**Current Tailpipe PM Issues: A California Update**

**Outline:**

Immensely progress has been made in reducing combustion generated nano-particle emissions from vehicle exhaust. The interaction of clean policy direction and technology deployment have dramatically changed the nature of the Internal Combustion Engine (ICE) fleet in California. Both light duty and heavy duty PM emissions standards have dropped of magnitudes.

The Air Resources Board is pursuing programs to understand the In-Use and Off-Cycle implications of the relatively new technologies used to accomplish these reductions. This presentation provides some example vignettes of the many ongoing ARB projects to quantify and evaluate the effectiveness of these PM control programs.

**Comprehensive Evaluation of PM filters In-Use in California**

**Basic questions:**

- Do PM filters increase the risk of truck fires?
- Do PM filters effectively reduce diesel PM by 90% or more?
- Do PM filters perform reliably in on-road applications?

**Methodology:**

ARB has a longstanding commitment to researching potential secondary effects arising from emissions control technologies. In particular, PM aftertreatment systems are increasingly moving to calibrations that minimize the need for user interventions as part of the PM filter regeneration process. However, some duty-cycles can produce exhaust conditions unfavorable to proper PM filter regeneration and require the user intervention to initiate an active regeneration while the vehicle is parked or stationary.

The concentration and composition of PM immediately downwind during a parked regeneration is of interest for assessing possible impacts on vehicle drivers and other nearby personnel.

ARB has constructed a small scale wind tunnel to examine the plume evolution from PM filter-equipped vehicles undergoing parked regeneration. Initial proof of concept testing has been performed. Studies are underway to examine the observed PM0 parameters dependence on environmental factors and vehicles’ PM filter history.

**Examining Light Duty Vehicle PM by Various Metrics**

**Effective particle density measurement setup**

- Effective particle density track found to be generally increase at small particle diameters but also decreased on larger diameters. Most vehicle technologies examined displayed behavior. In some cases, the Effective Particle Density function with duty cycle. The exception was the turbocharged direct injection diesel (TDI) with PM filter technologies which displayed a much more uniform effective particle density independent of duty cycle for further investigation.

- Application of Effective Particle Density to PM mass determination.

**Examining Heavy Duty Vehicle PM by Various Metrics**

- In addition to IPSD mass, other particle parameters measured for a variety of on-road applications and evaluated for demonstration in an on-road testing campaign.

**Conclusions:**

- PM filters do not increase the likelihood of truck fires and are manufactured in accordance with federal and state safety requirements.
- PM filters are effective in removing more than 98% of toxic diesel PM emissions.
- PM filters are operating properly, and most trucking fleets are not having problems with their engines or PM filters.
- Some fleets are experiencing problems with their PM filters, but engine durability and adequate maintenance practices are the primary reasons for these problems.

**Recommendations:**

   - Staff and testing resources are being dedicated to new in-use emission monitoring programs which will ultimately lead to improved engine certification standards.
   - Additionally, staff is considering amendments to ARB’s Emissions Warranty Information Reporting regulations to hold manufacturers accountable for high warranty claims that result in excess emissions.

2. Educate Truck and Bus Owners and Operators.
   - Staff is working with industry to identify best possible maintenance practices to maintain proper functioning, and to disseminate information to fleet managers on best practices and how to implement enhancements to ARB’s outreach and education activities, and through modeling and other industry organizations.

3. Enhance Certification Programs.
   - Staff is developing improvements to ARB’s certification program requirements that will provide better data on proper maintenance, greater warranty protection, and better assurance of engine component durability over a vehicle’s life.

   - Staff is advocating for increased heavy duty truck OBD requirements to help ensure these vehicles and their emission control systems are properly maintained and achieving to the desired emissions and localized risk reduction.

5. Continue to Provide Assistance to Fleets Operating Retrofits On-Road and Off-Road Applications.
   - Staff will continue to investigate fleet concerns with retrofit performance issues and road performance and provide assistance to help improve proper retrofit operation.

Full Report available for download:


**Summary**

Internal Combustion engines will remain important during the e-Mobility demonstration and evolve in parallel to indeed continuing in road applications for a significant time horizon. Robust technologies exist for meeting stringent PM standards in both light and heavy duty sectors. Well controlled gravimetric measurements appear to give similar levels of PM emissions reduction in near field conditions to more sophisticated off-line instrumental methods. The high resolution mass analysis of the in-use PM emissions inventory under actual driving conditions is important for understanding engine and emissions control system durability to prevent a derogation-based return to less controlled emissions rates. Actual use performance is most important in evaluating the expected emissions gains promised by the stringent PM standards.

ARB has identified In-use emissions performance improvement resources as potentially higher yield than further lowering of On-Road PM standards.

Future Work to Promote Heavy Duty Use in California:

- Continue full implementation of Heavy Duty On-board Diagnostics (OBD) for proper identification and efficacious repairs.
- Conduct validation studies to ensure that the required OBD functions are met.
- Conduct independent laboratory simulations of co-implimented OBD algorithms.
- Develop an Inspection and Maintenance (I&M) program for the Heavy Duty sector.
- Seek expanded regulatory authority to initiate recall based on high reported emissions warranty claims.
- Expand heavy duty emissions warranty period to correspond more closely to typical vehicle useful life.