MJB&A

CONCORD, MA - WASHINGTON, DC

47 Junction Square Drive
Concord, MA 01742

978-369-5533
www.mjbradley.com

MJB&A Issue Brief ■ November 4, 2015

Responding to EPA Allegations, VW Admits to Installing "Defeat Devices" on Diesel Engines

On September 18, 2015, EPA issued a notice of violation of the Clean Air Act to German carmaker, Volkswagen (VW). The notice alleges VW violated the Clear Air Act when they knowingly manufactured and installed "defeat devices" in the engines of 482,000 four-cylinder Volkswagen and Audi diesel cars sold in the U.S. from model years 2009 to 2015, which resulted in higher in-use nitrogen oxide (NOx) emissions from these vehicles than allowed by EPA regulations. Affected vehicles include the Jetta, Beetle, Audi A3, Golf, and Passat, all with four-cylinder 2.0 liter turbocharged direct injection diesel engines (TDI).

According to EPA regulations, a defeat device is an "auxiliary emission control device (AECD) that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation." EPA alleges that VW installed software in the engines' electronic control modules that can determine when the vehicle is being tested on EPA's certification test cycle, based on inputs such as the position of the steering wheel, the vehicle speed, the duration of the engine's operation, and barometric pressure. When the software detects that a vehicle is being tested, it enables the full capability of the engine's emission control system, lowering engine-out NOx emissions to comply with EPA regulations. When the software detects that the vehicle is not being tested, the emission control system is turned off, or de-rated, allowing NOx to increase.

VW has since admitted the cheating and has indicated that the same software was installed on an additional 10.5 million vehicles sold in other countries. Market repercussions have fallen on the company quickly. The company's CEO, Martin Winterkorn, resigned on September 23, the day after VW admitted wrong doing, and VW stock has fallen to a third of its price before the announcement. VW has indicated that they have set aside $7.3 billion this fiscal year to cover costs related to the scandal.

Key Takeaways

- In accordance with the Clean Air Act, EPA can fine VW up to $41,250 for every vehicle it sold in the U.S. with a defeat device – or as much as $15.7 billion. EPA can, and certainly will, also require VW at their own expense to recall all 482,000 U.S. vehicles, to remove the defeat devices and ensure that in the future they do not emit excess NOx. VW is also facing class action lawsuits from customers worried that their future fuel costs will increase after the fix and/or that the value of their vehicles will fall. Total U.S. costs for VW to fix this problem could exceed $1 billion, in addition to any EPA fines.
- Owners of these vehicles will almost certainly face increased operating costs after VW removes the defeat devices from their engines – due to either reduced fuel economy or increased use of diesel emission fluid (DEF), depending on what emission control system is installed. Annual operating costs could increase by $40 or more for 12,000 miles of driving.

- In-use emissions from these vehicles are 8 to 34 times greater than allowed by EPA standards, depending on the installed emission control system and the type of driving (highway versus city). By the time VW removes the defeat devices from all 482,000 U.S. cars they will likely have emitted more than 42,000 tons of excess NOx – equivalent to the emissions from more than 550 billion miles of driving in a car that meets EPA standards, or to the NOx emitted by 15 U.S. coal-burning power plants annually.
- The emission standards in other countries are less stringent than EPA standards. Nonetheless, excess NOx from the 10.5 million vehicles that VW sold with the defeat device software overseas could exceed 500 million tons through 2017. If regulators or customers in these countries force VW to remove the defeat devices from these cars, and bring them into compliance with European emission regulations, VW's additional costs could reach between $10 and $30 billion.

Background

Federal emissions regulations for new vehicles limit the amount of NOx, volatile organic carbon compounds (VOC), carbon monoxide (CO) and particulate matter (PM) that can be emitted from vehicle tailpipes. NOx and VOC are limited because they are "ozone precursors" – in the presence of sunlight atmospheric NOx and VOC are chemically transformed into ground level ozone, or smog, which is a respiratory irritant that has been linked to a number of negative health effects.

Current EPA emission standards limit allowable NOx emissions from all U.S. cars to no more than 0.07 grams per mile.[1] Compliance is based on testing using the Federal Test Procedure (FTP) - representative vehicles are mounted on a chassis dynamometer and operated over a specific set of test cycles in a laboratory. EPA's regulations also specify that in-use emissions should be no more than this limit for at least 120,000 miles of driving.

EPA was first alerted to potential problems with VW diesel vehicles in May 2014 when West Virginia University published the results of emission testing of three diesel cars, including a 2012 VW Jetta TDI and a 2013 VW Passat TDI. Testing was performed on five different in-use routes, including one that represents high-speed highway driving and three that represent slower-speed urban driving. In terms of average speed and other metrics these routes are similar to the FTP test cycles.

WVU's results showed that the third diesel tested (not a VW) generally met EPA's standards (<0.07 grams per miles (g/mi) NOx) during both urban and highway driving. However, both VWs emitted significantly more NOx than allowed. The Jetta emitted 0.99 g/mi NOx on the highway route and as much as 2.38 g/mi on one of the urban routes. NOx emissions from the Passat were lower, but still averaged 0.55 g/mi on the highway route and as much as 1.31 g/mi on one of the urban routes. Subsequent evaluation of the same vehicles by the California Air Resources Board (CARB) confirmed that they met the EPA NOx standards when tested using the FTP.

EPA questioned VW about this discrepancy, and the company offered various explanations. VW agreed to a voluntary recall in December 2014, but subsequent testing by EPA and CARB indicated that the changes VW made under the recall were not effective. Further evaluation by CARB failed to verify any of the technical explanations offered by VW. EPA and CARB refused to approve Certificates of Conformity[2] for VW's 2016 model year vehicles

[1] Individual models can be certified to a higher level, but annually each manufacturer's sales must average to no more than this limit. The VW diesel cars in question were all certified by VW to this fleet average limit, based on testing using the federal test procedure.

[2] Without a Certificate of Conformity verifying compliance with EPA emission regulations car manufactures cannot legally sell vehicles in the U.S.

until the company explained the reasons for high in-use NOx emissions from their 2009 to 2015 model year vehicles, and provided adequate assurance that this would not happen on future vehicles. At that point VW admitted that they had installed a defeat device on these vehicles, in the form of a sophisticated software program that could determine when the vehicle were being tested.

Most recently, EPA, CARB and Environment Canada's lab performed additional testing and found that three more vehicles models (VW Touareg; Porsche Cayenne; and the Audi A6 Quattro, A7 Quattro, A8, A8L, and Q5) (years 2014 to 2016) installed similar defeat device software. These vehicles are slightly larger, equipped with the 3.0 liter diesel engine. On November 2, 2015, EPA issued a second notice of violation of the CAA to VW, alleging that the NOx emissions are up to nine times the legal limit of emissions in these models.

Why are VW diesel in-use emissions high?

In order to meet current EPA emission limits all diesel vehicles need to use "after-treatment" devices installed in the tailpipe to remove NOx and PM produced by the engine before it enters the atmosphere. To remove PM, diesel vehicles use a diesel particulate filter (DPF). To remove NOx there are two different technologies that could be used: a lean NOx trap (LNT), or selective catalytic reduction (SCR). Both of these technologies use catalysts to promote chemical reactions in the exhaust that reduce nitrogen oxides to elemental nitrogen, but they do it in very different ways.

During normal "lean" operation of the diesel engine, when there is a lot of excess oxygen in the exhaust, barium or other oxides in an LNT catalyst chemically bind nitrogen oxides, removing them from the exhaust and storing them in the catalyst. However, the catalyst must be periodically "regenerated" to remove and reduce stored nitrogen. To do so, additional diesel fuel is injected into the exhaust to create "rich" conditions for a short period of time. This causes the stored NOx to release from the barium catalyst and allows it to be reduced to elemental nitrogen, preventing it from entering the atmosphere, across a second reducing catalyst which is similar to the catalytic converter installed on gasoline vehicles for the same purpose. The more NOx that is produced by the engine, the larger the LNT storage catalyst needs to be, and/or the more frequently it needs to be regenerated, and the more diesel fuel is required for the regeneration.

SCR systems do not store NOx like LNT systems; they use a single reducing catalyst to continuously reduce nitrogen oxides to elemental nitrogen. However, because diesel engines operate lean they need a "reductant" to allow this to happen. The reductant of choice for diesel engines is a solution of 32% urea in water. This urea solution is typically referred to and sold as "diesel emission fluid' (DEF). The DEF is injected into the exhaust ahead of the catalyst and the nitrogen oxides are reduced across the catalyst. The more NOx that is produced by the engine the larger the SCR catalyst needs to be, and the more DEF is required.

VW sold diesel vehicles in the U.S. with both LNT and SCR systems. Starting in model year 2009 the Jetta TDI was introduced in the US with an LNT system as part of its emission controls. The next year the Golf TDI and Audi A3 TDI went on sale in the U.S., followed by the Beetle TDI in model year 2012; all of these models used LNT through the 2014 model year. Also in model year 2012, VW introduced the Passat TDI in the U.S., but this model did not use LNT – it came with SCR. In the 2015 model year, VW discontinued the use of LNT and all of its U.S. diesel models were sold with SCR systems (Jetta, Golf, Beetle, Passat, Audi A3).

Of the 482,000 diesel vehicles that VW sold in the U.S. with defeat devices about two thirds have LNT systems and one third have SCR systems. During the WVU testing, NOx emissions were significantly higher from the LNT-equipped VW car than from the SCR-equipped VW car.

The reason why in-use emissions from these vehicles is higher than it is on emissions tests varies depending on whether they use LNT or SCR. For Jetta, Golf, Beetle, and Audi A3s with LNT systems it is likely that at times when the defeat software determines that the vehicle is on an official emissions test the LNT system is regenerated at a rate that lowers NOx to the level required by EPA (<0.07 g/mi). However, it is likely that when the software determines that the vehicle is not being tested the engine ECM regenerates the LNT system less frequently, thus saving fuel, but also allowing more NOx to exit the tailpipe. It is also possible that VW did not size the LNT catalyst to be effective if used all the time. It is likely that VW installed the defeat software to increase real-world fuel economy, and also potentially to reduce the cost of the LNT system, on these vehicles.

Similarly, for the Passats and all model year 2015 vehicles equipped with SCR systems, when the defeat software determines that the vehicle is on an official emissions test the engine ECM likely injects enough DEF to reduce NOx to the level required by EPA. However, when the software determines that the vehicle is not being tested the engine ECM likely injects less DEF into the exhaust, thus allowing more NOx to exit the tail pipe. VW advertises that the DEF tank only needs to be re-filled every 15,000 miles, or less than once a year for the typical customer. Based on the WVU testing it is likely that the DEF tank would have to be re-filled three times as often (more than twice a year) if the defeat software was not installed.

What will VW have to do to fix the problem?

EPA will almost certainly issue a mandatory emissions recall for all model year 2009 and later VW diesel vehicles with 2.0 liter TDI diesel engines. This means that VW will be required to notify all customers who own one of these vehicles, to bring it to a VW dealer to be fixed at no charge. At a minimum, the fix will require that the engine ECM be reprogrammed to remove the defeat software. If existing ECMs can be reprogrammed this could cost VW less than $100 per car, but if the ECMs must be replaced with new hardware this could cost VW more than $500 per car.

It is also possible that VW may be required to replace the catalysts or other components of the LNT and SCR systems on these vehicles to increase their capacity or activity, or to correct any durability issues. This could cost a thousand dollars per car, or more. In the extreme, VW may need to make other changes to the base engines to reduce engine-out NOx; the bill for this would certainly be thousands of dollars per engine. VW has already hinted that on some engines (likely those equipped with LNT) the required fix will include significant hardware changes, not just removal of the defeat software. It is possible that for these vehicles the existing LNT systems will need to be removed and replaced with new SCR systems.

Any fix will increase fuel use for Jetta, Golf, Beetle, and Audi A3 vehicles with LNTs by 2% or more; this will reduce in-use fuel economy by at least one mile per gallon, costing owners an additional $40 or more per year in fuel bills. DEF use will likely triple for Passat cars with SCR – again costing their owners an additional $40 or more per year.

Given the fact that their costs will increase, many VW owners will likely be reluctant to get their cars fixed. This will be of concern to EPA, which will want VW to provide incentives to ensure that the recall is completed on as many cars as possible, as quickly as possible. Class action lawsuits against VW may also force additional compensation to vehicle owners. If VW is forced to pay owners' additional fuel and DEF bills for the remainder of the emissions warranty period (120,000 miles) on all 482,000 affected U.S. cars these costs will add up to at least $70 million. All together VW's costs to fix this problem could total $1 billion or more in the U.S. – in addition to any fines levied by EPA.

How does VW cheating affect the environment?

Based on the WVU test data, the Jetta, Golf, Beetle, and Audi A3 cars with defeat devices are each emitting about 43 pounds more NOx per year than allowed by EPA and the Passat cars with defeat devices are each emitting about 25 pounds per year excess NOx[3]. By the time all of these defeat devices are removed (likely 2017 at the earliest) the 482,000 vehicles in the U.S. will have emitted more than 42,000 tons of excess NOx into the atmosphere. This is equivalent to an additional 550 billion miles of driving in cars that meet EPA standards, or to the NOx emitted by 15 U.S. coal-burning power plants annually.

What about VW cars sold overseas?

Most, if not all, of the 10.5 million diesel vehicles that VW sold with defeat software in other countries were certified to Euro 5 emission standards, which are somewhat less stringent that EPA standards. Nonetheless, if the defeat software works in a similar manner on these cars they may already have emitted more than 300,000 tons of excess NOx, and will continue to emit more than 130,000 tons of excess NOx every year until the software is removed and they are brought into compliance with EU emission standards.

While it is already clear that EPA will force VW to fix the in-use NOx problem on cars sold in the U.S. it is not clear that regulators in other countries will be as aggressive, if only because they lack the full complement of enforcement tools provided to EPA under the Clean Air Act. Compared to EPA regulations, Euro 5 has relatively weak in-use compliance and enforcement provisions. The Euro 5 legislation has only vague language about in-use compliance, which has never been clarified by the European Commission in implementing regulations. Euro 5 also does not require manufacturers to conduct any in-use testing (as EPA regulations do) and once issued "type approval" for a given vehicle (the equivalent of EPA's Certificate of Conformity) is good until emissions standards change – it does not need to be renewed each model year as required by EPA. This gives approval authorities limited basis for revocation of type approval based on poor in-use performance.

If European regulators – or customer litigation – forces VW to implement similar fixes as what is likely to be required in the U.S., total costs for VW to get this scandal behind them could reach $10 - $30 billion worldwide.

[3] Based on 12,928 miles per year and assuming 60% urban/40% highway driving

Contacts

Dana Lowell
Senior Vice President and Technical Director
dlowell@mjbradley.com
(978) 369-5533

Kaley Bangston
Policy Analyst
kbangston@mjbradley.com
(978) 369-5533

About Us

MJB&A provides strategic consulting services to address energy and environmental issues for the private, public, and non-profit sectors. MJB&A creates value and addresses risks with a comprehensive approach to strategy and implementation, ensuring clients have timely access to information and the tools to use it to their advantage. Our approach fuses private sector strategy with public policy in air quality, energy, climate change, environmental markets, energy efficiency, renewable energy, transportation, and advanced technologies. Our international client base includes electric and natural gas utilities, major transportation fleet operators, investors, clean technology firms, environmental groups and government agencies. Our seasoned team brings a multi-sector perspective, informed expertise, and creative solutions to each client, capitalizing on extensive experience in energy markets, environmental policy, law, engineering, economics and business. For more information we encourage you to visit our website, www.mjbradley.com.