State of California
AIR RESOURCES BOARD

RESEARCH PROPOSAL

Certification and In-Use Compliance Testing for Heavy-Duty Diesel Engines to Understand High In-Use NO_X Emissions

Resolution 15-16

May 21, 2015

Agenda Item No.: 15-4-1

WHEREAS, the Air Resources Board (ARB or Board) has been directed to carry out an effective research program in conjunction with its efforts to combat air pollution, pursuant to Health and Safety Code sections 39700 through 39705;

WHEREAS, a research proposal, number 2787-282, entitled "Certification and In-Use Compliance Testing for Heavy-Duty Diesel Engines to Understand High In-Use NO_X Emissions," has been submitted by the University of California, Riverside, for a total amount not to exceed $500,000;

WHEREAS, the Research Division staff has reviewed Proposal Number 2787-282 and finds that in accordance with Health and Safety Code section 39701, the results of this project will help ARB develop future air quality plans by providing insight into why emission rates from heavy-duty vehicles may be higher than emissions measured during certification; and

WHEREAS, in accordance with Health and Safety Code section 39705, the Research Screening Committee has reviewed and recommends funding the Research Proposal.

NOW, THEREFORE BE IT RESOLVED that the Air Resources Board, pursuant to the authority granted by Health and Safety Code section 39703, hereby accepts the recommendations of the Research Screening Committee and staff approves the Research Proposal.

BE IT FURTHER RESOLVED that the Executive Officer is hereby authorized to initiate administrative procedures and execute all necessary documents and contracts for the Research Proposal as further described in Attachment A, in an amount not to exceed $500,000.

I hereby certify that the above is a true and correct copy of Resolution 15-16 as adopted by the Air Resources Board.

Tracy Jensen

Tracy Jensen, Clerk of the Board

ATTACHMENT A

"Certification and In-Use Compliance Testing for Heavy-Duty Diesel Engines to Understand High In-Use NO_X Emissions"

Background

Considerable reduction in nitrogen oxides (NO_X) emissions is needed for the State of California to meet ambient air quality standards for ozone and particulate matter. To achieve some of the reduction, the Board adopted a NO_X emission standard for model year 2010 and later heavy-duty (HD) on-road engines of 0.20 g/bhp-hr. This represents a 90 percent reduction compared to the pre-2010 standard. To meet the standard, most diesel engine manufacturers are using selective catalytic reduction (SCR) aftertreatment systems. SCR requires adequate temperatures in the exhaust to function effectively, and as a result engine emissions will exceed certification emissions when the engines are cold. However, it has been observed during many in-use test programs that emissions from in-use vehicles exceed emission levels expected based on the engine certification standards, even when the engines are fully warmed up. The cause of this discrepancy is unknown, but has implications for State Implementation Plans (SIP) as well as the effectiveness of potential rules to further lower emission standards.

Objective

The objective of this research is to understand why in-use NO_X emission rates from warmed-up, SCR-equipped vehicles in normal use exceed the emission rates engine-certification emission rates. Possible sources of the discrepancy include: certification engines are pampered special engines compared to in-use engines; engines respond differently to certification test equipment than to in-use test equipment; and, certification test cycles are not representative of in-use test cycles.

Methods

The contractor will select two in-use vehicles with engines from different engine manufacturers, each having an in-use NO_X emission rate significantly higher than the engine certification emission rate. For each vehicle, the contractor will establish baseline in-vehicle emission rates over the road using a Portable Emission Measurement System (PEMS), and on a chassis dynamometer, recording second-by-second engine speed, torque, and NO_X emissions over several driving cycles including the HD Urban Dynamometer Driving Schedule (UDDS). The contractor will next remove the engine from the vehicle, install it on an engine dynamometer, and measure second-by-second emissions over several cycles including the Federal Test Procedure (FTP) certification cycle, and an engine-UDDS cycle using the speed and torque points measured during UDDS chassis dynamometer testing. The contractor will finally re-install the engine in the vehicle, and repeat chassis dynamometer testing to verify that the in-vehicle baseline emissions have not changed. The contractor will analyze the data to compare engine test versus in-vehicle test emissions, will prepare a detailed report, and will deliver all data to ARB for independent analysis.

Expected Results

This project will provide detailed NO_X emission test data on engines from two different engine families. The second-by-second emissions data will allow comparison of

emission rates at similar or identical speed and torque points using different test methods. The data will allow:

- Comparison of certification emission rates measured on a certification engine with emission rates measured using engine certification test methods on an in-use engine, which will help distinguish whether certification test engines are highly tuned special cases compared with typical in-use engines.
- Comparison of emissions measured using engine dynamometer methods with emissions measured using chassis dynamometer methods at the same engine speed and load points, which will help determine whether engines are emitting differently on the engine dynamometer than in a vehicle, even though engine speed and load are the same.
- Comparison of similar but different engine cycles such as engine-FTP and (derived) engine-UDDS, which will help determine if the engine is over-tuned to provide best emission performance only over a very narrowly defined emission cycle rather than over a range of operating conditions.

Significance to the Board
This project will provide critical information to help ARB understand why emission rates measured from in-use vehicles are substantially higher than the emission rates measured during engine certification. This information will help ARB to design potential improvements to certification and in-use compliance procedures that might be needed to develop effective emissions reduction strategies for statewide air quality plans.

Contractor:
University of California, Riverside

Contract Period:
24 months

Principal Investigators (PIs):
Thomas D. Durbin, Ph.D.
Kent Johnson, Ph.D.
Georgios Karavalakis, Ph.D.

Contract Amount:
$500,000

Basis for Indirect Cost Rate:
The State and the University of California, Riverside have agreed to a ten percent indirect cost rate.

Past Experience with the PIs:
The team of investigators has a great deal of experience in the collection and analysis of truck and engine emission testing. ARB has collaborated very successfully with this team at University of California, Riverside on a number of related projects in the past.

Prior Research Division Funding to the University of California, Riverside

Year	2014	2013	2012
Funding	$ 1,288,560	$ 777,062	$ 0

BUDGET SUMMARY

University of California, Riverside

"Certification and In-Use Compliance Testing for Heavy-Duty Diesel Engines to Understand High In-Use NO_X Emissions"

DIRECT COSTS AND BENEFITS			
1.	Labor and Employee Fringe Benefits	$ 118,359	
2.	Subcontractors	$ 0	
3.	Equipment	$ 0	
4.	Travel and Subsistence	$ 2,100	
5.	Electronic Data Processing	$ 0	
6.	Reproduction/Publication	$ 0	
7.	Mail and Phone	$ 0	
8.	Supplies	$ 3,800[1]	
9.	Analyses (testing)	$ 181,388[2]	
10.	Miscellaneous	$ 157,588[3]	
	Total Direct Costs		$ 463,235
INDIRECT COSTS			
1.	Overhead	$ 36,765	
2.	General and Administrative Expenses	$ 0	
3.	Other Indirect Costs	$ 0	
4.	Fee or Profit	$ 0	
	Total Indirect Costs		$ 36,765
TOTAL PROJECT COSTS			**$ 500,000**

[1] Supplies include test fuel ($750) and materials ($3,050) for mounting the engines and aftertreatment such as tubing, piping, fittings, calibration and test gases, and electrical items related to the control of engines.
[2] Analyses include fees for engine-dynamometer ($70,000), chassis-dynamometer ($67,888), and PEMS testing ($43,500) at the University of California, Riverside laboratories.
[3] Miscellaneous include cost for facility rental ($95,588), truck lease ($50,000), and services of removing and replacing the engines ($12,000).