

EPA Clean Diesel Engine Implementation Workshop

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Heavy Duty On-Highway Diesel Engine Certification Test Procedure Issues at the 2007- 2010 Emissions Levels

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EPA Heavy Duty On-Highway Engine Emissions Standards

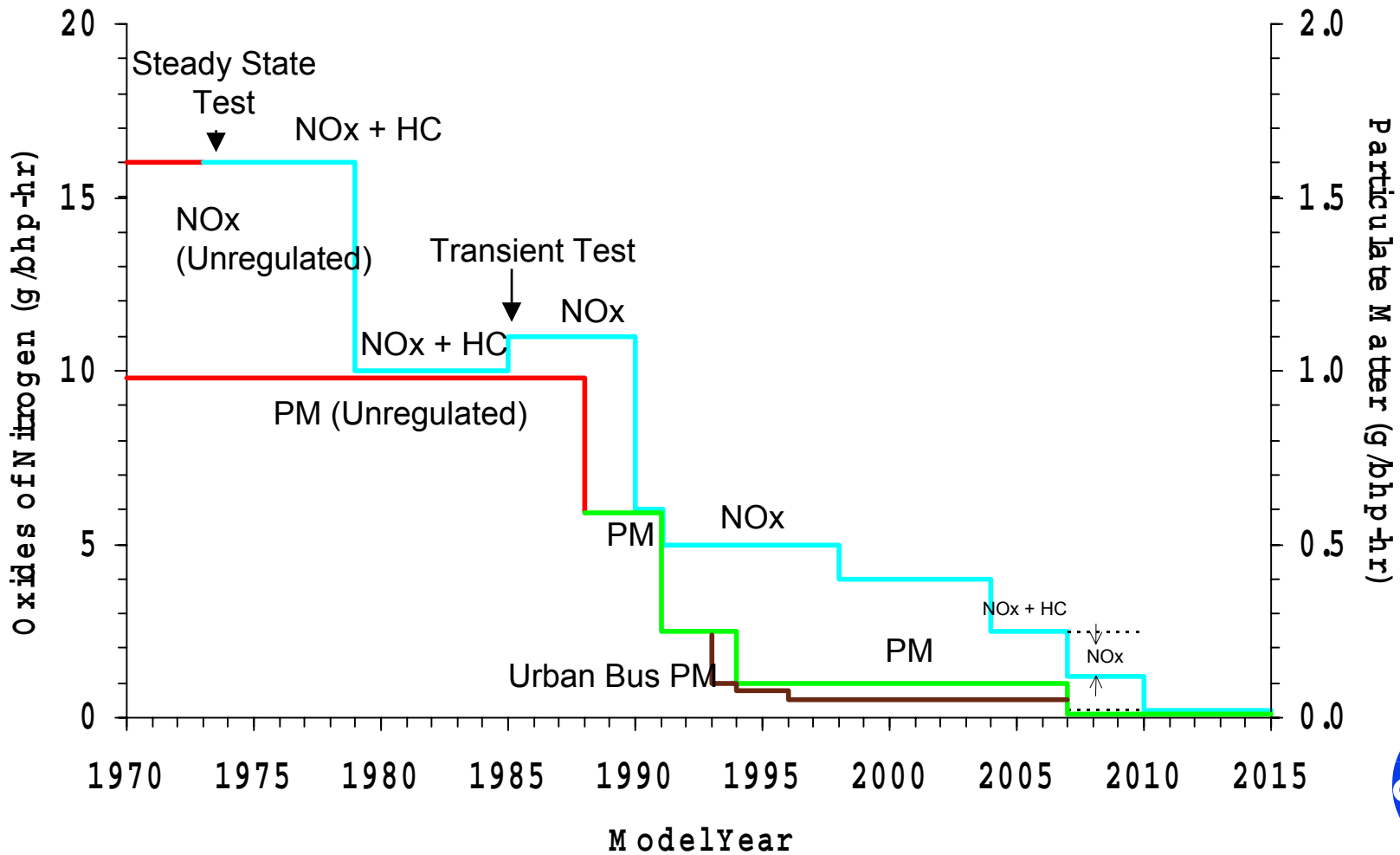
	NOx g/bhp-hr	PM g/bhp-hr	NMHC g/bhp-hr
(Phase-in)			
2007-2009	~1.2	0.01	~ 0.10
(Final)			
2010-2012	0.2	0.01	0.14

Includes blow-by emissions

SAS 8-6-2003



EPA Heavy-Duty Engine Emission Standards



Engine Certification Test Requirements

- Prior to the Consent Decree only the Transient cycle sequence was required for emissions certification
 - Only one emissions certification hurdle
- More complex requirements now and in the future
 - Transient cycle sequence
 - 13 mode steady-state Supplemental Emissions Tests (SET) with mystery points
 - Not To Exceed (NTE) zone
 - Multiple emissions certification hurdles
 - A challenge even at today's levels, more challenging in the future



Emissions Certification Procedures

- Major measurement techniques have remained the same in spite of the significant reduction in emissions standards.
- Fundamentally they are very similar to the techniques developed when transient emissions regulations were introduced in the 1980's
 - All the engine exhaust is diluted using a Constant Volume Sampling (CVS) system
 - Gaseous emissions are sampled from the dilution tunnel and the concentrations are measured by continuous gaseous analyzers
 - Particulate emissions are sampled from the dilution tunnel and are diluted once again before being collected on a particulate filter. The weight difference of this filter before and after the particulate collection is used in determining particulate emissions



EPA/EMA Collaborative Effort

- Much effort has been taken to introduce improvements to these techniques to enable emissions determination at the future emissions levels
- EPA and EMA have jointly worked to improve these techniques but much work still needs to be done
- No major breakthroughs have surfaced - incremental improvements have been achieved
- Largest gains have come from specifying tighter controls in the measurement procedure and in using more capable instruments
- Research activity on improving emissions measurement is continuing

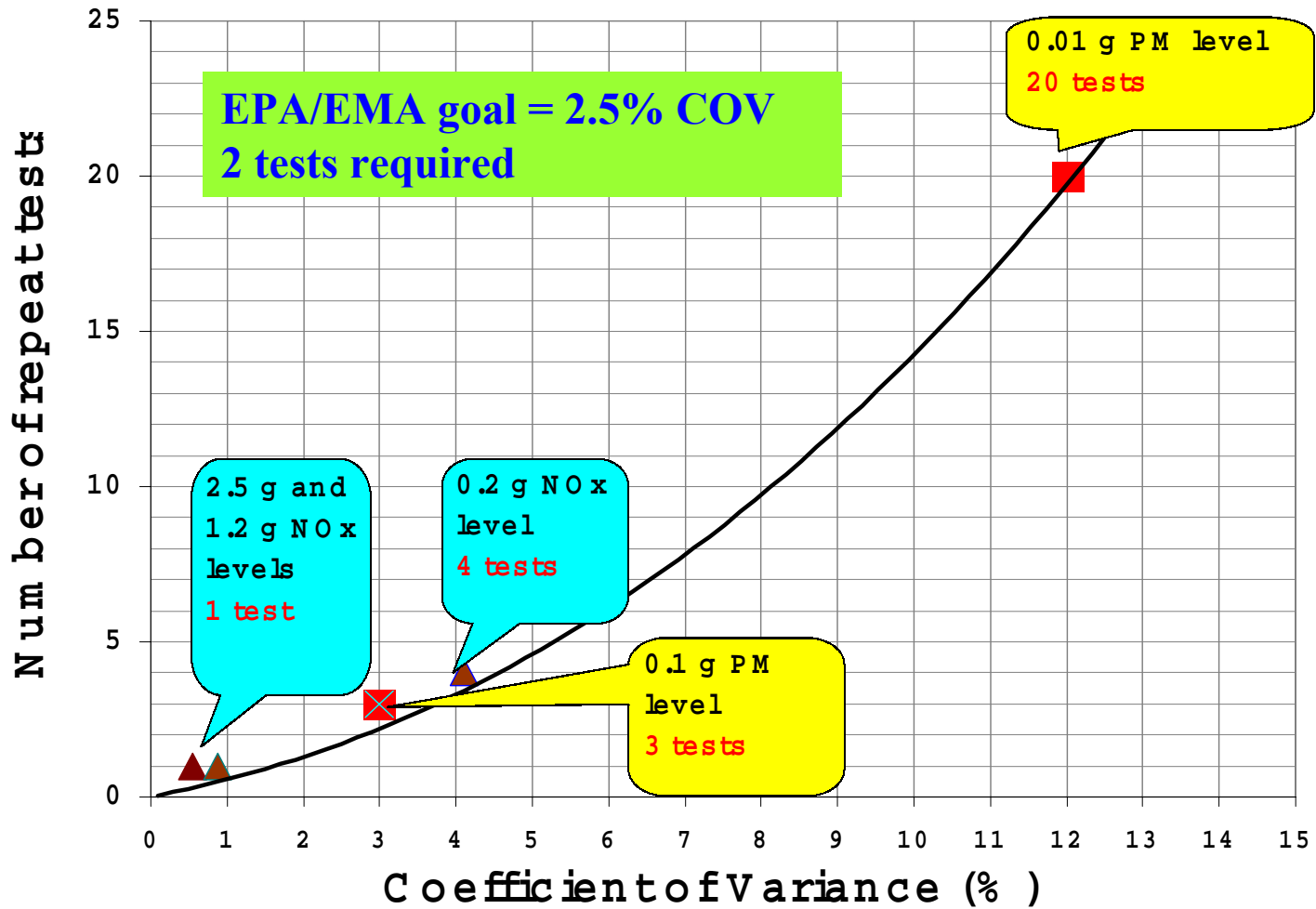


Emissions Variability is a Key Issue

- It is not enough to reduce emissions levels from the engine and aftertreatment device.
- As emissions levels are reduced there is increased emissions measurement variability.
- Variability in the measurement of emissions components based upon the prescribed procedure has to be low.
- Increased measurement variability adds cost and time to all aspects of engine design and testing.



Number of Tests Required to Discern a 5% Difference in Two Means



PM - New Challenges

- At 2007 levels, PM will be nearly all semi-volatile aerosols with very little carbon.
- We now know that the formation of these aerosols is highly path dependent - i.e. how exhaust is cooled and diluted.
- This is expected to cause high variability, especially between different test sites.
- EPA's research efforts at SwRI and the new CRC E-66 project on 2007 PM measurement research will help improve measurement issues and reduce variability.



NOx and HC - New Challenges

- Current technology NOx and HC analyzers cannot meet the new accuracy specification and the wide dynamic concentration range expected in the future.
- This will drive us to the “**Heated Bag**” option to average the sample concentration and use low range analyzers to read the bags.
- However, there are no suppliers of heated bag sampling systems. These systems must be developed.



Summary

- The 2007-10 emissions standards represent a significant technological challenge:
 - **a ten fold reduction in NOx and PM.**
- EMA and EPA have been working cooperatively in making a similar effort in reducing variability.
- Although improvements have been made, variability has not been reduced as much as it is needed.
- It does not look like we are close yet.
- The increased time for engine development is going to compound the difficulty in meeting the standards.



Background Information
on Changes in the 2007
Procedures



General Changes

- Added a 3rd CVS type based on a subsonic venturi (SSV) for more flexibility in setting CVS flow
- Added allowance for averaging samples from multiple instruments - lowers the instrument component of total variability by $1/\sqrt{n}$ at the cost of duplicating instruments. Does not help variability due to other factors
- Added rules for considering alternate measurement techniques.



PM Related Changes

- Lowered balance precision - from 20 to 2.5 μg
- Added a preclassifier to reject large particles that are not part of engine exhaust
- Added lower limit on PM sample temperature - from 125 °F (51.7 °C) max to 47 \pm 5 °C (107.6 to 125.6 °F)
- Added specifications for primary and dilution air filtering
- Reduced size, number and specifications for filter media - from 70 mm, double, fluorocarbon-coated glass fiber or membrane filters to 47 mm single, Teflon coated borosilicate glass fiber high efficiency filter (TX40) or Teflon membrane filter (Teflo)
- Standardized filter holder (based on ambient PM samplers)



PM Related Changes

- Tighter tolerances on weigh room T & H - from 22 ± 3 °C & 9.4 ± 3 °C dew point & 45 ± 8 % RH to 22 ± 1 °C & 9.5 ± 1 °C dew point
- Recommended Class 1000 clean room specifications
- Added buoyancy correction
- Reduced reference filter drift limit from ± 40 to ± 10 μg
- Added requirement for static neutralizers and grounded tweezers
- Added allowance to take multiple weights and use mean
- Lowered lower limit on primary and secondary dilution air temp from 20 °C (30 °C max) to 15 °C min (no upper limit)
- Lowered minimum conditioning time from 60 to 30 min
- Preconditioning of the entire sampling system



NOx Related Changes

- Tighter specification for continuous analyzers - from $\pm 2\%$ of point down to approximately 4% of Full Scale (FS) (or $\pm 0.08\%$ of FS) to 2% of point down to 1/2 of the average concentration that would yield a BS emissions value equal to the standard. On a ppm basis this is equivalent to going from a current specification of ± 0.28 ppm (based on a 350 ppm FS) to ± 0.015 ppm needed at the 2007 levels. That's 19 times more accurate!
- Added specifications and check for NOx analyzer interference from CO2 and H2O.
- Added allowance for bag sampling (must be heated to prevent condensation)

