Abstracts

SESSION 9 – Diesel Engine Development and Durability

Chair: **Ken Howden, U.S. Department of Energy**

The Diesel Engine Powering Passenger Cars – Today and Tomorrow

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Volkswagen AG

In Europe Diesel passenger cars have long been accepted. The need for reduced carbon dioxide emission and for increased energy supply are two reasons for this acceptance. In Europe Diesel engines are held to different emission standards than gasoline engines. Diesel vehicles have lower carbon monoxide standards but are allowed higher oxides of nitrogen. There are continually steps being taken to ensure that the new Diesel engines will comply with future emission standards (i.e. need for aftertreatment). In Europe, Diesel vehicles are already highly competitive with gasoline engines and future Diesel technology will ensure this competitiveness continues.

In the U.S. Diesel vehicles are not common for passenger cars and light-duty trucks. What is stopping the Diesel engine from flourishing in the U.S.? Will new carbon dioxide emission regulations, or energy supply problems help promote the Diesel engine? There is the known challenge of reaching the future Environmental Protection Agency Tier II emission standards. This and other concerns will be explored.

Lowest Engine Out Emissions as the Key to the Future of the Heavy-Duty Diesel Engine – New Development Results

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Latest development results on heavy-duty Diesel engines show that it is possible to achieve the United States emission limits for 2010 with exhaust gas aftertreatement. Exhaust gas aftertreatment systems with deNO_X and filter efficiencies of at least 90 percent will be mandatory in order to achieve the future nitrogen oxides (NO_X) and particulate matter (PM) levels. Achieving these levels will require engine concepts with a peak firing pressure capability of at least 200 bar, cooled exhaust gas recirculation (EGR) with EGR rates of 25 percent at full load, injection systems with a pressure potential of 2,400 bar, and two-stage turbocharging. Turbocharger efficiencies of more than 50 percent are required to keep the fuel penalty within acceptable limits. The same will apply for Europe in case it adopts the United States limits. If NO_X limits were set to approximately 1.0 instead of 0.27 g/kWh, then the reduced requirements on the engine would allow significantly better fuel economy.

Cummins/DOE Light Truck Diesel Engine Progress Report -- 2004

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Cummins continues the design and development of the V-family engine system with the Department of Energy's (DOE) partnership. Requirements of the Light-Truck Automotive market in the United States have been studied and the proposed V-family of engines is believed to meet those needs. The engine system combines the requirements of a very fuel-efficient commercial Diesel and the performance and sociability requirements of a gasoline engine. Results show that the full Environmental Protection Agencies (EPA) Tier II Bin 5 Emission results are achieved, while also meeting the fuel economy targets established by the DOE. Ongoing system developments for improved overall robustness are shown including air-handling system, noise, and overall vehicle performance. General aftertreatment system design and direction is discussed.

An European Perspective of US 07 / EURO 5 HD Engines and Chassis Technologies

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First emission regulations were introduced more than thirty years ago. At the beginning, visible emissions drove regulation philosophy: smoke was regulated first. Nitrogen oxides (NO_X) came later as acid rain effects became evident. Particulate emissions were restricted as their detrimental health consequences were discovered.

Several different test procedures emerged in relation with local situations. To improve big cities air cleanliness, step transients were enforced to reduce gear shifting black clouds, later U.S. Federal Test Procedure was the first non steady state cycle to be introduced. At the end all countries are merging to the same philosophy: steady state and transient cycles, NTE (not to exceed) figures, and random check of steady points.

But in practice different test procedures can lead to favor different emission control technologies. This is true in exhaust aftertreatment systems selection as they are efficiency sensitive to gas temperatures. Efforts to develop harmonized procedures are underway. Fuel quality, sulfur content, is coming to converge, as well.

Nevertheless, Europe and U.S. will not introduce the same technologies for U.S. 07 and EURO 5 regulation steps. Out of the panel of potential technologies Europe has selected selective catalytic reduction, and U.S. exhaust gas recirculation to control NO_X while a Diesel particulate filter has been chosen as a common way to control particulates. Everybody knows the infrastructure concern of urea distribution played an important role in not selecting SCR to be introduced in the US market.

Within the Volvo group future products development is progressing enough to propose a fair comparison of U.S. and European ways. First is regulation compliance that both technologies will meet. Second are customer demands: high fuel economy, high reliability, and durability. Third is original equipment manufacturer request that enough margin for the satisfaction of shareholders.

The comparison given includes all factors an OEM operating on both sides of the Atlantic can control. A brief approach of carbon dioxide emission aspect is proposed.

Beyond U.S. 07 and EURO 5, next steps of regulations will come. Expectation is to better serve simultaneously the environment, our customers, and our shareholders.

Light Duty Diesel Engine Technology to Meet Future Emissions and Performance Requirements of the US Market

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For Diesel powertrains to establish a significant role in the U.S. light-duty vehicle market numerous technical and commercial challenges must be overcome. Nitrogen oxides (NO_X) emission reduction to meet the stringent requirements of the Environmental Protection Agency Tier II Bin 5 is widely recognized as the most significant technical challenge. Major research efforts within the industry have been focused on this problem and have successfully demonstrated the feasibility of achieving the required levels through a combination of engine and aftertreatment technologies. As 2007 approaches, more emphasis is being placed on ensuring robust emissions control over vehicle life and balancing low emission with other cost, performance, and fuel economy attributes to deliver viable products to the U.S. market. Analysis has shown that engine development to improve emission control in-cylinder can provide significant NO_X reduction at lower cost than an exhaust aftertreatment based approach. Furthermore, minimizing the aftertreatment NO_X reduction requirement mitigates the risk of emission compliance over life.

This paper provides an interim report on an approach to meet the technical and commercial demands of future U.S. light-duty Diesel products, with particular emphasis on the light-duty truck sector. The ACTION (Advanced Combustion Technology for Improved engine-Out NO_X) strategy described applies incremental developments in combustion, air handling, and control technologies to conventional Diesel engines. Reduced emissions are enabled through highly pre-mixed and lower temperature combustion. Current results from single and multi-cylinder engines are tabled and applied to potential U.S. applications by vehicle simulation.