

# **EPA's 2001-Published Heavy-Duty Diesel PM Test Procedure Changes**

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# Introduction

- EPA made significant changes to 40 CFR Part 86, Subpart N as part of the 2007 Heavy-Duty Diesel Engine Regulation
- Worked closely with engine manufacturer's experts in certification test procedures
- Available at:  
<http://www.epa.gov/otaq/regs/hd2007/frm/frdslreg.pdf>

# §86.1306-07; Overview

- New test procedures may be implemented immediately
  - Certain procedures must be used with others
- Application for approval of alternate procedures is now specified, including:
  - Theoretical explanation
  - Detailed description of any hardware and software
  - Detailed description of any calibration, operation and maintenance procedures
  - Statistical comparison of experimental results

# §86.1310-07; Analytical Systems

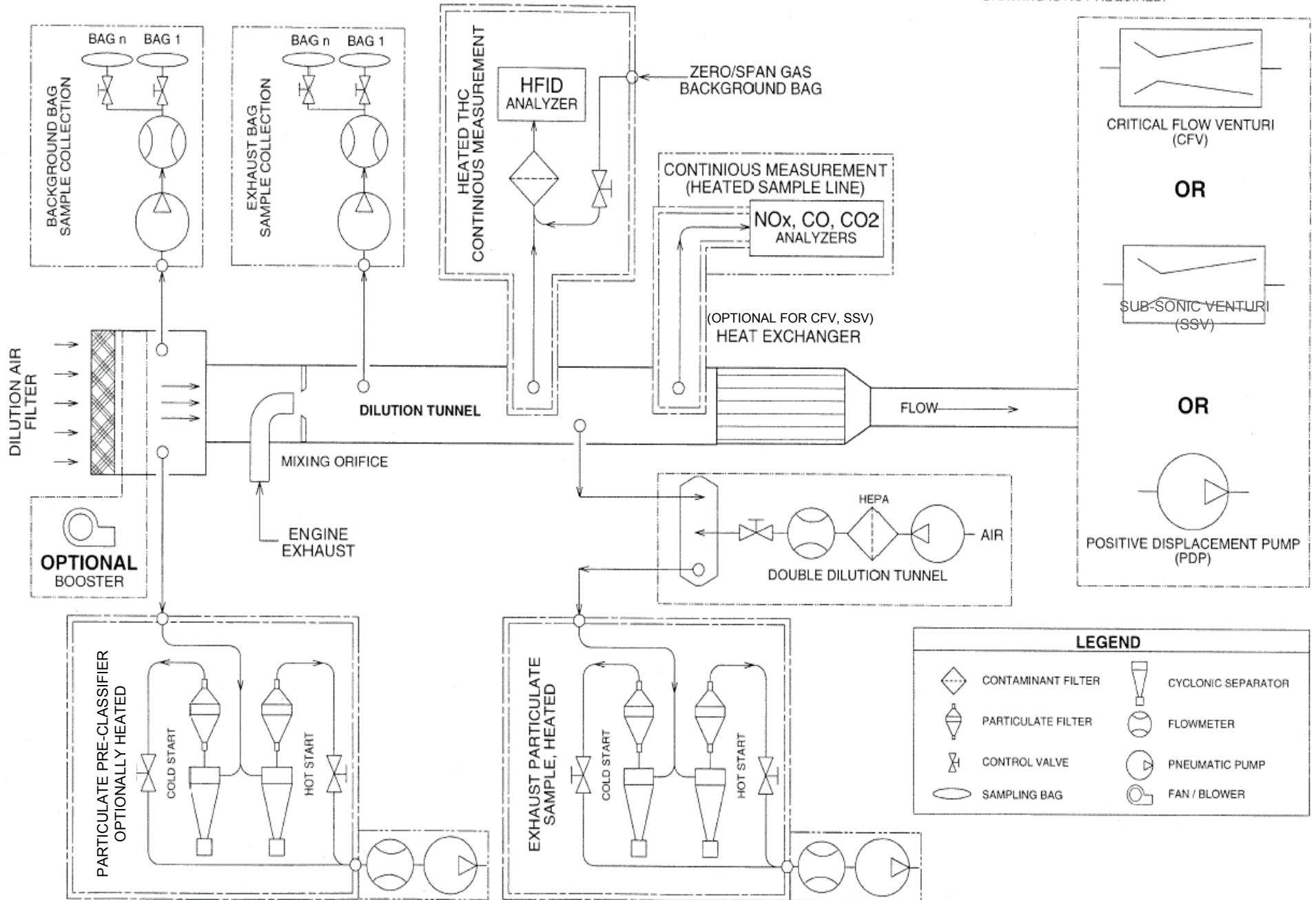
- Multiple sampling systems are allowed
- Recommended low thermal capacity dilution tunnel
- Recommended CVS mixing test
- Dilution air filtration is specified
  - 98% efficient filtration for primary, HEPA for secondary
- Dilution air minimum temperature: 15C

# §86.1310-07; Analytical Systems

- Smaller PM probe allowed
- Double dilution is required for PM sampling
- Preclassifier required after double dilution
  - 99% penetration at 1 $\mu$ m, 50% cut at 2.5-10 $\mu$ m
- ~47mm diameter filter diameter required
- High efficiency filter media required (e.g. TX-40, Teflo)
- Single filter cartridge and cartridge holder design specified
- Filter face temperature: 47  $\pm$  5 C

Figures to § 86.1310-2007

NOTE: SCHEMATIC REPRESENTATION ONLY.  
EXACT CONFORMANCE WITH THIS SCHEMATIC  
DRAWING IS NOT REQUIRED.



DILUTION AIR FILTER

OPTIONAL BOOSTER

DILUTION TUNNEL

MIXING ORIFICE

ENGINE EXHAUST

ZERO/SPAN GAS BACKGROUND BAG

CONTINUOUS MEASUREMENT (HEATED SAMPLE LINE)

(OPTIONAL FOR CFV, SSV) HEAT EXCHANGER

FLOW

DOUBLE DILUTION TUNNEL (HEPA, AIR)

PARTICULATE PRE-CLASSIFIER OPTIONALLY HEATED

EXHAUST PARTICULATE SAMPLE, HEATED

LEGEND

# §86.1312-07; Filter room

- More stringent temperature and dew point specifications
  - 22±3C (±1C at microbalance), 9.5±1C dewpoint
- More stringent reference filter weight change: 10ug
- More stringent microbalance performance specifications
- Require balance operator grounding to balance
- Specified electrostatic neutralizer performance
- Allowed repeat weighing and statistical analysis
- Required buoyancy correction
- Recommended vibration, electrostatic, and draft isolation of microbalance
- Recommended Class 1000 clean room conditions



# PM Filter Handling





# §86.1334-07; Preconditioning

- Added 20 minute steady-state high temperature preconditioning cycle

## §86.1337-07; Test Run

- No longer require engine detachment from CVS during hot soak

# Additional Guidance Given in 2002

## “Dear EMA” Letter

- Worked closely with manufacturers and met on a monthly basis to understand mfr. needs
- Clarified a sound sequence to implement PM measurement changes incrementally
- Provided an improved statistical test for equivalent methods
- Provided approvable practices on
  - PM measurement techniques
  - Forced aftertreatment cool-down
  - Subsonic Venturi calibration

# EPA's Assessment of Current Measurement Variability

- Current variability does not limit laboratories at 2007 certification levels
- EPA has demonstrated this with 2007-level data
- Not via statistical or “thought” experiments
  - Data not based on product literature on instrument performance
  - Data not based on speculations on emissions dynamic range

# NO<sub>x</sub> Measurement

- Low NO<sub>x</sub> measurements agree well between bag and continuous analyzers
- EPA believes that today's continuous measurement technique is viable for certification at 2007-levels

# Continuous versus Bag NOx Measurement Using Old Beckman 955

- Comparison made on hot start HDD FTP.
- Dual path NOx adsorber system.

Test #	HD010002	HD010003	HD010005	HD010006	HD010007	HD010010	HD010011	HD010012	HD010014	HD010015
Continuous NOx (g/hph)	0.203	0.432	0.094	1.330	0.455	0.116	0.197	0.302	0.830	0.868
Bag NOx (g/hph)	0.201	0.424	0.091	1.247	0.454	0.115	0.194	0.300	0.796	0.854
Bag NOx (ppm)	1.840	3.879	0.818	11.382	4.082	1.023	1.738	2.656	7.232	7.738
Bag (g/hph) Mass % Difference	1.38	1.70	3.22	6.70	0.23	1.07	1.43	0.63	4.28	1.67



# Continuous versus Bag Measurement Using New Horiba CLA-720MA

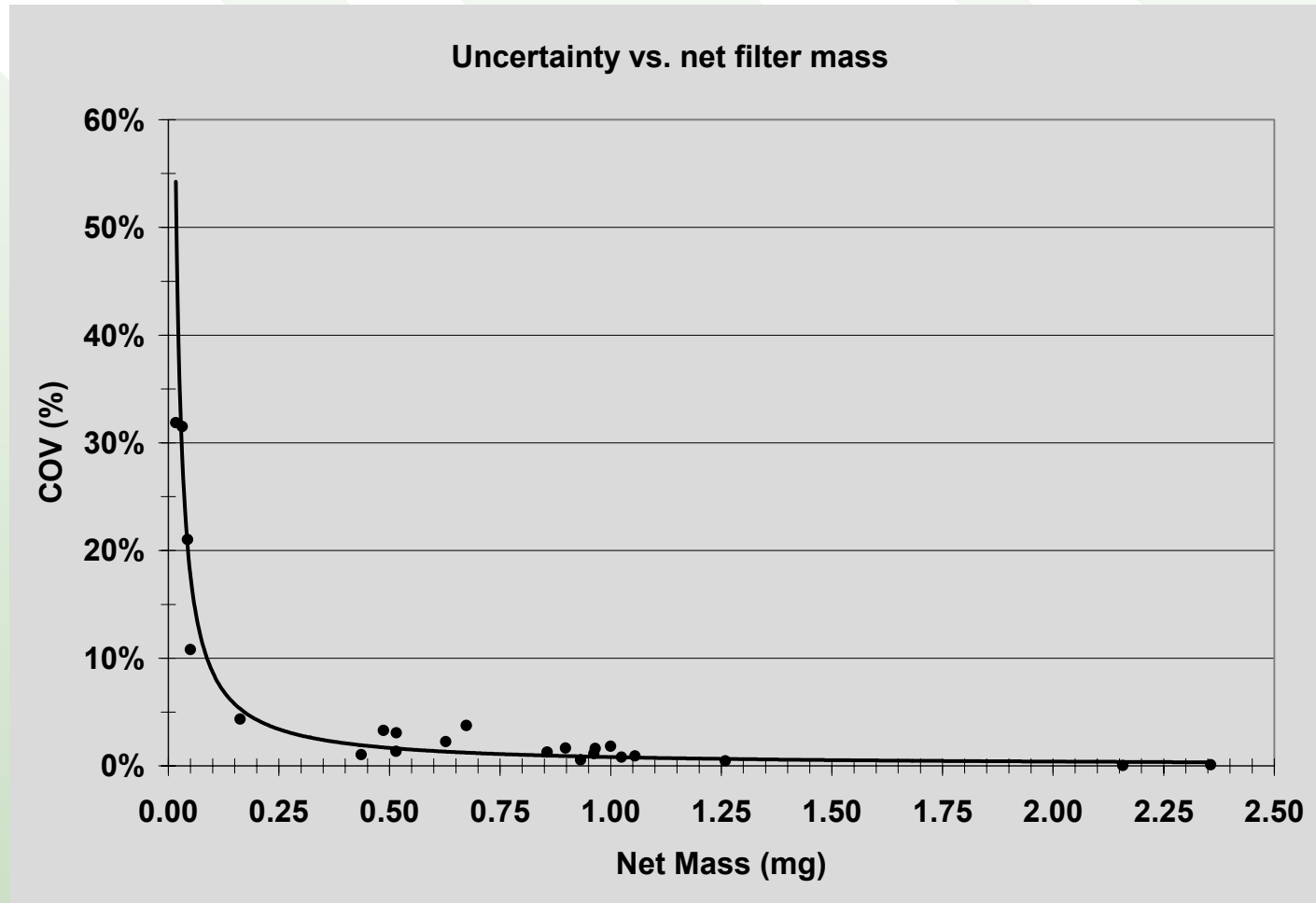
- Comparison made on hot start HDD FTP.
- Dual path NOx adsorber system.

Test #	E0120001366	E0120001367	E0120001369	E0120001370	E0120001380	E0120001381	E0120001383	E0120001391	E0120001392	E0120001395
Continuous NOx (g/hph)	0.339	0.399	0.620	0.940	4.144	3.486	3.521	1.917	0.569	0.403
Bag NOx (g/hph)	0.343	0.397	0.611	0.946	4.147	3.497	3.556	1.887	0.570	0.408
Continuous NOx (ppm)	2.211	2.612	3.954	5.949	25.220	21.630	21.74	11.62	3.620	2.744
Bag NOx (ppm)	2.190	2.586	3.908	5.878	24.843	21.332	21.42	11.45	3.583	2.725
Bag (g/hph) Mass % Difference	-1.17	0.50	1.47	-0.63	-0.07	-0.31	-0.98	1.59	-0.18	-1.23
Bag (ppm) Concentration % Difference	0.94	0.99	1.19	1.21	1.52	1.40	1.50	1.53	1.02	0.69

# PM Measurement

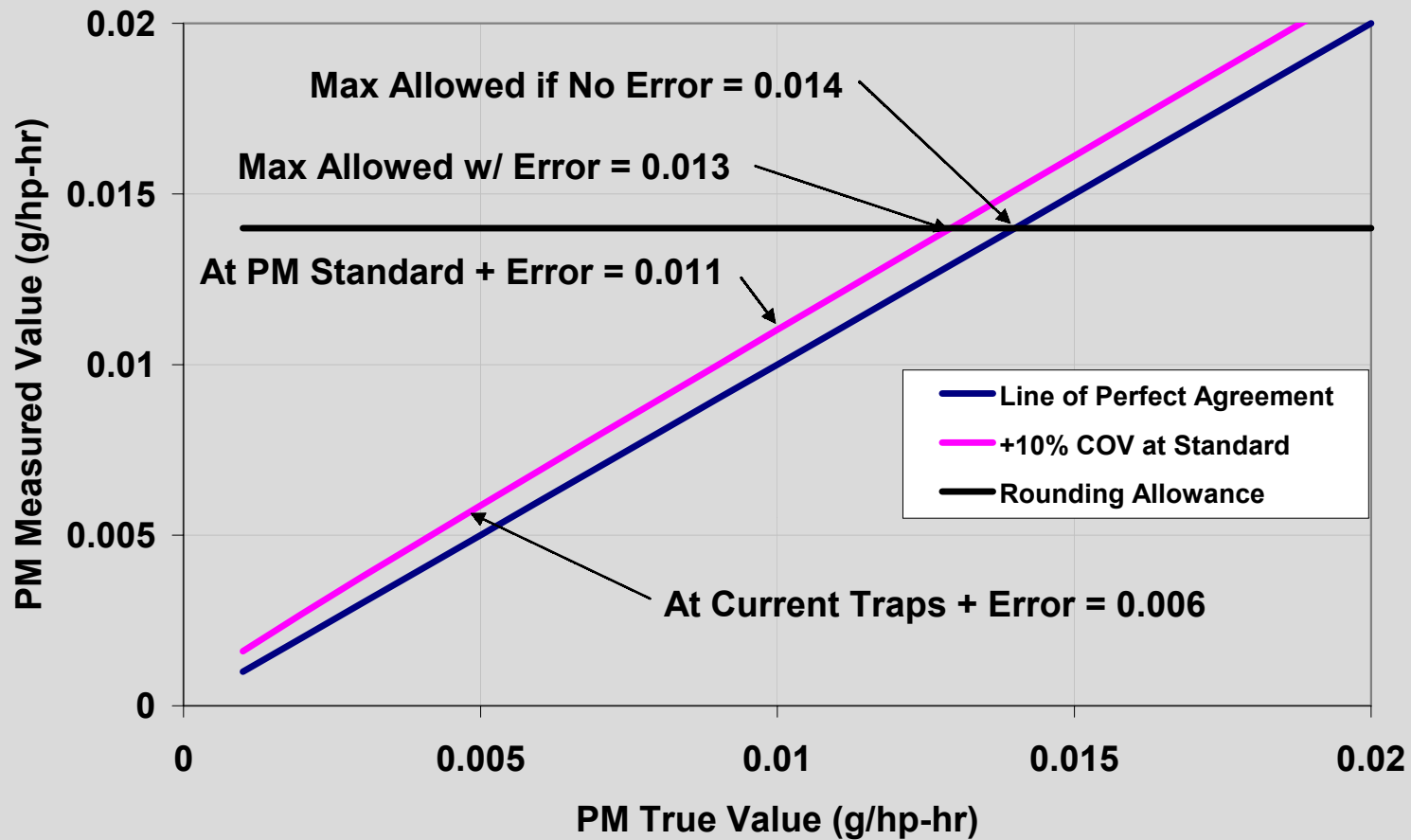
- Microbalance weighing is largest source of variability
- Current variability is only 25% of rounding allowance at the standard
- Repeat reference filter weights at  $\pm 1.5\mu\text{g}$  is achievable
  - EPA results consistent with Ford and SwRI
  - Indicates that 30-60  $\mu\text{g}$  filter loading is sufficient

# PM Measurement Concern

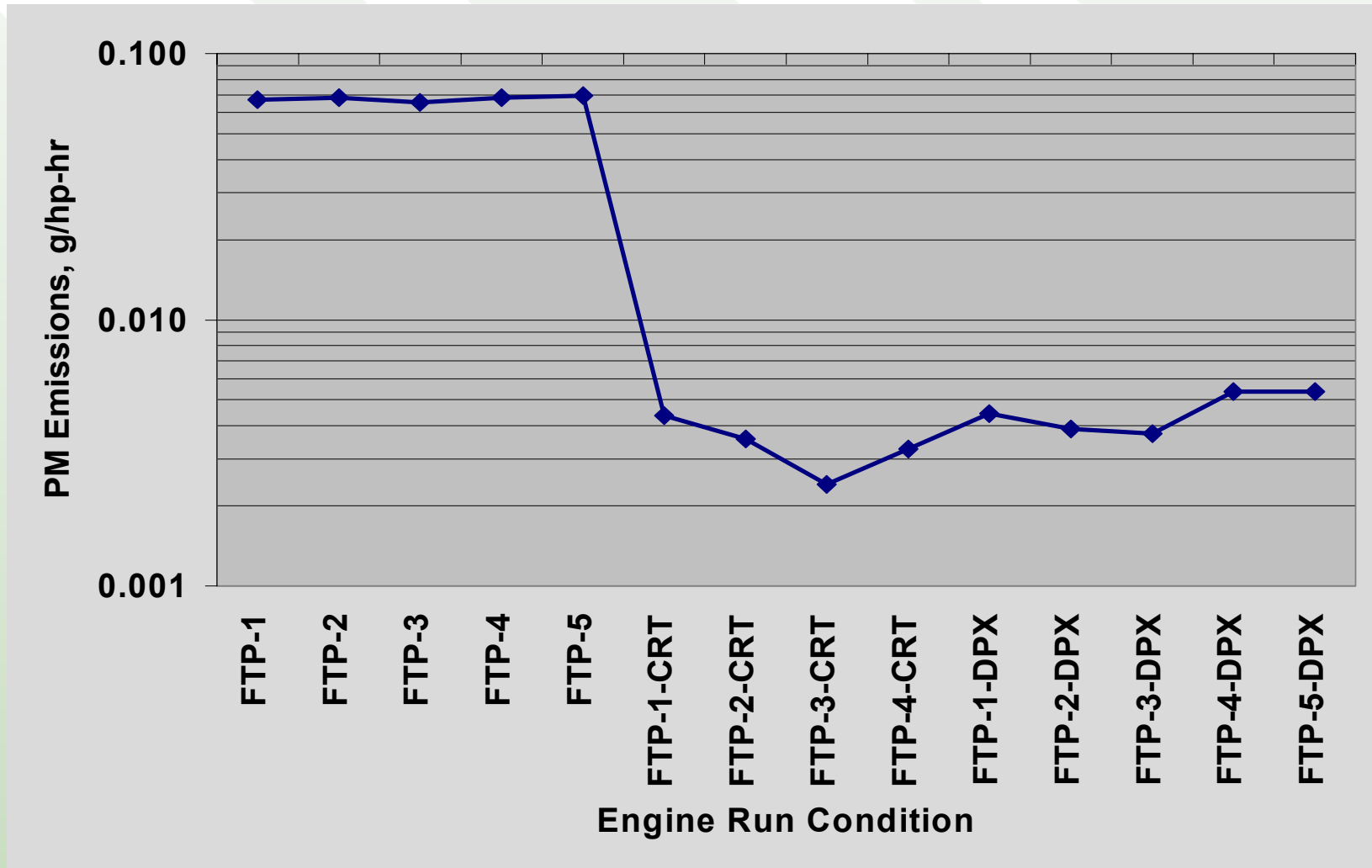


# PM Measurement

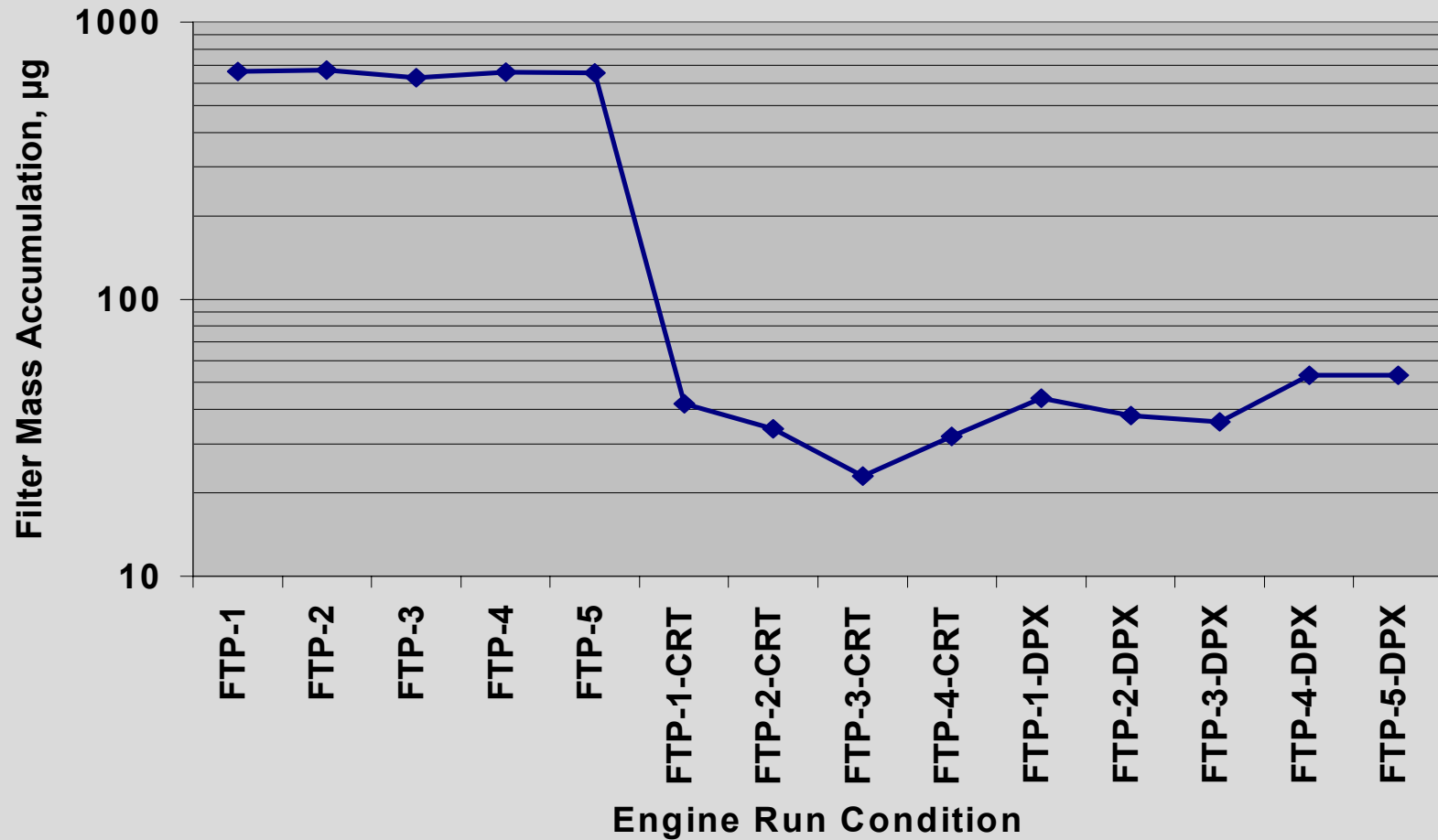
## Today's PM Measurement Accuracy and Rounding Allowance



# FTP PM Emissions For Engine Out and Post Traps



# FTP CVS Filter Weight Gain For Engine Out and Post Traps



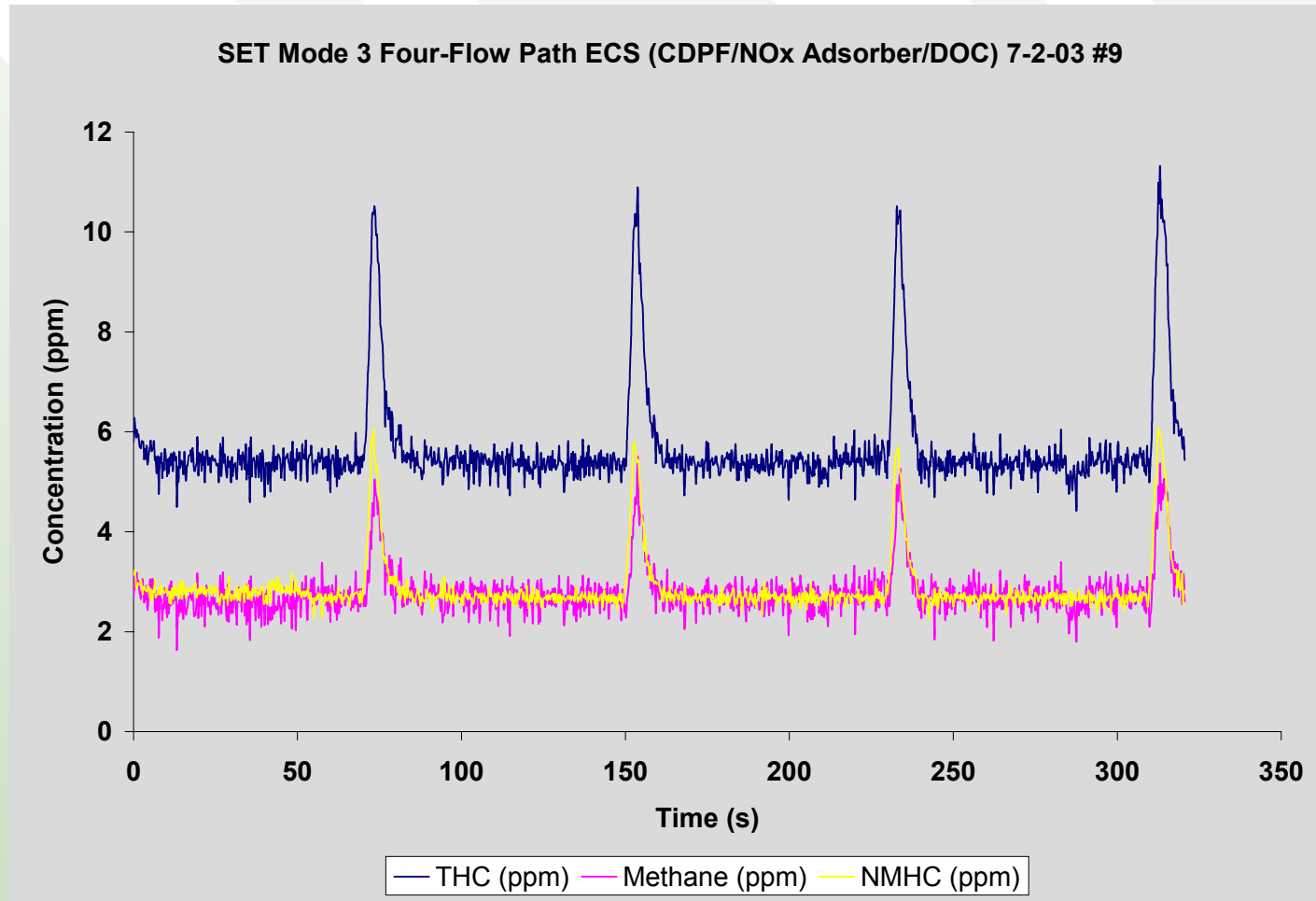


# NMHC Measurement

## ■ NMHC

- Have met standards using aftertreatment
  - » assuming  $\text{NMHC} = 0.98 * \text{THC}$
- Recent measurements indicate
  - »  $\text{NMHC} = \sim 0.5 * \text{THC}$
- Latest results are now less than  $\frac{1}{2}$  of the standard

# NMHC Measurement



# EPA's Next Steps

- Ensure lab-to-lab variability is well-controlled
  - Continue mfr. lab tours such as at EPA, SwRI, and CARB
  - Continue to meet with manufacturers to ensure correct implementation of new test procedures
- Committed to pursuing improvements
  - Implementing highly recommended a-b-a PM weighing
  - Procuring state-of-the-art systems
    - » New low NO<sub>x</sub> diesel analyzers
    - » New 2007 PM measurement system
    - » New heated bag system for HC
    - » Low-loss dilution tunnel
  - Supporting measurement research: CRC E-66
  - Preparing Part 1065 for future application for on-highway