



Johnson Matthey
Catalysts

On-Road Demonstration of Ultrafine Particle Control using Continuously Regenerating Diesel Particulate Filters

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- JM CR-DPF:
 - Extremely effective at removing 95%+ of engine-out particle mass emissions
 - Tests on particle number emissions have raised concerns about role of CR-DPF in nanoparticle formation
 - Previous work has suggested that these particles could be primarily sulfate (Kittelson *et al.*, CRC E-43 Final Report)



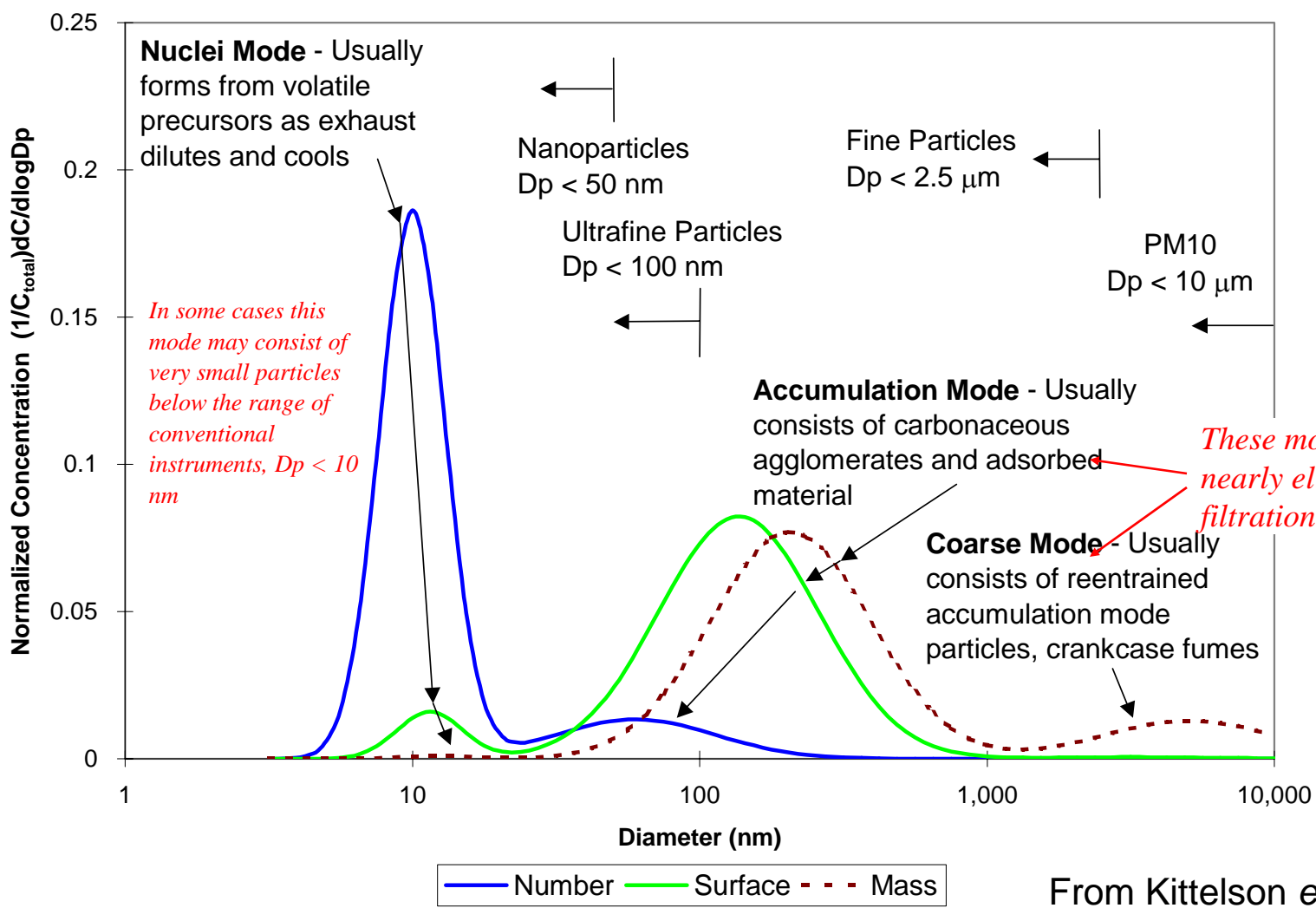
Experimental Approach



- Hypothesis:
 - Observed nanoparticles are sulfate-related
- Approach: Treat CR-DPF system as a chemical reactor
 1. Control sulfur content IN
 2. Control sulfur content OUT
- Proof:
 - If both controls show reduction in nanoparticle number, particles must be sulfate-related
 - Cross-check with chemical analysis



Classic PSD Schematic



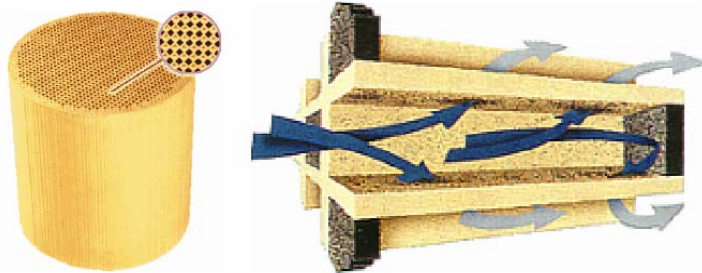
From Kittelson *et al.*, 2006



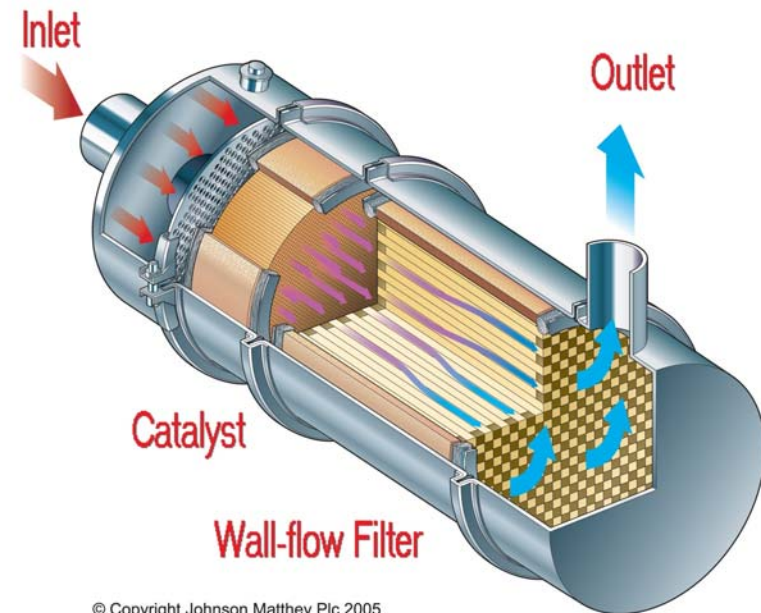
Filtration for PM Removal



(a)



(b)



- a) Wall-Flow Filter (courtesy Corning, Inc.)
- b) JM CR-DPF (DOC + Wall-Flow Filter)



Test Conditions (1)



- All tests conducted on U of M MEL
- Year 2000, 12 L, 12 cyl 287 kW engine
- 65 mph cruise on Minnesota rural freeway



Test Conditions (2)



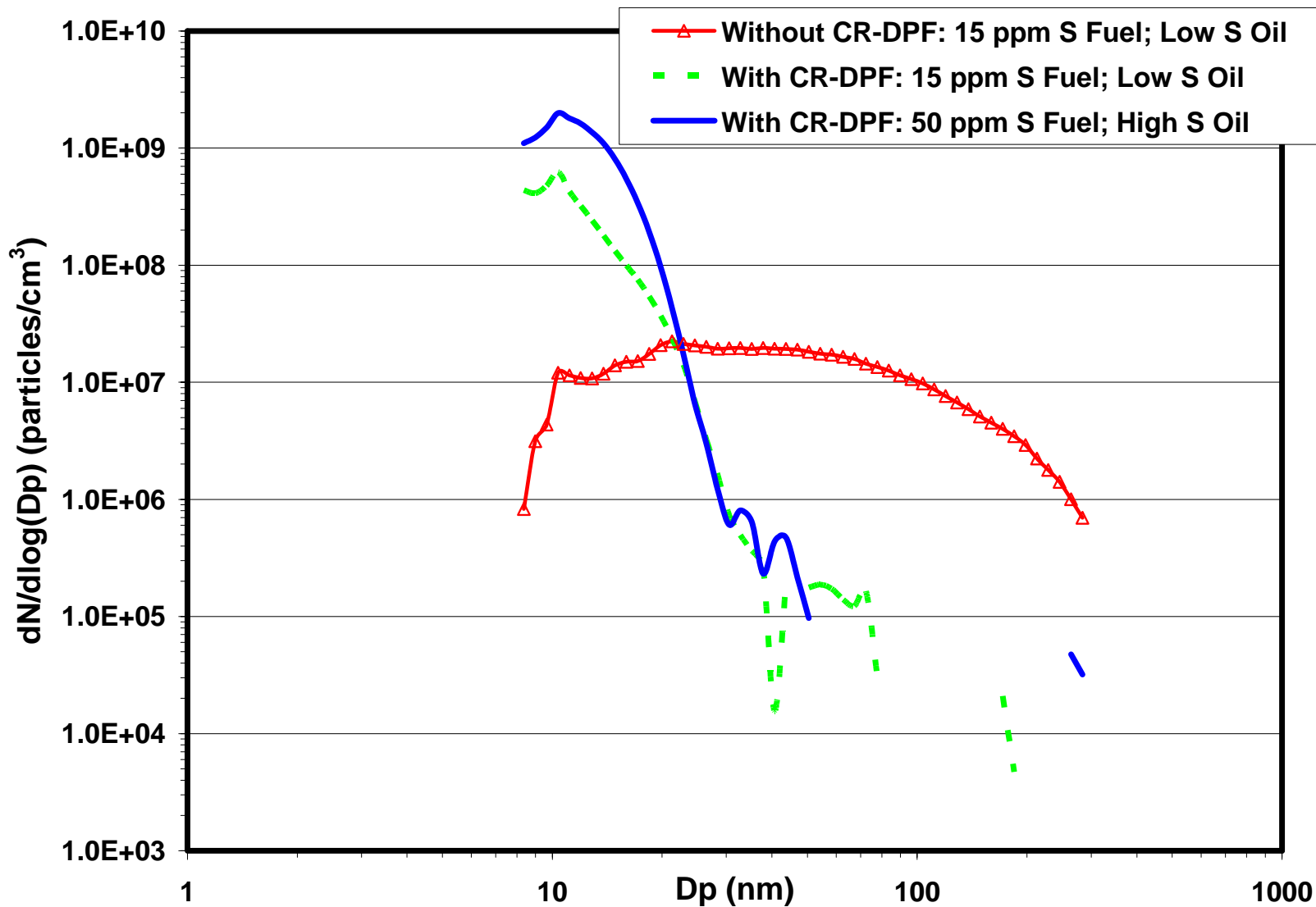
- Control of S IN:
 - 50 ppm S fuel + ~5000 ppm S lube oil
 - 15 ppm S fuel + ~1500 ppm S lube oil
- Control of S OUT:
 - Use of low S fuel + low S lube oil
 - System tested with and without S trap
- Fuels from BP (15 ppm S: ULSD—2007 compliant), lube oils from Castrol



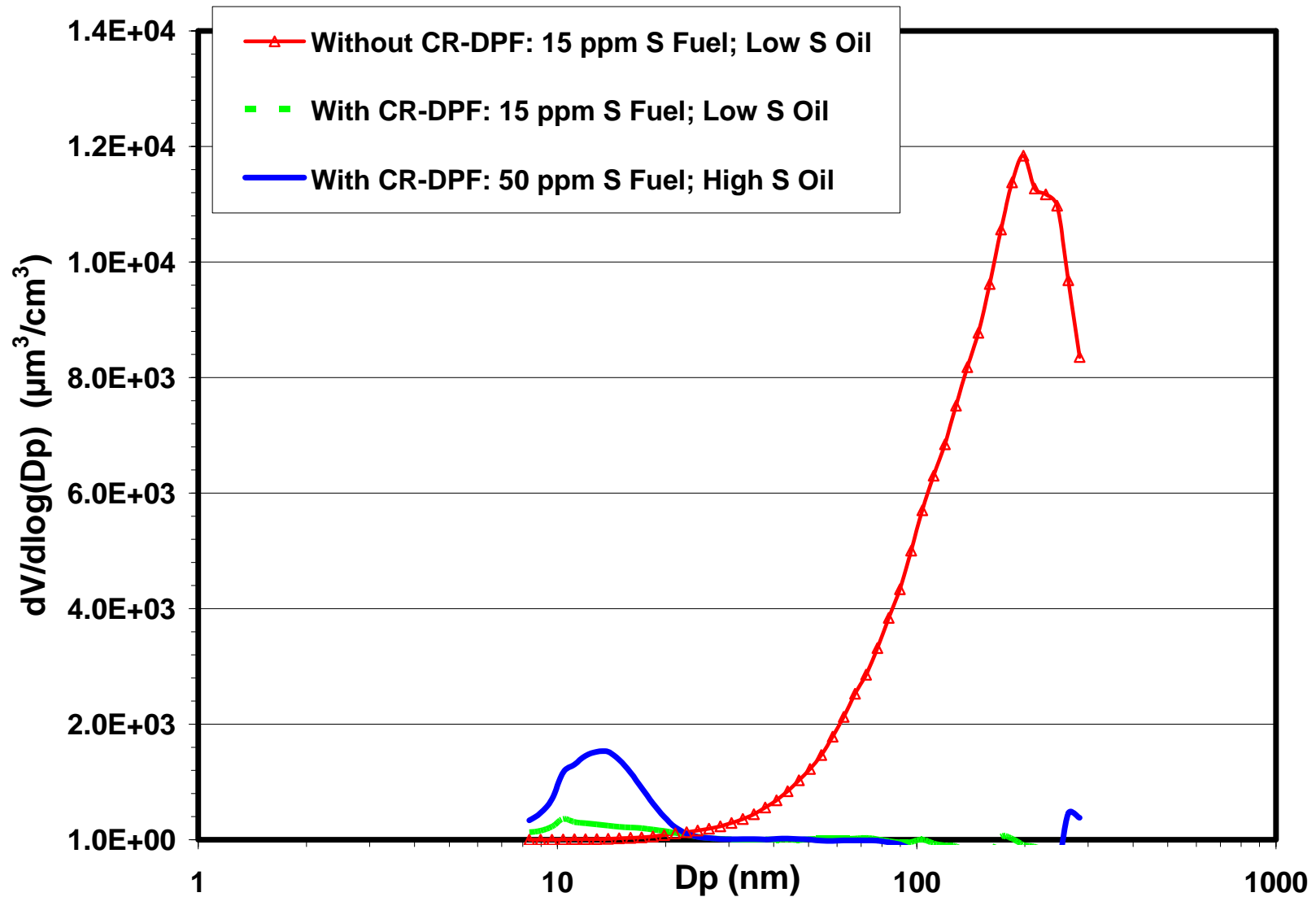
1. Control Sulfur Content IN



Lower S in, lower ultrafine number out



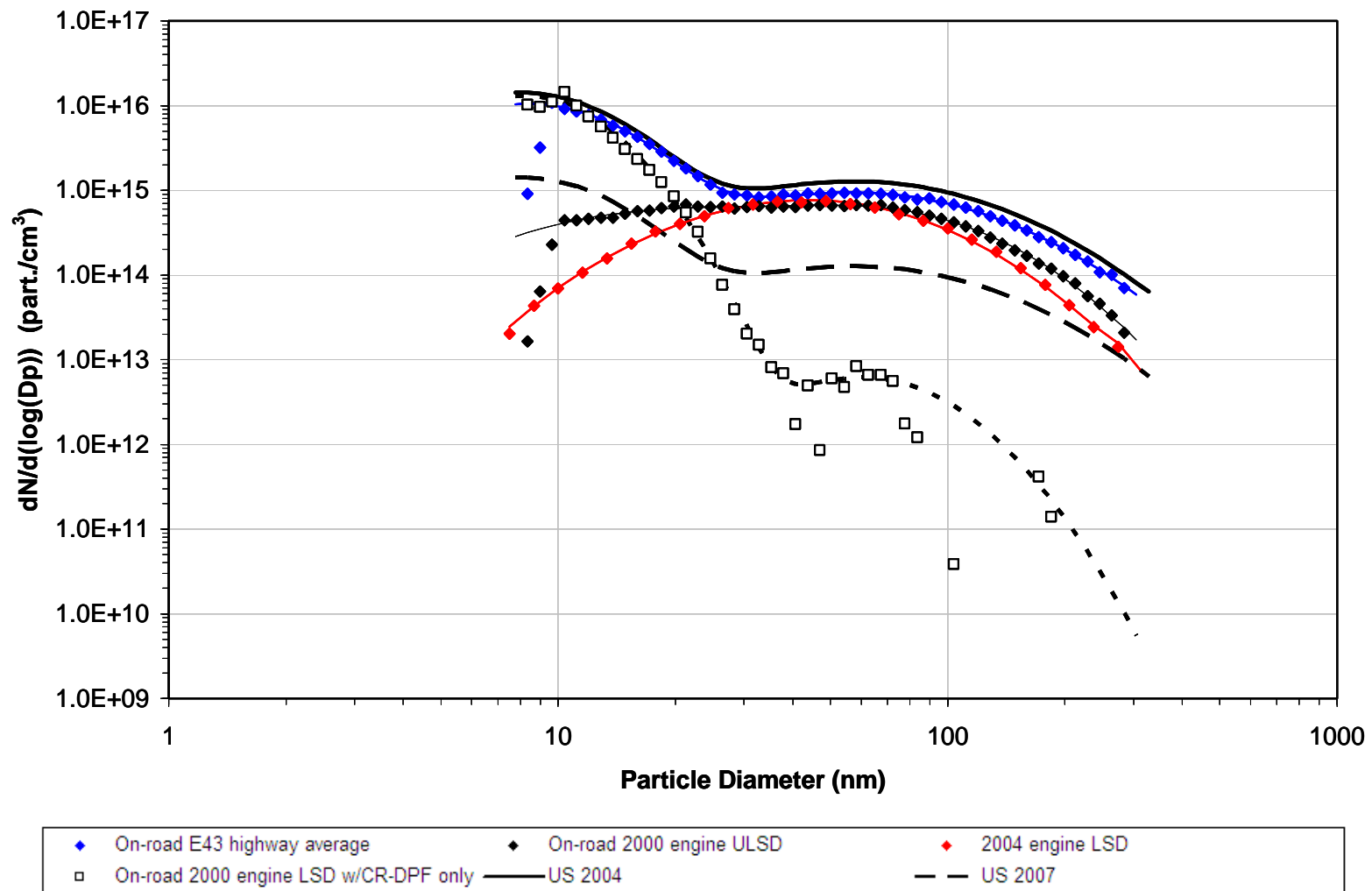
Lower S in, lower ultrafine mass out



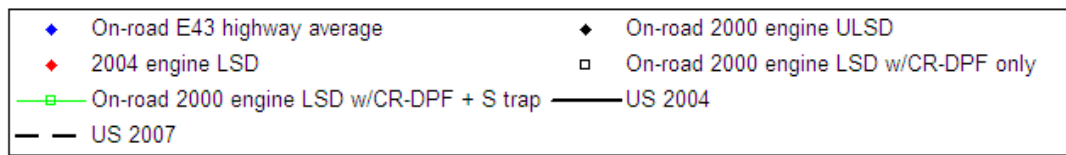
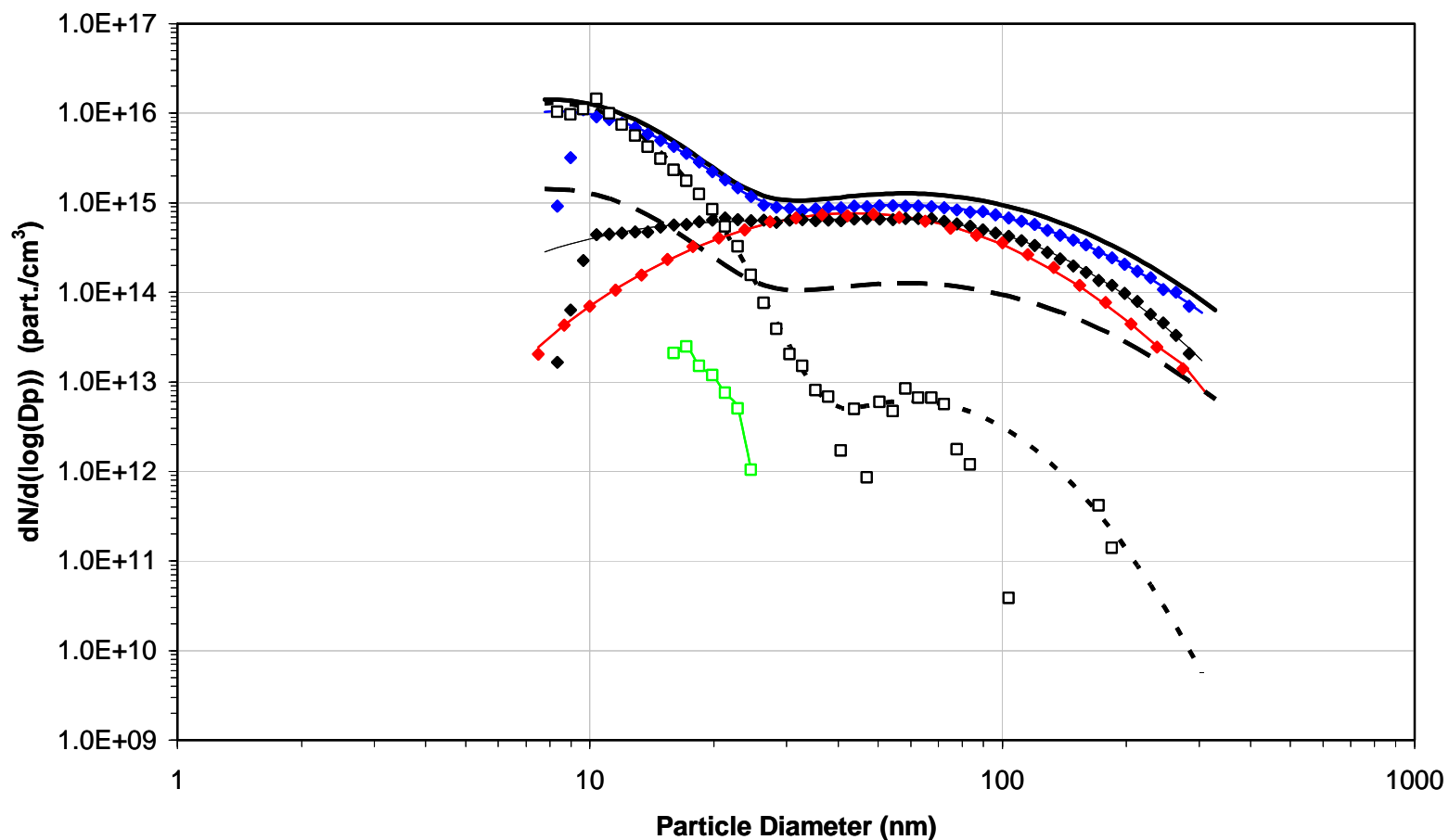
2. Control Sulfur Content OUT



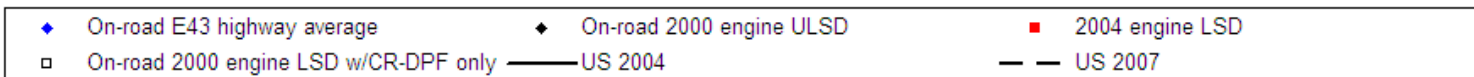
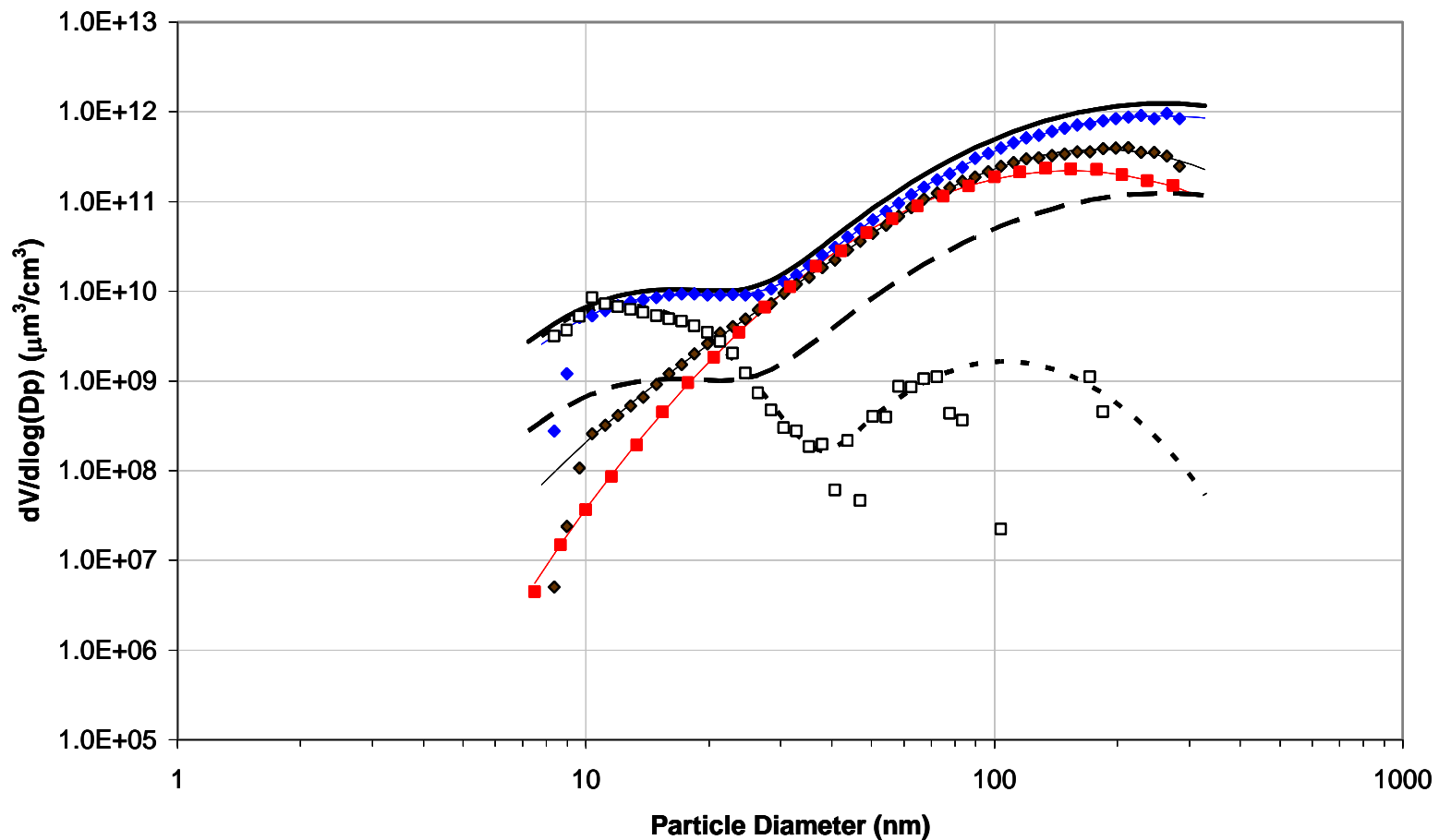
Ultrafine number, no S control OUT



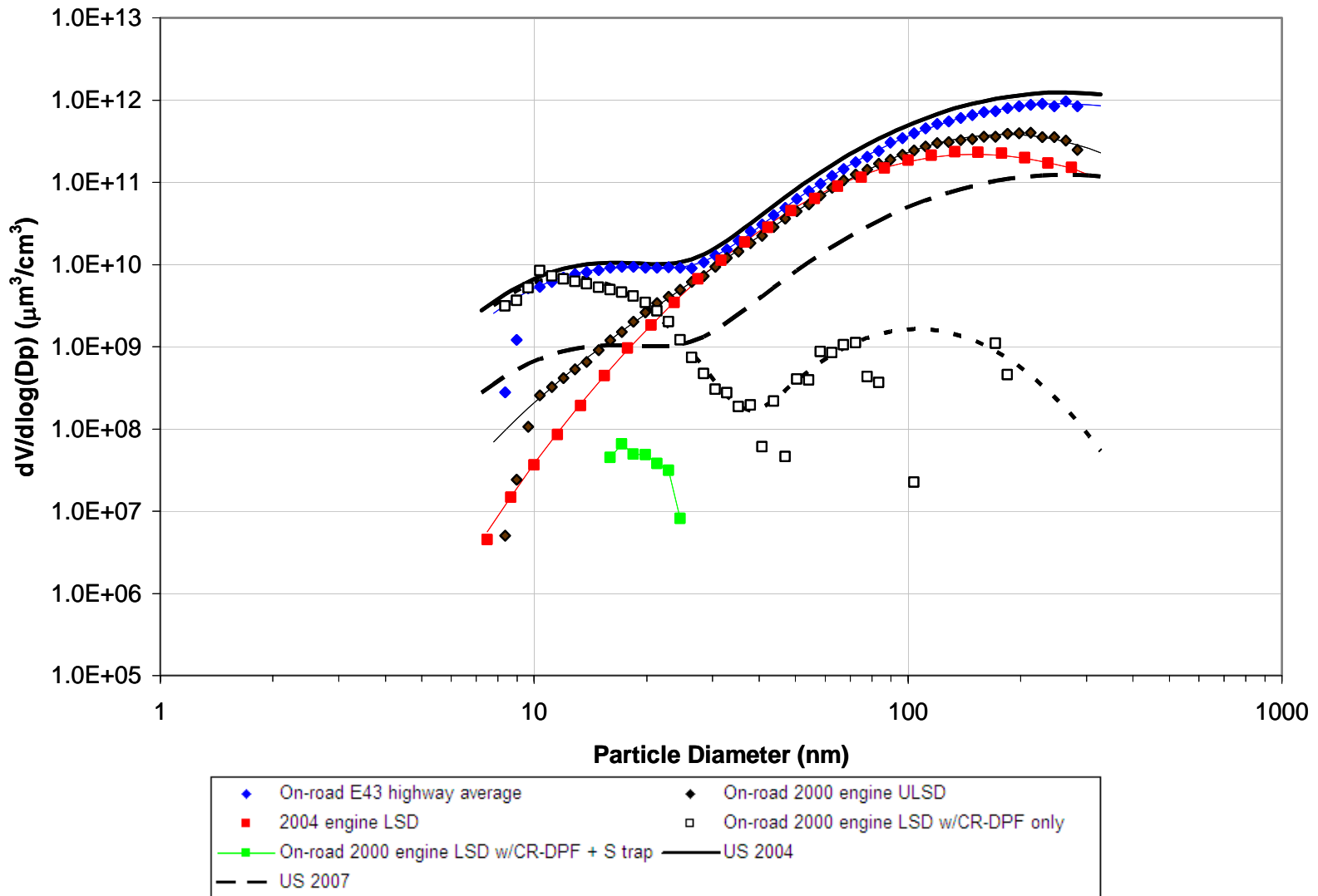
Ultrafine number, with S control OUT



Ultrafine mass, no S control OUT



Ultrafine mass, with S control OUT



Summary



- CR-DPF causes significant reductions in accumulation-mode particles
- Increase in nucleation-mode particle number observed—particle analysis indicates sulfate
- Control of S content IN:
 - Use of lower S fuel and lube oil led to reductions in nucleation-mode particle number
- Control of S content OUT:
 - Use of sulfur trap downstream of CR-DPF led to significant reductions in nucleation-mode particle number



Conclusions



- Nucleation-mode particles emitted by CR-DPF found to be sulfate
- Minimization of sulfur content could lead to dramatically lower number (and mass) emissions from tailpipe
 - Low S fuel, lube oil
 - Use of S trap



Acknowledgments



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- Global Fuels Technology, BP plc
- Global Lubricants Technology, BP plc
- Corning, Inc.
- Volvo Technology Corporation



Glossary



- JM: Johnson Matthey Inc.
- CR-DPF: Continuously Regenerating Diesel Particulate Filter
- PSD: Particle Size Distribution
- PM: Particulate Matter (used here in the context of particle mass)
- DOC: Diesel Oxidation Catalyst
- U of M: University of Minnesota
- MEL: Mobile Emissions Laboratory

