

# Measuring the Emission Benefits of Cleaner Burning Fuels

**US EPA & Mexico Workshop**

Vera Cruz, Mexico  
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<http://www.cert.ucr.edu>

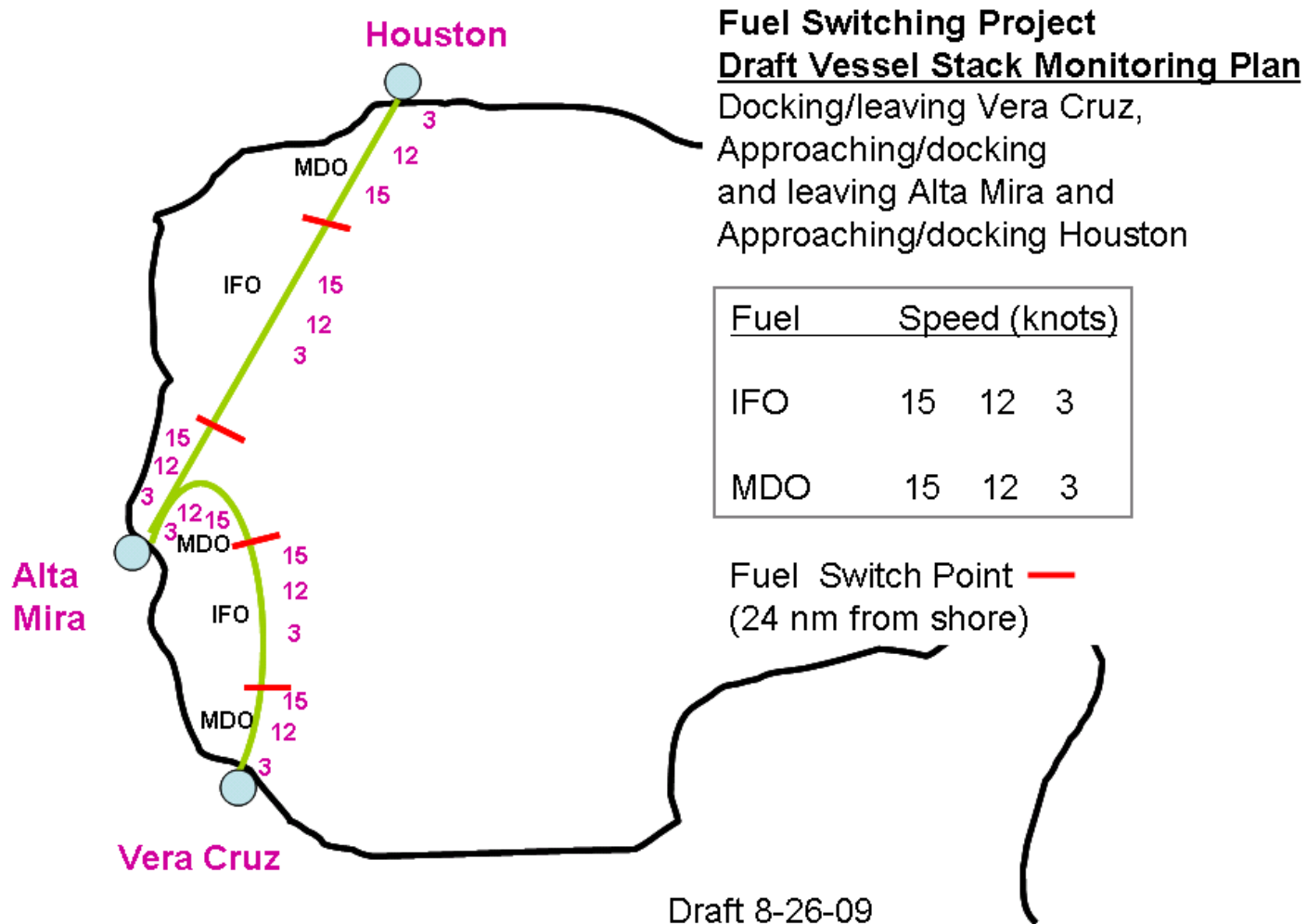
# Acknowledgement of Partners

- Government of Mexico
- United States Environmental Protection Agency
- Port of Houston
- Hamburg Süd
- ICF Consulting

# Discussion Topics

- Goal: measure emissions from:
  - Auxiliary engines (AE)
  - Main propulsion engine (ME)
- Planned Approach
  - Test with distillate (light) and bunker (heavy) oil
  - Use European test cycles
  - Use European measurement methods
- Questions?

# Planned Ship Route and Speeds



# Test Fuels

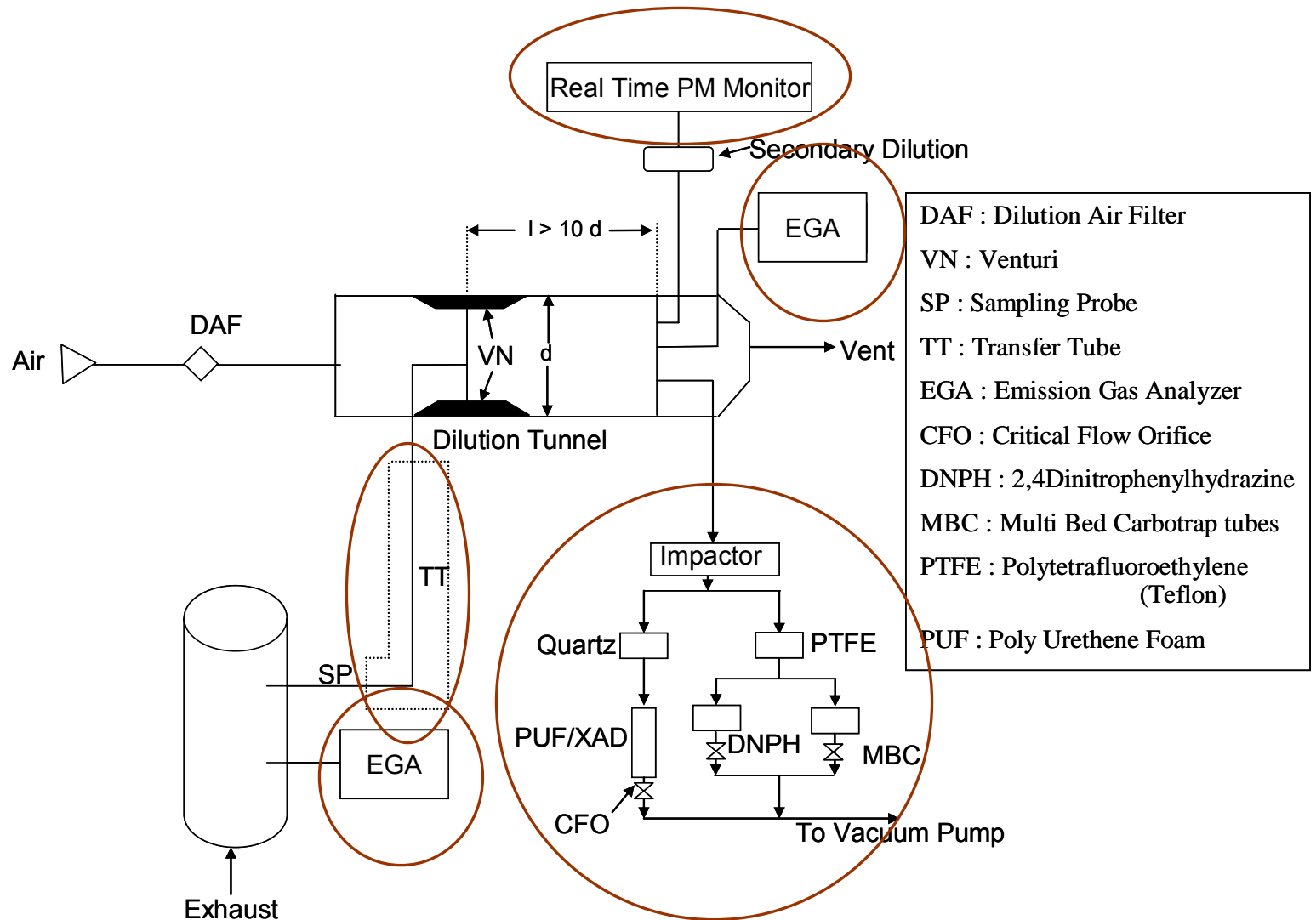
- Heavy Fuel Oil (HFO)
  - Commonly known as bunker fuel or residual oil
  - Residual fraction from crude refining
  - Used on main engine and boiler
  - Very high viscosity and high sulfur content (2.6% m/m)
- Marine Gas Oil and Marine Distillate Oil
  - Refined fraction from crude distillation
  - Used on auxiliary engine
  - Lower sulfur content (0.16 %m/m)

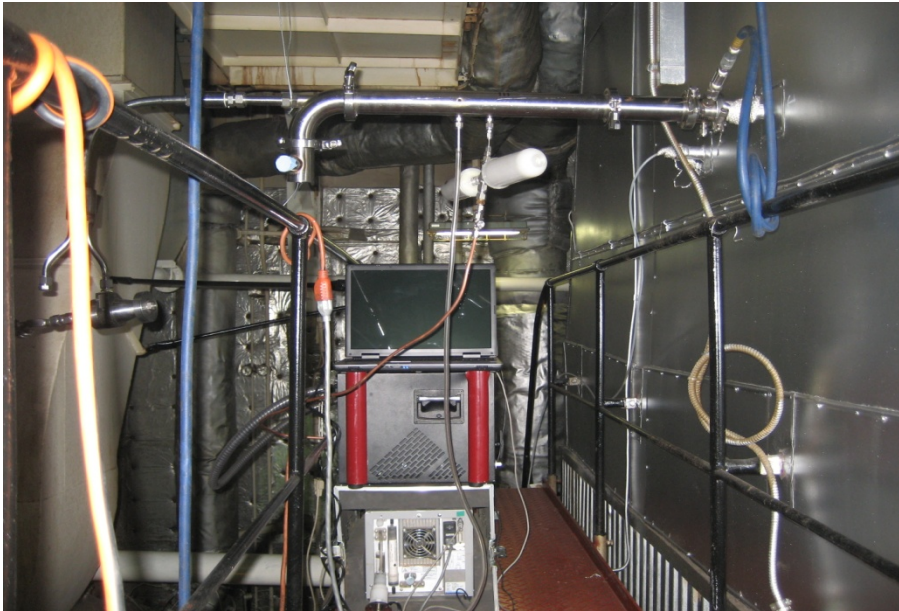


# Measuring Emission Factors

- Requires close collaboration of the ship owner and Chief Engineer to coordinate schedule.
- Engine operation
  - Follow European ISO 8178-4 standard cycles
  - At sea: follow in-use conditions
- Gases monitored by ISO/EPA methods
  - NO<sub>x</sub> Chemiluminescence detector
  - CO<sub>x</sub>,CO<sub>2</sub> Non dispersive infrared
  - HCs GC/FID
  - SO<sub>x</sub> Calculate from fuel
- Measure particulate matter (PM)
  - Use ISO 8178-1 partial dilution method
- Emission factor determined from power setting & calculated mass flow

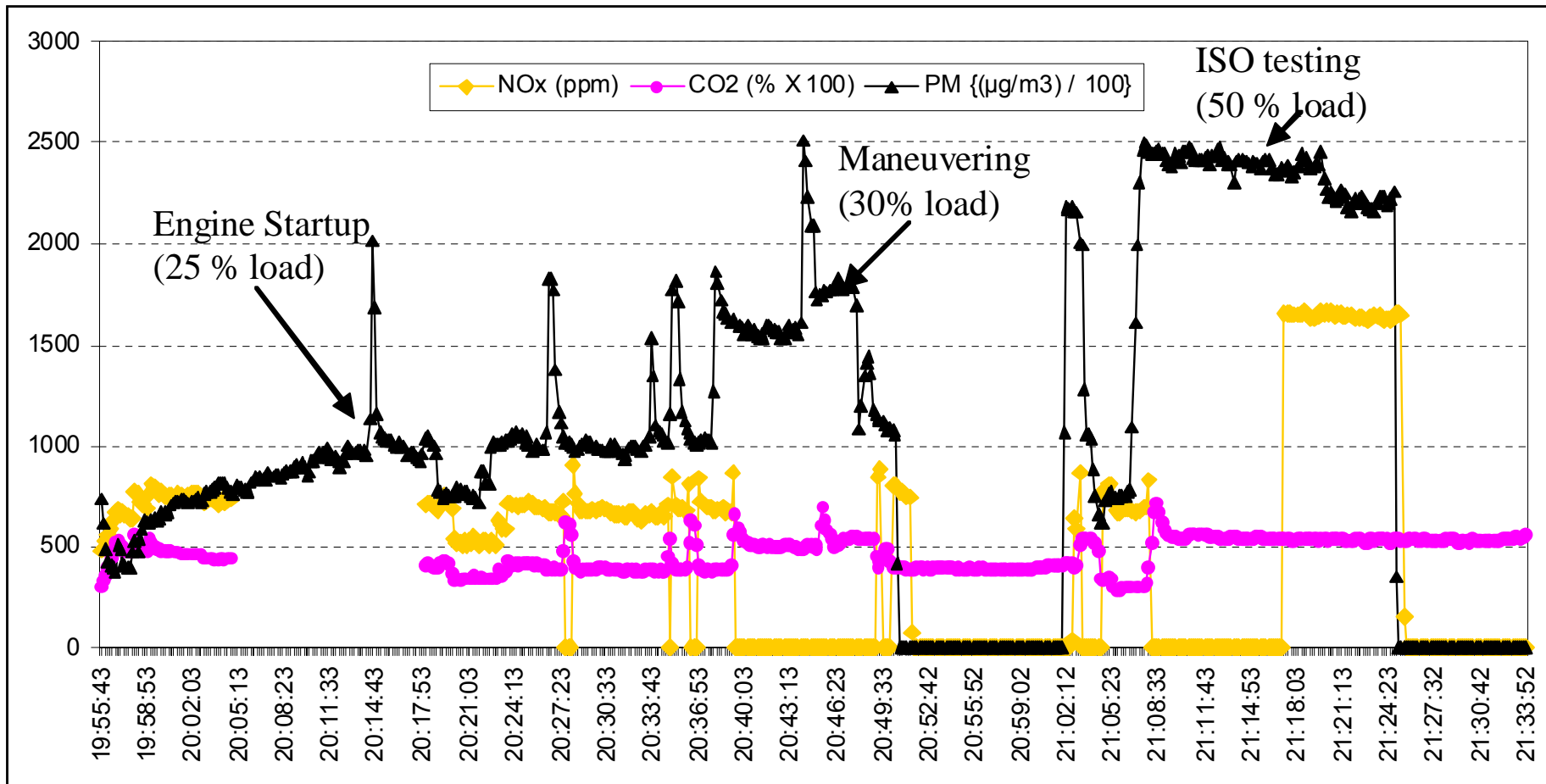
# Flow Diagram of the Sampling System



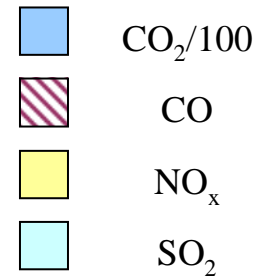
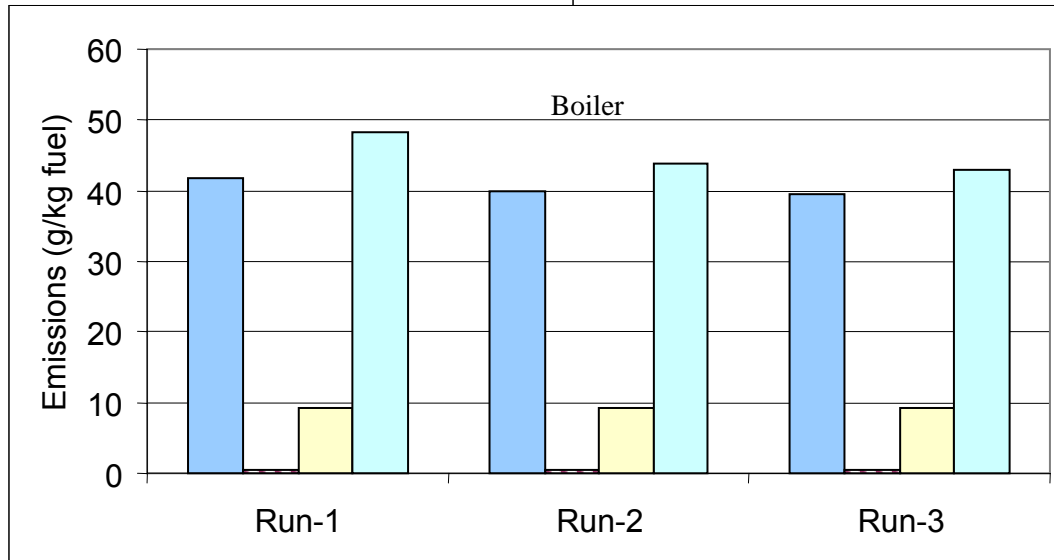
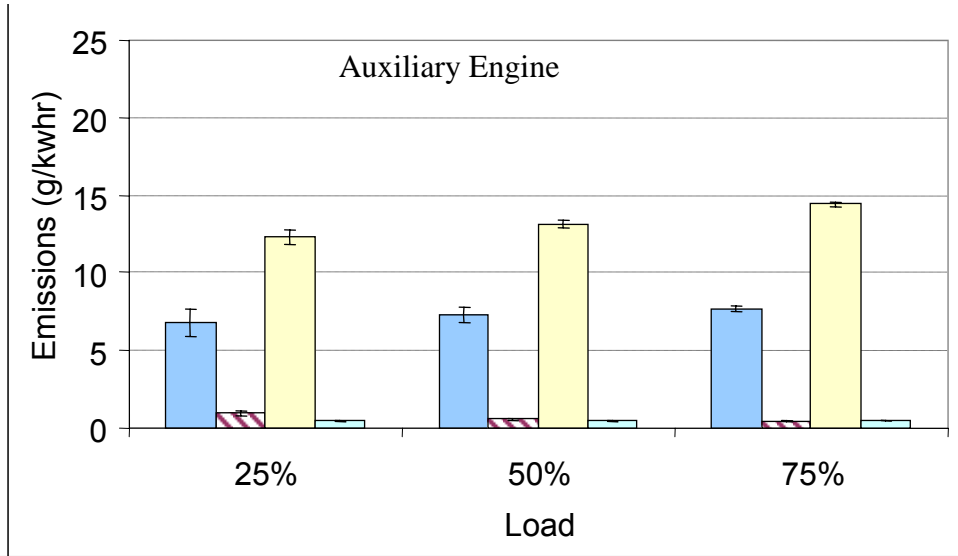
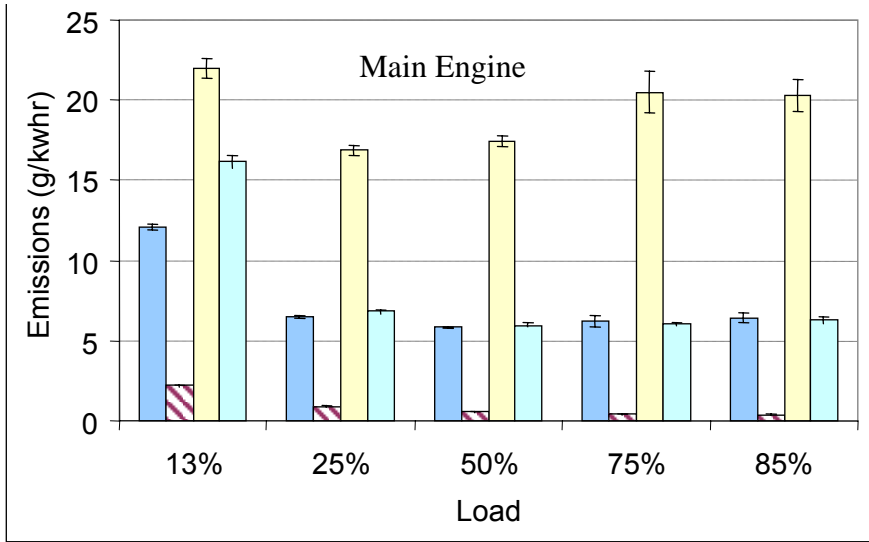




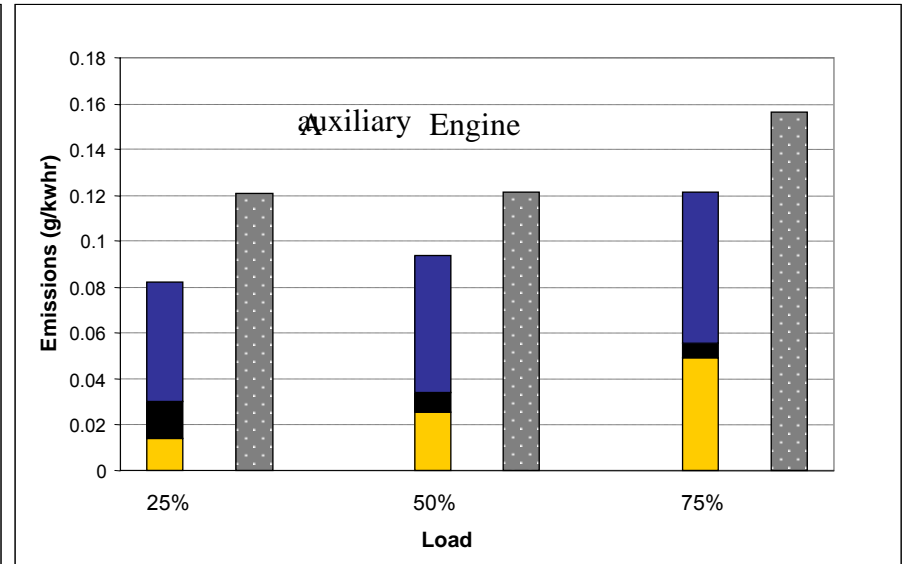
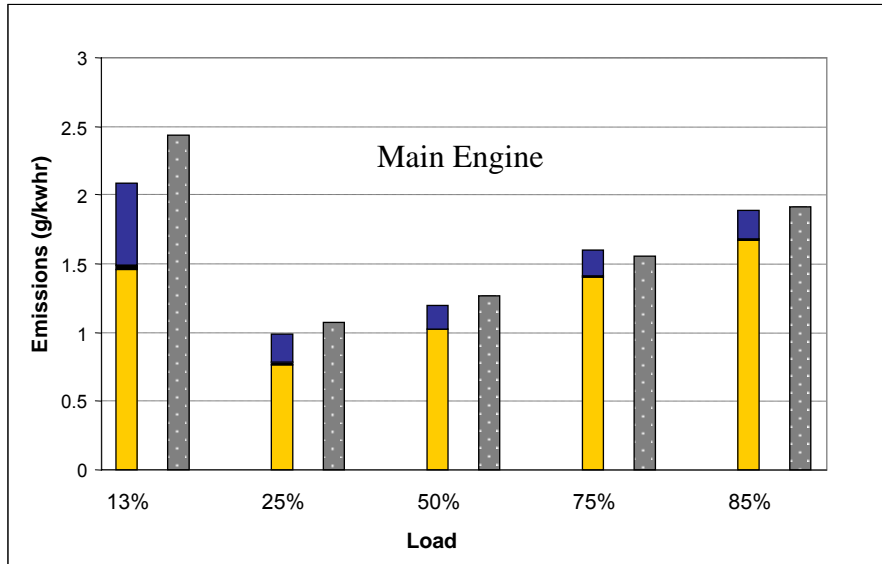
# Example: Real Time Gas & PM Emissions for Main Engine



# Example: Gaseous Emissions

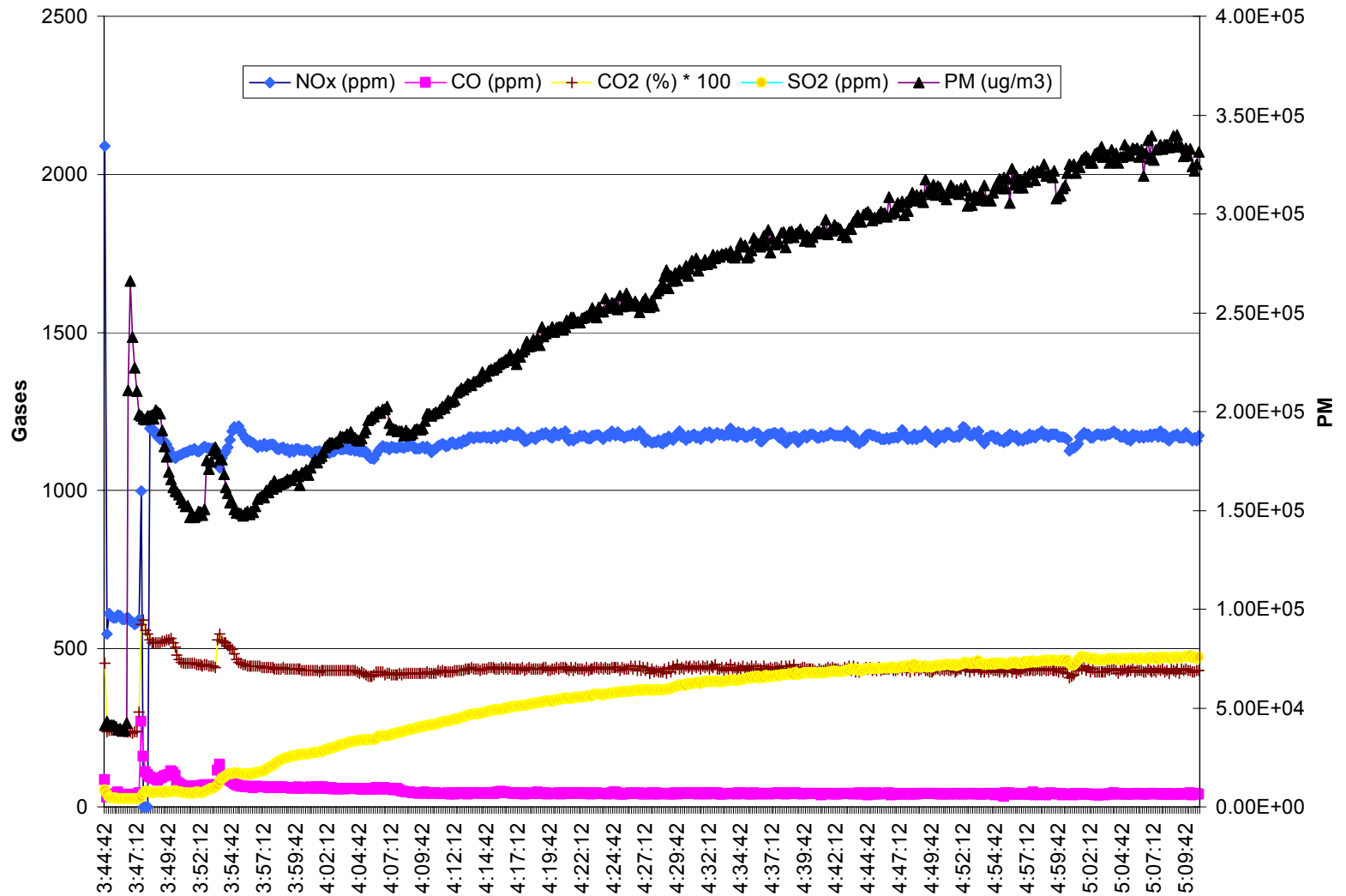


# Example: PM Emissions & Fractions



- Hydrated sulfate (75%) + EC (5%) + OC (25%)  $\approx$  PM
- Sulfur from fuel to Sulfate Conversion
  - Main Engine : 1.4% to 5% as engine load increased from 25% to 75%
  - Auxiliary Engine : 1.9% to 3.9% as engine load increased from 25% to 85%

# Example: Gas & PM Emissions on Going from Distillate to Heavy-fuel Oil



# Summary

- Methods developed for measuring emissions on ships at sea
- Prior study showed switching from heavy-fuel oil to distillate fuel:
  - Lowered NO<sub>x</sub> by 5 – 10%
  - Lowered PM up to 80% since primarily sulfate and related to fuel sulfur
  - There is a transition time to convert from one fuel to another.
- Current research will provide a measure of the benefits of switching to a cleaner burning fuel..