



***HDIUT Compliance Project
“Lessons Learned”
with Combined Gaseous & PM PEMS***

**CeCERT PEMS Conference and Workshop
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Particulate Matter (PM) Measurement Allowance Program Concluded with “Game-Changing” Regulation

Amendments to In-Use Testing for Heavy-Duty Diesels, Measurement and Instrumentation, and Off-Highway Engine Regulations



Office of Transportation and Air Quality
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
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CISD-10-22 (HD)

SUBJECT: Notice of Alternate System Approval

Dear Manufacturer:



68448 Federal Register / Vol. 75, No. 215 / Monday, November 8, 2010 / Rules and Regulations

- PM measurement allowance established.....in-use PM is a “GO”
- Enforceable in-use PM delayed 2 years
- Flexibly granted for which test order to conduct Pilot PM, 2 programs / 4 years
- AVL 494 PM PEMS approved
- Clarified Not-To-Exceed (NTE) accounting during emission control system regeneration events
- Permitted Engine Control Module (ECM) fuel-based emissions mass flow calculation

Stipulations for use of AVL 494 PM PEMS



- Approved for field testing only
 - Not laboratory certification
- Real-time soot measurement complemented with gravimetric filter sampling
- PM is computed from real-time soot, filter mass, and real-time measurements:
 - Hydrocarbon (HC) concentration
 - Exhaust flow
 - Exhaust temp
- Additional reporting requirements
 - Uncorrected and Corrected PM data
 - Correction Factors from HC-to-PM logic

Volvo HDIUT Compliance Test Equipment



- Horiba OBS 2200 Gas PEMS
- AVL 494 PM PEMS
- UniCAN-2 Pro data-logger:
 - ECM, global positioning system (GPS), external sensors
- Internally-developed hardware:
 - Gassing system
 - 2 Power supply options
 - * Alternator + inverters
 - * Stand-alone generator
 - Safety systems
 - Installation, equipment security
- Internal + Horiba + AVL software tools



Horiba OBS 2200 Gas PEMS



- Used by Volvo for all Enforceable Gaseous and Pilot PM HDIUT programs
 - High Reliability
 - Sufficient Accuracy
 - Excellent data yield
- Upgrades under implementation:
 - Hourly span
 - Lower carbon monoxide (CO) range
- Improvements under development:
 - Ammonia scrubber upgrade
 - * Currently use special filters
 - CO “ringing” resolution
 - * wet sampling phenomena



Powering PEMS

- Equipment uses “laboratory” 120-VAC power supplies
- 2 on-board powering options are switchable to shore



! Safety Assurance !

- * Fusible link at battery & key subsystems
- * System “kill switch” within driver’s reach



Generator or Alternator + Inverters

Gassing System

- Air Liquide 3AL-size cylinders
- 40 CFR §1065-certified Vehicle Emission Zero (VEZ) Air, Flame Ionization Detector (FID) fuel, & Calibration Mixture
- 18+ hours continuous operation

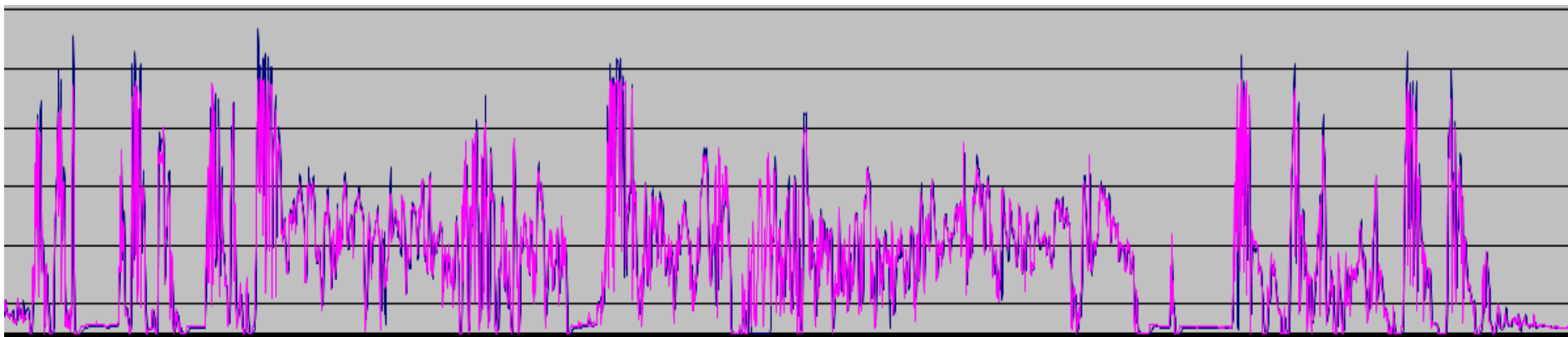
! Safety Assurance !

- * Limited gas volume
- * Secure mounting, externally vented
- * Flow limit/shutoff protection



Time Alignment

- Concentration data is inherently aligned by OBS procedure
- Exhaust flow signal is aligned to carbon dioxide (CO₂) concentration.
- ECM modeled exhaust flow is aligned to OBS measured exhaust flow
- PM PEMS data is aligned to ECM by shared trigger and constant offset
- Data integrity validated by real-time and NTE carbon balance checks



Assessment of AVL 494 PM PEMS Experience

- Unit supplied to Volvo is pre-series production hardware
 - Overall functionality and reliability are excellent
 - Minor issues related to cold start-up
 - One test had several momentary diluter “drop outs”
- As integrated into the Volvo setup, the gravimetric filter sampling system lacks signal input access to apply rigorous control logic
 - Required extra data is not continuous although filter sampling is continuous
 - * Hourly gas PEMS zero event ceases real-time data input
 - * FID must be operational and accurate
 - Signal input is also needed for control of filter loading during emission control system regeneration events
 - * Implementation would require regulatory interpretation
- Mathematical correction of soot + HC to PM does not extrapolate to properly functioning diesel particulate filter (DPF)-equipped engine
 - Low filter loading combined with dominating artifacts yield grossly exaggerated corrections, fortunately compliance has not been affected
- No schema exists to report through EPA’s central data exchange (CDX) the additional data requirements

Recommended Industry / Agency Action

- **Move forward with organization of EMA In-Use Issues Task Force**
 - Many issues lingered after close of measurement allowance program
 - Regulatory ambiguity is to the detriment of the regulated party
 - Knowledge base is fading, our successors will not have the background experience
 - PEMS usage for regulatory requirements appears to be on the rise
- **Bring closure to open regulatory dialogue**
 - 40 CFR §86 1370-2007(g), 250 °C Exhaust Temp w/ after-treatment NTE handling
 - PEMS reliability / data requirements, definition of a valid test
- **Refine the specifications for PM PEMS**
 - In particular, for the AVL 494 ...
 - * Support implementation of “Improved Science” for PM correction calculations
 - * Establish required calibrations and system checks
 - * Assure that reporting requirements are synchronized with CDX schema structure

Open Discussion



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