

The Tennessee Tech University (TTU) Emissions Testing Team reviewed the EPA document “Chassis Dynamometer Testing of Two Recent Model Year Heavy-Duty On-Highway Diesel Glider Vehicles” dated November 20, 2017 and emailed the following questions to EPA on November 28, 2017. EPA responses to their questions are below.

**TTU Question 1:** The tested Gliders 2016 & 2017 were ‘loaned’ vehicles, with 179,273 and 30,600 miles respectively. Why were these Gliders chosen to test instead of a newly refurbished /remanufactured glider engine from a rebuilder? It is our understanding of how the EPA tests OEM Heavy Duty Engines for the EPA Certification process.

**EPA Response:**

- The purpose of the EPA glider emission testing was not to evaluate whether the remanufactured engines meet the EPA engine-based emission standards. This research was conducted primarily for EPA to update our assessment of the emissions inventory impacts for air pollutants from commercial vehicles due to the recent large increase in sales of glider vehicles, and also to estimate the emissions impact if EPA’s current standards for glider tractors are repealed. The best way to develop such emission inventory impacts is to measure the emission from in-use vehicles, not by performing the engine-based tests that would be needed to compare rebuilt glider engines to EPA’s engine-based emission standards.
- The two vehicles EPA tested represent a range of mileage, though we would have preferred to test at least one vehicle with mileage closer to the EPA regulatory useful life (435,000 miles) or beyond.
- EPA standards and regulations require a certification process which includes tests of new engines and with deteriorated parts to quantify the emissions at the end of the regulatory useful life to ensure compliance with EPA standards. EPA’s regulations require engines to meet these standards throughout their regulatory useful life. EPA’s compliance process includes both EPA testing of in-use vehicles, as well as mandatory Manufacturer-run In-use Vehicle testing of a subset of engines within their useful life to demonstrate compliance with the EPA emission standards, including the Not to Exceed (NTE) standards.

**TTU Question 2:** Who loaned the two Glider vehicles?

**EPA Response:**

- The vehicles were provided to EPA by a truck dealership for the purpose of the testing.

**TTU Question 3:** Our understanding is that Fitzgerald and other glider assemblers sell many options to customers, including KIT ONLY, customer supplied engines, and factory

remanufactured engines from Cummins and Detroit Diesel. Can you please provide the VIN #s to allow us to determine the engine set-up?

**EPA Response:**

- Both glider vehicles were equipped with engines tagged with serialized Fitzgerald placards, as well as warning placards advising to contact Fitzgerald prior to any mechanical work to be performed.
- We treat the VIN and engine serial number of borrowed vehicles used in research as Personal Identifiable Information and do not release them.

**TTU Question 4:** Did you verify that the ECM's were set to the engine rebuilder's specifications? ... or did you verify that the ECMs had not been modified, altered, or tampered with prior to testing?

**EPA Response:**

- Beyond the existence of the Malfunction Indicator Light illumination (MIL), which could indicate modification or tampering, EPA did not verify that the ECM as installed had not been modified, altered, or tampered with prior to testing. As discussed in response to Question 1, the purpose of this test program is to understand how these vehicles are emitting in the real world. We would note that, based on the EPA testing as documented in the EPA test report, these vehicles exhibited test results consistent with engines of their particular vintage, that is, highway heavy-duty diesel engines produced between model years 1998 and 2002, and the emission performance is also consistent with the emission performance in general of a 10-15 liter diesel engine which does not include modern emission-control technology such as exhaust gas recirculation, diesel particulate filter, or a SCR-based NOx reduction catalyst.

**TTU Question 5:** Did you leak test the cylinders, verify boost, or verify the fuel maps for the test?

**EPA Response:**

- EPA does not routinely do these verifications on test articles within their regulatory useful life unless there is a MIL illuminated or we have other reasons to suspect issues. Also, as discussed in response to Question 1, the purpose of this testing is to understand how these vehicles are emitting in the real world.

**TTU Question 6:** Were the gliders and the 'other recent model trucks' tested on the same day? ... or was the comparison data pulled from existing test outcomes for the 'other trucks'?

**EPA Response:**

- All of the tractors were tested in the same heavy-duty chassis dynamometer test cell as the glider vehicles according to the protocols included in Title 40 of the Code of Federal Regulations, Part 1066 to ensure the repeatability and quality of the data. This includes control of the test cell ambient conditions. Each of the vehicles were tested on different days. The comparison data for the two other tractors documented in the EPA test report come from existing test data collected by EPA using the same test cell, test equipment, and test procedures.

**TTU Question 7:** Did all four test vehicles have the exact same operating fluids (fuel / oil / coolant, etc.)? If different, please provide the operating fluid information for all four vehicles.

**EPA Response:**

- All four test vehicles were tested with the same fuel, which met the EPA highway certification diesel fuel specifications. The coolant and oil were as-received. For the International Day cab tractor, this was the factory-fill. For the other three vehicles, they were as maintained by the owner.

**TTU Question 8:** Why were the Glider Kits emissions compared to ‘other recent model trucks’ instead of the 2010 EPA Clean Air Act Emissions Standards?

**EPA Response:**

- As discussed in the response to Question 1, a principal goal of the glider tractor testing was to measure the emissions performance in an actual vehicle under representative driving cycles and to compare those to newly built engines/tractors, in order to provide EPA with the data on which we can estimate the overall real-world emissions impact of glider vehicles. We are not trying to compare the glider vehicles to EPA’s 2010 and later engine-based standards. EPA staff already were aware that glider engines derived from engines which were originally designed and built to comply with EPA’s standards in the 1998-2002 timeframe will not meet EPA’s 2010 and later standards. EPA’s standards and test procedures have changed significantly in the past 20 years. Today’s newly built engines must meet EPA standards for a regulatory useful life of 435,000 miles, while the 1998-2002 standards only applied for a regulatory useful life of 290,000 miles. EPA’s standards today require a mandatory Manufacturer-run In-use, on-the-road, testing of vehicles acquired and driven by actual users – this program did not exist and does not apply to the 1998-2002 model year engines. Today’s EPA standards include mandatory On-Board Diagnostics requirements, which did not exist and did not apply for the 1998-2002 model year engines. In addition, EPA’s emission standards for NOx and PM for current model year engines are significantly lower than the standards that applied in 1998-2002, and OEMs have nearly universally utilized significant degrees of advanced technology to achieve the 2010 and later standards, including but not limited to

electronic fuel injection systems at a level of manufacturing quality and design limits which did not exist in the 1998-2002 time frame, turbocharger technology at a level of manufacturing quality and design limits which were not utilized in the 1998-2002 time frame, cooled exhaust gas recirculation technology, diesel particulate filter technology, and SCR-based NOx catalysts.

**TTU Question 9:** Why is the Particulate Matter reflected in milligrams per mile instead of the standard g/bhp-hr? ... and why are the others reflected in per mile increments?

**EPA Response:**

- We use different metrics depending on the purpose of the testing or the comparison we are making. Three of the common metrics are discussed below.
- 1) **Work-based metrics** (like grams per brake-horsepower hour) are used for certification and compliance based on engine testing using the EPA regulatory certification cycles for the EPA engine-based emission standards. To develop an estimated comparison to the standards, we reported PM, CO, NOx, and NMHC in g/bhp-hr over the UDDS and SET Intermediate speed test cycles on pages 18-20 of the November 20 glider test report. The comparison was done with the chassis test results from the UDDS cycle because this vehicle cycle was created using the same methodologies and in-use data as was used for the Heavy-duty Engine Federal Test Procedure (FTP) cycle. For the other drive cycles included in the November 20 report, Table 11 can be used to convert g/mile results to estimated g/hp-hr.
  - 2) The test results for each drive cycle from our HD chassis test site are reported in **grams per mile** (or in the case of particulate matter, milligrams per mile). This is typical of chassis testing and is a metric that many stakeholders and researchers are familiar with. It is also representative of how emissions are emitted in the real-world.
  - 3) We also evaluate emissions in **grams per second** to develop emission rates (factors) in EPA's vehicle emissions inventory projection model – the EPA MOVES model. The MOVES model relies on data from on-road testing or chassis testing. Emission rates are developed in terms of grams per second for a given operating mode, which is dependent on vehicle speed and power.

**TTU Question 10:** What was the fuel economy on the 'other recent model trucks'?

**EPA Response:**

- CO<sub>2</sub> emissions are directly proportional to the road load of the vehicle. Because we did not measure the actual road load of the vehicles, we used the same target road load coefficients in the two sets of comparisons (at 60,000 and 80,000 miles). Therefore, the comparison only evaluates the performance of the powertrain and may not be

representative of the difference in CO<sub>2</sub> emissions that these vehicles would experience in-use. In all cases, the CO<sub>2</sub> emissions were lower in the glider powertrains. This is not unexpected given the known trade-off between NO<sub>x</sub> and CO<sub>2</sub> emissions with respect to injection timing and similar engine calibration techniques and the relatively higher NO<sub>x</sub> emissions for the glider vehicles.

- The CO<sub>2</sub> results shown in Figures 18 and 19 can be converted to mpg using the conversion factor of 10,180 grams of CO<sub>2</sub> per gallon of diesel fuel.

**TTU Question 11:** Can you provide the equivalents to Tables 12-13-14 for the ‘other recent model trucks’?

**EPA Response:**

- We do not have equivalent test data for the other recent model year trucks for the information presented in Tables 12-14 of the November 20 test report.
- We developed the chassis-based Supplemental Emission Test (SET) test procedure during the testing of the second glide to represent the steady-state operation of the engine-based SET cycle. This was done for two reasons. First, it provides steady-state results to complement the transient UDDS results. Second, following our conversation with TTU in early November where we learned that TTU had done testing at several steady-state operating conditions, we believe this SET testing would provide a useful comparison when considering the steady-state data gathered by Tennessee Tech.

**TTU Question 12:** While repairing Glider #1 and testing it ‘as-is’ may be representative of the real world performance, have any OEM trucks been tested in similar conditions? If so, what were the results?

**EPA Response:**

- All vehicles used in this type of in-use testing are tested “as-is” after inspection to determine whether they are in proper working order and when necessary, at a mileage less than full useful life. Glider #1 is the only vehicle that we have tested that has had a check engine light on.
- Testing a heavy-duty vehicle with a check engine light on is useful for EPA. We took advantage of the opportunity to test Glider #1 as-received and after the repair. The HD exhaust emission rates in MOVES are comprised of emission rates of normal operating vehicles plus an impact due to tampering and/or malmaintenance of the vehicle. The emission rates post-repair would be compared against the emission rates currently in MOVES representing normal operating vehicles.

**TTU Question 13:** Given the condition of Glider #1, is it fair to say the glider vehicles were pulled off the road and tested ‘as-is’? Were the two OEM s used for comparison also pulled off the road and tested ‘as-is’?

**EPA Response:**

- Yes, the glider vehicles were tested as-is after a visual inspection – please also the responses to Questions 1 and 2. This is typical of the procedures we use to develop emission factors for our MOVES emissions model, which represents emissions from a full range of in-use vehicles. We obtain a significant amount of engine data in the “new” condition at certification and manufacturers provide some in-use emissions data of well-maintained vehicles to demonstrate compliance with the EPA Not-to-Exceed emission standards. The data that is more difficult to obtain are the emissions from in-use vehicles, which is represented by the “as-is” condition.
- The Freightliner sleeper cab discussed in the November 20 glider test report was an in-use vehicle pulled in for testing after over 360,000 miles of use and was tested “as-is” after a visual inspection. The International day cab discussed in the November 20 glider test report was purchased new and was tested after approximately 10,000 miles of mileage accumulation.

**TTU Question 14:** The test fuel used in this program met EPA Highway Certification diesel fuel specifications in 40 CFR part 1065 as stated in Table 2. Further the gliders went through a triple drain and flush procedure shown in Table 3 to ensure the engines were performing on the Test Fuel. Can you provide the fuel properties for the two comparison vehicles and the original test dates for those vehicles?

**EPA Response:**

- All of the vehicles were tested using the same certification diesel fuel.
- The International day cab tractor and Freightliner sleeper cab were tested between April 28 and May 9, 2017.