ADVANCED
ENGINE SYSTEMS
INSTITUTE

October 23, 2019

The Honorable Frank Pallone, Jr.
Chairman, House Committee on Energy and Commerce
2125 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Chairman:

I am writing to request that a recent report (or its executive summary, both attached) from the Manufacturers of Emission Controls Association (MECA) be included in the record of today's full Committee hearing on "Building a 100 Percent Clean Economy: Solutions for Planes, Trains, and Everything Beyond Automobiles."

The report makes clear there is available and cost-effective technology to dramatically and quickly reduce nitrogen oxides (NOx) from heavy-duty vehicles in a way that complements continuing and deeper reductions in greenhouse gases. The so-called "tradeoff" raised by opponents of tighter NOx regulations can be overcome with technologies like cylinder deactivation, hybridization, and others.

Swift and significant NOx reductions from heavy-duty engines and vehicles is essential for achieving the 2015 national ambient air quality standards for ozone by mandated attainment dates, particularly because their emissions are a growing proportion of NOx inventories. These reductions are critical for protecting public health in the Northeast, California, the Midwest around Chicago, Houston-Galveston and elsewhere, but are even more important in severely congested urban corridors and port regions where economically disadvantaged people are more heavily exposed to pollution.

Thank you for your consideration. My trade association stands ready to help you and your staff as the Committee moves forward on its important goals.

Sincerely,

Christopher Miller
Executive Director

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TECHNOLOGY FEASIBILITY FOR MODEL YEAR 2024 HEAVY-DUTY DIESEL VEHICLES IN MEETING LOWER NOX STANDARDS

June 2019

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Contents

Executive Summary 1
1.0 Background 4
2.0 Overview of NOx Control Technologies 5
2.1 Control of Nitrous Oxide (N_2O) 9
3.0 Assessment of the Capabilities of Today's Engines and Aftertreatment 10
3.1 Technology Options to Meet Real World GHG and NOx Standards 12
3.2 Achieving NOx Conversion at Low Load 15
4.0 Feasibility Demonstration of Achieving 0.05 g/bhp-hr NOx Emissions with Current Aftertreatment Designs 17
4.1 FTP Emission Results from Engine Dynamometer Testing 19
4.2 Modeling of Composite FTP Emissions 20
4.3 Modeling Emissions over the Low Load Cycle 22
5.0 Conclusions 23
References 24

List of Figures and Tables

Figure 1. Evolution of heavy-duty emission control technology from 2010-2019 6
Figure 2. Comparison of a standard substrate (left) with an advanced high porosity substrate (right). 7
Figure 3. Demonstration of copper zeolite-based catalyst improvement at fresh and aged conditions. Three catalyst formulations are shown: a current version and two successive generations of catalysts. A) Exhaust temperature 200°C; B) Exhaust temperature 600°C. 8
Figure 4. Impact of catalyst loading on NOx conversion efficiency. Test conditions were 1000 ppm NO only, ammonia-to-NOx ratio (ANR) of 1 and space velocity of 120,000/hr. 9
Figure 5. CO_2 and NOx certification test data for heavy-duty diesel engines certified from 2002 through 2019. Source of data: U.S. EPA. 12
Figure 6. Exhaust temperature increase as a function of cylinder deactivation in a low load cycle 14
Figure 7. Effect of heated dosing on start of urea injection in SCR. 17
Figure 8. System configurations tested to demonstrate the feasibility of 2024 engine emissions. 18
Figure 9. NOx emissions from FTP hot-start tests with four variations of emission control systems. 20
Figure 10. N_2O emissions from FTP hot-start tests with four variations of emission control systems. 20
Figure 11. Modeled composite FTP NOx emissions from the latest generation commercially available SCR catalyst and two different SCR system volumes. 21

Table 1. Modeling Current Emission Controls Performance over Low Load Cycle 22

Executive Summary

The transportation sector was responsible for over 7 million tons of NOx emissions in the U.S. in 2014, with 50% of this sector's NOx attributed to heavy-duty on- and off-road vehicles and equipment. NOx is a precursor for both ground level ozone and secondary $PM_{2.5}$ which are regulated under the National Ambient Air Quality Standards (NAAQS) because of their adverse effects on human health and the environment. Due to the continued exposure of millions of Americans to poor air quality, both the United States Environmental Protection Agency (EPA) and California Air Resources Board (CARB) have announced rulemakings focused on revising the heavy-duty truck emission standards, with a particular focus on tighter limits for oxides of nitrogen (NOx). EPA is targeting implementation in the 2027 timeframe while CARB is focusing efforts on phasing in more stringent standards in 2024 and again in 2027 with the hope of aligning with EPA as a national standard.

In this report, MECA provides our assessment of technologies being commercialized by component suppliers, including MECA members, to help their customers comply with future lower NOx standards. We present dynamometer test results and emission models from fully aged aftertreatment systems installed on heavy-duty on-road engines to offer several compliance paths that are technologically and economically achievable by model year (MY) 2024 without significant changes to today's engines or aftertreatment. The models used have been optimized over decades of testing of accelerated aged commercial catalysts and validated against real world emission control systems. The technologies outlined in this assessment are either commercial or market ready options that can be deployed on vehicles by model year 2024 to achieve 0.05 gram per brake horsepower hour (g/bhp-hr) on the heavy-duty FTP certification cycle and approximately 0.2 g/bhp-hr in low load operation using the proposed low load certification cycle being developed at Southwest Research Institute under a contract from CARB. It is important to state that there are several technology paths to achieve these levels of emissions, and some of them can simultaneously lower greenhouse gas emissions, such that the NOx reductions do not compete with the CO_2 reductions.

The following assessment is based on the implementation timeline presented by CARB staff at the January 23, 2019 public workshop as well as the assumptions laid out in the CARB staff white paper released on April 18, 2019 (CARB, 2019). In the latter, CARB staff signaled a plan to align the regulatory provisions for the first phase of NOx tightening with the second implementation stage of the Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2 (hereafter "Phase 2 GHG regulation") in 2024. Assumptions include that the OEMs will have to meet a Federal Test Procedure (FTP) certification standard with current cold start and hot start weightings, a Ramped Modal Cycle Supplemental Emission Test (RMC-SET) and the proposed Low Load Cycle (LLC) based on profile LLC-7 (CARB, 2019). Included, as part of future requirements, is a revised heavy-duty in-use testing (HDIUT) protocol that replaces the current not-to-exceed (NTE) based protocol with a moving average windows method with a 10% low power exclusion, similar to that required under Euro VI-D. Finally, the technologies considered in this assessment are assumed to be designed to meet a 435,000 mile full-useful life (FUL) and a 350,000 mile or 5 year warranty, with the latter going into effect in 2022 in California.

The conclusions in this paper can be summarized as follows:

1. **Compared to emission controls on MY 2010 U.S. diesel trucks, today's compact aftertreatment systems are 40% lighter, 60% smaller, and substantially less expensive.**

Manufacturers continue to optimize diesel emission controls, such as DOC, DPF and SCR, in order to promote uniform catalyst coating, improve NOx conversion efficiency, reduce back pressure on the engine, and reduce thermal mass. New substrates are designed with thinner walls or higher porosity, which allows the coating of better catalysts without sacrificing durability. This has resulted in higher catalyst loading per volume of substrate and led to downsizing of systems from those available in 2010. Furthermore, catalyst development has produced higher activity catalysts that can provide higher NOx conversion with lower catalyst loading. While the cost of new heavy-duty trucks has increased at approximately 1% per year, the cost of emission controls has come down, representing a lower percentage of the cost of a new truck. These advances have brought higher compliance margins and lower certification levels while still meeting future GHG standards. Advanced catalysts and substrates combined with better engine and urea dosing calibration can be readily employed to meet tighter NOx limits in 2024 without any significant changes to today's system design. Based on a survey of MECA's members, we estimate the cost of emission controls on a future ultra-low NOx truck to be similar to the cost of emission controls on a MY 2010 truck.

2. **Several vocational engine families have demonstrated the capability of achieving NOx emissions 50-75% below today's standards, while also meeting future heavy-duty greenhouse gas limits for vocational engines.**

Since 2010, setting stringent emission targets for both CO_2 and NOx through realistic regulations and expanding the calibrator's tool box from the engine to the powertrain has allowed engineers to achieve simultaneous NOx reductions and engine efficiency improvements. A review of EPA's heavy-duty certification tables (U.S. EPA, 2019) indicates that a number of diesel engine families certified since 2010 have shown the ability to achieve 0.1 g/bhp-hr and lower tailpipe NOx levels over the composite FTP certification cycle. Of those engines, several have demonstrated the ability to meet future Phase 2 GHG regulation limits for vocational engines that go into effect in 2021, 2024 and 2027. History has shown that once emission control and efficiency improving technologies were required on engines, the traditional trade-off relationship between CO_2 and NOx emissions at the tailpipe has been overcome and reductions of both pollutants could be achieved simultaneously.

3. **A wide variety of technology options can be deployed on heavy-duty engines and vehicles to reduce engine-out NOx while improving fuel economy to reduce the total cost of ownership of trucks.**

The number of on-engine technology options and strategies that OEMs may choose to deploy to meet both a 2024 NOx standard and the 2024 CO_2 standard has grown dramatically in recent years, as a result of the Phase 2 GHG regulation. Technologies such as cylinder deactivation (CDA), high efficiency variable geometry turbochargers with exhaust gas by-pass, and start-stop systems are only some of the commercially available fuel saving technologies that can be implemented by 2024. Some of these strategies can be deployed on cold-start to heat up aftertreatment and keep it hot under low engine load operation. Other technologies that are being demonstrated on vehicles include 48V electrical architectures combined with regenerative braking and small batteries that can electrify auxiliary components on the engines such as air conditioning compressors, water and oil pumps, EGR pumps, electric assist turbochargers, electrically heated catalysts, 48V motor-generators, 48V electric fans and auxiliary power units to take the load off the engines. Technologies like CDA and 48V mild hybridization can enable simultaneous NOx and CO_2 reduction, and once implemented, these technologies will deliver fuel savings to truck owners.

4. **Strategies for reducing emissions during periods of low load operation, combined with improved engine calibration and control of urea dosing, can be applied to heavy-duty trucks by 2024 to enable emission control systems to achieve an FTP emission limit of 0.05 g/bhp-hr and a Low Load Cycle (LLC) limit below 0.2 g/bhp-hr.**

Engine calibration and thermal management combined with advanced catalysts and substrates have improved to the point where a current engine plus aftertreatment system can achieve FTP emissions below 0.05 g/bhp-hr NOx with compliance margins that OEMs need for full useful life durability. During cold-start and low-load operation, engine calibration and thermal management, including the technologies listed in (3) above, can be applied to reduce engine out NOx emissions and provide additional heat to aftertreatment systems. Better catalysts and urea dosing systems can achieve high NOx conversion during lower temperature operation. Further compliance margins can be achieved through modest increases in catalyst volume, while still maintaining the size of future emission controls below those on model year 2010 trucks. Some engine manufacturers may choose to include a light-off SCR catalyst before the DOC in a twin SCR system arrangement with dual urea dosing, to gain experience with the types of strategies that may be needed for lower NOx limits in 2027. The approaches discussed for meeting 2024 NOx limits utilize improvements in thermal management and engine calibration, and existing aftertreatment system designs that employ newer high efficiency catalysts and coating strategies. Simulations of commercial catalysts over a low load cycle show that low temperature ammonia delivery through the use of heated urea dosing can deliver NOx emissions below 0.2 g/bhp-hr over the LLC, representing extended low-speed operation and idling.