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Note by the EMIS Secretariat

Summary of replies of car manufacturers to EMIS Questionnaire

Replies received from BMW, Daimler, Fiat, Ford, Hyundai, Jaguar Land Rover (JLR), Kia, Mitsubishi, Nissan, Opel (General Motors), Peugeot (PSA), Renault , Suzuki, Toyota, VOLVO and VW.

As for Cadillac, General Motors, the mother-company of Cadillac Europe GmbH, replied that since Cadillac Europe is not offering models equipped with a diesel engine nor has it done so in the past, and given that most of the questions asked are predominantly diesel technology related, Cadillac Europe GmbH will not respond as an individual company – however, General Motors have already replied to the questionnaire.

One reply is still outstanding - Honda.

NB: This summary is intended to provide a concise version of the substantial amount of information received through the questionnaires and thus facilitate the use of that information. For more details on specific OEMs, please refer to the original answers.

1. In previous hearings we have heard that the exhaust systems are vulnerable to clogging and corrosion. Can you describe how you as a producer adapted the materials used in order to fulfil warranty requirements, leak-free assembly requirements and customer demands for long service life? What is the effect of the higher temperatures that SCR needs to properly function with the materials used?

Daimler confirmed that the exhaust system they use is made of corrosion-free high-grade stainless steel, so no corrosion problems exist. There are tests done for fluid leakage and welding seams produced and assembled as such that leaks are avoided. However, SCR fluid properties in overdose can lead to deposits and reduce the system effectiveness. **Suzuki** and **Fiat** also use stainless steel but admit some corrosion could still occur in presence of condensation and acidic solutions. **PSA** confirms the SCR technology it uses is very reliable and resistant at all temperatures but the EGR valves are vulnerable to corrosion and clogging especially the low pressure EGR - hence PSA uses only high pressure which could operate between -10C to +55C. **Hyundai** & **Kia** also use stainless steel for their EGR, also use DPF and LNT, SCR is under further development - all these are thoroughly tested at all stages. **Mitsubishi** uses the needed material in its current emissions control systems to satisfy requirements and SCR is under development. **Renault, Nissan** and **Opel** admit the exhaust system could be subject to these problems and not only materials but overall design and positioning of the system are key to avoid these. **Ford** shares above views that these problems do exist however also do proper materials, system design and numerous tests to assure safety and durability. **JLR** respond that

EGR has a lot more limitations than SCR especially in cold weather and aggressive driving - which limitations could be decreased with proper system design - their SCR systems are not constrained as the EGR. **Toyota** also uses EGR, also in combination with LNT & SCR - calibration of the systems is needed to avoid malfunctions in certain conditions. **BMW** and **Volvo** also admits to clogging problems possible at low exhaust gas temperatures. SCR issues are mostly resolved with coupling with LNT and improving design of UREA spray, yet with EGR some control strategies also need be applied. **VW** also confirms the main difficulties it faces are with EGR.

With regards clogging***, OEMs admit to the inherent limitations mainly of the EGR systems*** but also SCR at low exhaust gas temperatures. However, the majority of the OEMs share that ***these could be limited for SCR with appropriate design of the system*** coupled with additional technology, in case such as LNT. For EGR it is less straight forward as only design might not be enough to reduce those risks and some admit to ***the need to use calibration or control strategies to protect the engine***. As for ***corrosion, all are using appropriate materials***, high quality stainless steel and conduct numerous tests to assure proper functioning and durability.

2. On average, how much does a diesel emissions reduction system cost when purchased and built in? Could you please specify these prices for an exhaust gas recirculation (EGR) system, a NOx storage catalytic converter (NOx trap) and a Selective Catalytic Reduction (SCR) system? And how much would a combination of multiple systems like these costs? In your experience: How many of these costs can be passed on to the buyer?

Prices of diesel emissions reduction systems vary depending on components used, engine volume and performance, vehicle size. Many do not share costs due to competitiveness issues and contracts with suppliers. Those who did gave the following. **Daimler** gives ranges of: EGR: 300-350 Euros, SCR+DPF: 1000-1800 Euros. **VW** quotes that for a 2l EU6 engine, the cost could be between 40-50% of the engine cost. **Volvo** - 1000 Euros for EGR+LNT+SCR. **Mitsubishi** EGR+LNT -1000 Euros. **JLR** range is EGR 300 Euros and SCR 1,000 Euros. **Nissan** - 1200 Euros for EGR+SCR. **Renault** does not use SCR but adding it now would mean 1,000 Euros additional cost. **PSA** - 200-500 Euros for EGR+SCR. **Fiat** -250-400 Euros for LNT, 600-1300 Euros for SCR.

BMW and **VW** and **Volvo** share that ***customers are not much willing to accept additional costs***, so these cannot be passed on directly to the customer. Customers of OEMs not in the high- price range vehicles could be particularly sensitive. However, as this is a ***legal requirement so regardless of the cost it is of course included in the vehicle price to be paid by the consumer***.

3. Why did car manufacturers focus mostly on the legal testing cycle NEDC if they knew that it was far from reality and had nothing in common with real emissions? Was it not possible to orientate yourself towards real driving emissions (RDE) -like values from the beginning to generate more trust from the customer? Why did the automobile industry not take the initiative on its own and communicated more realistic exhaust values of their products?

Without exceptions all OEMs share the same view. ***NEDC test is the legal requirement*** that allows for ***consistency, reproducibility and reliability by all manufacturers*** so they produce emissions values that could be compared by the consumer and the TAAs. The NEDC did reflect the available vehicle and test measuring technology at the time the regulation was adopted. Then there was ***no agreed alternative standard*** that could be used. The ***RDE and WLTP were not available in the past*** and only now are reaching the consistency and reliability, comparability that NEDC offered. The PEMs technology that makes RDE possible today was not available when the majority of vehicles on roads today were in development.

All OEMs also welcome the RDE tests and have initiated steps to prepare themselves for meeting the new requirements

4. Article 5(2) of Regulation 715/2007/EC allows for certain derogations to the prohibition of defeat devices that reduce the effectiveness of emission control systems. Do the vehicles you produce make use of the derogation, and if so – could you please describe in detail under what conditions do you employ the derogation? Have you indicated and justified the conditions of the operation of such defeat devices to the type approval authority when applying to type approval? If not, why not? Were you ever requested by the technical services or type-approval authorities to provide clarifications on the use of derogations under article 5(2)?

All OEMs share that they use the derogation that are justified for technological reasons due to the limitations specifically of the EGR systems such as high exhaust gas T (coming from high engine load) or low exhaust gas T leading to clogging with soot deposits or combustion instability. ***OEMs try to maximise the T window*** into which the EGR is efficient and does not pose harm to the engine. This window is to be expanded for current models on the road and further more for new ones to be developed.

All producers are currently providing the authorities with detailed AES/BES descriptions as provided by Regulation (EU) 2016/646, which was not a legal requirement before and no TAA ever requested such information.

5. During recent investigations (e.g. in Germany) manufacturers admitted to using so called "thermo windows" to switch off emission control systems under certain ambient temperatures in order to protect the engine. It has become clear that there is a broad range of temperatures used for lower switch-off limits (e.g. below 10°C or 17°C). This suggests that the setting of these temperature limits are rather arbitrary. Please explain the discrepancy in temperature limits used by car manufacturers to justify switching off emission control systems (including EGR). Are these limits really needed to protect the engine and at which ambient temperatures?

Following from answers to Q5, ***all OEMs use thermal windows***. Reducing operation of emissions systems is justified in order to not only protect the engine but also maintain the durability of the systems. ***How wide the window depends on the type, properties, design (engine layout) and combination of the emissions systems used*** - ***the higher the combination of systems*** (like EGR+LNT+SCR+DPF) ***the wider the T range that they cover***. OEMs largely do not agree the setting of the window is arbitrary but strictly linked to the specifics of the vehicle in question.

This explains the different windows among different OEMs. Ford for example states its switch off T is -10+38C. **Renault** quoted reducing its EGR below +17C and above +35C. **Hyundai** & **Kia** quote -10+50C. For **Mitsubishi** it is -12+56C. For **BMW** the lower end is below 0C.

6. Do you use emissions control systems with different operational limits (e.g. ambient temperature or engine loads) or quality (design, components or materials used), or of different durability when producing vehicles for US and EU markets? Are you aware of such discrepancy between OEMs on the EU market?

Yes, ***differences exist*** and they stem from the ***different legislation and operating conditions in both markets - such as road conditions, climate, speed limits, fuel quality and customer behaviour***, as quoted by OEMs who do sell diesel vehicles on both markets.

7. At a meeting of transport ministers in Luxembourg on 7 June 2016, the following wording on when the ban on defeat devices should not apply was proposed: “even if the best available technologies are included, no other technology is available to protect the engine against damage or accident and for safe operation of the vehicle”. In this regard, what is your understanding of “the best available technologies”? Can you provide us with a list of currently “best available technologies” for lowering NOx and CO2 emissions?

All OEMs believe ***there is no best available technology*** and disagree with the suggested proposal as the ***optimal solution depends on the engine/vehicle combination, performance characteristic and operating conditions all in consideration with competitiveness/affordability***. Technological neutrality is what industry requires. The important aspect is that ***manufacturers continue to develop new technologies*** in looking what is best for their specific needs. A number of OEMs converge that at least ***for the Euro 6d the need would be of EGR+LNT+SCR combination*** to achieve the requirements needed. A few even mention that best technology for reducing both NOx and CO2 is ***moving faster to electric and hybrid vehicles***.

8. With emissions norms progressively tightening, the introduction of the WLTP testing in 2017 and new emissions measurement procedures better reflecting real-driving conditions (RDE), what is, according to your own research and experience, the optimal combination of the best available technologies in order to comply with NOx and CO2 standards? Are the required technologies currently available for mass production or do they need more research and development before they can deliver the expected results? Do certain best available technologies damage the engine? If yes, why?

See answers to Q7. **Fiat** and Suzuki suggest SCR with Diesel Oxidation Catalyst (DOC), DPF and EGR. **PSA** suggest DPF+SCR. **Toyota**, **Hyundai**, **Kia**, **Renault, BMW, Volvo** and **Nissan** - EGR+SCR+LNT. **Ford** doesn’t believe that any currently available technology can meet all future emissions regulations - SCR+LNT will be needed for most but still more R&D is needed. For **JLR** it is engine technology with SCR & LNT. Mitsubishi -SCR+ EGR. **Daimler** has designed a new diesel engine with a new combustion process and integrated emissions control system planned for roll-out to all diesel cars in the next 3 years.

EGR is the one that is quoted as posing most of the problems for the engines, but is the most mature technology. In any case, ***all of them require further R&D***.

9. Do you agree with the statement that the engine control unit (ECU) is a black box, without type-approval obligation and without external supervision on how it is configured or how it functions? Would you be in favour of the introduction of a type-approving provision for this unit with, for instance, the possibility for the certificating authority of accessing the software and its code, and request detailed information on the use of the software, in order to avoid any unwanted software modifications, including unwanted modifications after type approval and before true production? What benefits or risks would you identify in such a procedure?

OEMs believe that ***there is already a lot of requirements in this field*** - the motor control unit and its software is type-approved, so are change management and software updates - any software changes are documented post TA. ***With the new requirements for AES/BES description to TAAs a lot will be disclosed***. Then ***checking full software*** will be a ***massive admin burden for authorities*** who would need to invest a lot in acquiring the new skills to manage that complex info. It will also be a burden for both OEMs and suppliers of the software. While software in principle should not be excluded from TA, a more efficient way to check that is via the new requirement for the AES/BES disclosure. Finally, any ***disclosure of software*** needs to be well managed and protected as it ***is confidential business information*** and hence ***very sensitive*** from competition point of view.

10. From the manufacturers point of view, what kind of role other aspects such as increase engine efficiency play in the emission reduction? What kind of research is carried out, other than the pipe-end technologies, to reduce the emissions?

All OEMs continually work on R&D to improve the engine efficiency as that would mean ***reducing emissions at source as*** well as the amount of fuel needed - work is carried out simultaneously on NOx and CO2 reduction. Most provided very detailed description of all ongoing R&D. Efforts focus on improving a) ***the combustion process*** - among others - fuel injection, combustion chamber design, turbocharge, air-to-fuel mixing, friction reduction, etc b) ***the emissions systems*** EGR SCR DPF. Some OEMs such as Toyota, PSA focus on ***research into hybrid***, plug-in hybrid and fuel cell hybrid vehicles, as well as ***reducing vehicle weight, improving aerodynamics***.

11. According to the JRC, exemption for the use of devices interfering with pollution control systems, as provided for in Article 5(2) of Regulation (EC) 715/2007, are not justified from a technical point of view as the same results (i.e. protecting the engine from damages) can be obtained in many different ways. Do you agree with this assumption? If not can you explain in detail why?

Most OEMs consider this Q has been to an extent answered in previous Qs. ***OEMs do not agree with this statement as EGR is still considered a core means of reducing NOx emissions and according to its limitations it does require for technical reasons recourse to the derogations***.

12. The EU law (Regulation 715/2007/EC Article 5(1)) requires manufacturers to equip vehicles so as to enable the vehicle to comply with the emission limit values contained in the Regulation "in normal use". How do you explain the conclusions of the German Federal Motor Transport Authority (Kraftfahrt-Bundesamt) investigation that on average the Emission Control Technologies are off or turned down around 75-80% of the time? Please describe in detail for which "normal use" conditions (temperature, altitude, engine load, etc.) your engines are designed to operate in Europe?

Most OEMs stress that the ***normal use conditions were not defined before RDE***. All agree and emphasise that ***emissions control systems operate under specific working conditions*** that exclude extreme temperatures, high altitudes and heavy car loads - what these extreme temperatures would be depend very much on the individual specifics of the different vehicles as explained earlier - OEMs stress that ***they try to extend these to as far as the technical set up in their vehicles allows*** them. In the absence of a definition for normal use some manufacturers link the achieving of the emissions limits with the regulatory test protocol.