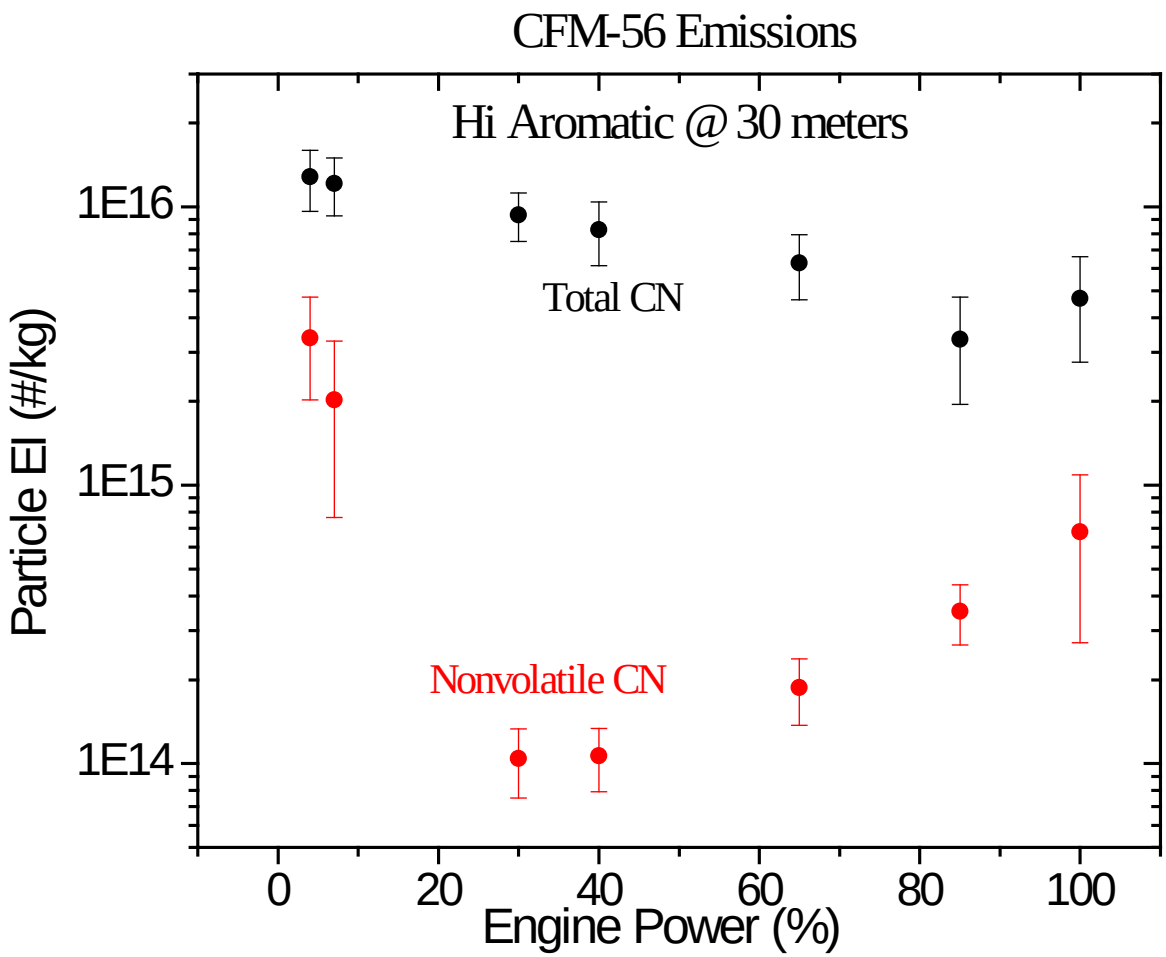
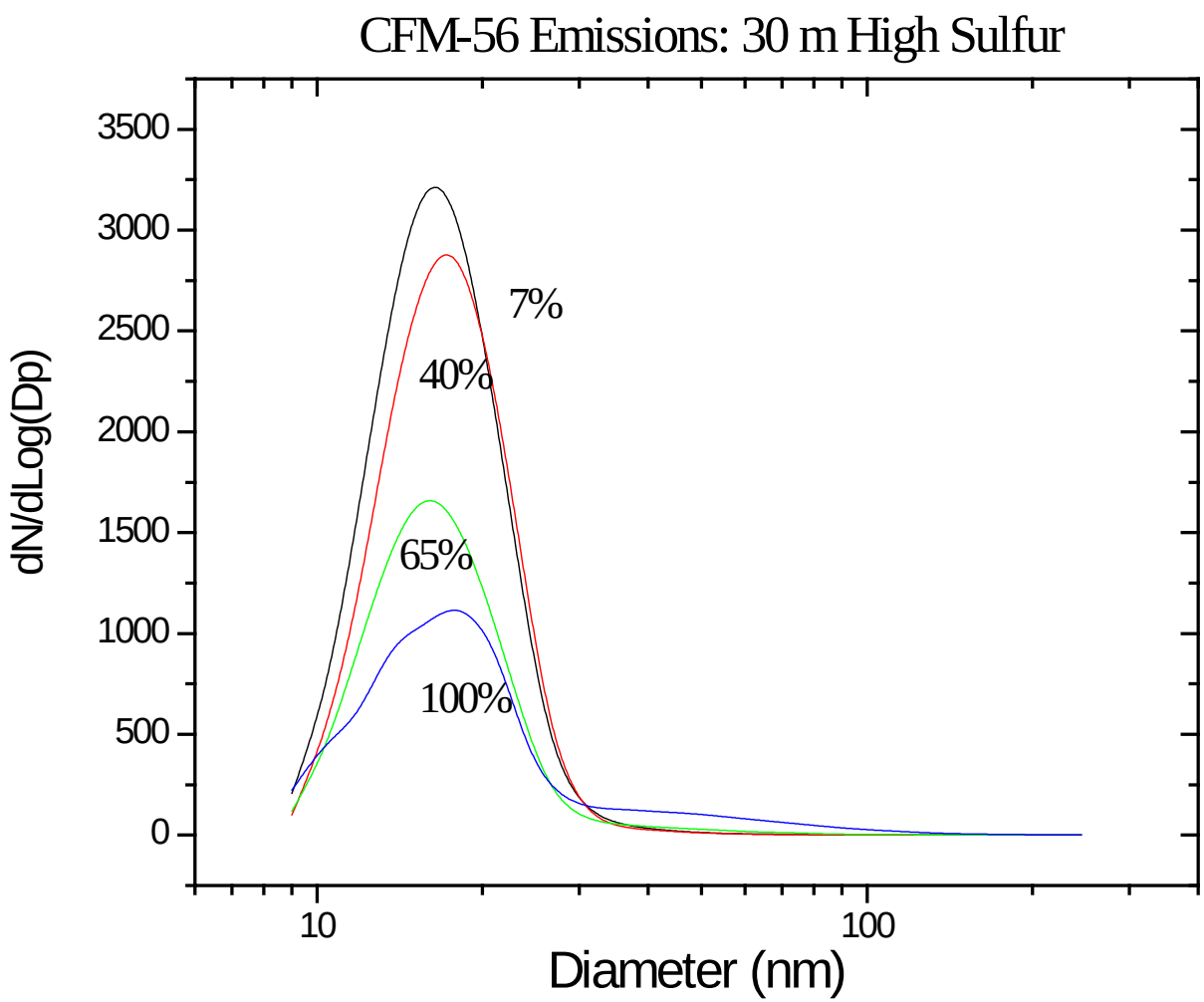
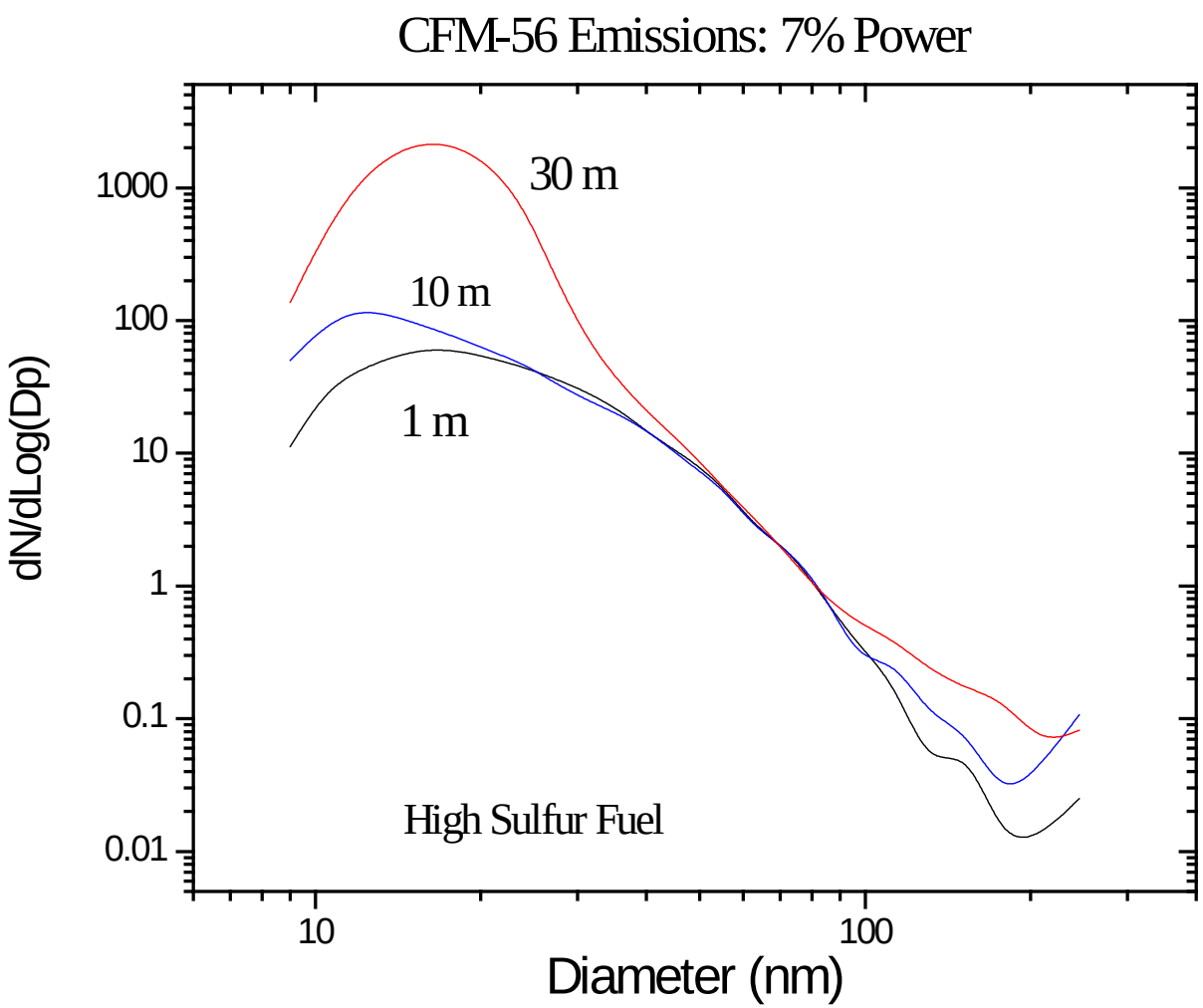


Particle Size Distributions at 30 m



Evolution of Size Distribution



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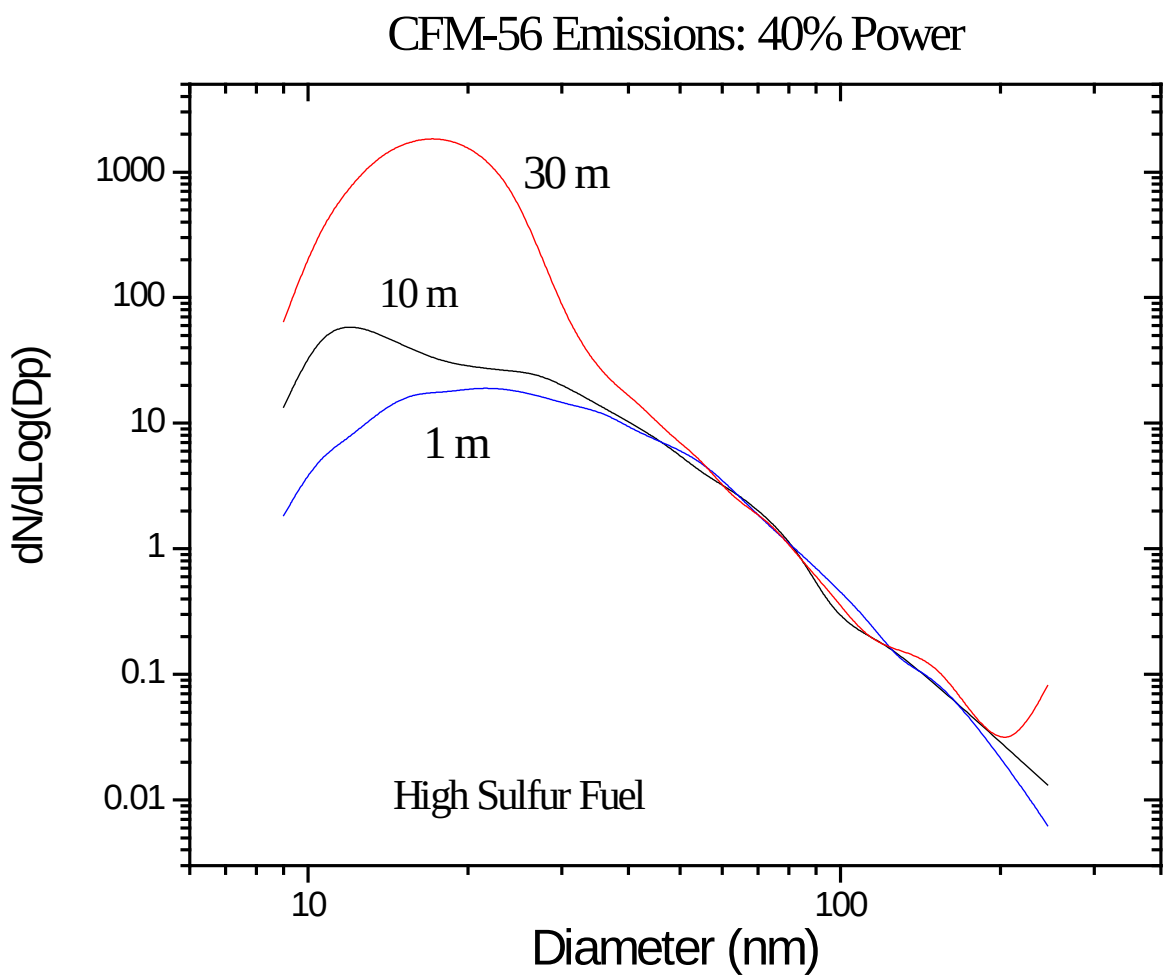

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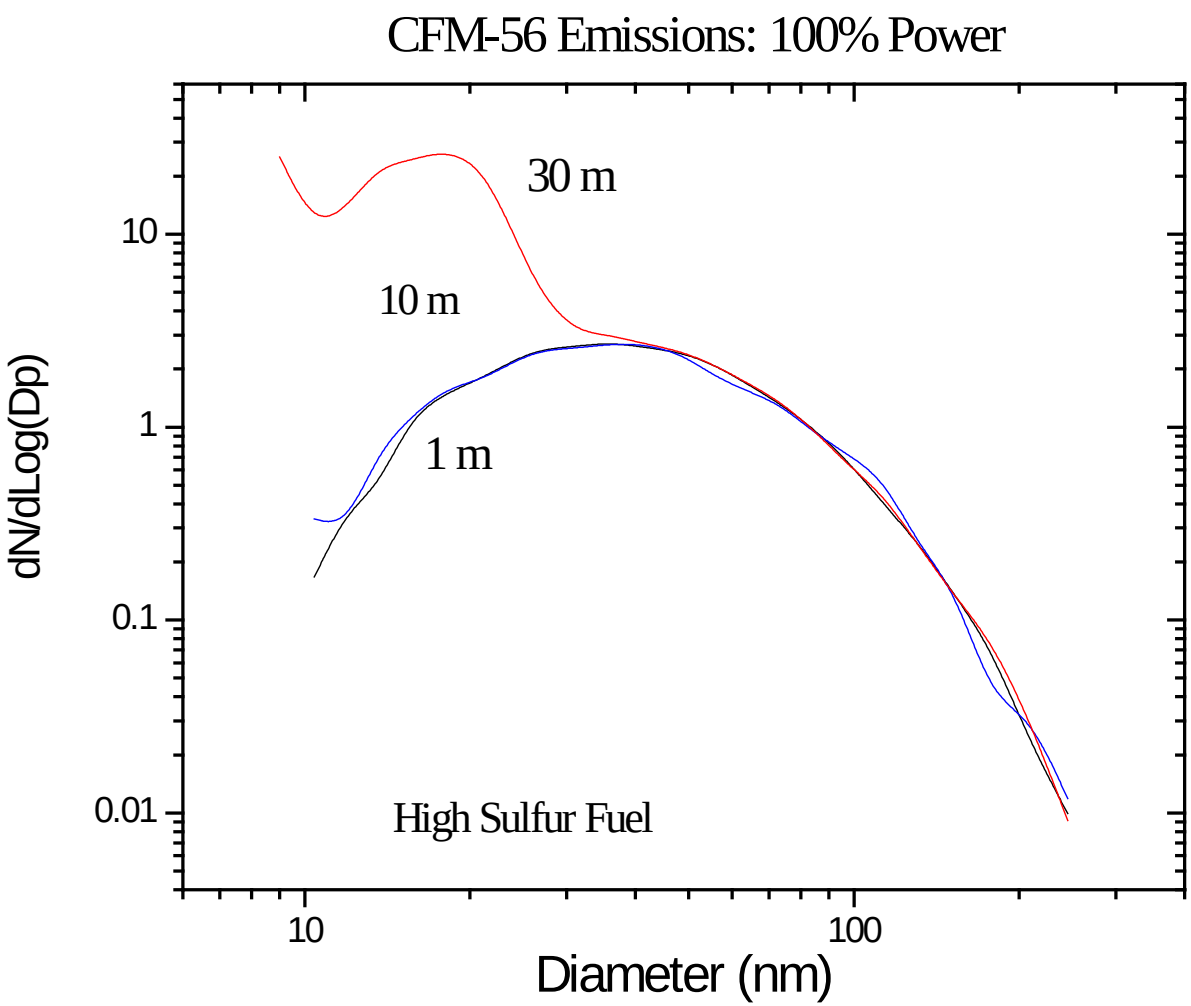

Summary of Results

- CFM-56 engine emits 10^{14} to 10^{15} nonvolatile particles per kg fuel burned
- Soot particle emissions are highest just after engine start and decrease in time for a given power setting
- Soot particle number EIs generally increase with power
- Soot particle size (and mass) increases with power
- Secondary aerosol formation is dependent on fuel sulfur content
- Secondary aerosols are typically 10 times more abundant in aged plumes than primary aerosols