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Submitted via email: adf@arb.ca.gov.

Re: Comments on the University of California at Riverside Final Report, *"Low Emission Diesel (LED) Study: Biodiesel and Renewable Diesel Emissions in Legacy and New Technology Diesel Engines"*

The American Petroleum Institute (API)[1] and its members commit to delivering solutions that improve air quality and reduce the risks of climate change while meeting society's growing energy needs. We support global action that drives greenhouse gas (GHG) emissions reductions and economic development. We appreciate the opportunity to provide comments on the subject study.

The California Air Resources Board (CARB) contracted with University of California at Riverside, Bourns College of Engineering, Center for Environmental Research and Technology (CE-CERT) to evaluate nitrogen oxides (NO_x) and particulate mass (PM) emissions from the use of renewable diesel (RD)/ biodiesel (BD) blends versus a petroleum-based CARB reference diesel fuel (CARB diesel) in two (one off-road and one on-road) new diesel technology engines (NDTEs), and one legacy off-road engine. The summary of test results provided in the CE-CERT report can be briefly paraphrased as follows:

1. In both **NTDEs** tested:
   - NO_x emissions from RD100 were shown to be no different than CARB diesel.
   - NO_x emissions from RD/BD blends were shown to be higher than observed in some previous studies.
   - Blending of RD with BD did not reduce excess NO_x emissions from BD.
   - PM emissions were shown to be very low and near background levels for all blends and there were no statistically significant differences.
2. In the **legacy** engine tested:
   - Results were shown to be within the range of prior studies.
   - RD100 reduced NO_x emissions by about 5% and PM by about 30% with respect to CARB diesel.
   - RD was shown to also reduce excess NOx from BD in the RD/BD blends.
   - The greater the BD concentration in the RD/BD blends, the greater the observed PM emissions benefits.

API Concerns

We have identified several issues with the test program scope and findings documented in the CE-CERT report. These include the sensitivity of the test measurement equipment, statistical significance of the results, and the relevance of the base diesel type, blend levels, test cycle and engine operation to diesel blends used in California. CARB and CE-CERT should investigate these issues and then post a revised, updated final report on the CARB website for public use.

Our concerns are discussed below:

[1] API represents all segments of America's natural gas and oil industry, which supports more than ten million U.S. jobs and is backed by a growing grassroots movement of millions of Americans. Our nearly 600 members produce, process, and distribute the majority of the nation's energy, and participate in API Energy Excellence, which is accelerating environmental and safety progress by fostering new technologies and transparent reporting. API was formed in 1919 as a standards-setting organization and has developed more than 700 standards to enhance operational and environmental safety, efficiency, and sustainability. *See* www.api.org.

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1. The absolute magnitudes of the reported average NO_x tailpipe emissions results for the NTDEs are very small and are accompanied by error bars that are large (presumably reflecting wide test-to-test variability) within the engine/fuel combinations tested. The consequent lack of statistical significance across the results by test fuel type suggests that no conclusions should be drawn concerning trends in fuel property effects on NO_x emissions for these engine types.

   It also is important to note that the biodiesel content of the tested blends is above the current CA permitted level (20 vol %), and, as such, the test engines may not be properly calibrated for operating with these fuels. This is particularly evident for the tests of the on-road NTDE over the transient FTP cycle. This engine appeared to run in different operating modes at some points and generate a subset of outlier results as discussed in Appendix A of the CE-CERT report.

2. The CE-CERT test program did not include test fuels containing CARB diesel blended with either biodiesel or renewable diesel, especially at blend concentrations in the range of 20 volume percent. Inclusion of these types of blends would have yielded information that is more representative of the biodiesel and renewable diesel blends that are in actual commercial use in low emission diesel engines today. CARB should consider including these fuels in a follow-on study to further clarify the fuel effects on emissions for the tested engine platforms.

3. There appears to be a typographical error in Table 3-1 of the CE-CERT report. It indicates that the "neat" renewable diesel (RD) fuel used in the CE-CERT study contains aromatics at a level of 1.2% by volume measured by ASTM D5186. However, the ASTM D5186 method reports values on a weight % basis. The same value (1.2) for the "neat" RD appears to be correctly listed on a weight % basis (per the ASTM D5186 method) in Appendix Table C.1 of the report. The two tables should be reconciled and made consistent.

   Additionally, can it be confirmed that the "neat" RD used in the CE-CERT study is 100% Renewable Diesel (R100) and does not contain a small amount of petroleum-derived ULSD (~1%)? Suppliers often add petroleum-derived ULSD to obtain tax credit for the RD material being supplied. The 1.2% aromatics value in the "neat" RD test fuel is higher than typical R100 which is virtually free of aromatics. This might be relevant as aromatics are known to impact NO_x emissions, as well as other tailpipe emissions such as PM, and could merit further investigation. CARB should ask CE-CERT to provide additional discussion on this topic in a revised version of the final report.

4. There is a typo on page 10, Table 3-5, *Specifications of the Test Engines*. The Engine Model description for the 2019 Cummins On-Road NTDE should be ISX15, not C-15.

5. Appendix F, page F-2, figure F-2, *Federal Test Procedure (FTP) certification cycle for on-highway engines,* reports Torque (ft*lb.). However, the torque values are too low for a Cummins ISX engine. From the Cummins website, an ISX with an Advertised Horsepower of 450hp, the peak torque ratings vary from 1550-1750 ft*lbs., which is much higher than the 1100-1200 ft*lb. peak values displayed in the curve. There is also a typo in the right y-axis label. The units of Torque should be (ft*lb.), not (ft*In). Note that this could be an instance of copying a generic torque curve for the FTP certification. If that is the case, then the figure should be relabeled, or the units changed to normalized percentages of peak torque.

6. We strongly urge CARB to consider conducting a program that evaluates emissions from low emission heavy-duty diesel engines tested over low-load cycles to develop a better, more robust understanding of the potential impacts of fuel properties. Engine control parameters, including boost and exhaust gas recirculation (EGR) rate, for low-load cycles can provide a better understanding of the effects of fuels on

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emissions than the typical conditions covered by the cycles evaluated in the CE-CERT study. In addition, since low-load cycles are included in the new CARB Omnibus HD vehicle regulations, CARB should include them in future test programs to ensure a more robust evaluation of design parameters.

7. The fuel effects on emissions that were observed in the CE-CERT study may not be similar to those for future engine technology, as original equipment manufacturers improve calibration and hardware strategies in anticipation of forthcoming rules such as the CARB Omnibus HD vehicle regulations.

CRC Test Program

As CARB staff already may be aware, in early January 2022 the Coordinating Research Council (CRC) initiated a program designed to follow-on efforts currently underway at Southwest Research Institute (SwRI) to evaluate low NO_x emission control technologies for heavy-duty engine application. This CRC program (CRC project RW-120 "Impact of Bioderived Fuels on Low NO_x Feasibility") is intended to provide insight on potential fuel-related impacts on heavy-duty engine and aftertreatment performance and durability. As performance demands for aftertreatment systems are expected to increase substantially in 2027+, it is imperative to understand the impact of alternative fuels on engine and aftertreatment performance.

Fuels of interest include biofuels such as biodiesel and renewable diesel. The test fuel blends for the CRC program will include B20 and B50 fuel blended with CARB diesel, as well as RD100 and blends of RD with biodiesel and CARB diesel. Test engine operating conditions will include low-load cycles and incorporate the aftertreatment system used in the CARB low NO_x technology assessment. This project seeks to evaluate pathways by which the impacts of alternative fuel compositions on engine-out NO_x and soot levels might influence the overall durability performance of (and emissions from) the engine and aftertreatment system. It will be performed in conjunction with the ongoing CARB and EPA low NO_x programs at SwRI.

The CRC program, although similar in nature to the one reported by CE-CERT, will be complementary and will help fill the knowledge gaps that currently exist. Testing is expected to begin in the second quarter of 2022 and to be completed in June 2022.

Thank you for the opportunity to provide input. I would be happy to answer any questions that may arise from our comments.

Sincerely,

David H Lax