In-Use, On-board Measurement of Particulate Matter Mass Emissions

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REAL-TIME PARTICULATE MASS MONITOR
MARI RPM-100
QUARTZ CRYSTAL MICROBALANCE

REAL-TIME PARTICULATE MASS MONITOR
MARI RPM-100
SAMPLE CONDITIONING SYSTEM

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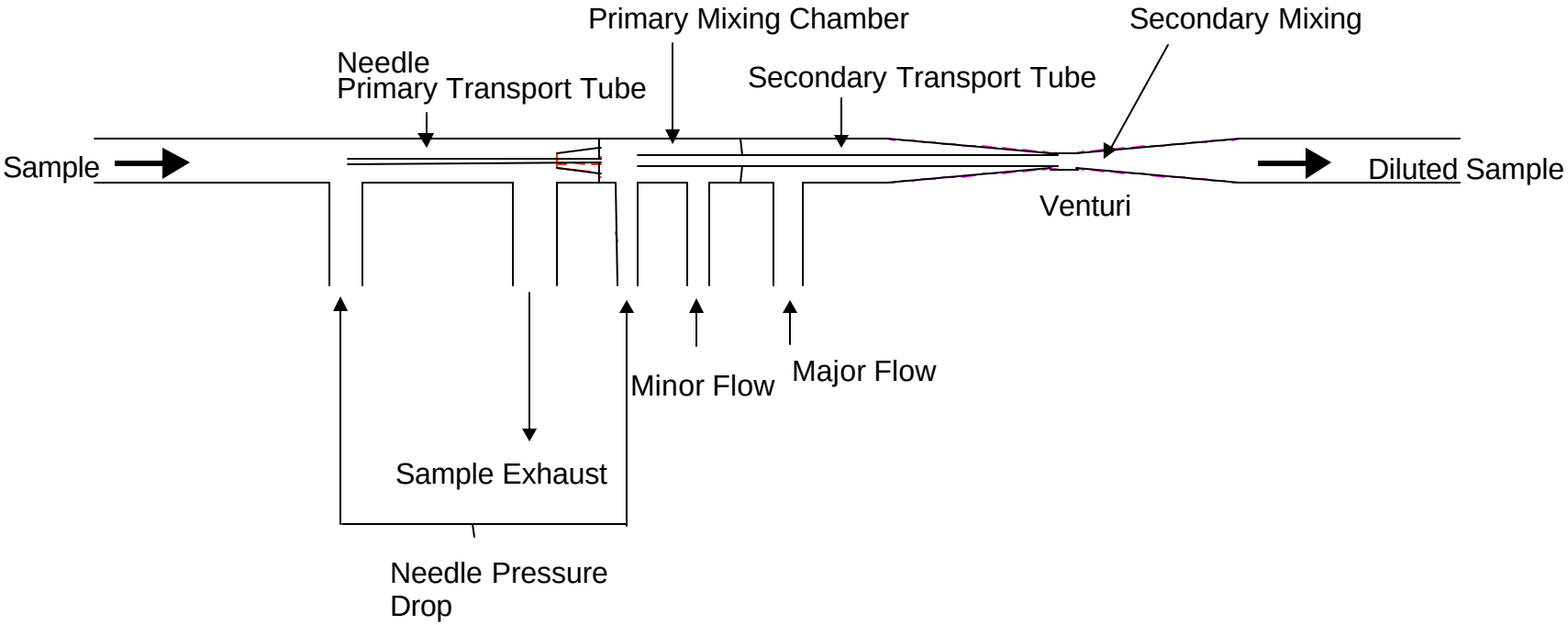
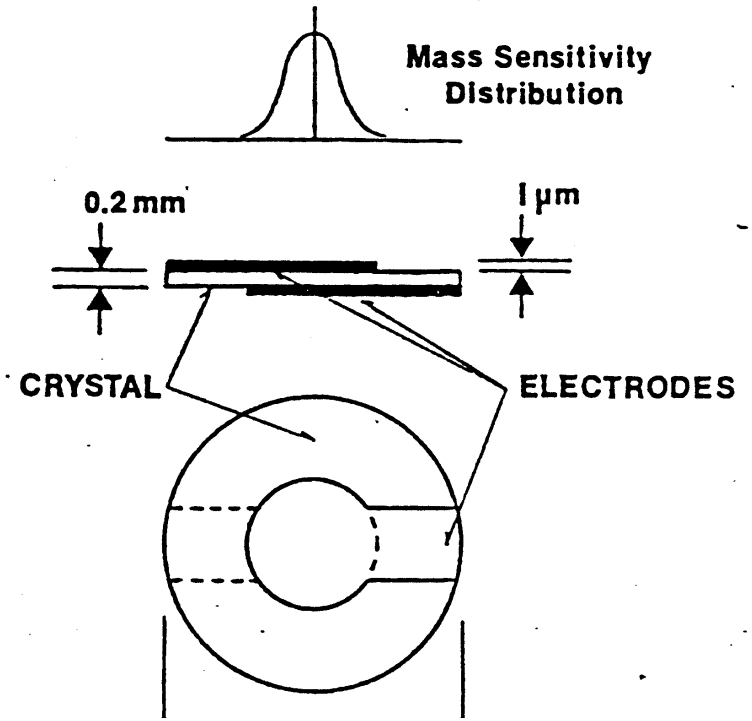
CAN Network Communication & RS 232; GPS Receiver RS 232

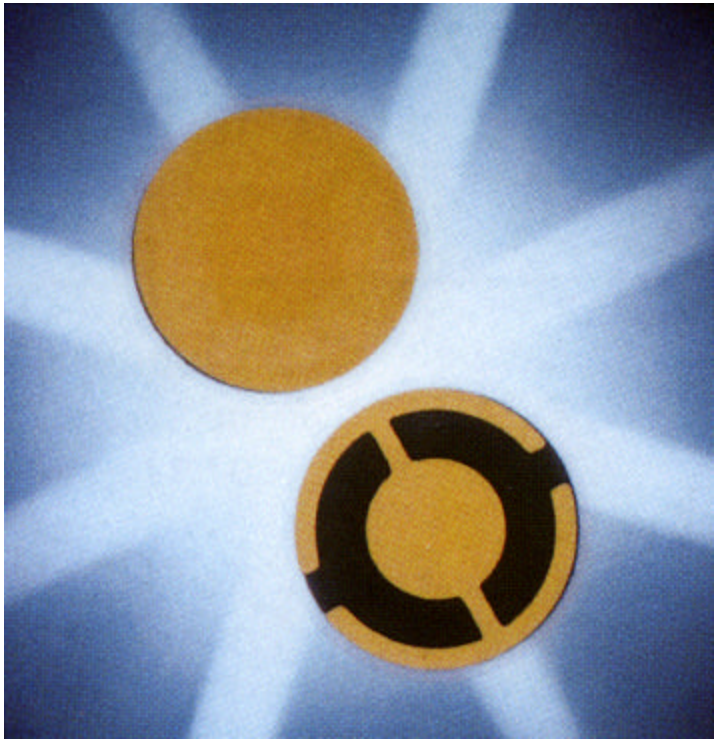
Sample Conditioning System
MARI SCS 110



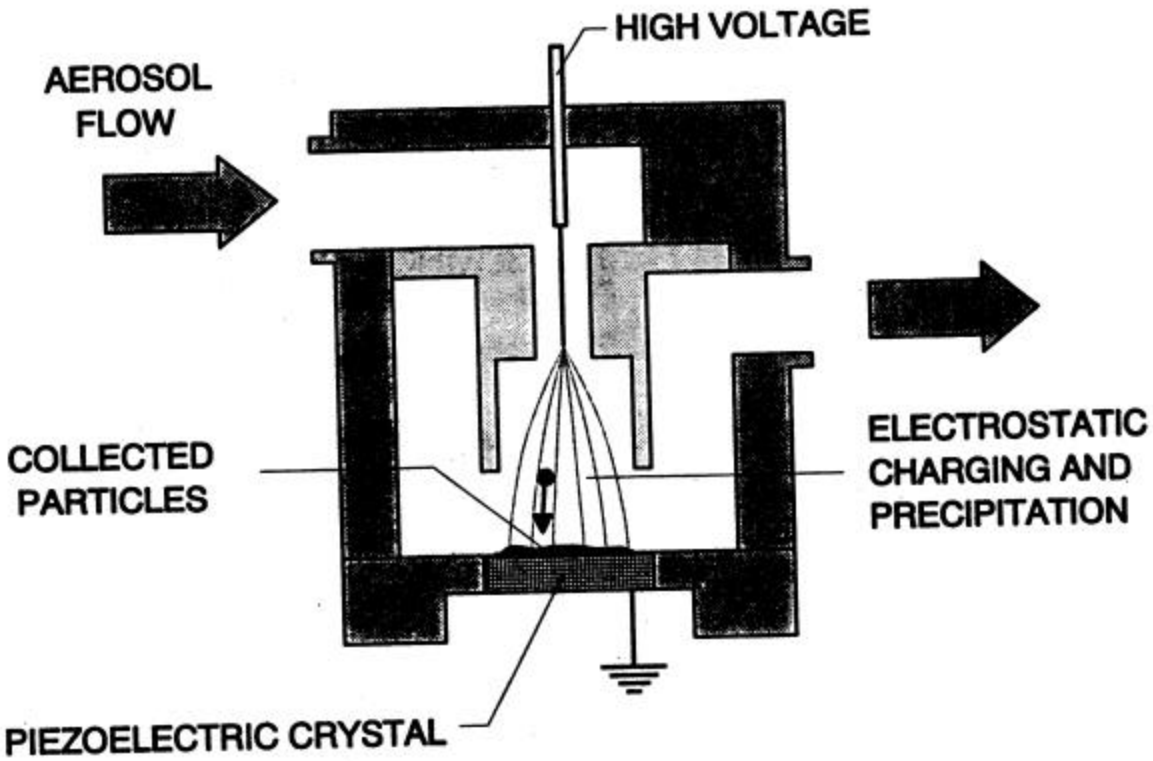
Concept


Mass Sensitivity
Distribution
0.2 mm
1 μm
CRYSTAL
ELECTRODES

Crystal Surfaces



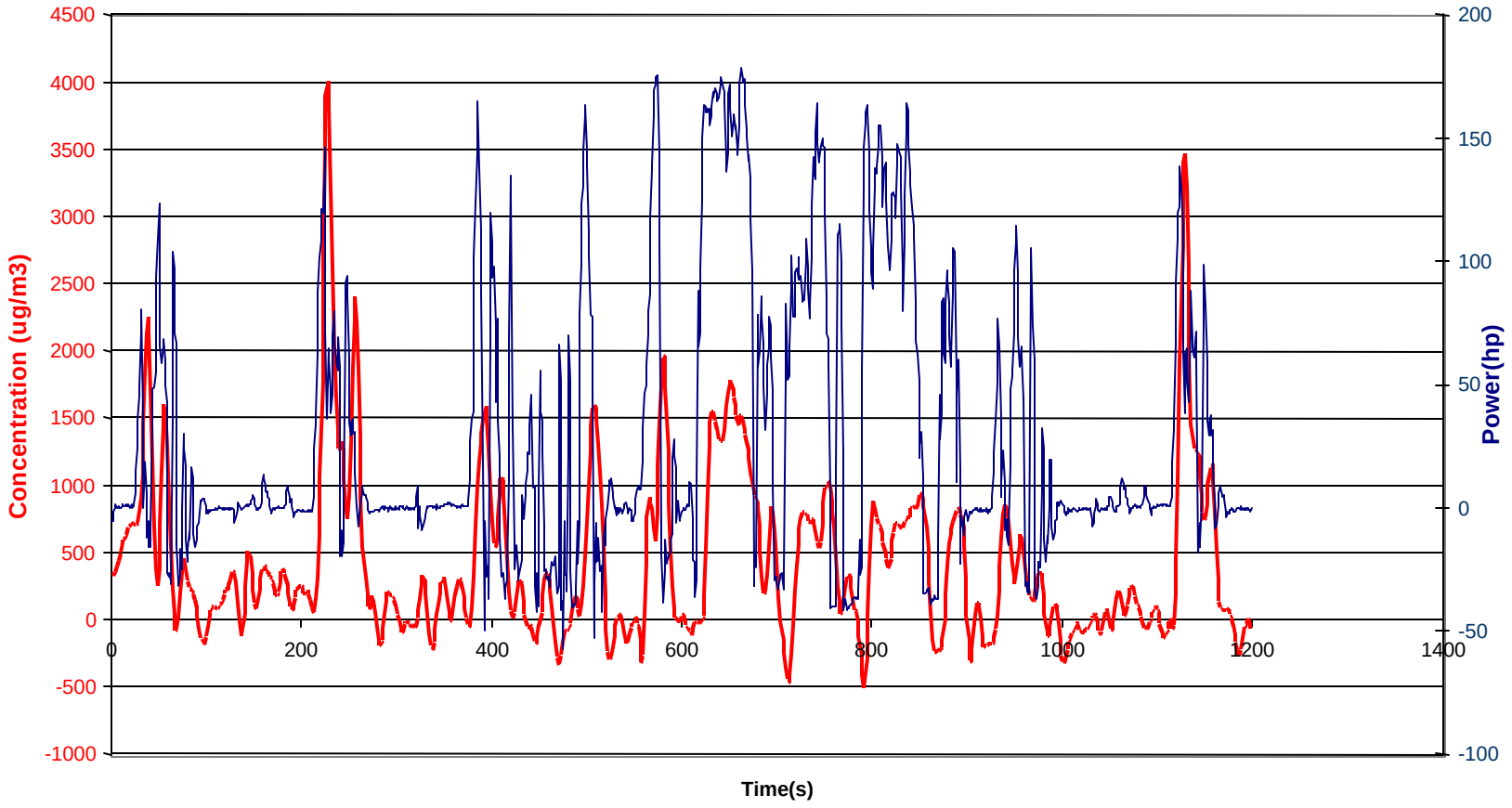
Point to Plane Precipitator



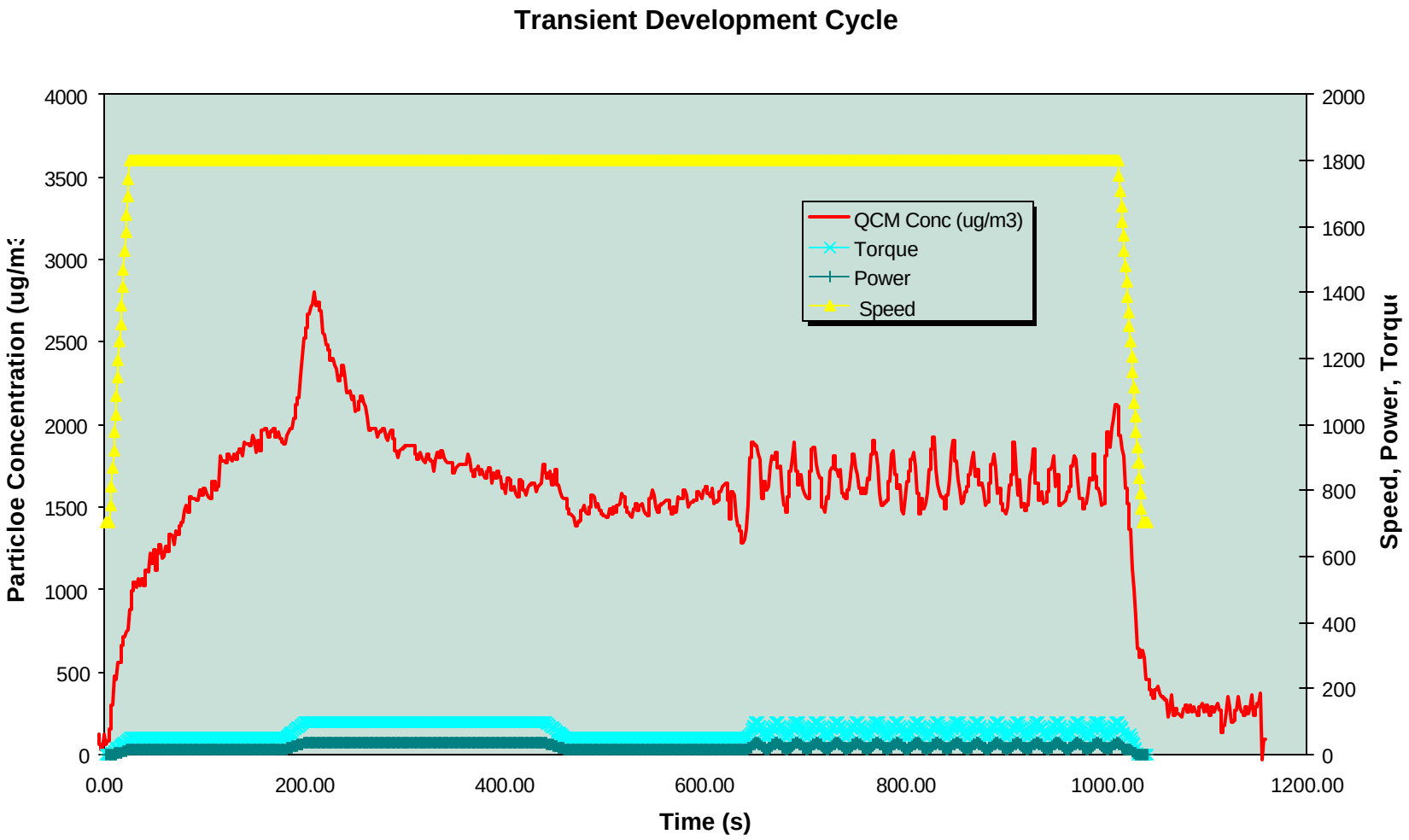
Quartz Crystal Microbalance

- **0.454Hz/ng**
- **Conc. Range**
  - **0-1000 m gm-3**
- **Accuracy**
  - **Better than 10%**
- **Data-logging interval**
  - **<1 second**

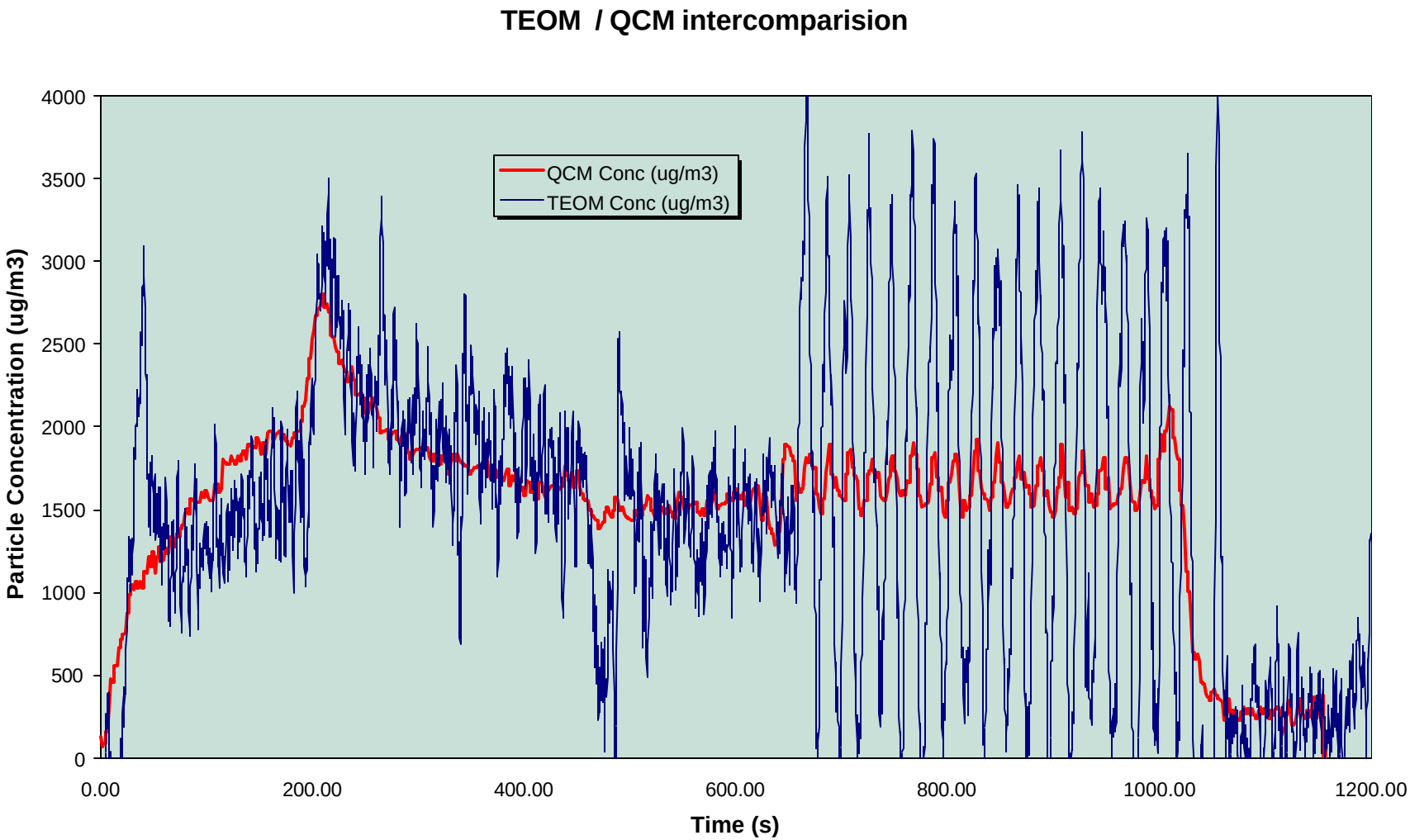
Continuous TPM Measured with *MARI* RPM-100
TPM Trace vs. Power: FTP Cycle



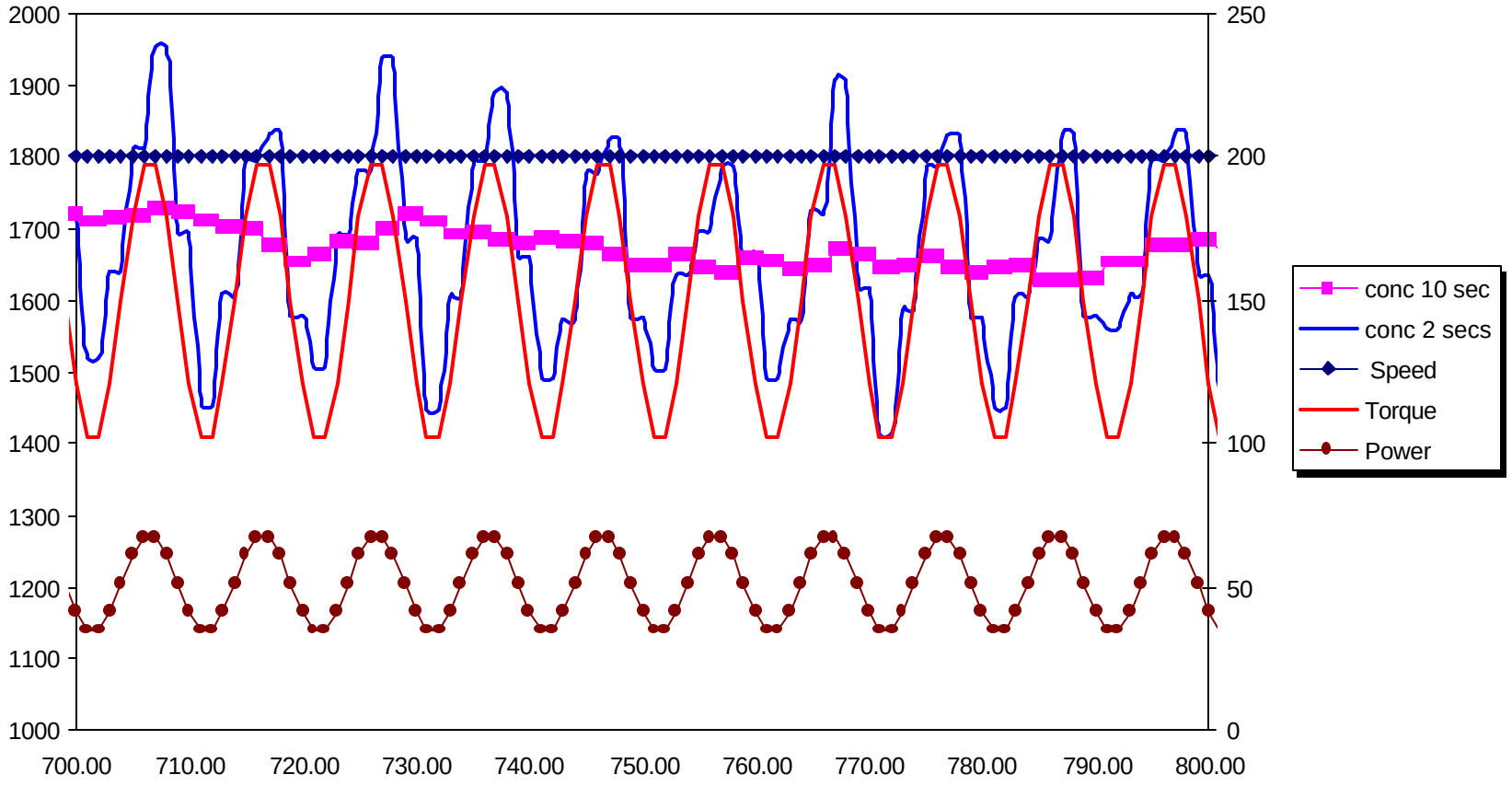
TPM Trace with *MARI* RPM 100 over a Transient Cycle



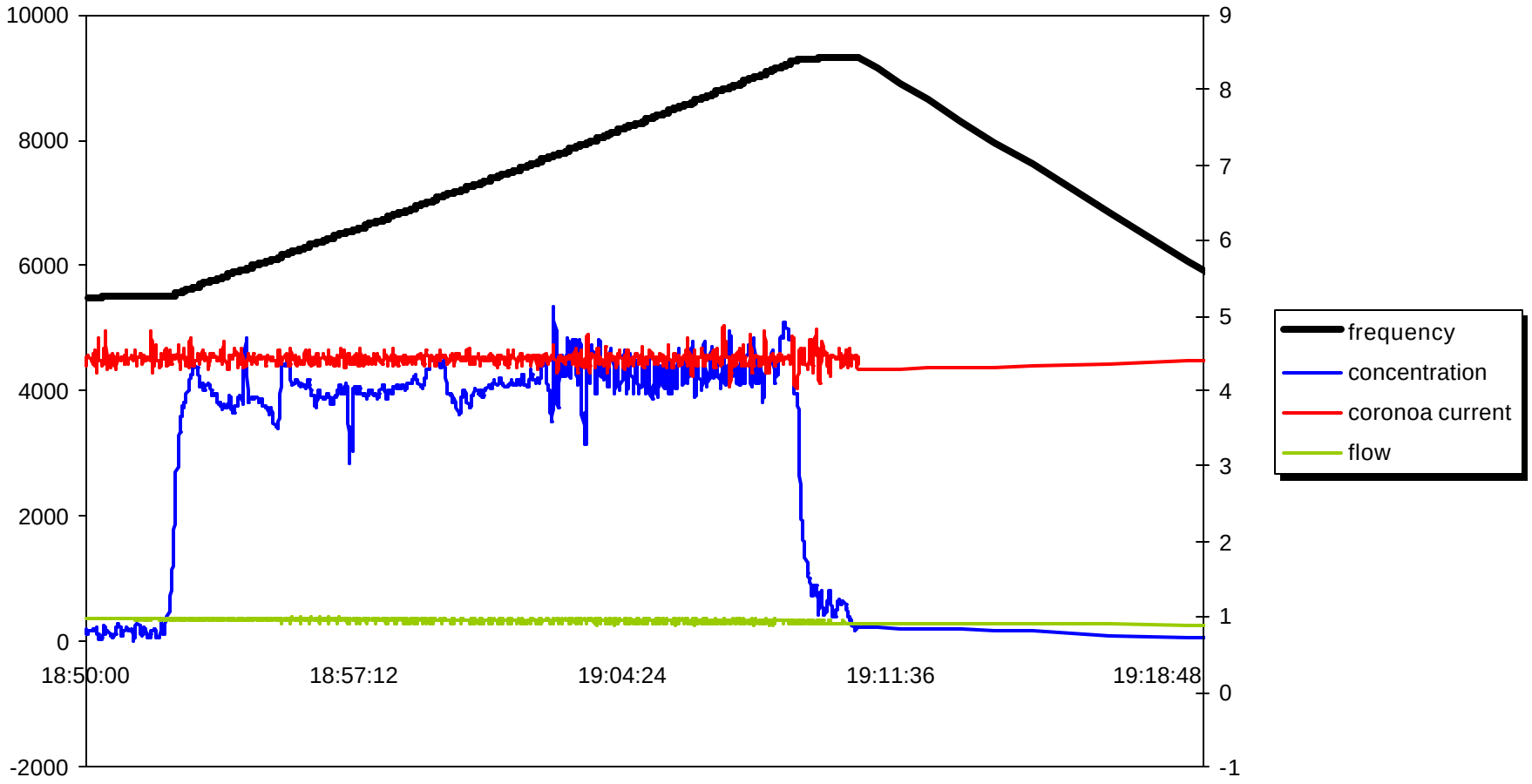
TPM Trace from TEOM Model 1105 and *MARI* RPM 100



TPM Trace over the Transient Portion of the Engine Cycle



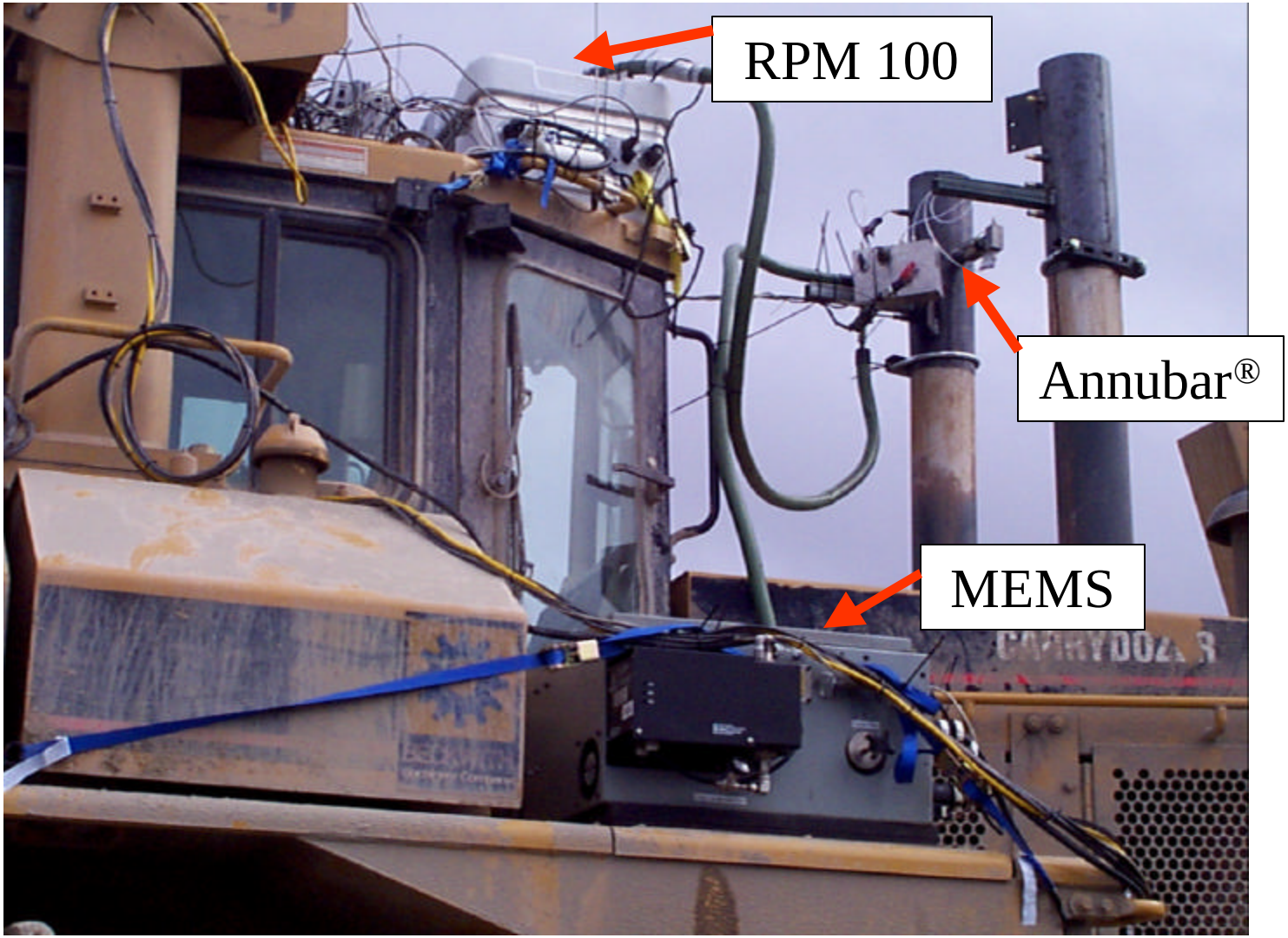
RPM 100 Parameters



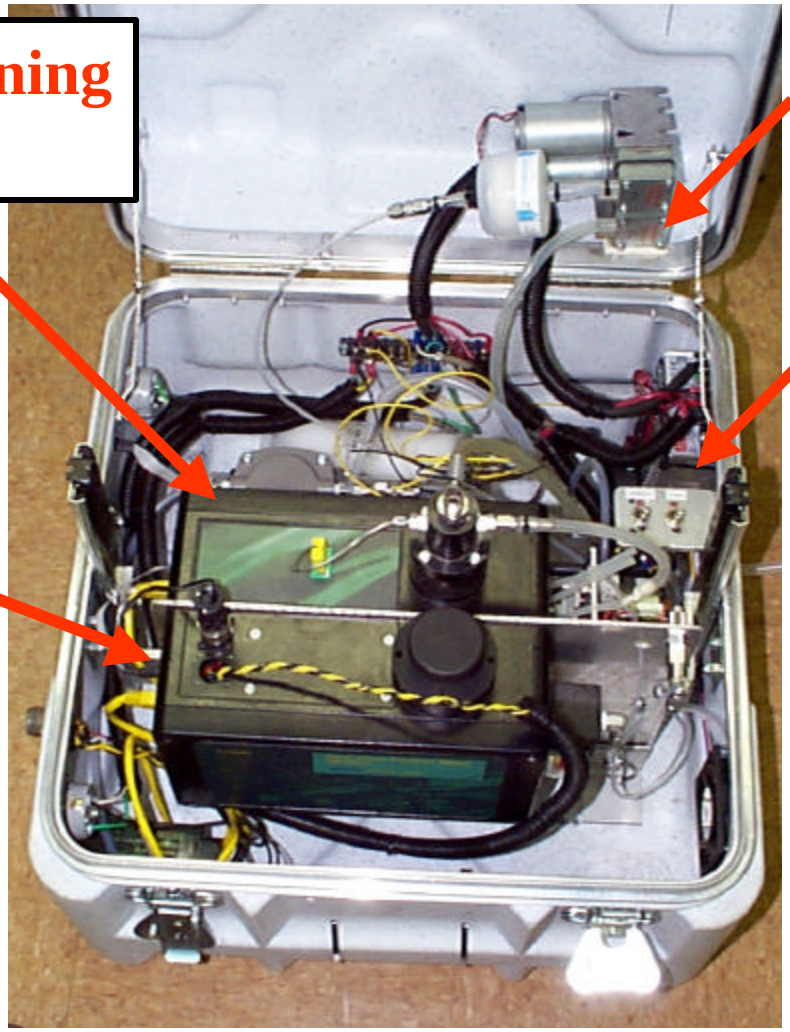
Caterpillar D11 Track-type Tractor with a 3508 V-8 Engine Operating at a Strip Mine in WV

Caterpillar D11 Dozer with a 3508 V-8 Engine Operating at a Strip Mine in WV

MEMS and RPM 100 on a CAT D11 Dozer with a 3508 V-8 Engine

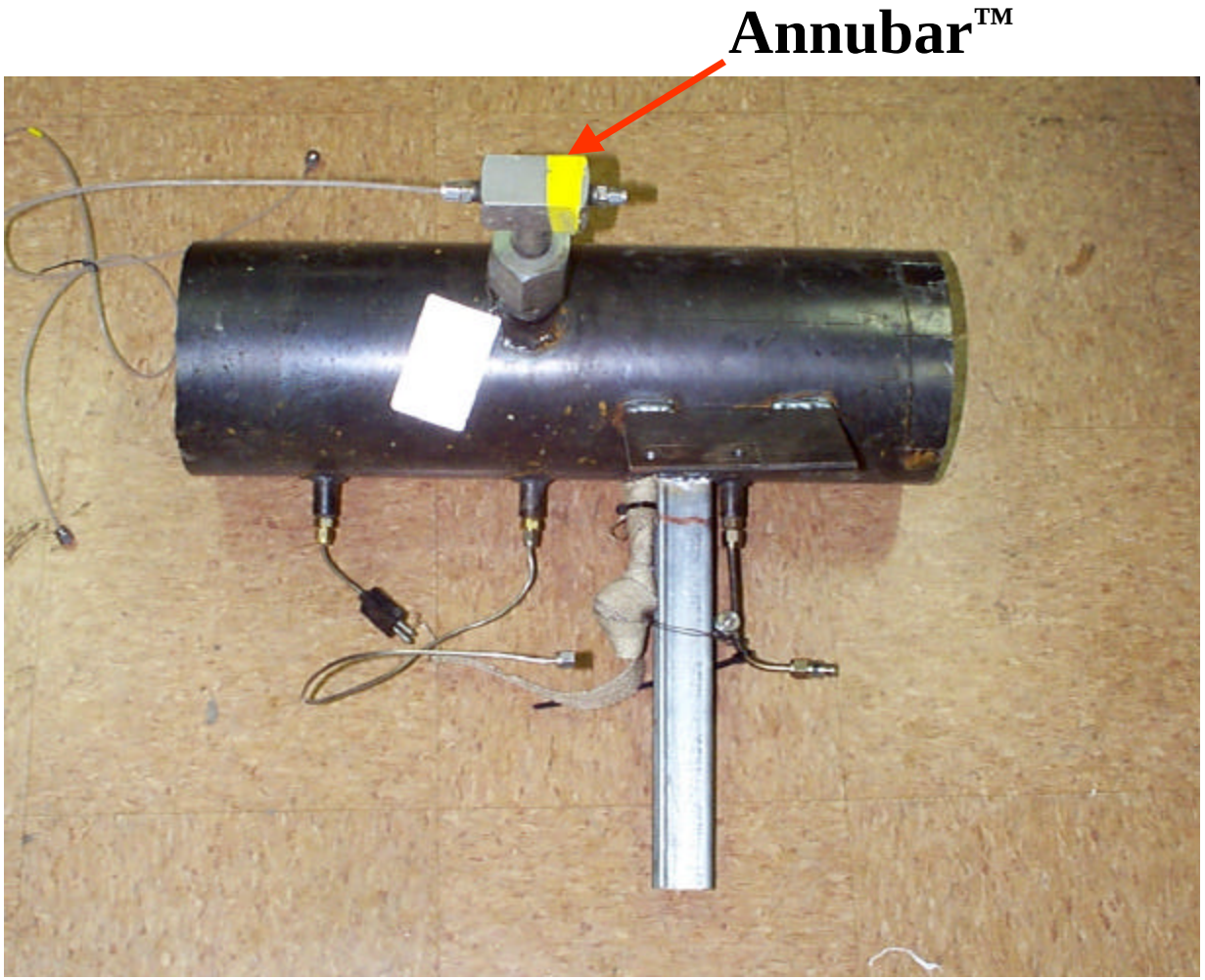


RPM-100 Packaged for the In-field Emissions Measurement from a Track-type Tractor

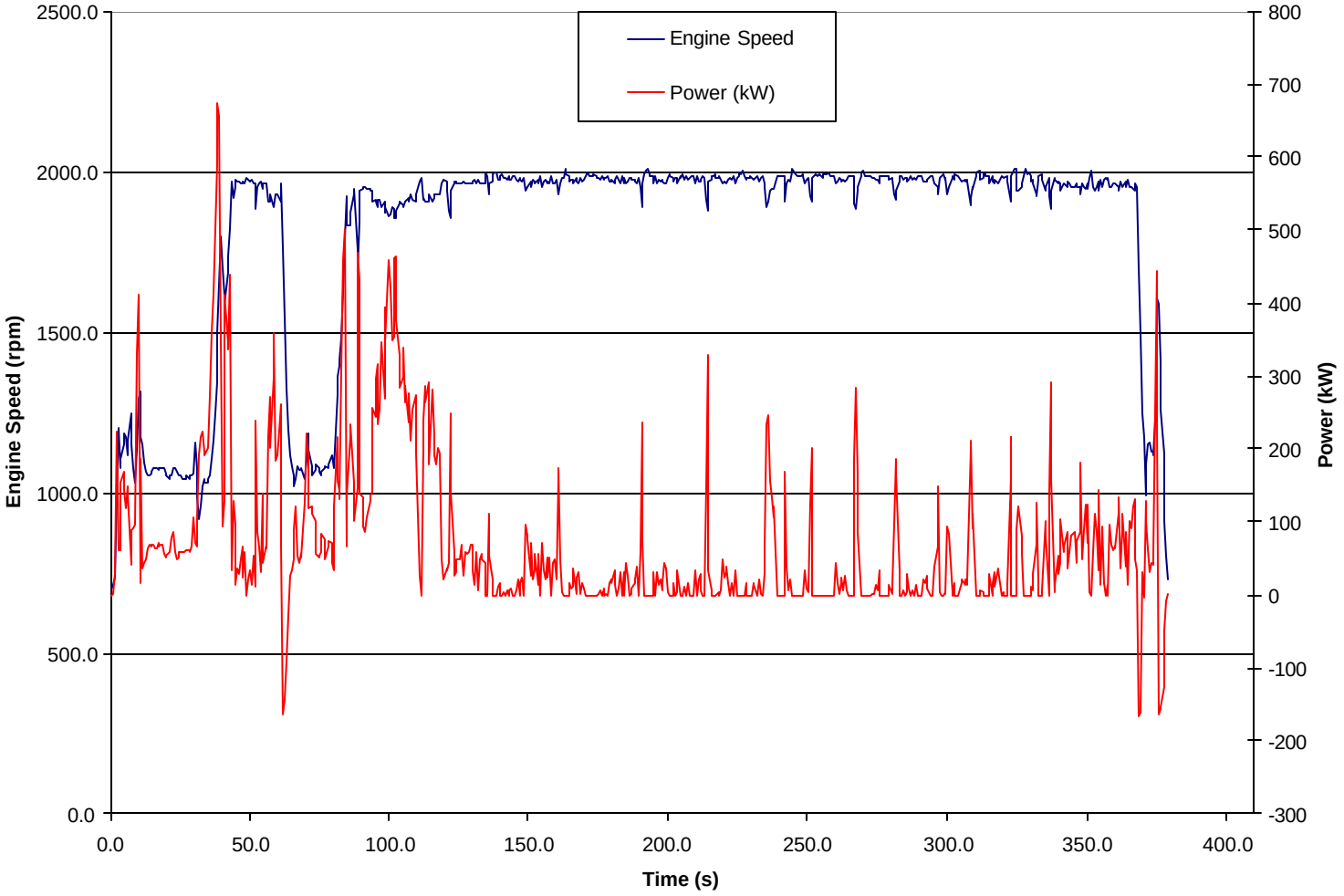


RPM-100 (QCM) in a Backpack

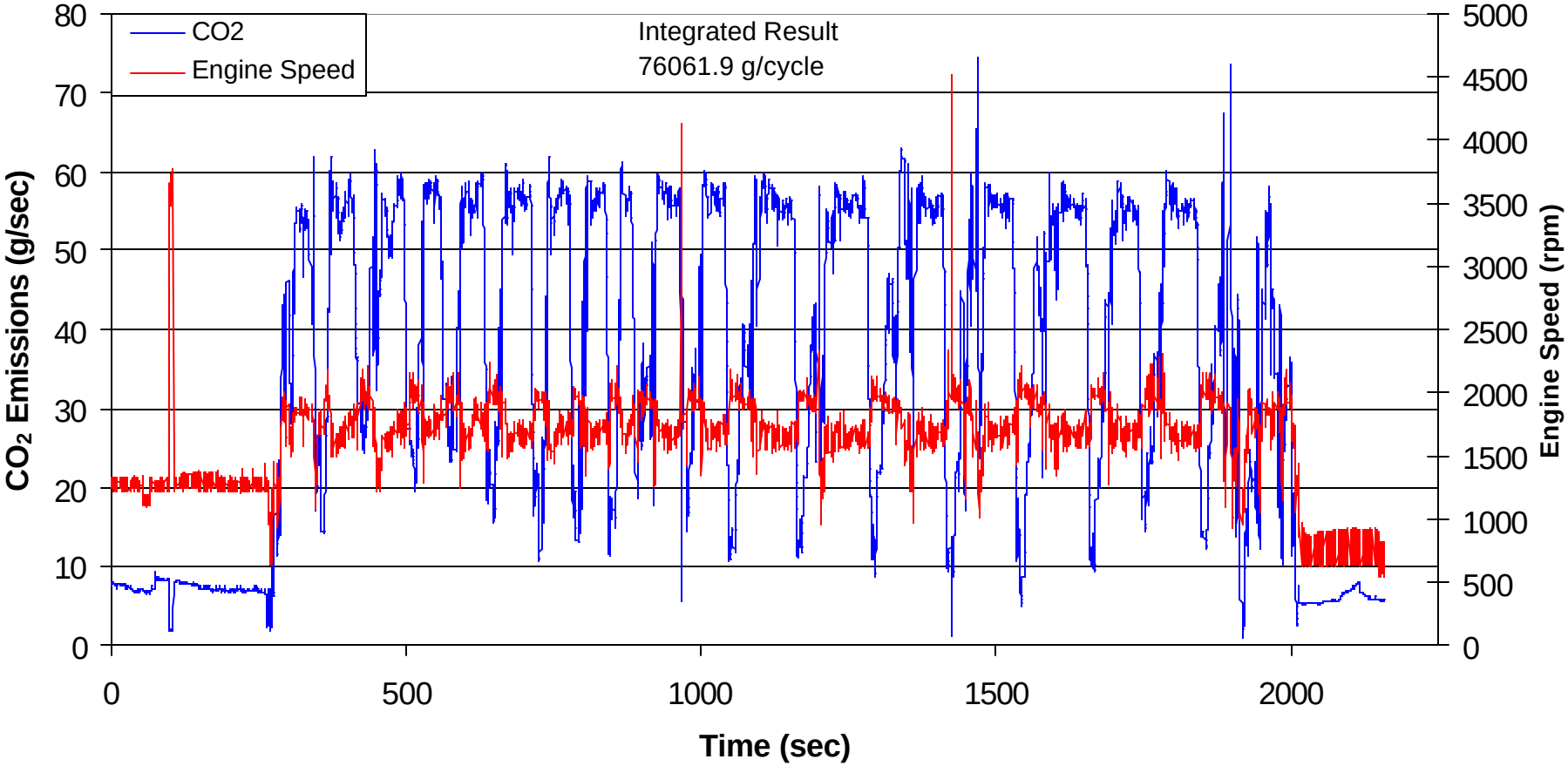
Raw Exhaust Flowrate Measurement/Sampling Section



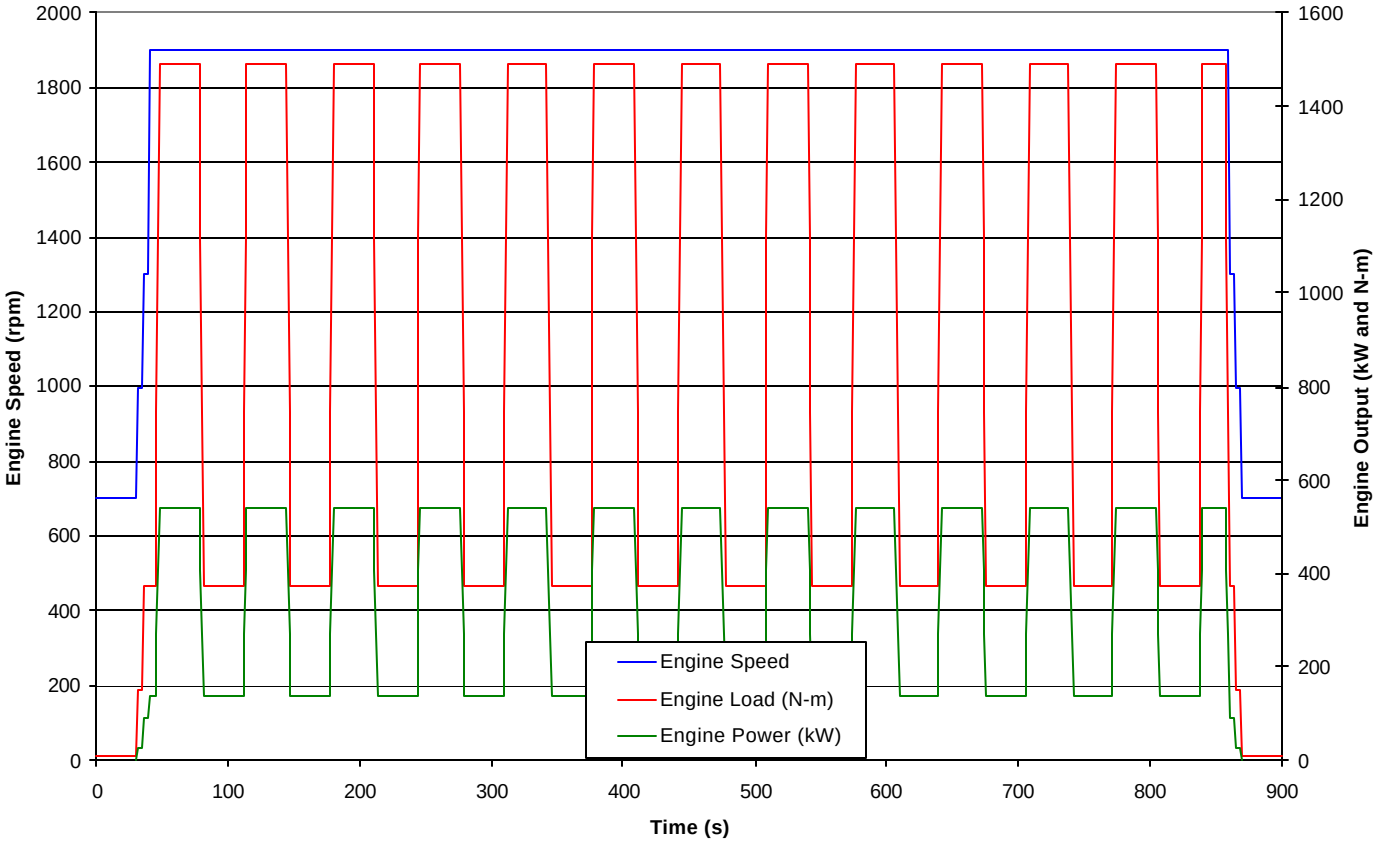
Engine Speed and Power Data Collected by Caterpillar during Track-type Tractor Transport



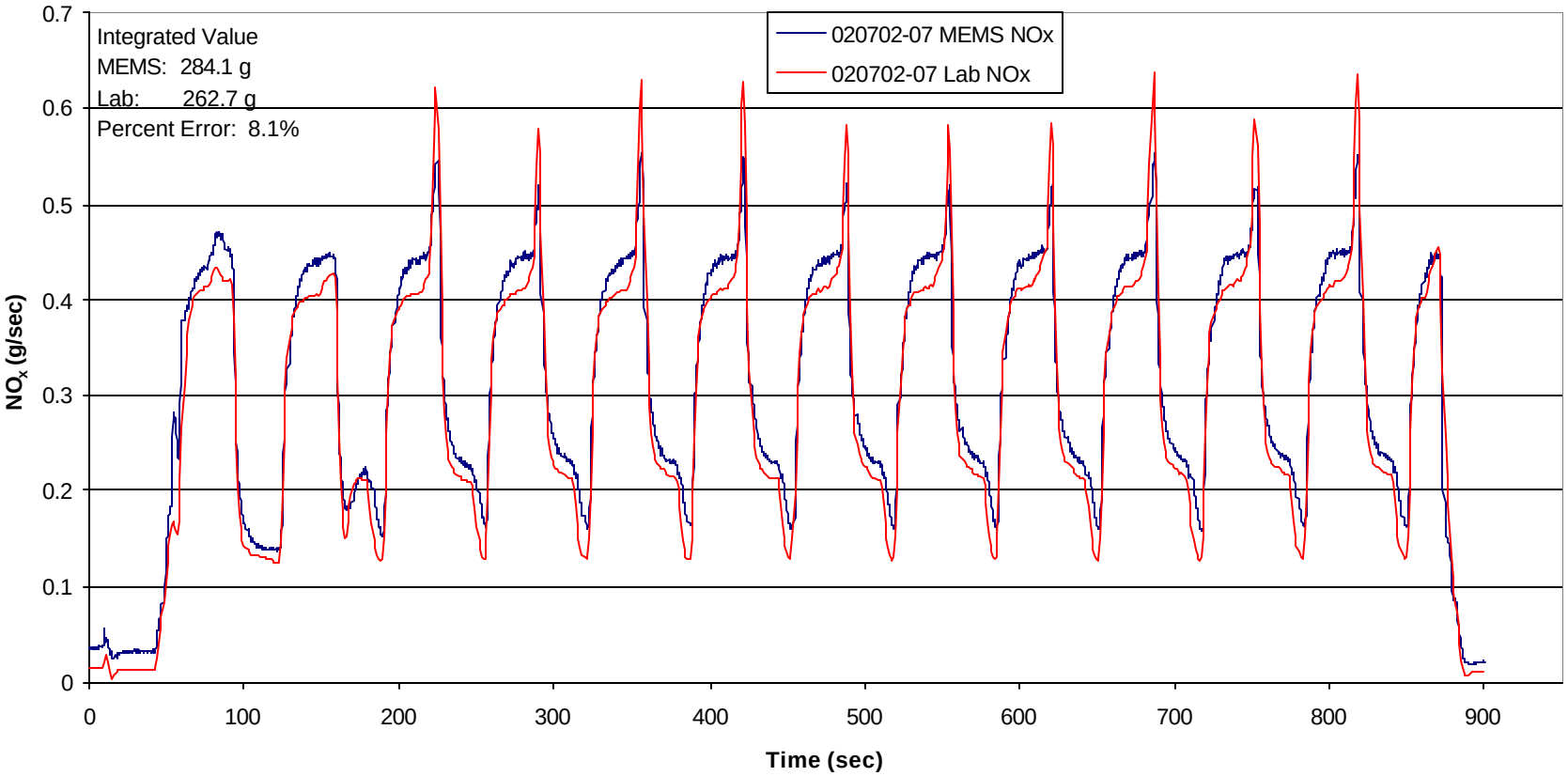
CO_2 Mass vs. Time for the First Track-type Tractor Test (Full Cycle)



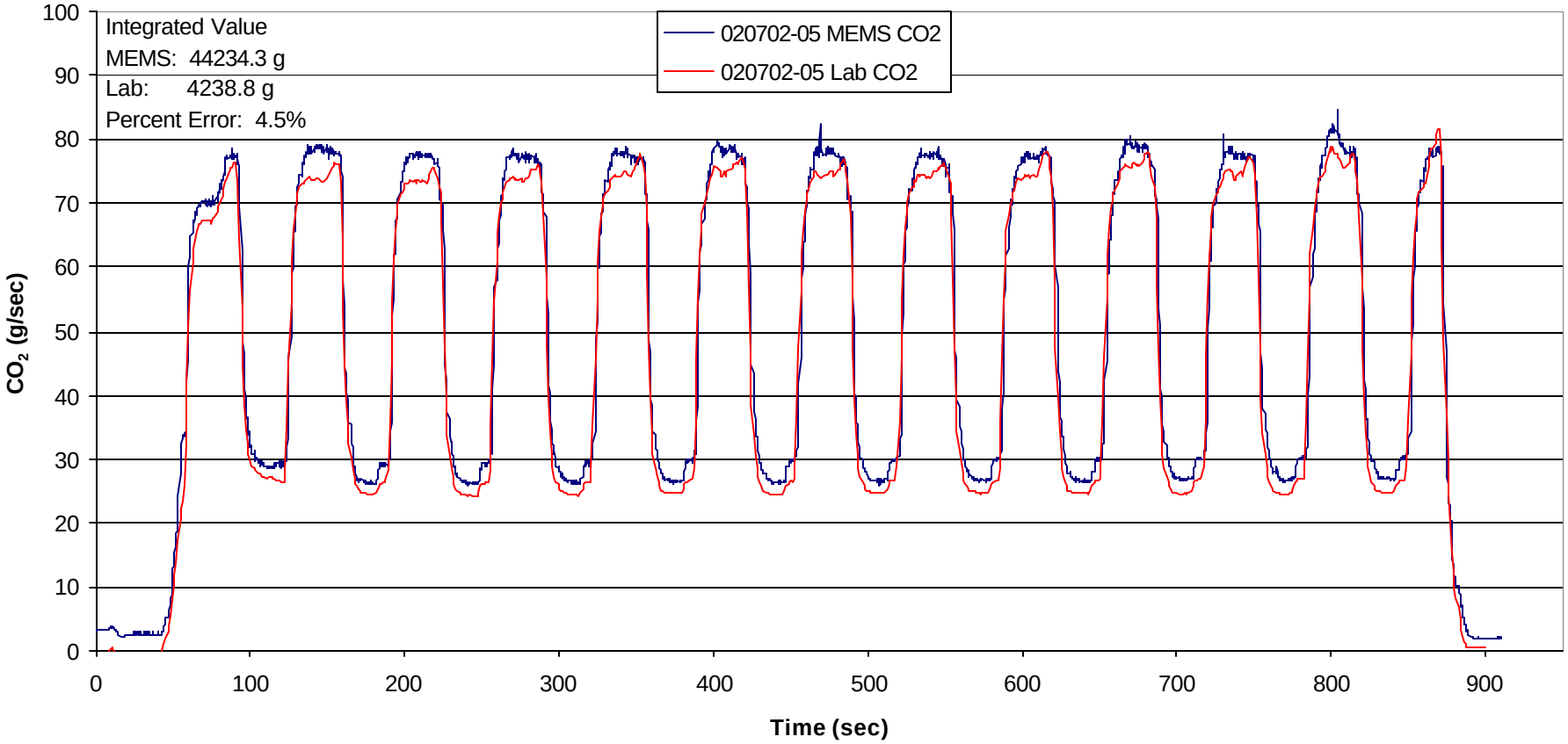
Dynamometer Test Cycle Designed to Evaluate the On-board Emissions Testing System in the Laboratory



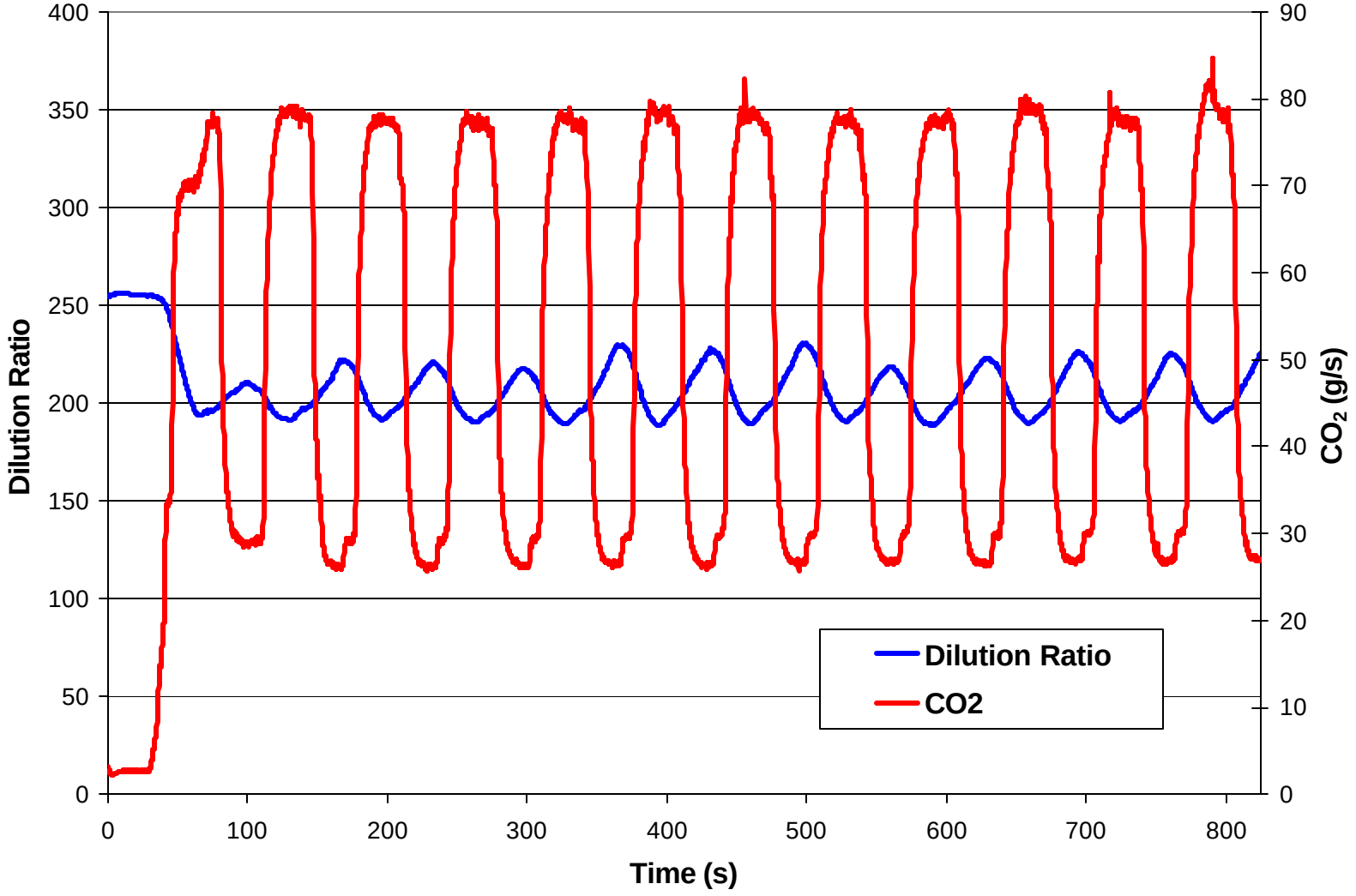
Comparison of Mass Emissions Rates of NO_x over a Transient Cycle Designed to Mimic In-field Dozer Operation – MEMS Results and Laboratory Results



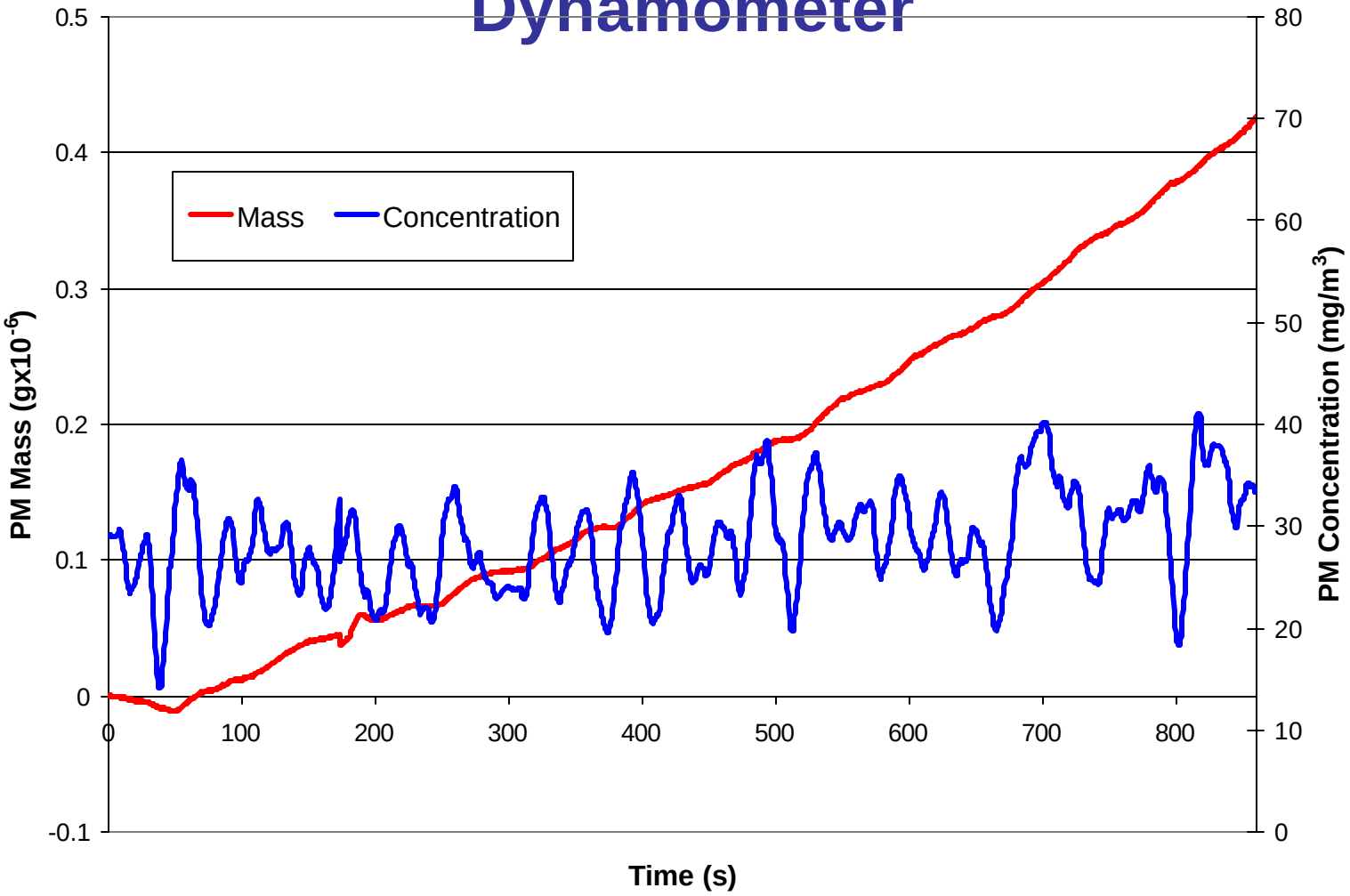
Comparison of Mass Emissions Rates of CO_2 over a Transient Cycle Designed to Mimic In-field Dozer Operation – MEMS Results and Laboratory Results



Dilution Ratio (Using the RPM-100) and CO_2 Mass Emissions Rate MY 2000, DDC Series 60 on an Engine Dynamometer



Continuous PM Mass Emissions Measurement with the RPM-100
MY 2000, DDC Series 60 on an Engine Dynamometer

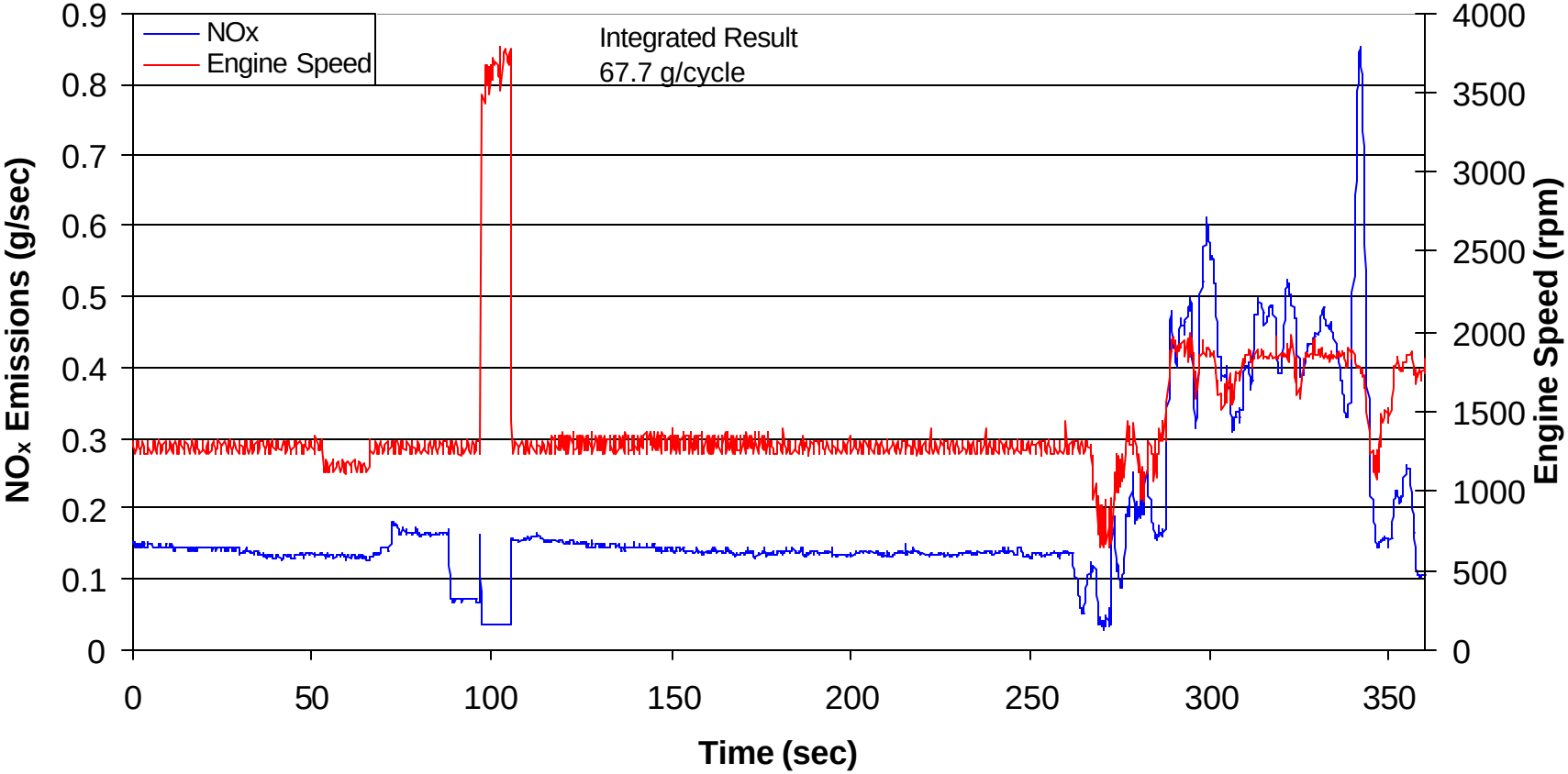


Gravimetric PM Comparisons Between the *MARI* RPM-100 and the Full-flow Dilution Tunnel

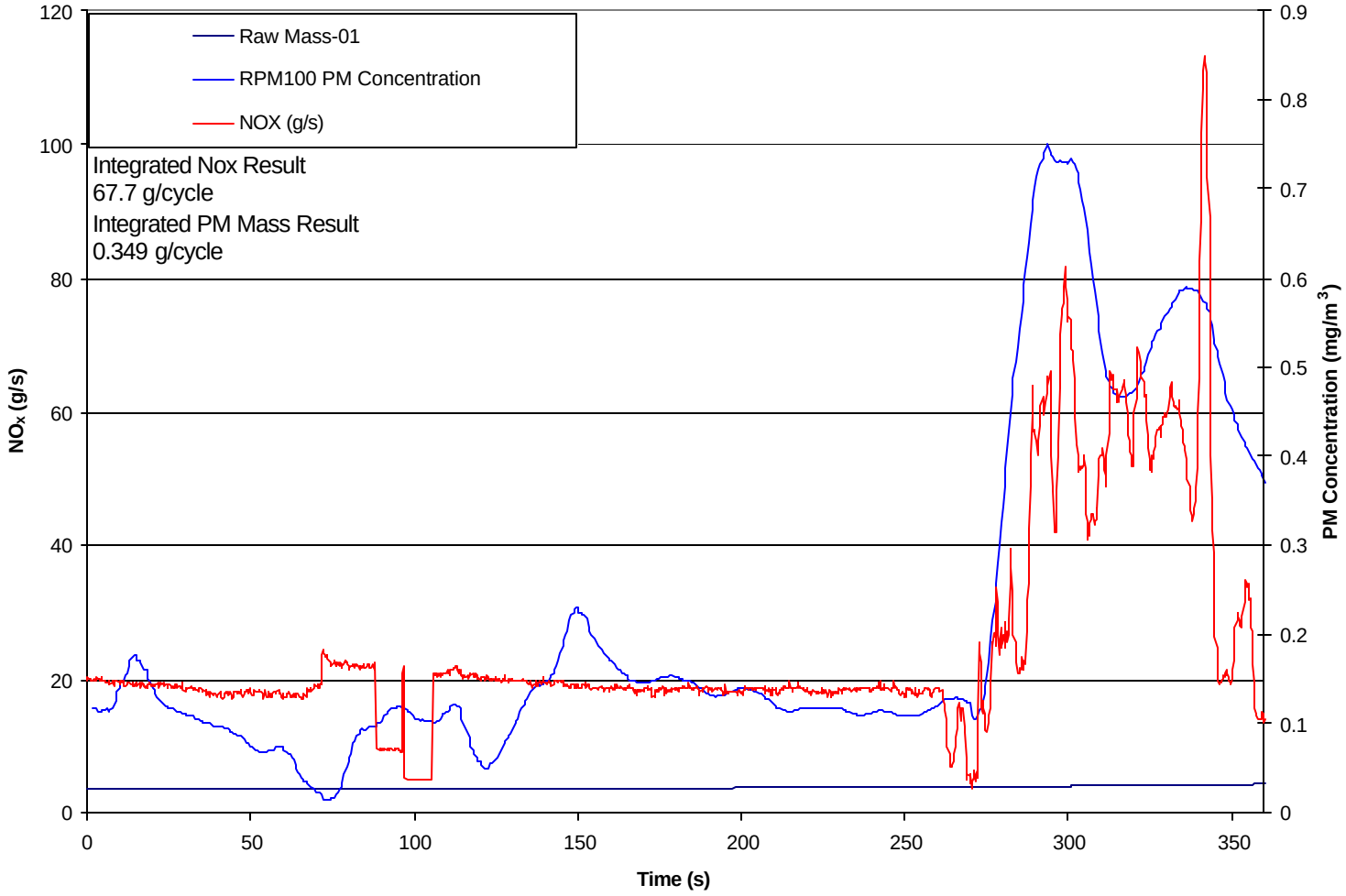
	Test 01	Test 02	Test 03
MARI RPM 100 Integrated PM Mass	0.74	1.97	1.73
Full-Flow Dilution Tunnel Gravimetric Integrated PM Mass	0.71	1.75	1.79
Percent Difference	4.2%	12.6%	-3.4%

***Note**: The RPM-100 sampled from the raw exhaust stream. The resultant error includes all sources of errors in the emissions measurement systems (exhaust flow rate; concentration; data acquisition; etc.)*

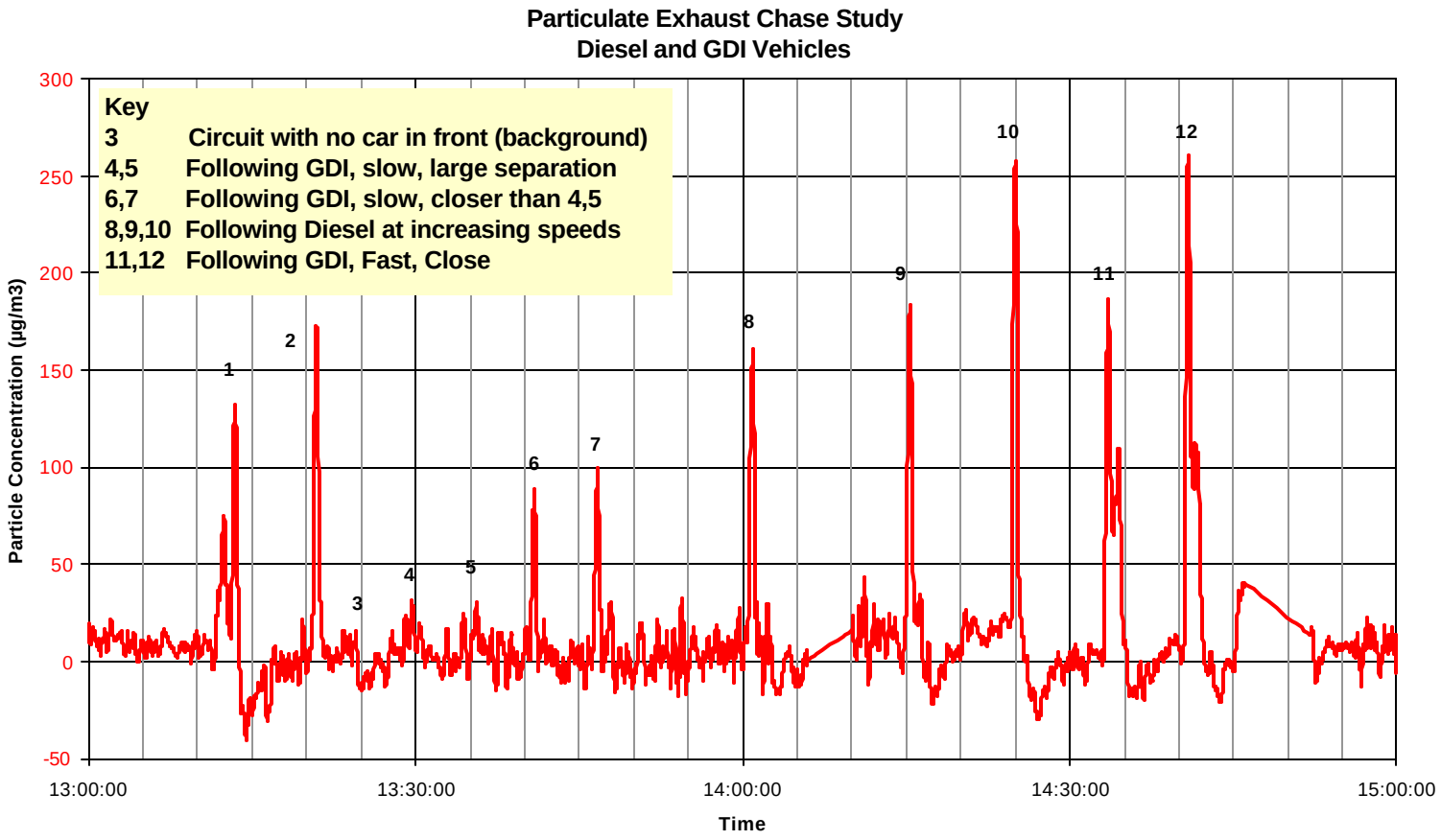
NO_x Mass vs. Time for a Track-type Tractor Test



NOx and PM Concentration Data for the First Track-type Tractor Test



Chase Studies



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