Engine Manufacturers Association®
Two North LaSalle Street, Suite 1700, Chicago, IL 60602
Tel: (312) 827-8700 | Fax: (312) 827-8737 | www.enginemanufacturers.org

California Office of Environmental Health Hazard Assessment
Biomonitoring Program
Scientific Guidance Panel Meeting
March 2-3, 2009

Comments of the Engine Manufacturers Association of the Feasibility of Diesel Exhaust Biomonitoring

The Engine Manufacturers Association (EMA) is the trade association representing all major manufacturers of internal combustion engines including diesel engines used in applications including on-highway trucks and buses, nonroad construction and farm equipment, marine vessels, locomotives, and stationary applications. EMA represents diesel engine manufacturers on engine emissions and regulatory issues, and is the primary voice of the industry with the US Environmental Protection Agency (EPA) and CA Air Resources Board (CARB).

OEHHA has recently proposed to list diesel exhaust as a designated chemical to monitor under California's Contaminant Biomonitoring Program. The proposed listing was discussed at the December meeting of the program's Scientific Guidance Panel, and OEHHA has added diesel exhaust to the list of designated chemicals. EMA has the following comments on several key issues surrounding the listing as well as whether Panel and OEHHA should consider diesel exhaust a priority chemical for monitoring.

1. **EMA does not believe that diesel exhaust should be listed as a designated or priority chemical in the biomonitoring program.**

First, diesel exhaust does not meet at least three of the criteria for listing under the Biomonitoring Program:

- There is no biomonitoring analytical method with adequate accuracy, precision, sensitivity, specificity and speed through which human exposure to diesel exhaust can be assessed
- There is questionable value using a biomonitoring program to assess the efficacy of actions to reduce diesel exhaust
- The incremental cost to perform the biomonitoring analysis is not reasonable.

Second, both CARB and EPA have established regulations and emissions standards for new diesel engines that reduce emissions of concern to near zero levels. CARB also has implemented regulations to apply the same stringent controls to existing sources of diesel emissions in the

State. Consequently, biomonitoring will not inform regulatory decisions nor provide useful information that will improve the health of populations in California.

Third, diesel exhaust in not an appropriate substance to include in the biomonitoring program since it is an emissions source and not a specific chemical. Diesel exhaust from today's highly regulated engines is virtually free of components present in previous diesel engines that have been linked to health issues. Rather than include a generic emissions source such as diesel exhaust which may no longer contain harmful constituents, OEHHA should designate specific chemicals within diesel exhaust that are of concern for consideration in the biomonitoring program.

2. **There is no biomarker for diesel exhaust, and none of the methods proposed by OEHHA have been validated or are likely to provide specific information regarding diesel exhaust exposure.**

Diesel engines are a widespread and ubiquitous source of combustion emissions throughout California but possess no unique combustion products. Finding a biomarker for diesel emissions or an emissions signature has long been a goal of researchers, regulatory agencies, and the motor vehicle industry. Despite numerous attempts by a variety of institutions, no unique atmospheric or human biomarkers have been identified. In atmospheric and ambient exposure studies, contributions of diesel emissions to ambient air pollution are estimated through source apportionment techniques, and those estimates vary considerably depending on the technique employed. The Health Effects Institute (HEI) completed a scientific review of this topic and concluded that there was no appropriate signature for diesel exhaust[1] as did a workshop convened by Health Canada.[2]

Specifically, with regard to the proposed biomarkers for diesel exhaust presented by OEHHA staff at the December 2008, Scientific Guidance Panel meeting, the following comments are submitted:

Urinary 1-hydoxypyrene. This is a marker for exposure to PAHs and is not at all specific to diesel exhaust. PAH's are a ubiquitous and fairly common airborne emission that is generated and emitted by a wide variety of sources – essentially any incomplete combustion of fuel as well as cooking. PAHs are found in a variety of emissions including gasoline, natural gas and diesel exhaust, tobacco smoke, food cooking. Although staff cites a paper (Toriba 2007) indicating that 1 nitropyrene could possibly serve as a biomarker for diesel exhaust, although it may serve as a biomarker for PAH exposure or exposure to pyrene sources, it cannot serve as a diesel marker. PAHs, pyrene, and nitropyrene are produced by many sources and the latter is created by atmospheric reactions. Consequently, it could only serve as a maker to those common sources and not diesel exhaust.

[1] Health Effects Institute Special Report. 2002. Research Directions to Improve Estimates of Human Exposure and Risk form Diesel Exhaust. HEI

[2] Autrup, H. 2002. Exposure Assessment using Biomarkers. Health Canada's Diesel Research Workshop.

Hydroxylated nitro-aromatic compounds. Staff reports that hydroxylated nitro-aromatic compounds may be found in urine and would indicate exposure to hyrdoxylated aromatic compounds and hypothesizes that they could serve as a diesel marker. However, as was the case above, such compounds are not unique to diesel engines but are emitted by a variety of combustion and industrial compounds. In addition, such compounds are found in the environment as products such as pesticides and can also form in the atmosphere. Both gasoline and diesel engines emit the substances, so its usefulness as a marker for diesel exhaust in ambient air is improbable.

Patterns of PAHs, IgE, and Vanadium. In the presentation to the Review Panel, OEHHA staff suggests that it maybe possible to determine diesel exhaust exposure through recognition of some pattern of other markers not unique to diesel. This has not been proven and is highly unlikely to be successful. In addition to the non-specific 1-hydroxypyrene marker noted above, staff suggests that the combination of IgE levels and Vanadium would result in a unique diesel marker. Regarding this issue, neither IgE nor Vanadium is specific to diesel exhaust exposure. Many other substances increase IgE levels including second-hand tobacco smoke, allergens in the environment, and ambient PM. Moreover, Ige levels depend on allergic responses in the population as well as the length of time since exposure to the triggering substance. As discussed below, Vanadium is not a marker for diesel exhaust, and in fact there is very little vanadium in diesel exhaust. Consequently, given the changing nature of diesel emissions, population variability in IgE response and the non-specificity of all three markers, there is no evidence to support using a pattern of three biomarkers to develop a biomarker for diesel exhaust.

Vanadium. In the discussion papers on diesel exhaust and vanadium, staff has indicated that Vanadium may serve as a biomarker for, or is characteristic of, diesel exhaust. Vanadium emissions are not unique to diesel engines but are present in the atmosphere from a wide variety of sources. It is emitted during the combustion of fossil fuels such as gasoline, diesel, and heavy fuels; it is emitted from industrial and refining operations; and it is used in manufacturing processes as well. Recent studies have characterized ambient vanadium levels in the South Coast and found that vanadium emissions may be associated with marine emissions but not diesel traffic.[3] Dr. Jamie Schauer identified vanadium emissions from both gasoline and diesel vehicles, but the largest source of vanadium was not exhaust but brake wear and road dust.[4] Moreover, recent efforts to characterize emissions from new clean-diesel technology indicate that vanadium emissions are below analytical method detection limits, thus providing further evidence that vanadium can not serve a marker for diesel exhaust. Regarding use of selective catalytic reduction aftertreatment using vanadium-based catalysts, a quick survey of EMA member companies indicated that no trucks will use such a catalyst in 2010. In fact, based on the configuration needed to reduce PM emissions using Diesel Particulate Filters, vanadium catalysts are not suitable for use on heavy-duty trucks because the exhaust temperature profile is too high. Vanadium is not a marker for diesel exhaust.

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[3] Arhami et. al. 2009 Size-segregated inorganic and organic components of PM in communities of the Los Angeles harbor. Aerosol Sci &Tech 43: 145-160.

[4] Chauer et al. 2006. Charcterization of metals emitted from motor vehuicles. HEI Reserch Report 133. HEI. Boston.

3. The current regulatory requirements and changing nature of diesel exhaust emissions negate the need for biomonitoring and greatly decrease the reliability of any potential diesel biomarker

Over that past decade, both the US EPA and CARB have established very stringent emissions standards for all mobile-source and stationary diesel engines. These regulations require that PM emissions be near zero. The technology necessary to achieve those stringent emissions levels, catalyzed diesel particulate filters (DPF), also reduce hydrocarbons, HAPs, and metals. In addition, through Air Toxics Control Measures, CARB is also regulating emissions from existing diesel engines and require replacement or retrofit with similar or identical emissions control levels. Consequently, the regulatory requirements in CA currently will bring PM and HAPs emissions levels from new diesel engines to near zero.

Because sufficient regulations to control constituents of diesel exhaust are already in place, biomonitoring will provide very little, if any, needed information. The current regulations apply the best available technology to reduce harmful emissions, and regulators and engine manufacturers are already doing everything possible to minimize emissions. Any progress in achieving those emissions reductions can be more easily monitored through emissions certification and in-use testing required by CARB as well as traditional ambient pollution trends analyses. An unproven and expensive biomonitoring program for diesel exhaust, even if it were technically feasible to complete, would add no value for public health.

Importantly, the approach to reduce emissions from diesel engines using a systems approach of ultra-low sulfur fuel, improved engine technology and DPF aftertreatment is extremely successful in reducing PM and HAPs emissions to near zero levels. This is germane to the biomonitoring program in two respects. First, there are few, if any, harmful emissions from today's diesel engines. Numerous emissions tests have demonstrated that PM is reduced by over 90 percent from pre-2007 levels. Hydrocarbon emissions are also reduced by a similar amount. As can be seen from the attached graphs showing emissions testing levels from HEI's ACES program, actual tailpipe emissions from DPF-equipped engines are an order of magnitude below regulatory emissions levels. As can also be seen from the attached table, the DPFs are extremely efficient in reducing metals and HAPS emissions, with many emissions levels reduced by 95-100%. Because of these reductions, new diesel engine technology that is currently being deployed has virtually no PM or HAPs emissions. Stringent emissions levels and new clean-diesel technology eliminate concerns regarding health effects from today's diesel engines.

Secondly, with regard to the potential biomarkers proposed for diesel exhaust by OEHHA, clean diesel technology eliminates the basis for using any of those markers. Again, PAHs, nitropyrenes, aromatic compounds, and most metals are reduced or eliminated from the engine's exhaust stream as the aftertreatment systems oxidize or trap these materials. As these new engines are entering the market, and as California's program to retrofit all existing engines is implemented, the emissions profile of the existing diesel engine fleet will be constantly changing. Emissions factors will be changing, the relative amount of emissions from diesel sources compared to other sources will be changing, and overall levels of exposure will be decreasing. Such significant changes in emissions make the scenario of identifying a diesel exposure maker by using a pattern on non-unique makers infeasible. The constant introduction

of much cleaner engines and consequent emissions factor changes creates a constantly changing dynamic that will alter the relative amount of emissions attributable to diesel. These changes will in turn change diesel exposure and alter the relative ratio of any potential markers. Given the changing environment, developing a diesel signature marker will not be possible.

Summary

EMA urges OEHHA and the Scientific Guidance Panel to reconsider the decision to include diesel exhaust on the list of designated and priority chemicals. There is no tested or validated biomarker for exposure to diesel exhaust and all of the proposed markers suggested by OEHHA staff are not unique to diesel. The possibility of using some combination of markers has not been examined or tested and would take years of development, even if it were possible. Moreover, current diesel emissions characteristics are rapidly changing and make any pattern of emissions or diesel signature totally unreliable for biomonitoring.

In addition to the technical issues with biomonitoring, new and retrofitted diesel engines with DPF aftertreatment essentially emit near-zero levels of PM, metals, and hazardous air pollutants. Regulations are in place to reduce potentially harmful constituents of diesel exhaust, and so there is questionable value in establishing an expensive biomonitoring program that will add little, if anything, to public health improvement.

Comments of the Engine Manufacturers Association

Diesel Exhaust and Vanadium

OEHHA

Scientific Guidance Panel Meeting

March 2, 2009

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- **Trade Association Representing Major Manufacturers of Internal Combustion Engines**
- **EMA Members Manufacture Diesel Engines Used in all Mobile and Stationary Applications**
- **EMA Represents Industry on Emissions Issues with ARB and EPA**

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Diesel Biomonitoring Issues

- **None of the proposed biomarkers are unique to diesel but are representative of many emissions sources**

- **Nitro-PAHs**
  - **PAH's produced by industrial processes as well as combustion, and so not unique to diesel**
  - **1-nitropyrene marker representative of many sources including gasoline, natural gas, cooking**
  - **Cannot serve as a diesel marker**

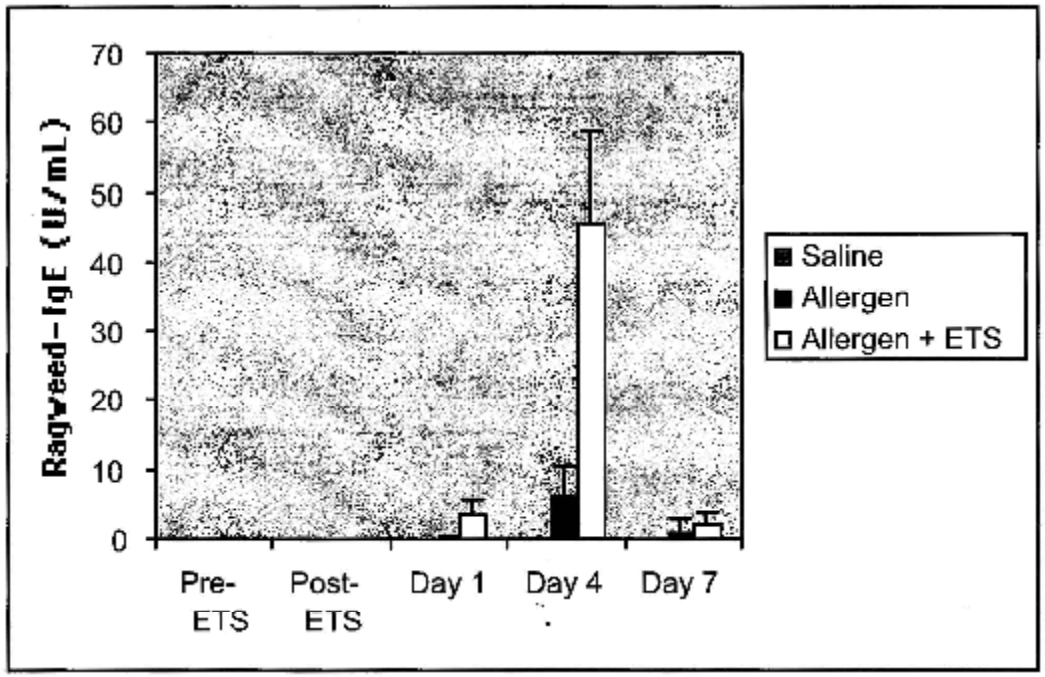
Diesel Biomonitoring Issues

- **Hydoxylated nitro-aromatic compounds**
  - **Produced by wide variety of sources, not just diesel**
  - **Nitro phenols/cresols emitted from combustion and industrial processes and also found in products**
  - **Found in both gasoline and diesel mobile source emissions**

Diesel Biomonitoring Issues

- **Patterns of Non-unique Biomarkers**
  - **Not Proven or Validated**
  - **1-hydroxypyrene not unique to diesel**
  - **Serum IgE – Many substances increase IgE levels including second hand smoke, ambient PM, and allergens**
  - **Response not limited or unique to traffic emissions – and not to diesel emissions**
  - **Dynamic and changing patterns of Diesel emissions make biomarker pattern unreliable**

Secondhand smoke exposure exacerbates IgE responses



Diaz-Sanchez et al., *J Allergy Clin Immunol*, 2006

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Diesel Biomonitoring Issues

- **Vanadium**
  - **Not characteristic of diesel exhaust**
  - **Vanadium emitted from oil combustion, refineries, industrial processes**
  - **LA study: Vanadium may be associated with marine but not traffic emissions**
  - **Schauer study indicates much more Vanadium from break/tire wear and road dust than in exhaust**
  - **Diesel emissions tests – V emissions below detection limits**
  - **Vanadium SCR not to be used on 2010 trucks**
  - **Preliminary testing indicates no V emissions from Vanadium-based catalysts**

Diesel Biomonitoring Issues

- **Conclusion – No unique or validated biomarker for diesel exhaust**
- **Studies and reviews by the Health Effects Institute concluded that there is no unique diesel signature or biomarker**
- **Similar conclusion by Health Canada Diesel Review Group**

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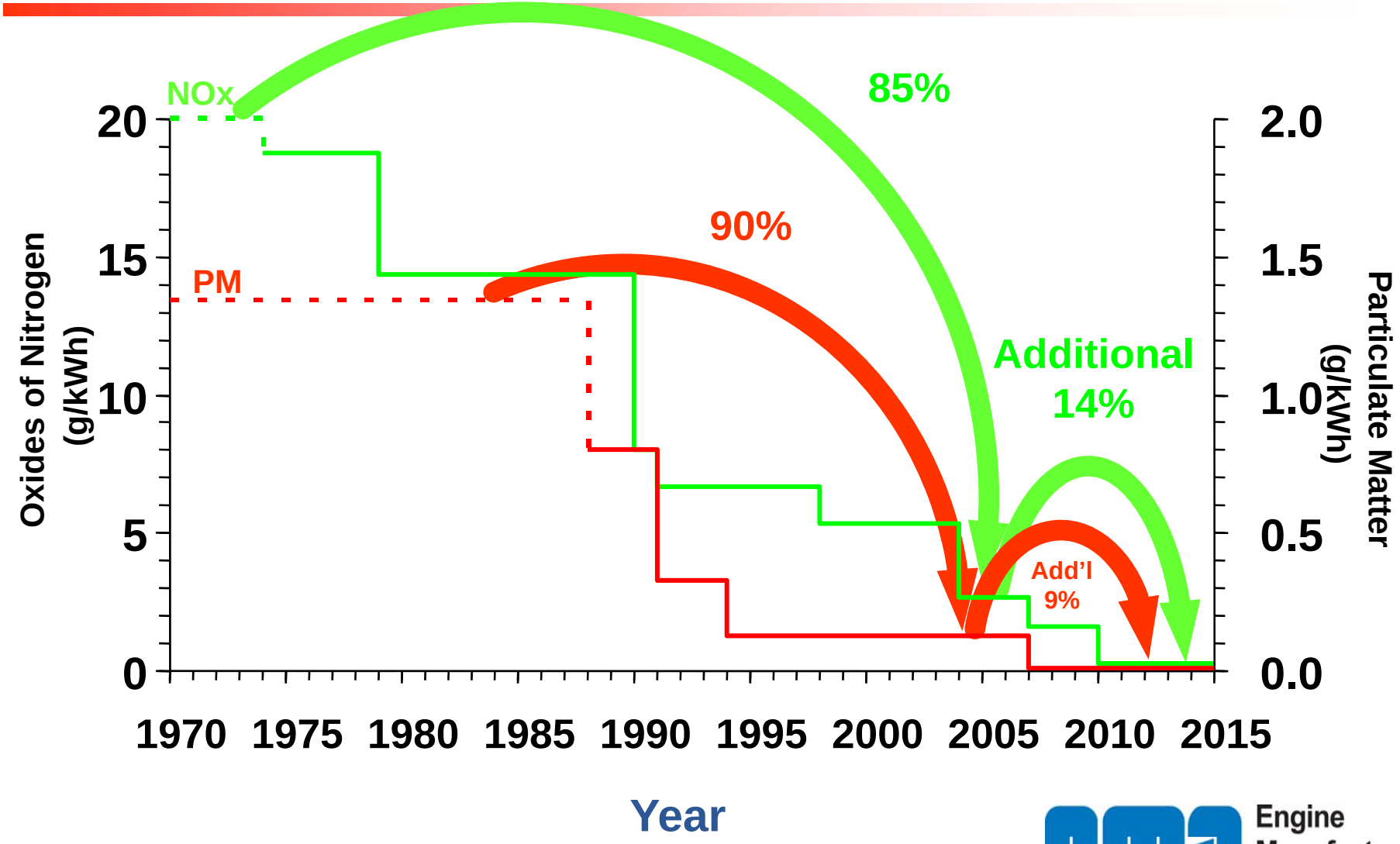
The Diesel Paradigm Has Changed – To Clean Diesel

- In California, virtually all categories of diesel emissions are being controlled and reduced.
- New engine emissions limits bring PM to near zero levels through catalyzed Diesel Particulate Filters (DPF)
- DPFs also significantly reduce hydrocarbons, PAHs and other air toxics, and metals through capture or oxidation.
- Result: New diesel engines with essentially no PM or HAPs emissions
- CARB applying same technology to existing engines through retrofit and replacement requirements

US On-Highway Emission Standards



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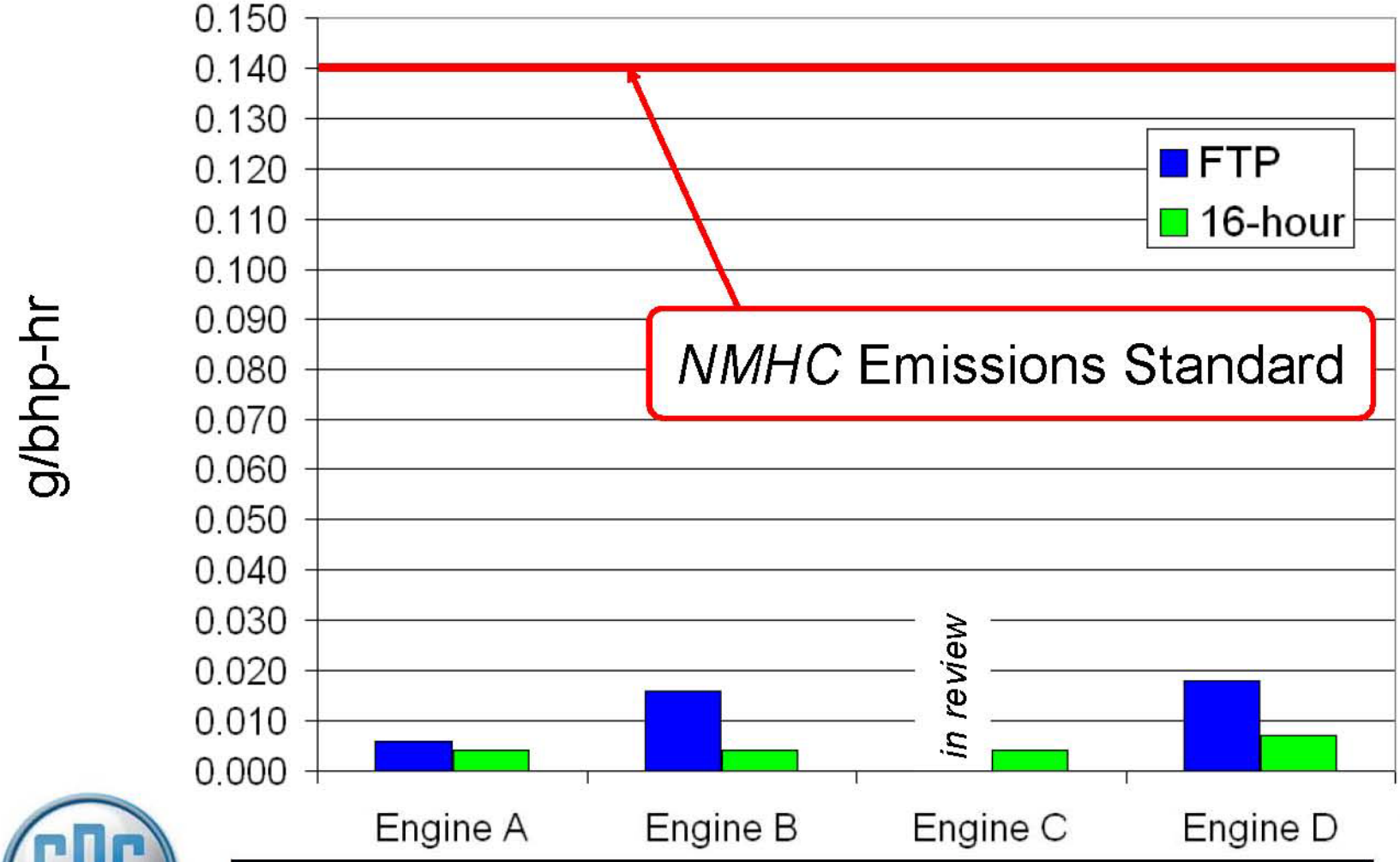
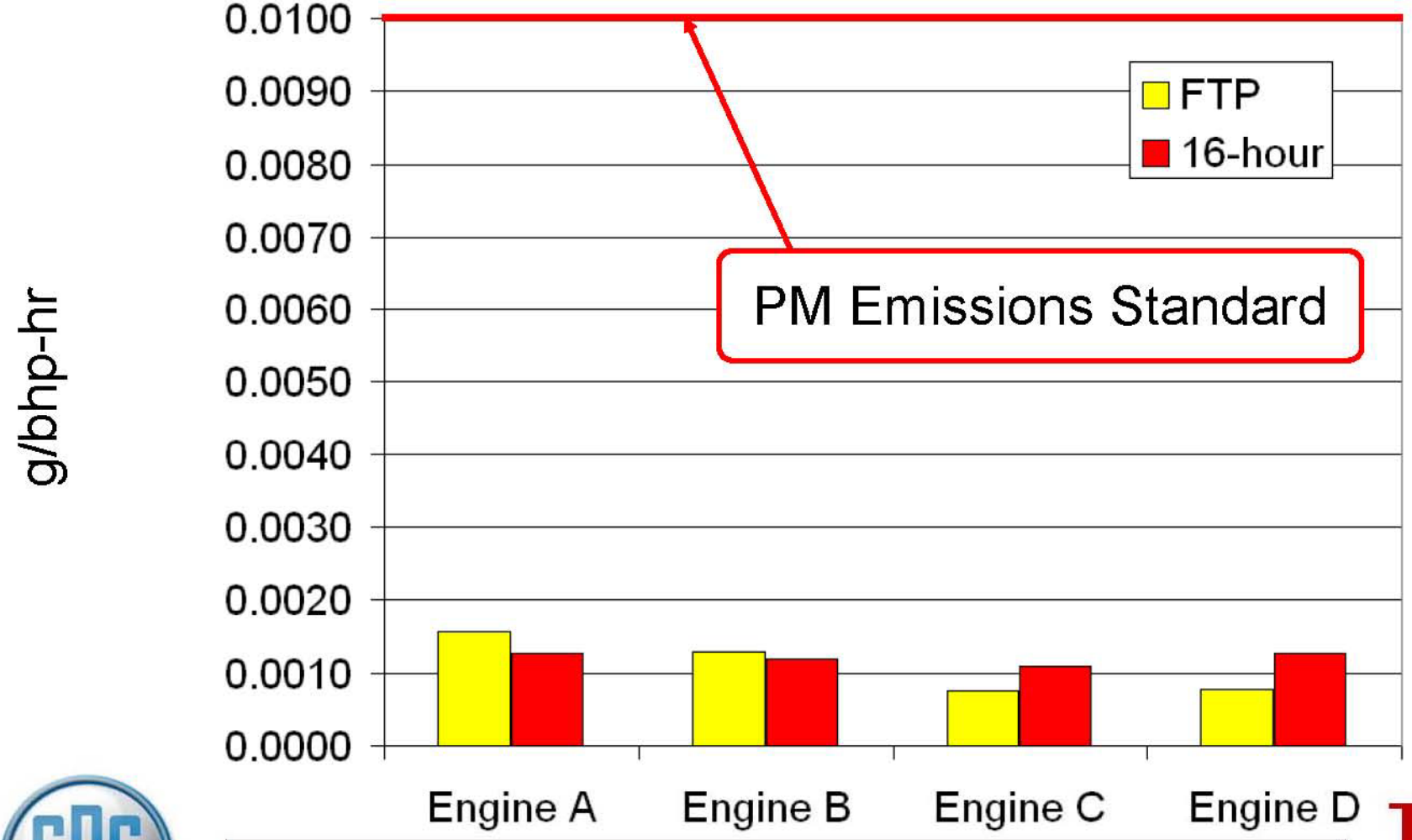
Phase 1 Regulated Emissions Data: Total Hydrocarbons



Data are preliminary, still subject to review

Phase 1 Regulated Emissions Data: Particulate Matter



Data are preliminary, still subject to review

ACES Results - Unregulated Emissions

Unregulated Emissions

Based on the 16-hour cycle, the great majority of unregulated emission species were below the level observed with 2004 engine technology used in CRC E55/59

Compounds	% Lower Than 2004 Engine Technology
Single Ring Aromatics	82%
PAH	79%
Alkanes	85%
Hopanes/Steranes	99%
Polar	81%
Nitro-PAH	81%
Carbonyls	98%
inorganic ions	38%
metals and elements	98%
OC	96%
EC	99%
Dioxins/Furans[a]	99%

[a] Relative to 1998 Engine Technology

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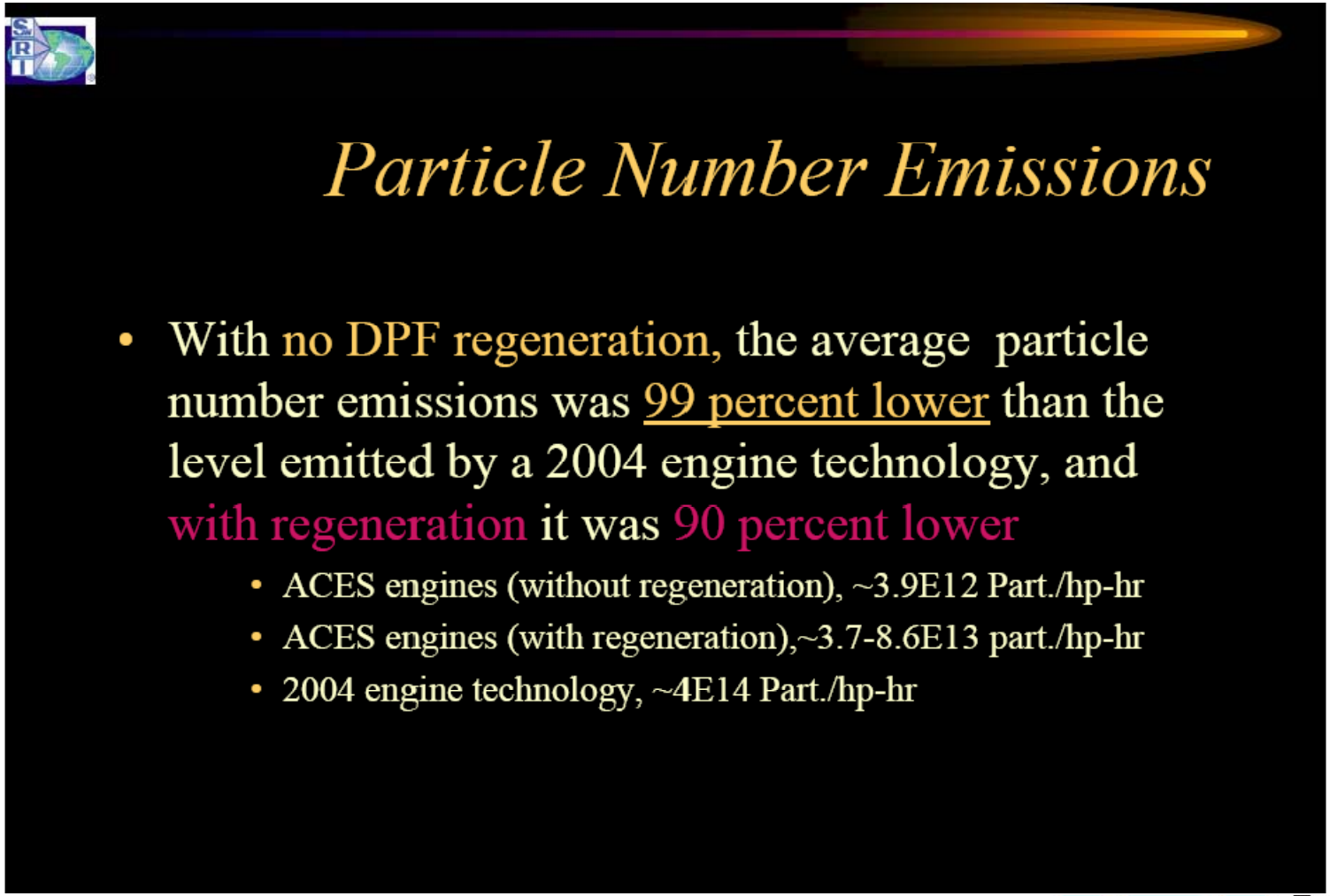
ACES Results – Particle Number



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Liu et al SAE Technical Paper 2008-01-0333 Reductions from DPF Equipped Diesel Engine

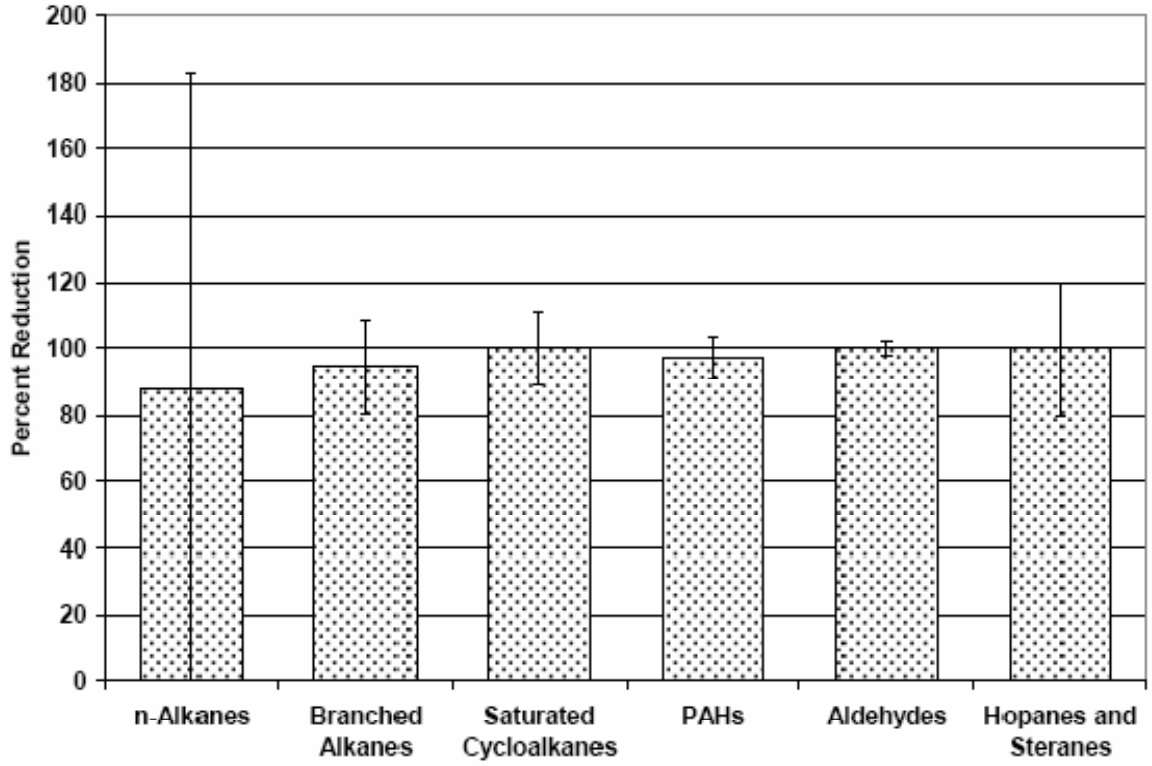

Figure 8. Organic Species Emissions Summary.

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Importance of Clean Diesel Technology to Biomonitoring Program

- Potential diesel biomarkers are no longer emitted or are significantly reduced in new diesel engines
- The introduction of new engine technology and retrofits will result in constantly changing emissions factors, making identifying or monitoring a pattern of biomarkers as a diesel signature impossible
- New clean diesel technology eliminates emissions that have been liked to health effects
- Today's diesel emissions cannot be associated with the 30-50 year old diesel emissions that were the subject of health effects studies – no longer the same emissions
- Today's technology is reducing harmful diesel emissions to near-zero levels; biomonitoring is not needed to inform future control efforts.

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Summary and Recommendation

- No Valid Biomarker for Diesel Engines
- Current regulations and technology are reducing potentially harmful emissions to near-zero levels
- Even if biomarker existed, biomonitoring for diesel exposure will not serve to improve public health
- “Diesel exhaust” is not a valid substance for listing

Summary and Recommendation

- Diesel exhaust is not an appropriate addition to the CA biomonitoring program
- EMA urges the Panel and OEHHA to reconsider listing diesel exhaust as a priority designated chemical under the biomonitoring program

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