



Development of a Dimethyl Ether (DME)- Fueled Shuttle Bus

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The Pennsylvania State University

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Air Products and Chemicals, Inc.



DME-Fueled Shuttle Bus Partners

- **Air Products and Chemicals, Inc.**
- **US Department of Energy, National Energy Technology Laboratory**
- **Pennsylvania Department of Environmental Protection**
- **Navistar International**
- **Champion Motorcoach**
- **DuPont Flourochemicals**
- **DuPont Dow**
- **Caterpillar, Inc.**
- **Parker Racor**
- **Clean Air Technologies, Int'l**

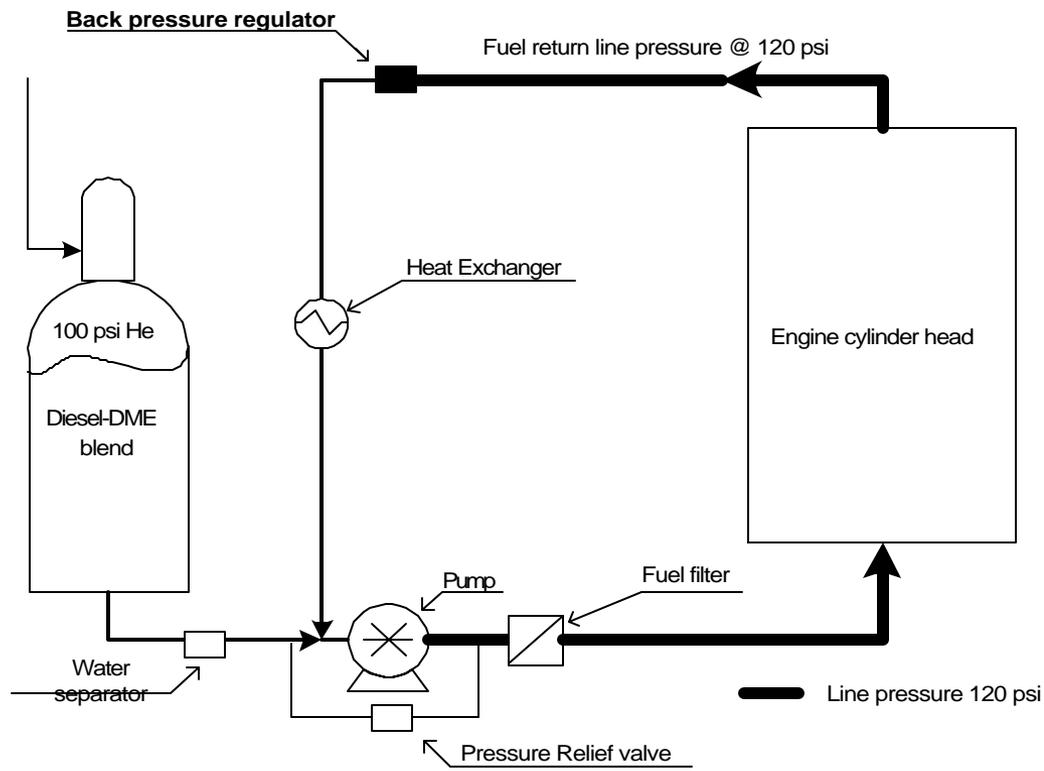


Objectives

- **Demonstrate DME-Diesel Fueling in a Campus Shuttle and Operate the Shuttle on DME-Diesel**
- **Through Laboratory and Field Studies, Determine How to Maximize the Amount of DME in the Blend without Sacrificing Fuel System Integrity**



Laboratory DME-Diesel Fueling System



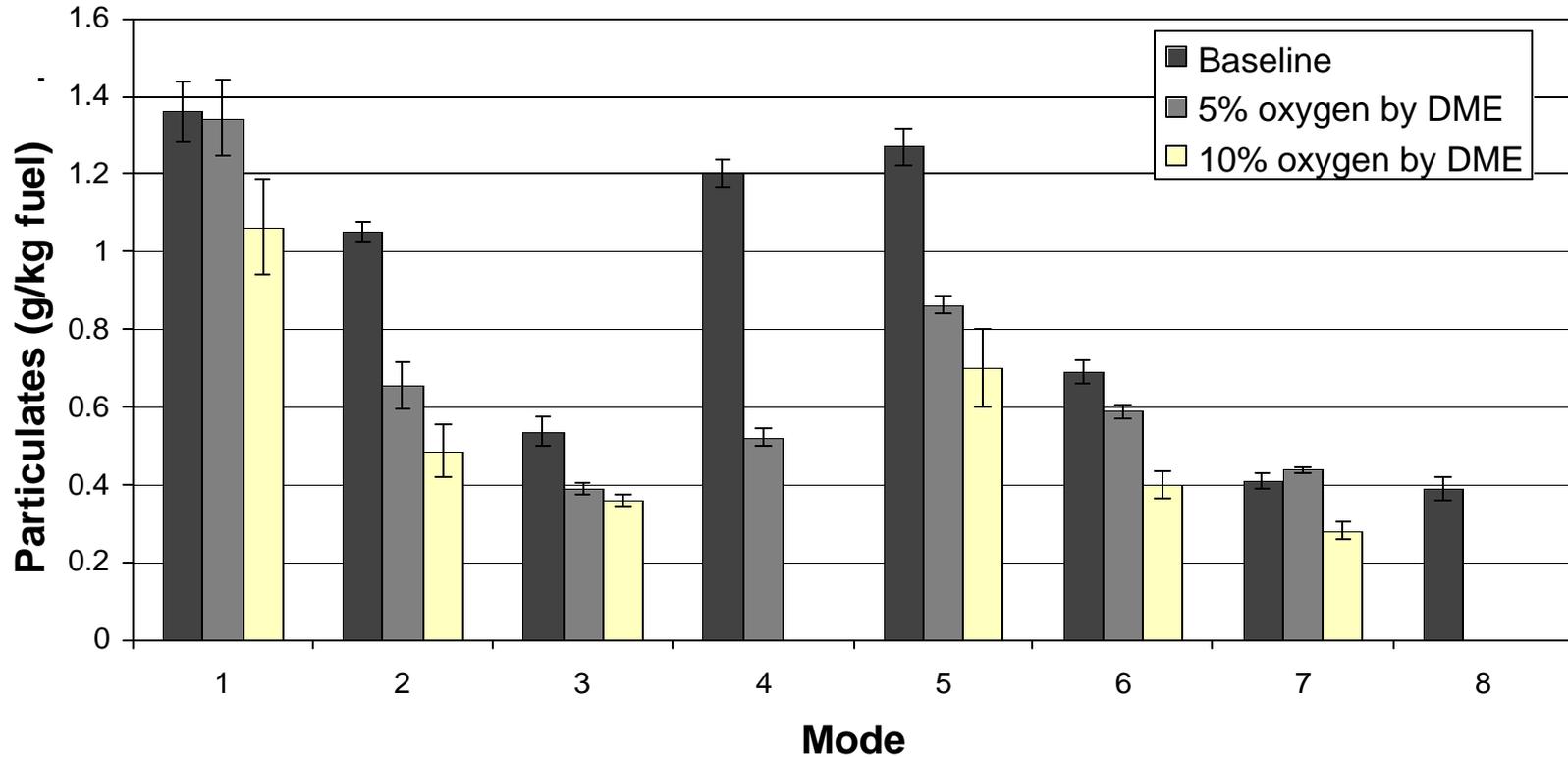


Navistar T444E V-8 Turbodiesel After DME-Diesel Conversion



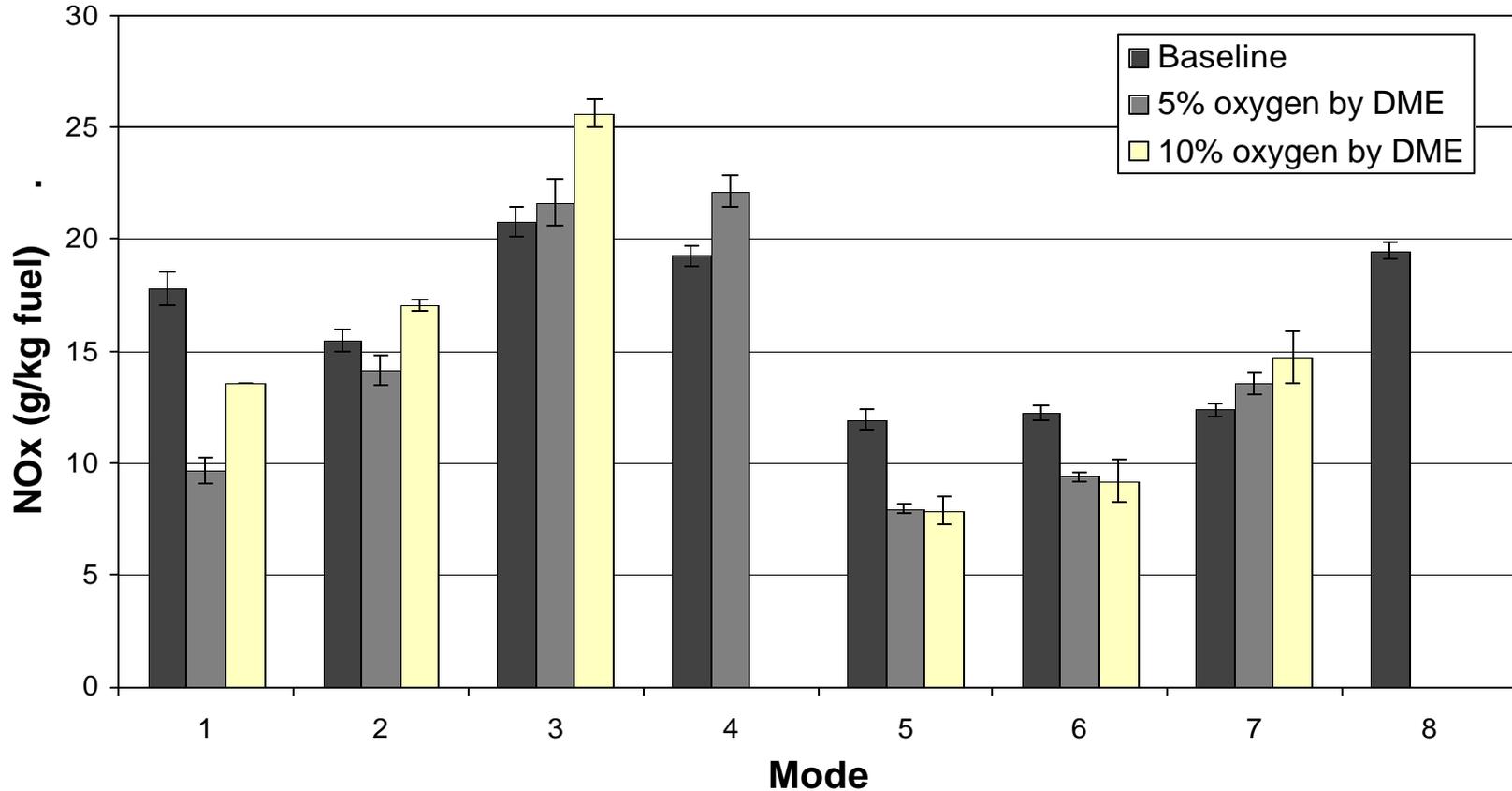


Particulate Matter Results per unit fuel consumed, g/kg fuel



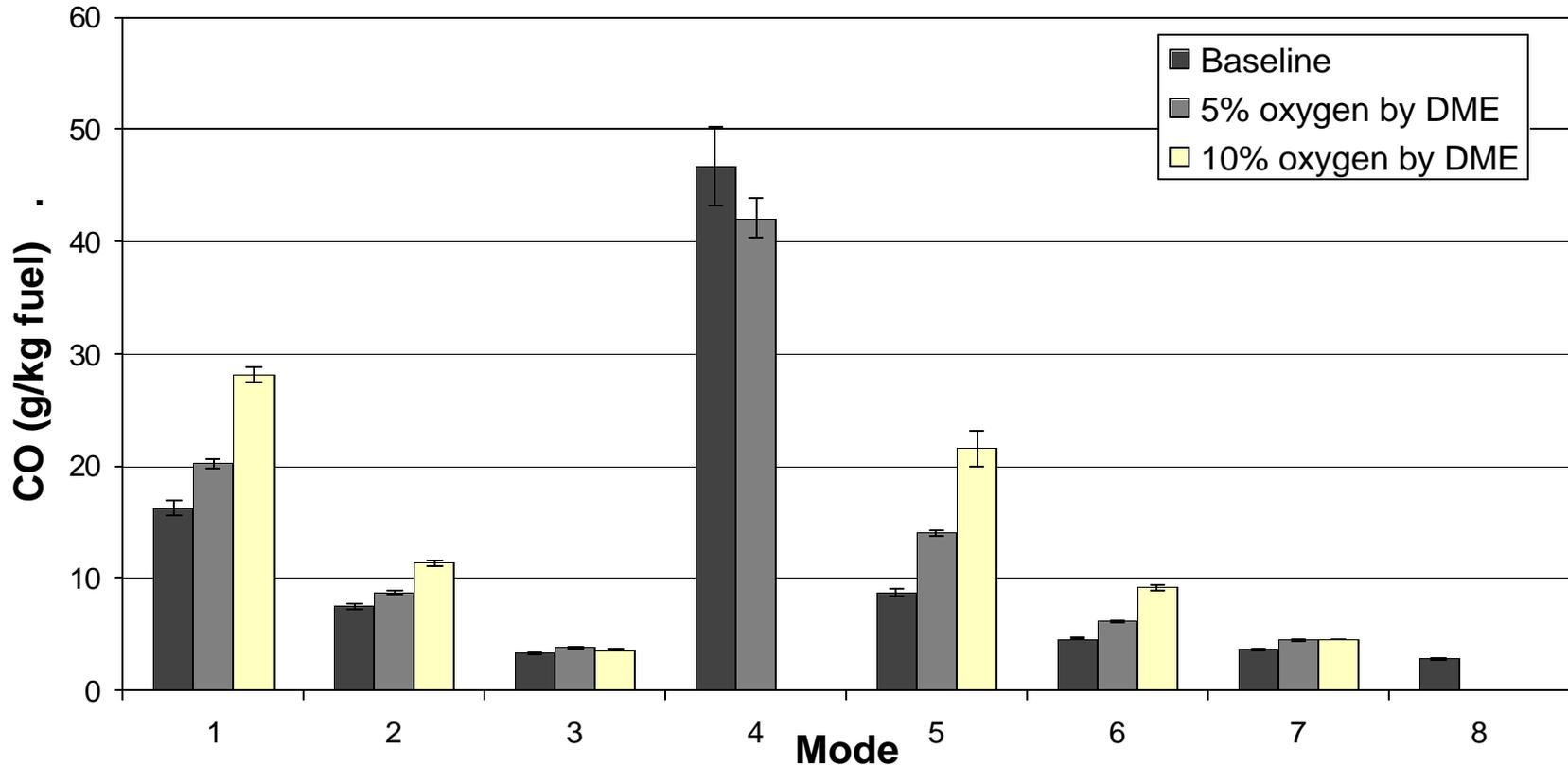


NO_x Results per unit fuel consumed, g/kg fuel



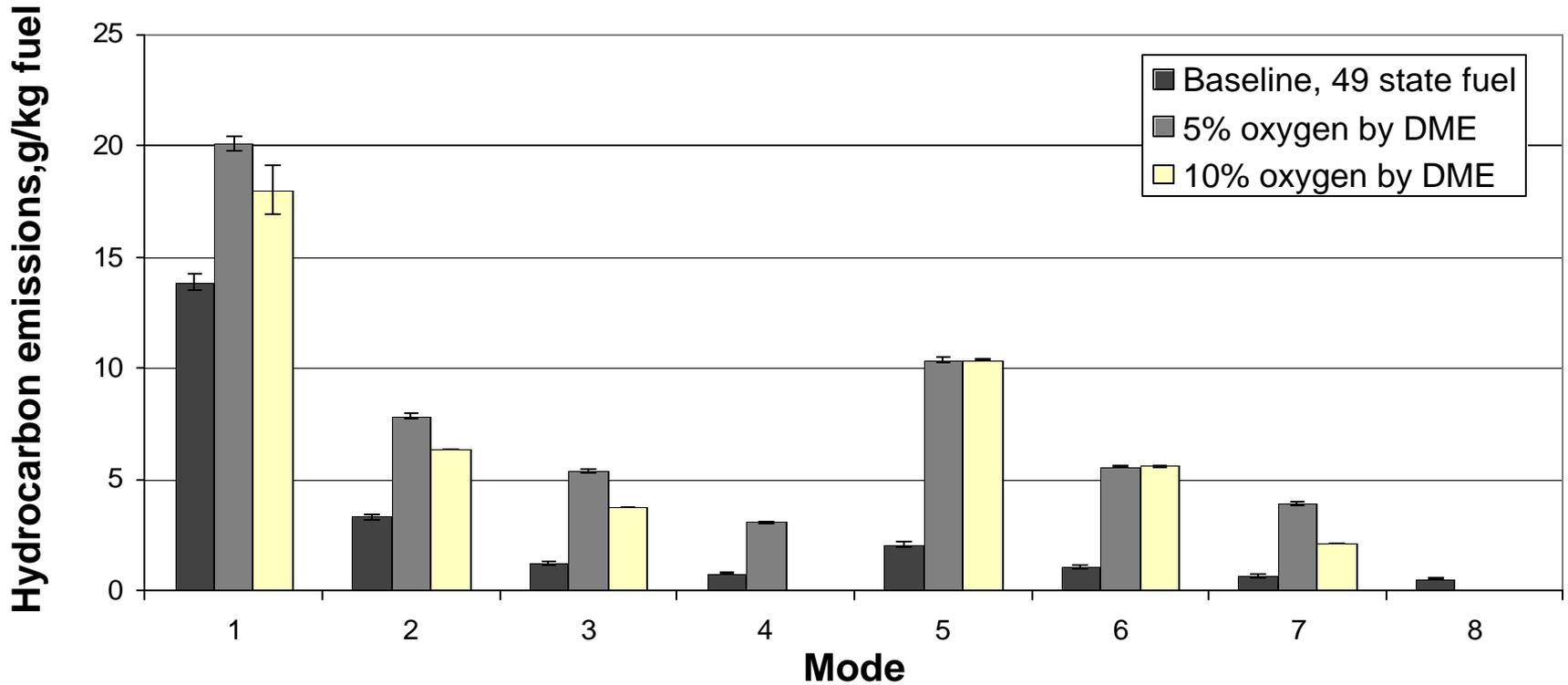


CO Results per unit fuel consumed, g/kg fuel





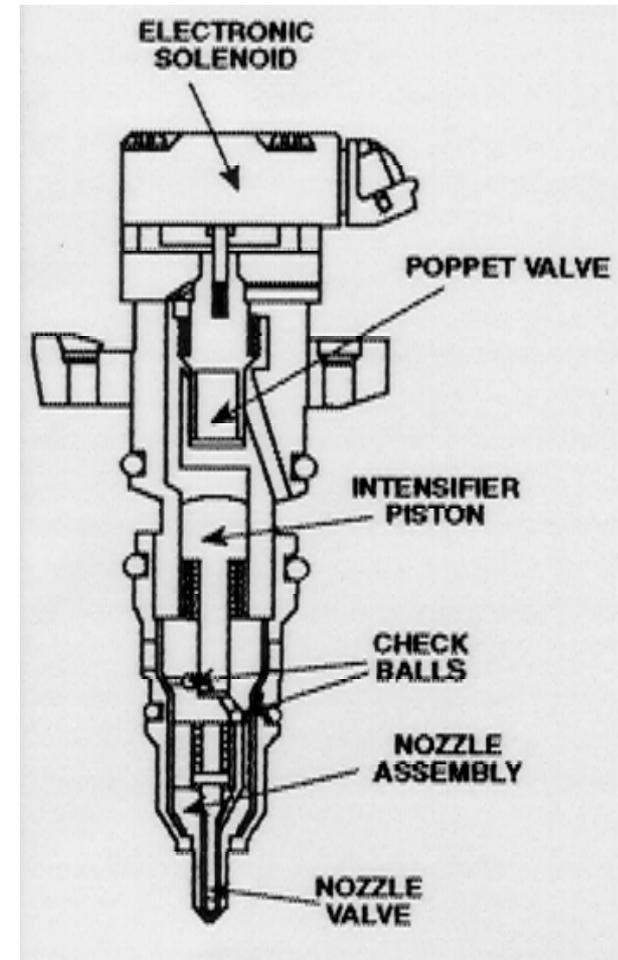
HC Results per unit fuel consumed, g/kg fuel





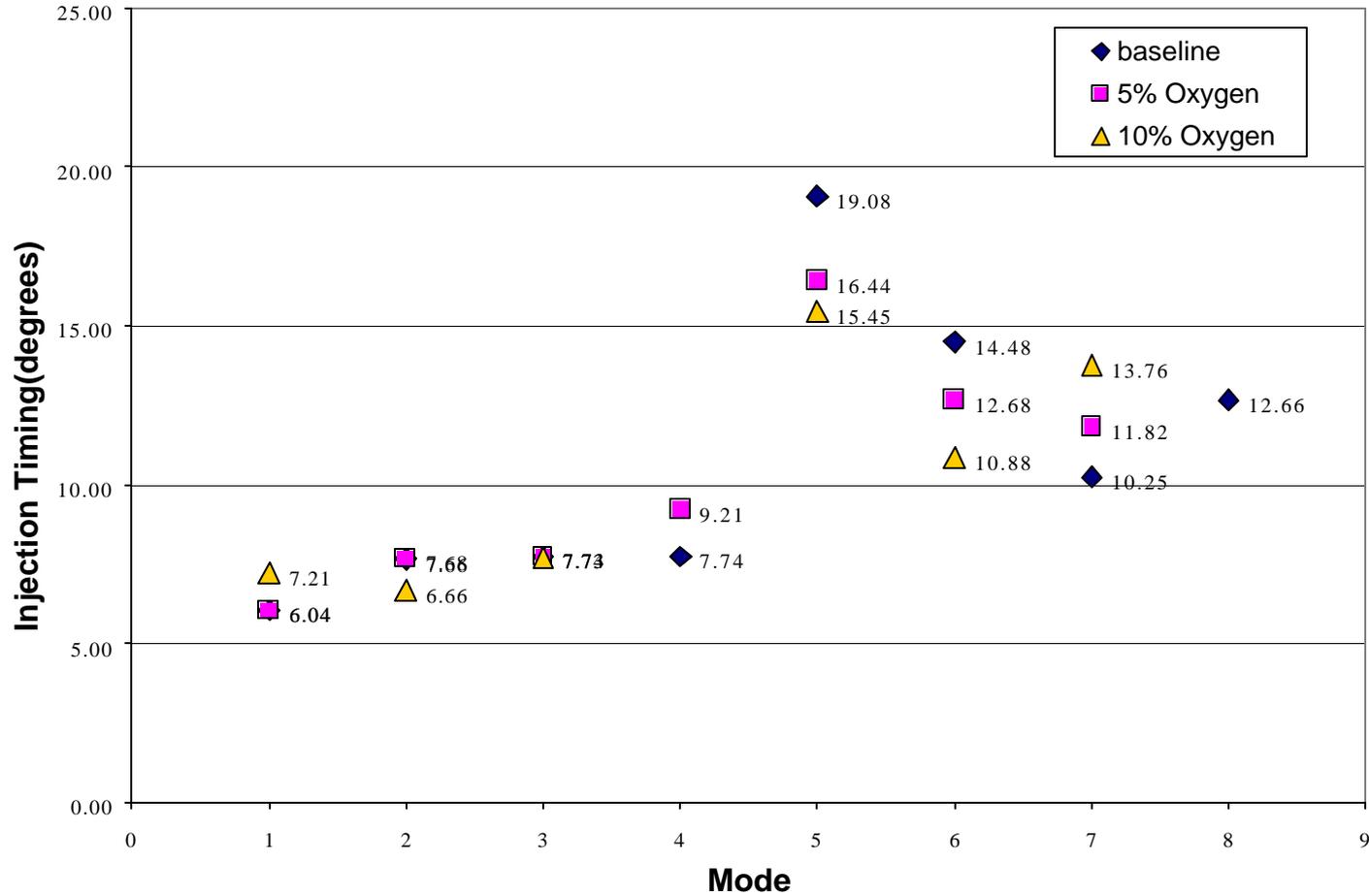
HEUI Fuel Injector

- Electronic Signal from Engine Control
- Volume of fuel is delivered per:
 - Injection Timing
 - Injection Pressure



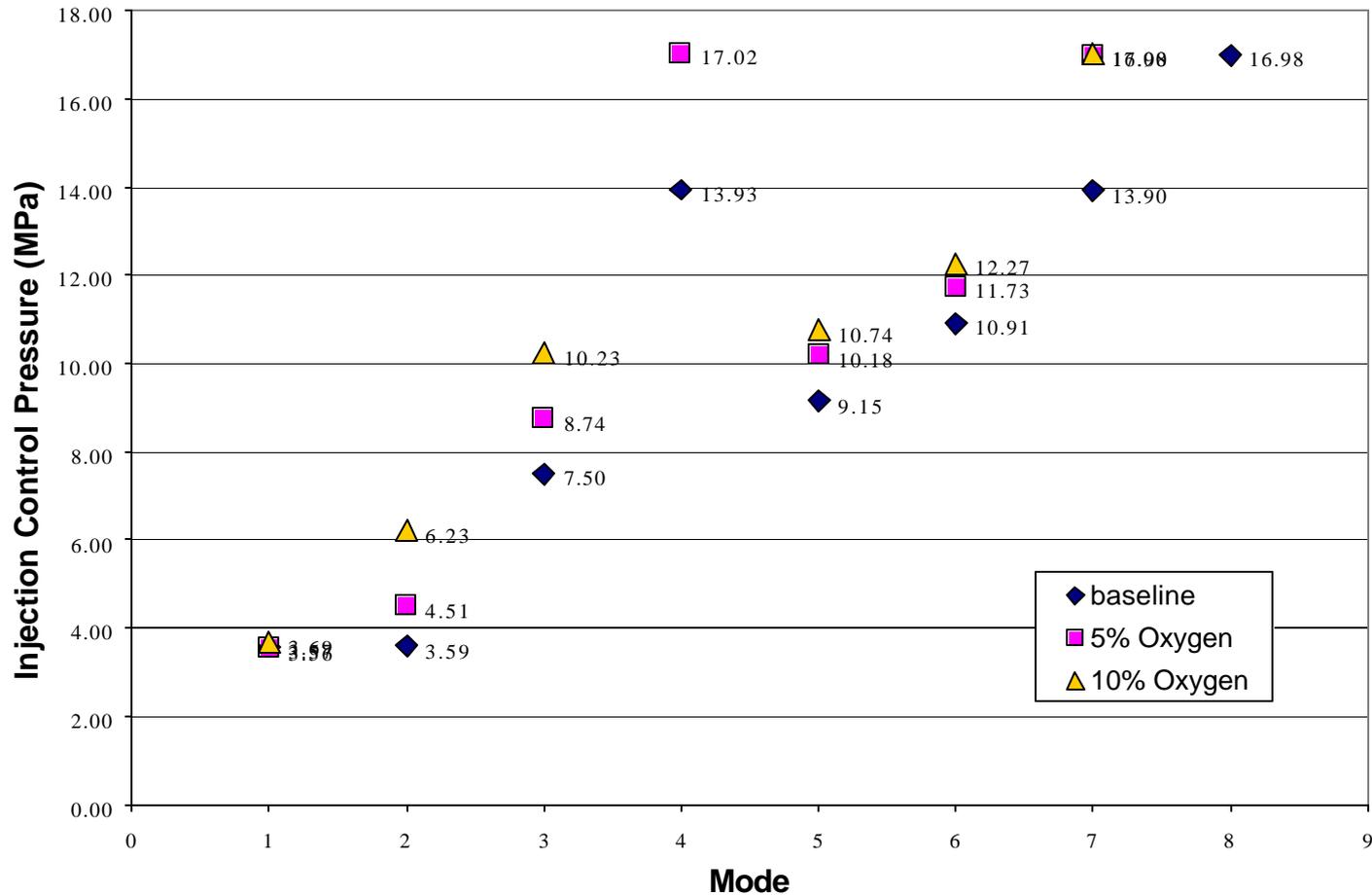


Fuel Injection Timing (Degrees Before Top Dead Center)



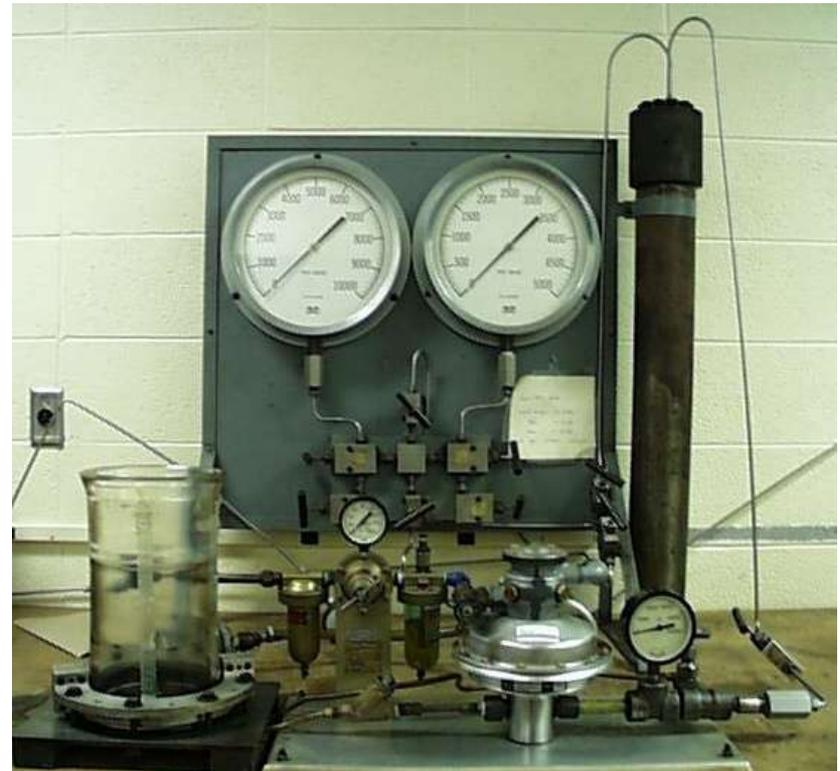


Fuel Injection Pressure (Degrees Before Top Dead Center)



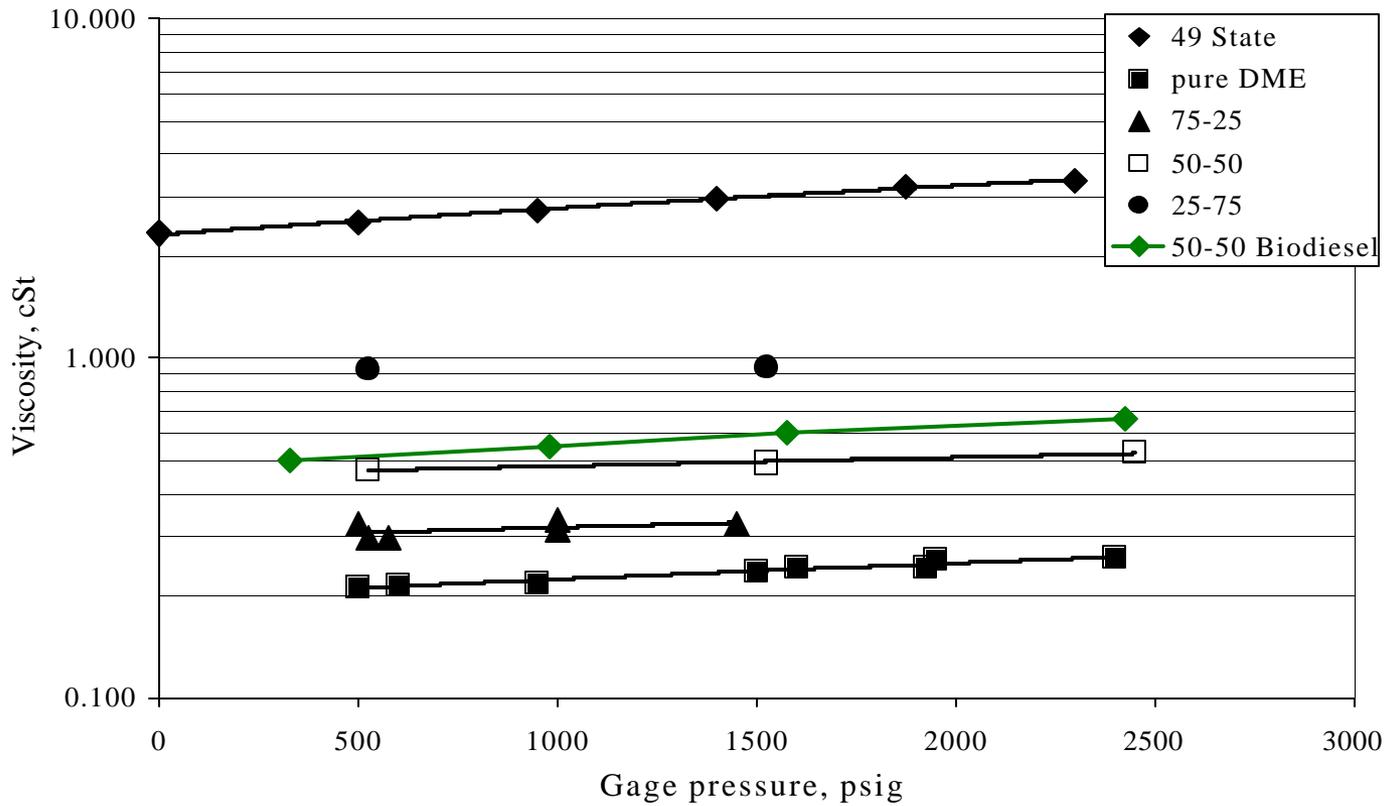


High Pressure Viscometer



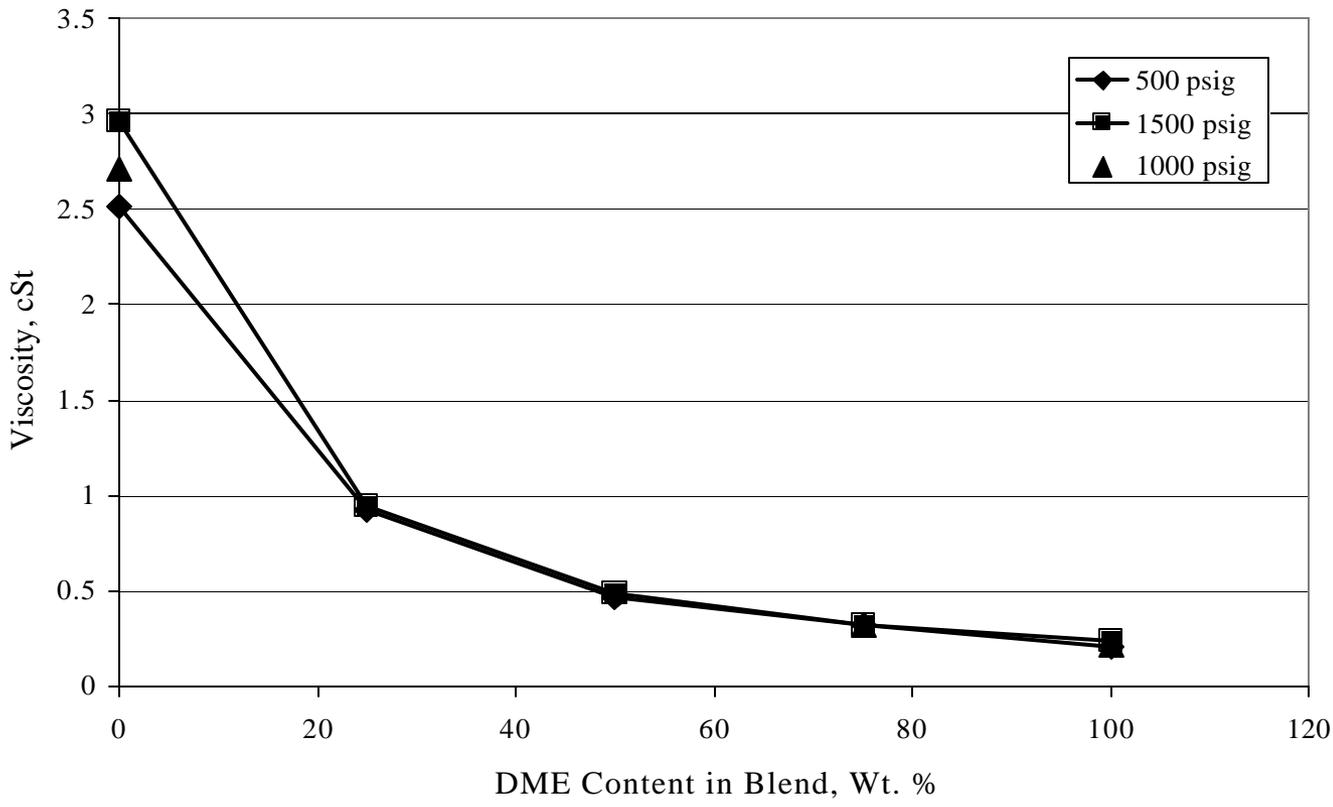


Viscosity of DME-Diesel Blends at Pressures from 500 to 2500 psi



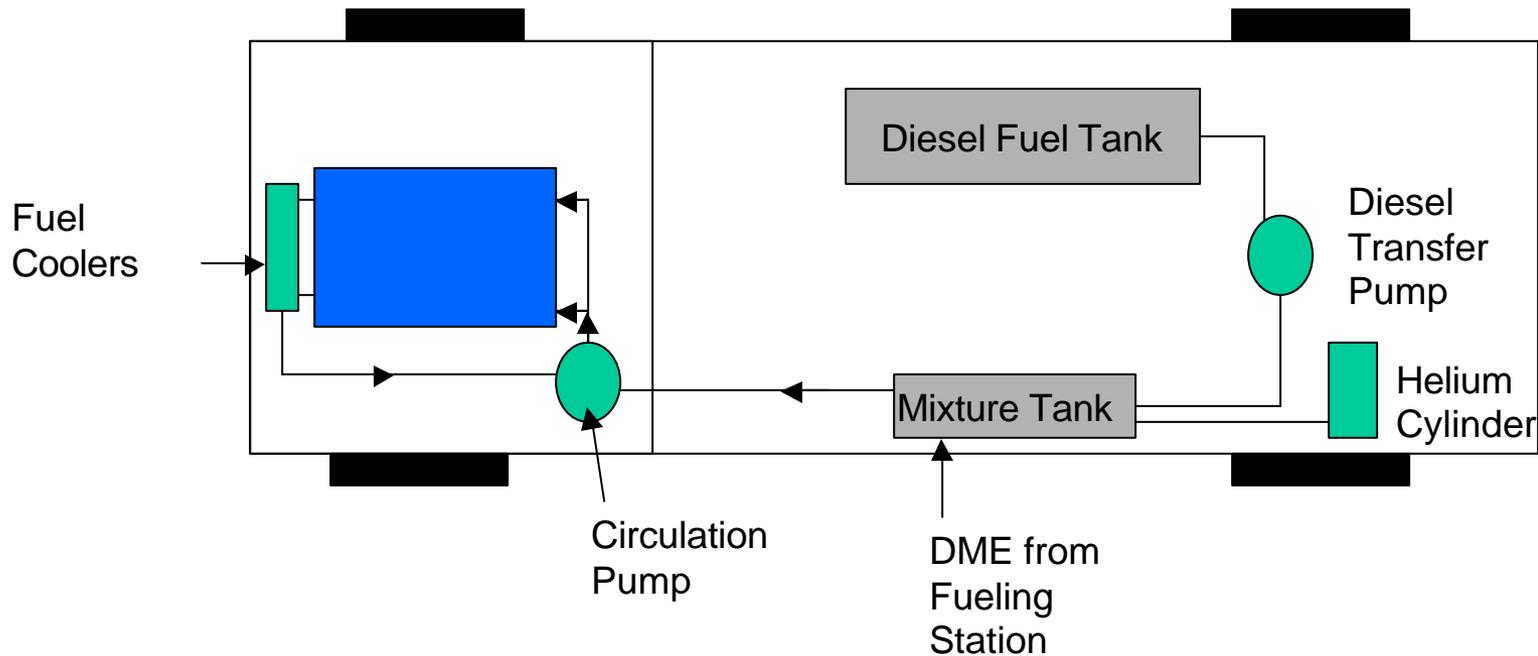


Blend Response of Viscosity to DME Addition at Various Pressures





Shuttle Bus DME-Diesel Fueling System



1. Fill Diesel Tank
2. Transfer Diesel to Mixture Tank while Venting Helium and Leftover DME
3. Transfer DME into Mixture Tank
4. Pressurize Mixture Tank with Helium to 90 – 120 psi
5. Start Engine and then Start Circulation Pump, which Keeps the Rail at 250 psi



Shuttle Bus DME-Diesel Fueling System



Fuel Coolers

Circulation Pump



DME Fueling Door

Mixture Tank:
40 gallon Recreation
Vehicle Tank for LPG



Shuttle Bus "Event," April 19, 2002





Staff Shuttle



Monday through Friday 7:20 am to 6:00 pm

Specifications: Service: every 20 minutes;

Vehicle: (1) 20 passenger Van/Bus with wheelchair lift

Effective 11/1/01 DS52859vh



STAFF SHUTTLE TIME TABLE—MINUTES PAST THE HOUR

Stops

1	Physical Plant	00	20	40
2	I.M. Building	02	22	42
3	Computer Bldg	03	23	43
4	Pollock/Bigler	04	24	44
5	Classroom Bldg	05	25	45
6	Osmond Building	06	26	46
7	Old Main	07	27	47
8	Hosler Building	08	28	48
9	Rec Hall	09	29	49
10	Pattee Library	10	30	50
11	Weaver Building	11	31	51
12	Creamery	11	31	51
13	Mitchell Building	12	32	52
14	Flower Garden	13	33	53
15	Business Services	15	35	55
16	Procurement Services	15	35	55
17	Support Bldg I & II	16	36	56
18	Dairy Barns	19	39	59



DME-Fueled Shuttle Bus

Faculty/Staff Shuttle Route





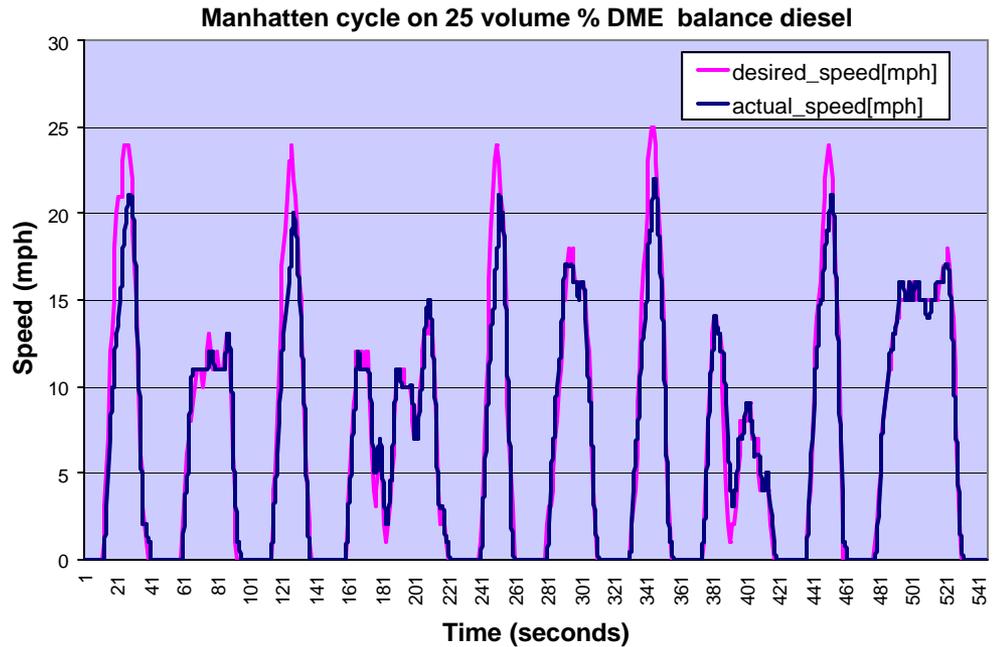
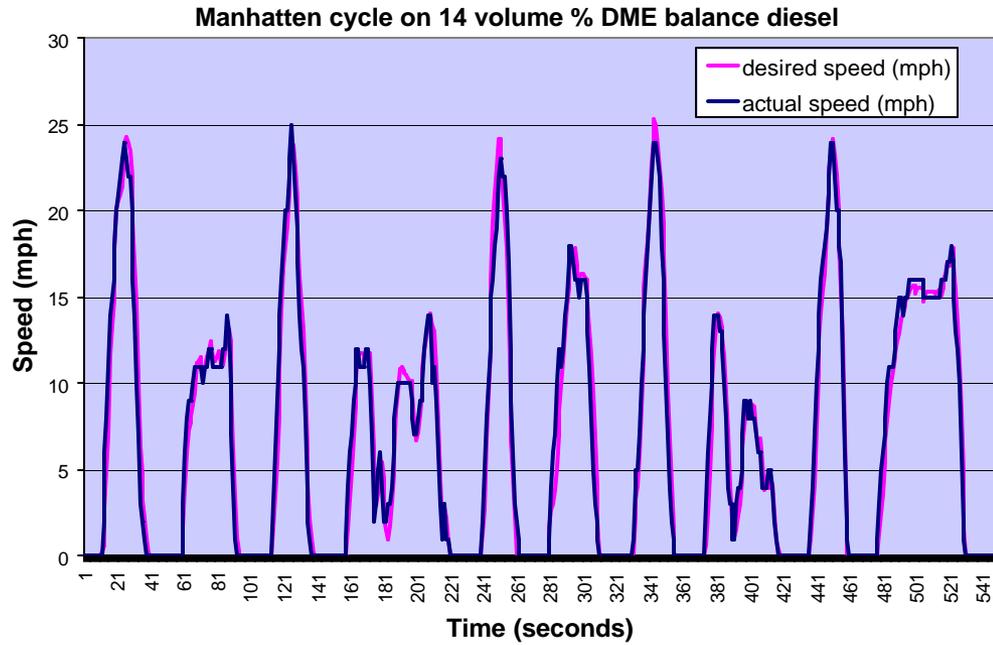
Emissions Testing at PTI Track



Exhaust
Sampling
Line

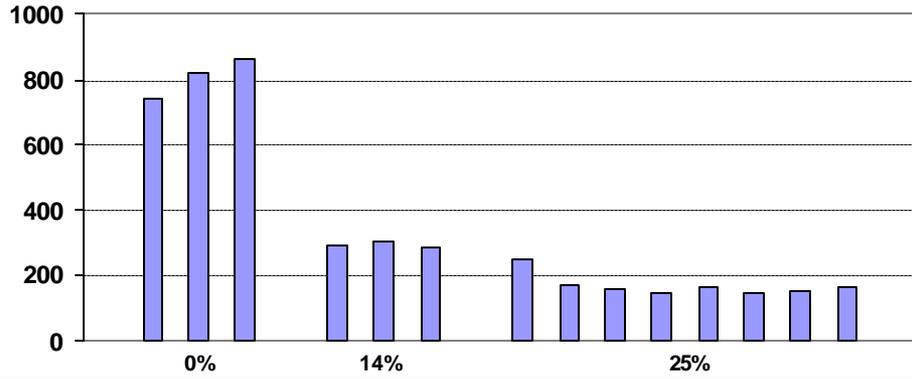


CATI
Portable
Emissions
Analyzer

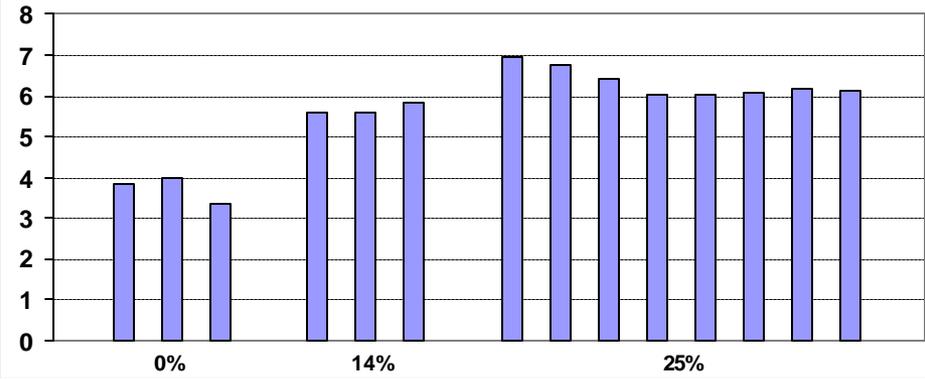




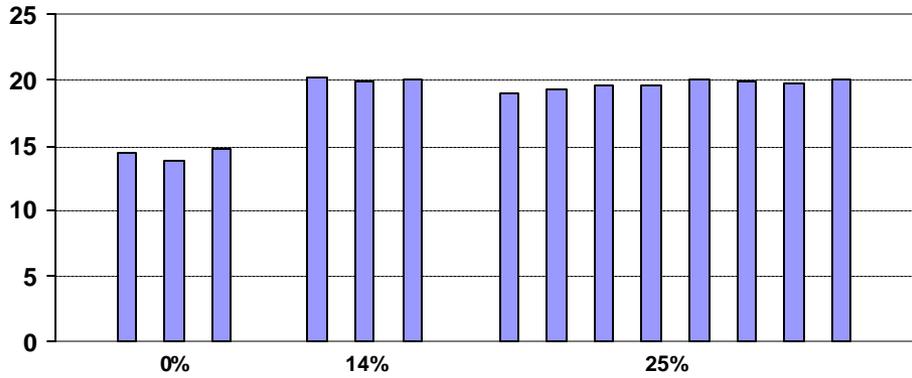
Manhattan cycle - PM [mg/test]



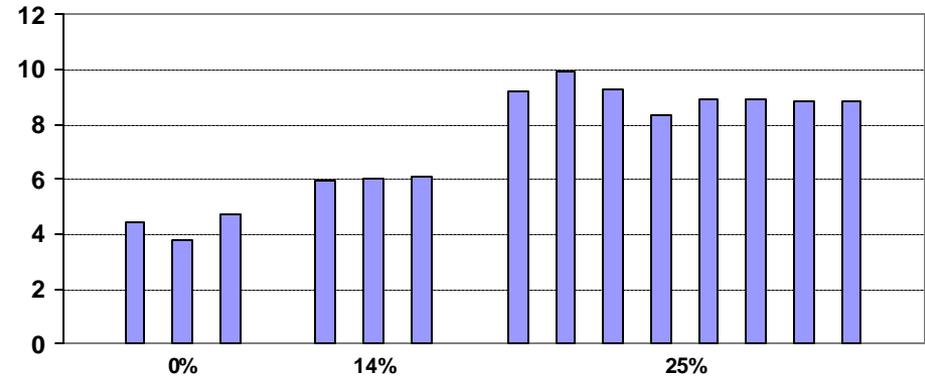
Manhattan cycle - HC [g/test]



Manhattan cycle - NO_x [g/test]

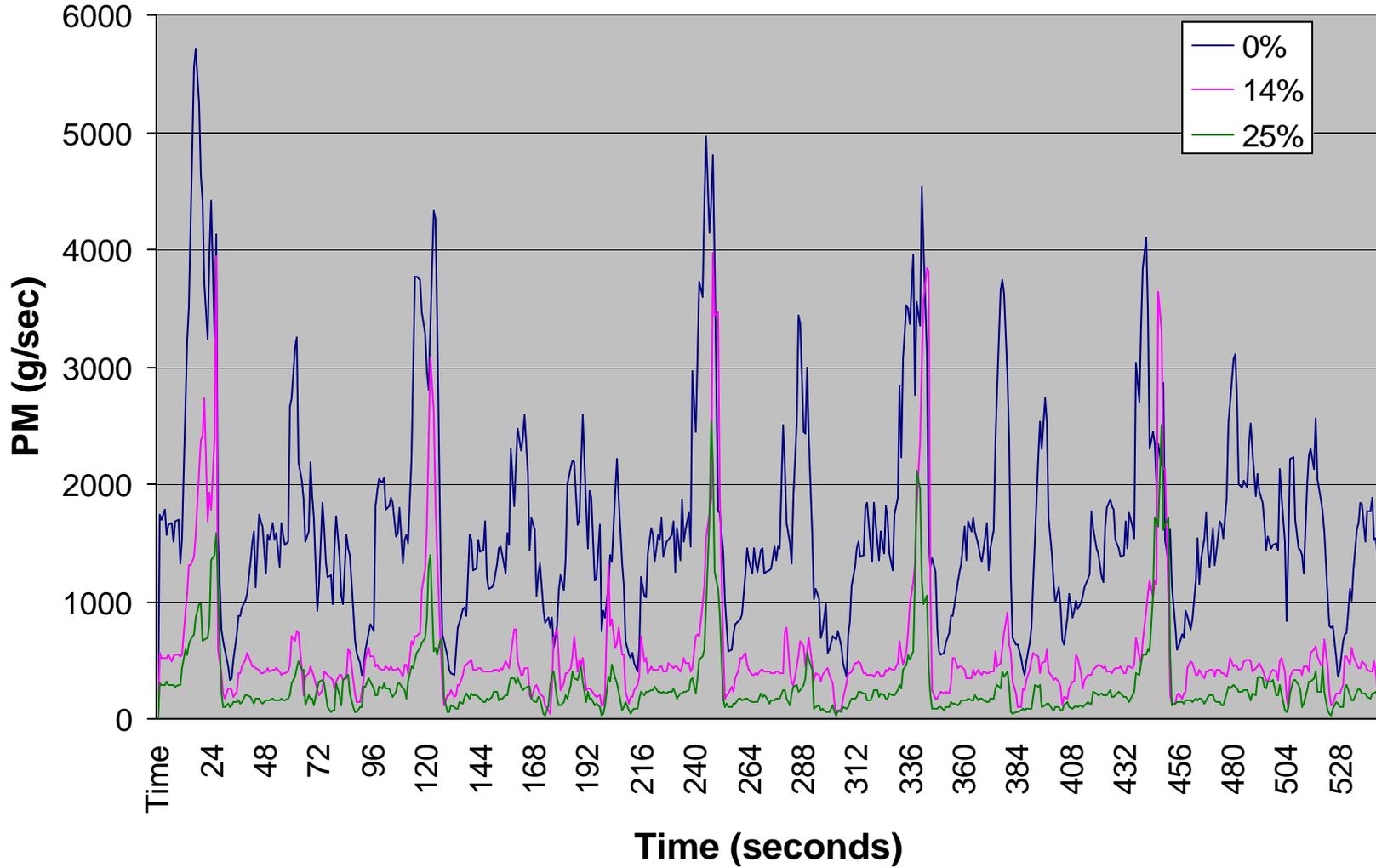


Manhattan cycle - CO [g/test]





Transient PM Emissions During Manhattan Cycle





Observations and Current Status

- **Shuttle Bus Deployed on Campus on June 5, 2002**
 - ➔ **Fuel Circulation Pump is a Weak Link in the System; Damaged Pump Replaced in Late June Solved Problems**
 - ➔ **Some Operational Issues Observed – Mostly Due to Heating of the Fuel in the Rail when Shifting from Heavy Load Operation to Idle; Hot Re-Start is Sometimes Difficult; Pull-Out into Traffic More Difficult at 25 wt.% DME**
- **Fueling Procedures Working Smoothly and Fueling “Station” is Functioning Well**
 - ➔ **Hand-Off of Fueling Responsibilities to Penn State’s Fleet Operations is Unlikely**
- **Target for Shuttle Operation Remains 25 wt.% DME-Diesel Blend, but Best Observed Operation is at 8-12 wt.%**
- **PM Emissions Decrease 80% with 25 vol.% DME-Diesel Blend in the Shuttle Bus Tests with Clean Air Technologies Analyzer**
- **The Shuttle Bus will Operate until September 30, 2002 on DME-Diesel Blends, mostly on 12 wt.% DME**