



Light-Duty Tier III PM Test Procedure Changes and Future PM Measurement Challenges

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EPA Tier 3 PM Standards

- Yesterday EPA promulgated new Tier 3 standards for light-duty vehicles
 - FTP
 - 3 mg/mi PM phase in starting MY 2017, completed by MY 2021
 - US06
 - 10 mg/mi PM MY 2017 – 2018
 - 6 mg/mi PM phase in starting MY 2019, completed by MY 2021
- Rulemaking required EPA to update and refine vehicle PM test procedures to minimize intra- and inter-lab variability
- EPA has been working with vehicle manufacturers for three years to arrive at agreed upon test procedures
- On horizon is ARB's LEV III MY 2025 standard of 1 mg/mi (possible pull ahead?)



Tier 3 PM Test Procedure

- Tier 3 PM chassis test procedures (40 CFR part 1066) were based on 40 CFR part 1065 engine test procedures
 - 1065 sampling system hardware and media; 1065.140, 145, and 170.
 - 1065 places limits on factors that control PM formation
 - Intent was to limit intra- and inter-lab variability and minimize differences between full flow and partial flow dilution sampling systems
 - CRC E-66 was used for guidance on what parameters to control
 - 1066 controls the same factors
 - There are some limit differences when compared to 1065
 - 1066 has provisions to increase filter loading
 - 1066 changed how background correction is performed



Tier 3 PM Test Procedure Changes

- The LD Tier 3 PM test procedures include the following requirements:
 - Dilution air temperature control, 15 to 52 ° C - 1066.110(b)(2)(iii)(A)
 - Filter face temperature, 47 ±5 ° C - 1066.110(b)(2)(iii)(A)
 - Dilution factor control, 7:1 to 20:1 - 1066.110(b)(2)(iii)(B)
 - Per phase (20:1 limit); or
 - Time weighted over duty cycle (could allow up to 25:1 over phase 2 of FTP, but time weighted cycle must still meet 20:1)
 - Residence time limit, 1 to 5 s (0.5 s from point of final dilution to filter if using 2° dilution air) - 1066.110(b)(2) (via reference to 1065.140(e)(3))
 - Filter face velocity (FFV) requirement, target 100 cm/s - 1066.110(b)(2) (via reference to 1065.170(c)(1)(vi))



Tier 3 PM Test Procedure Changes - Background

- Test article variability aside, we see background variability and low filter loading as two major challenges to address overall sample variability, especially as standards approach 1 mg/mi.
- EPA internal test program
 - Collected simultaneous background samples from three locations in 1066 compliant PM sampling system
 - Dilution air (HEPA filtered and sampled during emission test)
 - Tunnel blank (sample from dilution tunnel post emission test)
 - Travel blank (travelled from weigh room to test cell and back, not exposed to test cell environment).
 - Results from study did not show a statistically significant difference between the 3 types of blanks – average 4.6 μg
 - Indicates that mass gain is due to environmental exposure or handling – direct effect on filter
 - Suggests that background correction should be applied without dilution factor



Tier 3 PM Test Procedure Changes – Background – cont.

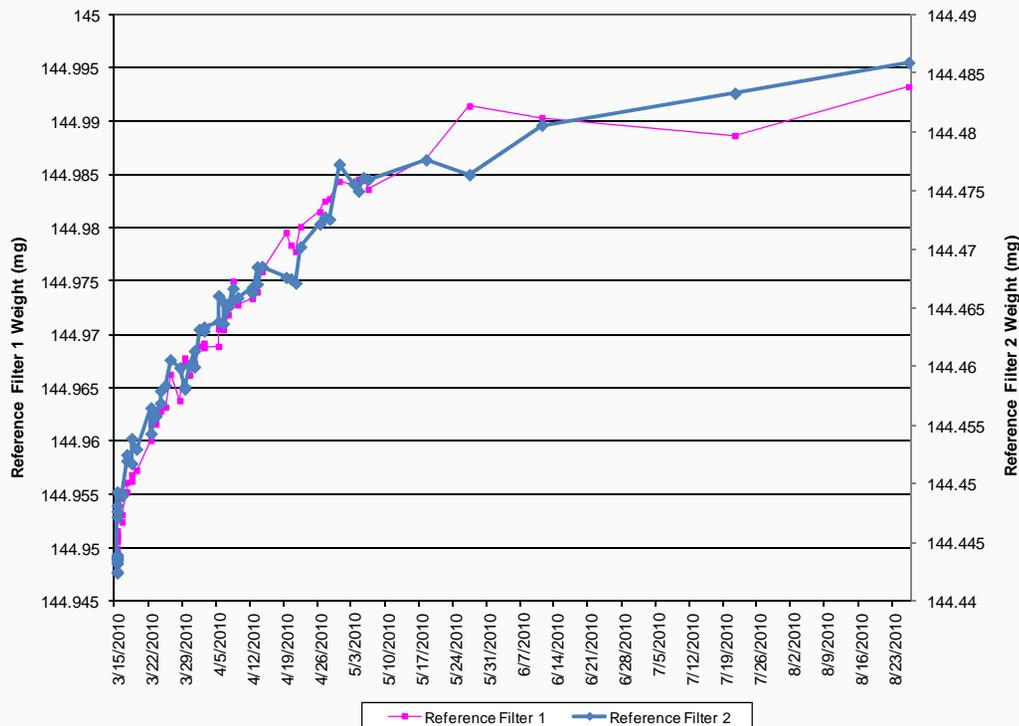
- Background correction limited to maximum of 5 μg or 5 % of the net PM mass expected at the standard, whichever is greater - 1066.110(b)(2)(i)
 - Using good engineering judgment, you do not have to collect a background sample for each test
 - Using moving average, background can be used across test sites
 - Filter manufacturer/material must be the same
- EPA removed dilution factor from the “mass of PM over the test interval” calculation (Eq. 1066.602-2)

$$m_{\text{PM}} = \left(\frac{V_{\text{mix}}}{V_{\text{PMstd}} - V_{\text{sdastd}}} \right) \cdot (m_{\text{PMfil}} - m_{\text{PMbknd}})$$



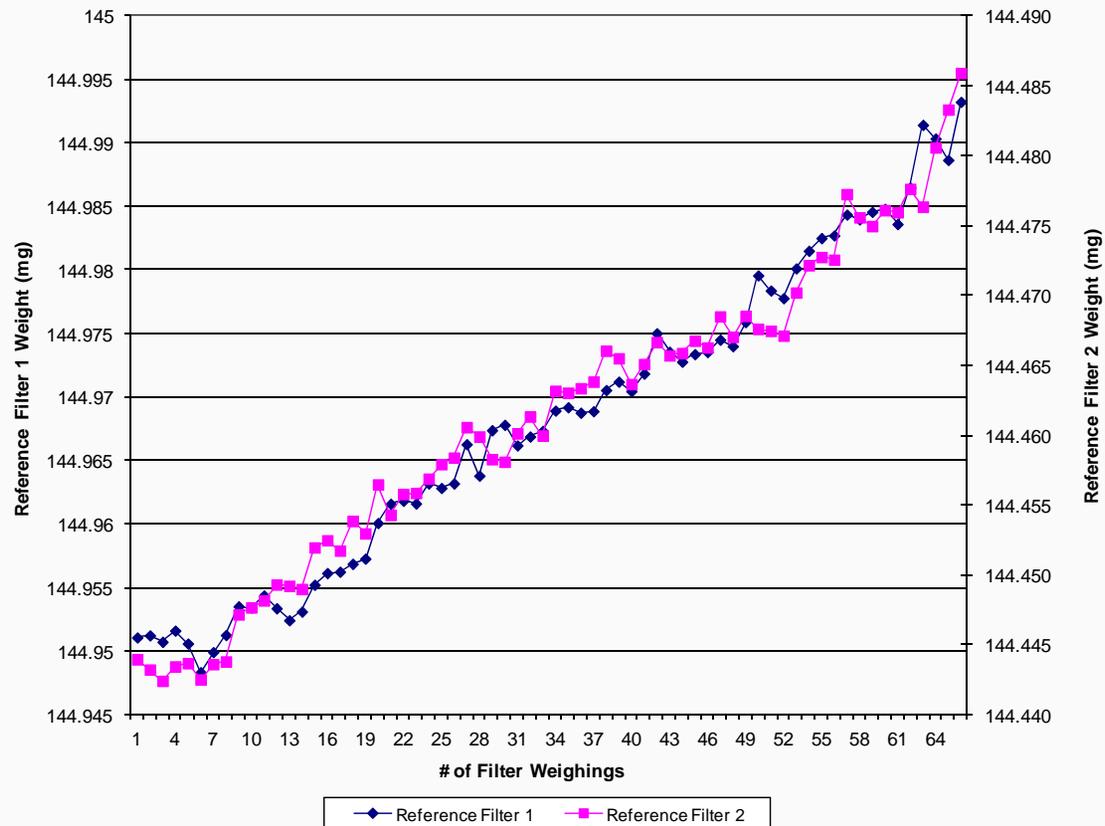
Tier 3 PM Test Procedure Changes – Reference Filter Study

- Study of 2 reference filters that did not leave weigh room.
- 40 to 45 ug mass gain on average over 5 months.
- Mass increase appears to correspond with filter handling event.





Tier 3 PM Test Procedure Changes – Reference Filter Study



U.S. Environmental Protection Agency



Tier 3 PM Test Procedure Changes – Filter Loading

- 40 CFR part 1066 also provides methods to increase filter loading – 1066.820(c)
 - Reduce the number of filters over FTP while maintaining composite phase weighting
 - Single filter method
 - Flow weight sample over 3 phase FTP
 - Sample over 2 UDDSs
 - Two filter method
 - Sample over 2 UDDSs or simultaneous sample during phase 2 of a 3 phase FTP



Tier 3 PM Test Procedure Changes – Filter Loading – cont.

- Use of a single filter sampling reduces test burden.
- The downside is that the flow weighting lowers the FFV during phase 1 and 3 to 43 and 57 cm/s respectively
 - Lower FFV during highest emitting phases
- Testing-to-date indicates a reduction in variability at emission levels greater than 3 mg/mi



Conclusion

- LD PM test procedures have been updated in support of the Tier 3 rulemaking.
 - Procedures target reducing variability and test burden.
- Further improvements are needed to reduce variability at the 1 mg/mi level
 - Increase filter loading
 - Resolve filter mass gain due to exposure to environment/handling.