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Defeat devices under the U.S. and EU passenger vehicle emissions testing regulations

One noteworthy aspect of the still-developing story concerning excess nitrogen oxide emissions from Volkswagen diesel cars is this: VW and other automakers have asserted that software managing the emissions control systems on some of their vehicles, which they acknowledge either is or would be considered an illegal defeat device under the U.S. vehicle emissions regulation, is either not a defeat device or not prohibited as such under the European Union regulation. It is noteworthy because the language defining and prohibiting defeat devices in the U.S. and EU regulations is nearly identical; the differences are minute and immaterial.

This briefing paper summarizes the relevant provisions of the current EU and U.S. regulations, reviews what is publicly known about the automakers' positions with respect to those provisions, and contributes an independent engineering perspective where that seems relevant. The intent is to provide useful context for evaluating proposals to revise and extend the regulations governing passenger vehicle type approval and real-world testing in Europe. Such a summary spotlights ambiguities in the EU regulation as it presently stands—and potentially in any regulation patterned on it, as many national vehicle emissions regulations are—that should be corrected as part of any effort to ensure that vehicle emissions standards are met in practice and not just in theory.

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U.S. AND EU REGULATIONS

A colloquial definition of an automotive defeat device would be anything intended to circumvent a vehicle emissions test. The U.S. and EU regulations are more precise.

The U.S. regulation (40 CFR §86.1803-01) defines a defeat device as follows:[1]

> *Defeat device means 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 and use, unless:*
>
> *(1) Such conditions are substantially included in the Federal emission test procedure;*
>
> *(2) The need for the AECD is justified in terms of protecting the vehicle against damage or accident;*
>
> *(3) The AECD does not go beyond the requirements of engine starting; or*
>
> *(4) The AECD applies only for emergency vehicles and the need is justified in terms of preventing the vehicle from losing speed, torque, or power due to abnormal conditions of the emission control system, or in terms of preventing such abnormal conditions from occurring, during operation related to emergency response. Examples of such abnormal conditions may include excessive exhaust backpressure from an overloaded particulate trap, and running out of diesel exhaust fluid for engines that rely on urea-based selective catalytic reduction.*

It additionally defines an AECD (§86.1803-01) as:

> *any element of design which senses temperature, vehicle speed, engine RPM, transmission gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the emission control system.*

And it prohibits (§86.1809-01) the use of defeat devices:

> *(a) No new light-duty vehicle, light-duty truck, or complete heavy-duty vehicle shall be equipped with a defeat device.*

Where the U.S. regulation defines a defeat device by reference to a separately defined AECD, the European Union regulation (Regulation (EC) No 715/2007 Art. 3, par. 10) combines the two into a single definition, using nearly identical language:[2]

> *'defeat device' means any element of design which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use;*

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1 Code of Federal Regulations, Title 40 Part 86 – Control of Emissions from New and In-Use Highway Vehicles and Engines. The text of the U.S. regulation is online at http://www.ecfr.gov/cgi-bin/text-idx?node=pt40.19.86&rgn=div5#se40.19.86_11809_601.

2 European Commission, Regulation (EC) No 715/2007 of the European Parliament and of the council of 20 June 2007. The text of the EU regulation is online at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:171:0001:0016:EN:PDF.

And, where the U.S. regulation specifies certain conditions in which an AECD shall not be considered a defeat device and then prohibits all use of defeat devices, the EU regulation (Art. 5, par. 2) prohibits all use of defeat devices but then specifies that the general prohibition shall not apply under the same conditions as are specified in the U.S. regulation for AECDs (save one, related to emergency vehicles), defined in closely similar language:[3]

> *The use of defeat devices that reduce the effectiveness of emission control systems shall be prohibited. The prohibition shall not apply where:*
>
> *(a) the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle;*
>
> *(b) the device does not function beyond the requirements of engine starting;*
>
> *or*
>
> *(c) the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions*

U.S. AND EU DEFEAT DEVICE ENFORCEMENT PROVISIONS

Where the U.S. and EU regulations diverge is in their provisions concerning how manufacturers obtain the exemption provided for under those carefully specified, effectively identical conditions, and in their provisions for penalizing the failure to disclose AECDs or the illegal use of defeat devices.

The U.S. regulation (§86.1844 [d][11]) requires manufacturers to submit to the EPA at the time of their application for a certificate of conformity "A list of all auxiliary emission control devices (AECD) installed on any applicable vehicles, including a justification for each AECD, the parameters they sense and control, a detailed justification of each AECD that results in a reduction in effectiveness of the emission control system, and rationale for why it is not a defeat device as defined under §86.1809." The regulation also requires manufacturers to provide, as deemed necessary by the EPA Administrator, detailed technical descriptions and calibration specifications of all emission-related components and AECDs (§86.1844-01[g][4-5]) and explicitly gives the Administrator authority to review the manufacturer's proposed justification, stating that an AECD "may be disapproved by consideration of currently available technology, whereupon the application for certification may be disapproved under §86.094-22(b) for the incorporation of a defeat device" (§86.094-21 [b][1][i][B]). This language gives clear and detailed guidelines as to the responsibility of both the manufacturer and the regulatory agency in terms of the level of detail to be provided, the timing of disclosure, and what the agency must evaluate and approve.

The EU framework regulation does not itself detail how the prohibition on the use of defeat devices, including the administration of exemptions, is to be implemented. Instead, Article 5(3) of Regulation (EC) 715/2007 empowers the Commission to adopt implementing measures setting out the "requirements for the implementation

3 Where the U.S. regulation also covers heavy-duty vehicles (among other things), the EU regulates HDVs separately, in Regulation (EC) No 595/2009. That regulation refers to defeat "strategies" rather than devices, but defines and prohibits them in substantially similar ways with similar exemptions. This briefing paper, however, will focus solely on light-duty vehicles.

of [Article 5(2)]" (which contains the language prohibiting defeat devices) via the "regulatory procedure with scrutiny" set out in Decision 1999/468/EC of the European Council. The justification for this is set out in Recital 26 of Regulation (EC) 715/2007, which states that "Power should also be conferred on the Commission to establish specific procedures, tests and requirements for type approval, as well as a revised measurement procedure for particulates and a particle number based limit value, and to adopt measures concerning the use of defeat devices, access to vehicle repair and maintenance information and test cycles used to measure emissions. Since those measures are of general scope and are designed to supplement this Regulation by the addition of new non-essential elements, they should be adopted in accordance with the regulatory procedure with scrutiny provided for in Article 5a of Decision 1999/468/EC."

The regulatory procedure with scrutiny requires the Commission to submit a draft measure to a committee composed of Member State representatives for review, and then to the European Parliament and Council for approval. This process resulted in EC Regulation 692/2008, which addresses the directive in Regulation 715/2007 to establish specific procedures, tests and requirements for type approval, as well as a revised measurement procedure for particulates and a particle number based limit value, access to vehicle repair and maintenance information, and test cycles used to measure emissions. However, Regulation 692/2008 does not explicitly define procedures by which manufacturers will disclose defeat devices or apply for one of the exceptions to the prohibition of defeat devices; assign authority to review such an application; or describe criteria by which an application should be evaluated, and the terms under which it may be approved or denied. That is, the EU implementing regulation, 692/2008, contains no close analog to the highly specific provisions in the U.S. regulation that govern how manufacturers' compliance with the ban on defeat devices is to be scrutinized during the type-approval/certification process.

In the U.S., civil penalties for violating the vehicle emissions regulation are spelled out not just in the regulation itself but also in general law, in the U.S. Code (42 U.S.C. §7524) and the Code of Federal Regulations (40 CFR §19.4). The U.S. Environmental Protection Agency may levy civil penalties of up to $37,500 per vehicle and $3,750 per sale of defeat device.[4] The agency has a long history of penalizing both foreign and domestic manufacturers for the use of defeat devices.[5]

The EU vehicle emissions regulation (EC 715/2007, Article 13) directs the Member States to "lay down the provisions on penalties applicable for infringement by manufacturers of the provisions of this Regulation and [to] take all measures necessary to ensure that they are implemented." The regulation was adopted in 2007, and Member States were to have notified the Commission by January 2009 of those provisions. In November 2015, the European Commission began an investigation into, among other things, whether "all Member States put in place effective, proportionate and dissuasive penalties to sanction infringement of the type-approval rules." A

4 For the EPA's summary, see "Clean Air Act Vehicle and Engine Enforcement Case Resolutions," http://www.epa.gov/enforcement/clean-air-act-vehicle-and-engine-enforcement-case-resolutions. The agency also uses its "Mobile Source Civil Penalty Policy" for determining penalties in enforcement settlements, http://www.epa.gov/sites/production/files/documents/vehicleengine-penalty-policy_0.pdf.

5 Megan Geuss, "Volkswagen's emissions cheating scandal has a long, complicated history," ArsTechnica, 8 October 2015, http://arstechnica.com/cars/2015/10/volkswagens-emissions-cheating-scandal-has-a-long-complicated-history/

January 2016 working document summarizing the replies the Commission had received to that point reports cursory information on penalties from only 18 of the 28 member states.[6] These range from fines to withdrawal of type approval, recall and repair obligations, and prison.

THE VOLKSWAGEN CASE

In September 2015 the U.S. EPA and the California Air Resources Board announced that a number of VW 2.0L diesel vehicle models sold in the U.S. during model years 2009 to 2015 had been equipped with illegal defeat devices.[7] The EPA's Notice of Violation stated that "VW manufactured and installed software in the electronic control module (ECM) of these vehicles that sensed when the vehicle was being tested."[8] The defeat device was described as a "switch" that "senses whether the vehicle is being tested or not based on various inputs including the position of the steering wheel, vehicle speed, the duration of the engine's operation, and barometric pressure." If the ECM senses parameters that are in line with the certification test procedure the ECM adjusts the emissions control system, by using an a specific emissions control scheme, to produce compliant emissions. At other times the ECM switches to an alternative emissions control scheme which optimizes for other performance characteristics. The number of vehicles affected in the United States was approximately 500,000, and VW acknowledged that some 11 million vehicles worldwide had similar software, including more than 8 million in Europe.

The EPA issued a second notice of violation in November 2015 for VW model year 2009–2016 vehicles equipped with 3.0L diesel engines stating that "VW manufactured and installed software in the electronic control module (ECM) of each vehicle that causes the vehicle to perform differently when the vehicle is being tested for compliance with EPA emission standards than in normal operation and use."[9] While the description of the defeat device was more detailed than in the September notice of violation, in both cases the vehicles were operating under two emissions control regimes: one during emissions testing, and one at other times. The EPA described the defeat device used in the 3.0L vehicles as software that determines when the vehicle has begun the FTP 75 certification test and then employs a low-NO_x temperature-conditioning mode, varying a number of engine parameters to yield lower engine-out NO_x and higher exhaust temperatures to achieve better conversion over the emissions

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6 [Commission Staff Working Document] Impact Assessment Accompanying the Proposal for a Regulation of the European Parliament and the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, European Commission, January 27, 2016, http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1453996334099&uri=SWD:2016:9:FIN. Additional analysis to complement the impact assessment: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST_5712_2016_ADD_3&from=EN

7 Bill Vlasic and Aaron M. Kessler, "It took EPA pressure to get VW to admit fault," *New York Times*, September 21, 2015, http://www.nytimes.com/2015/09/22/business/it-took-epa-pressure-to-get-vw-to-admit-fault.html; Jeff Plungis and Dana Hull, "VW's Emissions Cheating Found by Curious Clean-Air Group", Bloomberg, September 20, 2015, http://www.bloomberg.com/news/articles/2015-09-19/volkswagen-emissions-cheating-found-by-curious-clean-air-group.

8 U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance, "Notice of Violation", September 18, 2015, http://www.epa.gov/sites/production/files/2015-10/documents/vw-nov-caa-09-18-15.pdf.

9 U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance, "Notice of Violation", November 2, 2015, http://www.epa.gov/sites/production/files/2015-11/documents/vw-nov-2015-11-02.pdf.

control catalyst. The software employs a timer that coincided with the time needed to run the FTP 75, after which the emissions control system switches to a different mode that immediately changes the parameters and creates much higher engine-out NO_x and lower conversion in the catalyst. The number of vehicles affected in the United States was approximately 85,000. For comparison, the number of Euro 5 and Euro 6 3.0L diesels sold by Volkswagen group in the EU is over 500,000.

All the affected VW vehicles in the U.S. were certified to the EPA's Tier 2, Bin 5 emissions standard. In the EU, they were regulated under the Euro 5 emissions standard.[10] These regulations set different NO_x emissions limits (43.5 mg/km in the U.S., 180mg/km in the EU for diesel vehicles) and require different test protocols and test cycles (the Federal Test Procedure [FTP 75] and the New European Driving Cycle [NEDC]). Exhaust aftertreatment systems are needed to meet the lower U.S. limits, and diesel vehicles in the U.S. market, including VW's, employ either selective catalytic reduction (SCR) or a lean NO_x trap (LNT), in combination with exhaust gas recirculation (EGR).[11] In the EU, EGR alone is typically sufficient to meet the NO_x emissions standard, although some Euro 5 diesel cars (including VW's SEAT Alhambra and Sharan 2.0L diesels and Golf 1.6L TDI) also use SCR or LNT. Thus, the ECM software used to change the emissions control system performance during certification testing will likely differ in some ways according to the specific emissions control technology used on a given model and the details of the certification test it is required to pass.

Volkswagen's responses to the two notices of violation in the U.S. differed, and the company has taken yet another approach in Europe. Volkswagen admitted to the EPA and CARB that it had installed and used defeat devices in its 2.0L diesel engines in the U.S. before the agencies issued the formal notice.[12] But VW initially denied that the software used in the 3.0L diesel vehicles identified in the November notice of violation constituted a defeat device, though the company did acknowledge that it had not followed the required notification and application process for an AECD under the U.S. regulation.[13]

In Europe, the most extensive public exposition thus far of VW's views on the relevant regulatory and legal questions from anyone associated with the company has come in oral and written testimony to the Transport Select Committee of Britain's House of Commons.[14] The testimony of the two witnesses, Paul Willis, managing director of

10 These standards have been succeeded by more stringent ones for later model year vehicles, Tier 3 in the U.S. and Euro 6. For details, see http://transportpolicy.net/index.php?title=US:_Light-duty:_Emissions and http://transportpolicy.net/index.php?title=EU:_Light-duty:_Emissions.

11 For explanation of these control strategies, see Manufactures of Emission Controls Association, "Emission Control Technologies for Diesel-Powered Vehicles," December 2007, http://www.meca.org/galleries/files/MECA_Diesel_White_Paper_12-07-07_final.pdf.

12 Alexander Stoklosa, "VW CEO issues statement on EPA emissions violations, apologizes for wrongdoing," Car and Driver, September 21, 2015, http://blog.caranddriver.com/vw-ceo-issues-statement-on-epa-emissions-violations-apologizes-for-wrongdoing/; U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance, "Notice of Violation", September 18, 2015, http://www.epa.gov/sites/production/files/2015-10/documents/vw-nov-caa-09-18-15.pdf.

13 Volkswagen Press Release, "Statement on the announcement by the United States Environment Protection Agency (EPA)", November 2, 2015, http://www.volkswagenag.com/content/vwcorp/info_center/en/news/2015/11/Stellungnahme.html.

14 UK Parliament, House of Commons Select Committee on Transport, "Volkswagen Group emissions violations one-off session-publications," http://www.parliament.uk/business/committees/committees-a-z/commons-select/transport-committee/inquiries/parliament-2015/volkswagen-group-emissions-violations-15-16/publications/.

Volkswagen UK, and Oliver Schmidt, an engineer with VW's office for group powertrain development, is carefully worded, but several key arguments concerning VW's position seem to emerge. First, that the EU regulation does not require manufacturers to "declare software." Second, that the EU regulation does not prohibit a vehicle from recognizing when it is undergoing a type-approval, or certification, test. Third, that at least under Euro 5 standards the EGR system is not part of the emissions control system, which "consists of an oxidation catalyst and a particulate trap." Fourth, that adjusting the performance of the EGR system to affect NO_x emissions when a vehicle has recognized that it is undergoing testing does not constitute a defeat device. Fifth, that the defeat device used on VW's U.S. market vehicles would have breached the EU regulation because it explicitly reduced the effectiveness of the SCR system or the LNT—i.e., was not only affecting the EGR system. Sixth, that the crucial difference between the U.S. and EU regulations is that in the U.S. "[e]very different mapping from base mapping that is not announced via an AECD application could be considered a defeat device" while (at least by implication) such an application is not necessarily required in the EU.

Volkswagen's apparent position that EGR is not part of the emission control system deserves particular emphasis, especially since exhaust gas recirculation is the primary way that NO_x emissions are controlled on Euro 5 vehicles (though a small number of Euro 5 vehicles do use LNT or SCR to control NO_x emissions). Defining the emissions control system in such a way as to exclude EGR would exempt the EGR system from a prohibition on defeat devices.

The U.S. and EU regulations differ in their approach to defining the emission control system. Although the phrase occurs hundreds of times in the U.S. regulation, it is never formally defined in the text of the regulation itself. However, the EPA defines exhaust emission control systems (plural) at length in a separate advisory document, which specifically includes exhaust gas recirculation among many other details.[15] In the EU, Regulation EC 692/2008 formally defines "emission control system" only as "in the context of the [on-board diagnostics, or OBD] system, the electronic engine management controller and any emission-related component in the exhaust or evaporative system which supplies an input to or receives an output from this controller." Even assuming that a definition specific to the OBD system would also be applicable to defeat devices, in this case the apparent specificity reduces rather than adds clarity. The OBD system monitors and reports hardware failures or deterioration, not performance—a malfunctioning NO_x sensor, for example, but not elevated NO_x emission levels—and requirements for that system's performance and testing are set out separately in Regulation 692/2008 (Annex XI). And while many components receive outputs from the EMC, including some that could belong to an EGR system, specifying "component[s] in the exhaust or evaporative system" neglects engine controls to reduce emissions, such as fuel-injection pressure and timing (which are involved in the EPA's notice of violation to VW concerning 3.0L diesel vehicles in the United States).

A definition of the emissions control system that is either overly narrow or imprecise risks permitting manufacturers to vary engine parameters that influence emissions in ways designed to tune performance differently for tests than for everyday driving. This

15 U.S. EPA, Office of Air and Waste Management, Mobile Source Air Pollution Control Advisory Circular A/C No. 20-B, 27 June 1974. Available online at https://iaspub.epa.gov/otaqpub/display_file.jsp?docid=14337&flag=1.

is particularly important if, as VW asserts, a regulation also does not prohibit a vehicle from recognizing when it is being tested.

VW AFTERMATH: OTHER MANUFACTURERS

In the aftermath of the VW revelations, other European automakers—BMW, Renault, Daimler, Opel, and Fiat—have been accused or come under suspicion of changing the performance of vehicle emissions control systems during real-world operation. The manufacturers' public statements have not been highly detailed, but responses from Renault, Daimler, and BMW make it clear that they are relying to at least some degree on the provision in the EU regulation that exempts a device from the prohibition on defeat devices when "the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle."

In November 2015 the German TV network ZDF had the Bern University of Applied Sciences (Switzerland) carry out tests on three Euro 5 diesel cars, including a BMW 320, for a documentary report that aired on 15 February.[16] The BMW vehicle generated 154 mg/km of NO_x during the official type-approval test on the NEDC, but when the NEDC cycle was reproduced on the road after a hot engine restart—when operating conditions did not exactly match the test protocol—NO_x emissions increased to 428 mg/km.[17] BMW provided a two-part explanation of the test results:

> *"a) For a "hot test", the vehicle has been parked at operating state temperature. Usually a few minutes pass until the actual measurement begins. During this time period (i.e. between running in the vehicle and beginning of the measurement) the engine compartment is heating up itself. During this period the boundary conditions for the engine combustion differ from the normal mode of operation. Vehicle parts (as e.g. the particulate filter) may not be allowed to be damaged and similarly the engine may not be allowed to go out under any driving conditions. For this reason the exhaust gas recirculation has to be reduced temporarily. As a result, for thermodynamic and reaction kinetic reasons the nitrogen oxides emissions increase temporarily.*
>
> *b) During the days when the BMW 320d was tested (according to the testing report it was on 29 and 30 of Oct 2015) the average temperature in Bern was around 10 degrees Celsius. Cold ambient temperatures influence the behavior of the engine. A modern engine has to react also to these kind of boundary conditions in order to avoid damage to parts such as the cooler for the exhaust gas recirculation. As a result this can again selectively lead to higher emissions." [18]*

In October 2015, the French type approval authority's technical service, UTAC, began a program to test emissions from 100 diesel vehicles. As of mid-January 2016, UTAC

16 Video available at http://www.zdf.de/ZDFmediathek/beitrag/video/2671832/Frontal21-Dokumentation-Die-Abgasluege#/beitrag/video/2671832/Frontal21-Dokumentation-Die-Abgasluege.

17 P. Comte, Y. Zimmerli, M. Güdel, J. Czerwinski, "Emissionsmessungen an einem BMW 320d Touring (Euro 5a) auf dem Rollenprüfstand und auf der Strasse", Bern University of Applied Sciences, November 2015, http://www.zdf.de/ZDF/zdfportal/blob/41471464/2/data.pdf.

18 Email correspondence between BMW and ZDF, December 2, 2015, http://www.zdf.de/ZDF/zdfportal/blob/41472728/1/data.pdf. (ICCT translation)

had tested 22 vehicles from various manufacturers, including at least five Renault vehicles (three Euro 6 Capturs and two Espaces, one Euro 5 and one Euro 6), and found emissions exceeding the allowable limits by four to five times.[19] The French government has released only limited information, but has publically stated that it has found no evidence of technology meant to cheat emissions tests on Renault vehicles. Renault's explanation to the French government of the excess emissions has been that the emission control system on those vehicles limits the EGR system's effectiveness to permit higher engine-out NO_x emissions at ambient temperatures below 17 °C and above 35 °C in order to protect the engine.[20]

A May 2015 study done by the consultancy TNO for the Dutch Ministry of Infrastructure and the Environment found excess NO_x emissions from several Euro 6 diesel passenger vehicles[21]. In January 2016 it was revealed that one of the vehicles tested for the TNO report was the Mercedes C220.[22] Daimler's response echoed BMW's and Renault's in its focus on ambient temperatures and the regulatory exemption that provides for protection of the engine and safe operation of the vehicle.[23]

> *[These observed discrepancies] are no indication of tampering, but primarily result from divergent statutory testing conditions in the laboratory. For example, when different temperature conditions prevail, the vehicle is operated under different loads, or other auxiliary equipment, such as air conditioning or seat heating, are turned on. In addition, the exhaust aftertreatment system is regulated within legal limits based on operating conditions in order to protect the motor and to ensure the safe of operation of the vehicle. This is to comply with legal requirements that the aftertreatment system is fully functional for at least 160,000 km. […]*
>
> *…Consideration of the ambient temperature and other data is critical to protect the motor over the full lifetime. All our engines ensure within legal limits that engine components are not damaged and that emission requirements are met over the entire lifetime.*

The public explanations from BMW, Renault, and Daimler are difficult to make sense of from an engineering perspective. Ambient temperature does not directly affect vehicle operation, the temperature of engine components, or emission control calibration. Normal engine operating temperature is typically controlled at around 90 °C by the engine coolant thermostat, and exhaust temperatures are determined

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19 Émilie Massemin, "Système de contrôle de la pollution automobile est totalement défaillant," Reporterre.net, January 22, 2016, http://reporterre.net/Le-systeme-de-controle-de-la-pollution-automobile-est-totalement-defaillant; Maxime Amiot, "Antipollution: pourquoi Renault se retrouve dans la tourmente," Les Echos.fr, January 18, 2016, http://www.lesechos.fr/industrie-services/automobile/021630089187-pollution-un-autre-modele-de-renault-pointe-du-doigt-1193290.php; France Nature Environment "Commission royal des premiers résultats très alarmants," February 11, 2016, http://www.fne.asso.fr/communiques/commission-royal-des-premiers-résultats-très-alarmants.

20 Philippe Jacqué and Laetitia Van Eeckhout, "Renault constraint de s'expliquer sur les failles de son moteur diesel," LeMonde.fr, January 19, 2016, http://www.lemonde.fr/economie/article/2016/01/19/devant-la-commission-royal-renault-revele-les-failles-de-son-moteur-diesel_4849711_3234.html.

21 Kadijk, G., Mensch, P., Spreen, J.S., "Detailed investigations and real-world emission performance of Euro 6 diesel passenger cars," TNO, May 18, 2015, http://repository.tudelft.nl/view/tno/uuid%3A40da980a-4c03-4b70-a9b1-240f9ea395f5/.

22 NOS.nl, "Meer vervuilende dieselauto's bekend," January 20, 2016, http://nos.nl/artikel/2081649-meer-vervuilende-dieselauto-s-bekend.html.

23 Written exchange between Daimler and DUH, January 28, 2016, http://www.duh.de/uploads/media/Antwort_Daimler_an_DUH_280116.pdf (ICCT translation).

primarily by the heat from combustion. More relevant indicators than ambient temperature would be, for example, engine coolant temperature, intake manifold temperature, or exhaust temperature.

Furthermore, the temperature ranges cited by Renault and BMW are narrower than any reasonable definition of normal conditions. Ambient temperatures below 17 °C (Renault's lower range) or 10 °C (BMW's) are common in Europe. The average temperature is below 17 °C in Paris 83% of the time, and below 10 °C 42% of the time; in London it is below 17 °C 75% of the time and below 10 °C 33% of the time.[24] It is in fact most important that NO_x emissions control systems work well at high ambient temperatures, as adverse health impacts from excess NO_x emissions are most acute on hot days. Thus, the changes to EGR operation after a hot restart (BMW) and above 35 °C ambient temperature (Renault) are likely to be especially problematic from a health point of view. The U.S. EPA, for comparison, considers operation at ambient temperatures 37.8 °C (100 °F) and above to be part of normal operation.[25]

Regulation 692/2008 does provide for verification of the vehicle carbon monoxide and hydrocarbon emissions at low ambient temperature, though it exempts diesel vehicles from this test. However, the section of the regulation exempting diesels from this low-temperature emissions test (Article 3, par. 9) requires that, when applying for type approval of compression ignition (i.e., diesel) vehicles:

> *manufacturers shall present to the Type Approval Authority information showing that the NO_x after treatment device reaches a sufficiently high temperature for efficient operation within 400 seconds after a cold start at -7 °C as described in the Type VI test.*
>
> *In addition, the manufacturer shall provide the Type Approval Authority with information on the operating strategy of the Exhaust Gas Recirculation (EGR) system, including information on its functioning at low temperatures.*
>
> *This information shall also include a description of any effects on emissions.*
>
> *The Type Approval Authority shall not grant type approval if the information provided is insufficient to demonstrate that the after treatment device actually reaches a sufficiently high temperature for efficient operation within the designated period of time.*

This suggests that Renault, BMW, and Daimler, prior to receiving certificates of conformity for the vehicles in question, had provided type approval authorities with information on how the EGR systems in those vehicles functioned at low ambient temperatures and the impact that had on emissions. However, under the EU regulation the information that manufacturers provide to type approval authorities is not publically available, so this cannot be confirmed.

A lack of clarity concerning what should be considered normal conditions also bears on other details besides ambient temperature. BMW indicated that

24 http://www.holiday-weather.com

25 U.S. Environmental Protection Agency, Office of Air and Radiation, Memo to heavy-duty automotive manufacturers, "Heavy-duty diesel engines controlled by onboard computers: guidance on reporting and evaluating auxiliary emission control devices and the defeat device prohibition of the clean air act", October 15, 1998, http://www3.epa.gov/otaq/cert/dearmfr/vpcd9813.pdf.

EGR must be reduced temporarily during a "hot test" to prevent damage to the diesel particulate filter (DPF). The company's statement lacks important details: what the exact conditions are that would trigger the EGR to be reduced, why these conditions would damage the DPF, what "temporarily" means. But from an engineering perspective, starting and running a vehicle after it had recently been turned off also falls well within the bounds of normal operation. Again for purposes of comparison, the U.S. test procedure explicitly includes a 10-minute period during which the vehicle is shut off, and after which the vehicle is restarted and the test cycle repeated. That is to say, by inference, that diesel vehicles sold in the U.S. are able to prevent damage to the DPF after a hot restart without significantly increasing NO_X emissions. Similarly, Daimler's statement suggests that the use of air conditioning would require reductions in the emissions control, though a definition of normal operation that excluded the use of standard equipment would seem difficult to defend from an engineering design perspective. The U.S. EPA introduced a test cycle that turns on air conditioning during the test specifically to ensure that emissions are controlled during its use.[26]

DISCUSSION

A survey of the publicly available information that has come to light in the wake of VW's admission that it installed illegal defeat devices on diesel passenger cars in the United States, combined with a close reading of the EU and U.S. regulations, raises the possibility that manufacturers have made use of ambiguities in the regulatory provisions that prohibit vehicle emission control defeat devices in Europe—specifically, ambiguities in how exemptions from the defeat device prohibition are administered and in the definition of emission control systems.

Proposals to reform the EU regulation (or others patterned on it outside Europe) should be scrutinized to assess the degree to which they would resolve those ambiguities. In particular, three questions should be asked: (1) whether and how proposed reforms would require manufacturers to disclose the presence of defeat devices as defined in the regulation; (2) what requirements would be imposed concerning how the listed exceptions to the prohibition on defeat devices must be claimed, evaluated, and approved or rejected; and (3) whether and how proposed new regulatory text defines key terms and concepts such as normal operating conditions, normal vehicle operation and use, and emissions control system.

There are currently two proposals on the table for revising the EU vehicle emissions control regulatory system: the RDE 2nd package and the New Type Approval Framework.

Draft regulatory text for the RDE 2nd package[27] would impose additional requirements for reporting emissions control strategy during the type approval process, which would likely come into force for type approvals beginning in 2017. This text was added in direct response to the VW disclosures. Manufacturers would be required to provide an "extended documentation package" to type approval authorities that

26 See details of US light duty emissions standards and test protocol, http://transportpolicy.net/index.php?title=US:_Light-duty:_Emissions.

27 European Commission, Commission Regulation (EU) amending Regulation (EC) No 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 6), 2015[draft], https://circabc.europa.eu/webday/CircaBC/GROW/automotive/Library/comitology_committees/technical_committee/51th%20meeting%20on%2028%20October%202015/RDE%202nd%20package%20after%20TCMV.pdf.

would include "information on the operation of all emission control strategies" as well as a "description of the fuel-system control logic, timing strategies, and switch points during all modes of operation."

While the new language represents an improvement, it does not address three important details on which the current regulation is imprecise: It does not give unequivocal guidance to Member States concerning the technical evaluation of the provided information; it does not enumerate criteria that should be used to approve or reject claimed exceptions to the defeat device prohibition; and it does not indicate how to determine which components are part of the emission control system.

In January 2016, the European Commission put forward a proposal that if approved by the European Parliament and the European Council would revise the current motor vehicle type-approval framework defined by Directive 2007/46/EC.[28] With regard to the subject of this briefing paper, the proposed new framework would require that "The approval authority and technical services shall have access to the software and algorithms of the vehicle."

The new language would contribute to making the type approval process more transparent. But, again, it does not address inexact language in the current regulatory text that appears to relate to manufacturers' public explanations of how and why they have modified vehicle emissions controls during on-road operation. Access to software and algorithms is not sufficient to make determinations on whether and how to evaluate and approve or reject claims of exception to the vehicle emissions control defeat device prohibition.

What is necessary is a thorough reporting and approval system for the use of all alternative emissions control calibrations, with a requirement to disclose the presence of "any element of design which senses temperature, vehicle speed, engine speed, transmission gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system"; and which places the burden on manufacturers to prove to qualified, independent experts at a detailed technical level, prior to type approval, that this alternative calibration is necessary and that no viable alternative solutions exist.

28 The full text of the proposal and accompanying documents can be downloaded at http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1453996101816&uri=COM:2016:31:FIN. A separate impact assessment of the proposal is available at http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1453996334099&uri=SWD:2016:9:FIN.