RDW Emission Test Programme

Results of the follow-up investigation into the presence of unauthorised *defeat devices*

July 2017

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1. Management summary

Background

This report follows on from the RDW's 'RDW Emission Test Programme' report, which was published in September 2016.

The reason for the emission test programme was the use of an unauthorised defeat device by Volkswagen AG. Because RDW had issued emission approval for thirty vehicles from eight manufacturers (Isuzu, Volvo, Hyundai, Kia, Suzuki, Opel, Chevrolet and Jeep), it wanted to investigate whether these vehicles had also been fitted with (unauthorised) manipulation instruments. In the emission test programme, RDW detected unexplainable emission deviations in sixteen vehicles from seven manufacturers. During the tests at the RDW Test Centre, (significantly) increased NO_x emissions were measured at particular speeds, times, distances or external temperatures.
This report describes the results and findings of the follow-up investigation that RDW conducted after publishing the interim report. The aim of this follow-up investigation was to determine whether the deviations detected in sixteen vehicles in the emission test programme can be attributed to protection of the engine.

Working method

RDW used the following working method in the follow-up investigation into the sixteen vehicles from the seven manufacturers:

- Ten vehicles were tested in the laboratory to validate the results.
- Manufacturers were obliged to supply additional information about the operation of the emission control system and demonstrate that the detected emission behaviour falls under the permitted exceptions.
- Multiple surveillance interviews were held with manufacturers.
- Where necessary and possible, RDW asked the manufacturer to make improvements to the vehicles.
- RDW shared its conclusions with the manufacturers.
- The information was also shared with the Public Prosecution Service.
- The conclusions were shared with the European Commission.

Investigation

It is not permitted to operate the emission system differently to the way it was used in the approval test, except if it is necessary to protect the engine. The indicative tests published in the interim report of September 2016 showed that significantly increased NO_x emissions were measured in sixteen vehicles in situations that deviated from the approval test. In some cases, the emissions were found to be much higher than during the type-approval test. RDW decided to conduct further research to interpret these differences between the results of the type-approval tests and the field tests. In addition, intensive surveillance interviews were held with manufacturers – amongst other things, about protection of the engine. All the manufacturers confirmed the results for their own types of vehicles in RDW's Emission Test Programme.

As a result of the follow-up investigation, RDW has come to the conclusion that the relevant manufacturers built the engines in such a way that they often only complied with the minimum approval requirements. Manufacturers have stated that recirculated exhaust gas (EGR) results in a significant NO_x reduction but also poses a number of problems. For example, the maximum mixing ratio is very specific. In particular, lower ambient temperatures cause the incrustation of soot because soot particles and unburnt hydrocarbons bond and condense in the EGR system and

the turbo. Moreover, all the manufacturers say that the difference between the emissions on the road and those in the laboratory were not transparent while Euro 5 and Euro 6 engines were being developed because mobile measurement equipment (PEMS) was not yet available at the time.
RDW believes that the manufacturers used the standards and testing regulations as development specifications when choosing their emission control, hardware and control systems. By doing this, RDW believes that the manufacturers have not complied with the stipulation in Regulation[1] that the vehicles must also satisfy these requirements in practice. This stipulation in the regulation has not been worked out in detail, so RDW cannot do anything about it from an (admission) perspective. The NO_x emissions also affect the CO_2 emissions. Manufacturers optimise the engine for CO_2 emissions (and therefore also for fuel consumption) while making concessions to the NO_x emissions.

The expected large-scale improvements after the Euro 6b standard was introduced in 2014 never got off the ground. Manufacturers decided to build on the familiar exhaust gas recirculation (EGR) system and add an NO_x storage catalytic converter that converts the NO_x into harmless N_2 and CO_2 (LNT) from time to time by enriching them. Most of the manufacturers were just able to satisfy the emission requirements under Euro 6b during the approval test with the old technology. For this reason, many manufacturers saw no reason to develop new (better) emission control systems for the Euro 6b requirements. The additional extra pollution in the engine was usually resolved by significantly modulating the EGR strategy outside the framework conditions for the emission test, which meant that the emission performances of the vehicles were considerably worse in practice.

Findings and conclusions

In RDW's follow-up investigation, major differences were detected between the seven manufacturers in relation to the way they limit the emissions in terms of both the technology used and the conditions under which the emission control system is fully implemented. For example, Volvo's EGR system works to around freezing point, while Opel switches off the system at around 18 °C.

Following the surveillance interviews, at RDW's request, the manufacturers supplied additional documentation and RDW also conducted extra tests.
Almost all of the files were closed from an admission perspective. The vehicles have already been adapted or are being adapted by the manufacturers. In a number of cases, the manufacturers plausibly demonstrated that this is not necessary or possible.

RDW came to the following conclusions on the basis of the test results, the interviews and the information that was supplied:

- Hyundai, KIA and Volvo plausibly demonstrated that the reduced operation of the emission control system is necessary to protect the engine.
- At FCA, it was found that the values were very high compared to the approval test. For the Jeep Wrangler, it was demonstrated sufficiently plausibly that the measures taken by FCA were necessary to protect the engine. For the Jeep Grand Cherokee, the NO_x emissions are many times higher when the NEDC test is started with a warm engine than when the same test is started with a cold engine.
  The need for engine protection in this case has not yet been adequately demonstrated. The Public Prosecution Service (OM) has been informed about this case. At RDW's request, FCA will roll out an update for the Jeep Grand Cherokee in July 2017 that is aimed at reducing the emissions in practice. This update will be assessed by RDW.
- At Opel and Chevrolet, it was found that the emission control system switches off under 14°C and 18°C, respectively. This is almost the same as the temperature at which the approval test is conducted. However, it was plausibly demonstrated that the emission reduction technology is

1. REGULATION (EC) No. 715/2007, Art. 4 clause 2 and Art. 5 clause 1, see Appendix 2

not robust, so there is a chance of engine damage at a lower temperature. It is therefore correct to state that the emission control system is modulated due to engine protection. In addition, for these vehicles it is not possible to implement a voluntary update and to continue complying with the values of the type-approval at the same time. In this case, therefore, RDW cannot take any measures to reduce the emissions even more in practice.
- At Suzuki, the justification was found to be sufficient, except for the reduced emission performances when the test takes longer than the usual emission test. This may indicate the use of a time-dependent emission control system. When a time-dependent control system is close to the test limits, it is unlikely that it is being used to protect the engine. If this is the case, RDW considers it to be unacceptable. It is the task of the Public Prosecution Service (Openbaar Ministerie) to decide whether this involves a punishable offence. RDW has therefore informed the Public Prosecution Service about this case. RDW tested an update that was offered by Suzuki, and a time-dependent emission control system could no longer be detected in the relevant vehicles after the update. This update is currently being rolled out. Further research is being conducted to more accurately determine how the time-dependent control of the emission control system works in the original vehicles.

To conclude, the vehicles can be divided into two categories:

- Vehicles for which it has been plausibly demonstrated that the reduced operation of the emission control system is necessary for engine protection: Hyundai i40, KIA Cee'd, KIA Optima, KIA Sorento, Jeep Wrangler Unlimited Van (2 variants), Volvo XC90 (2 variants), Suzuki SX4, Opel Mokka (Euro 5 and Euro 6), Chevrolet Aveo, Chevrolet Orlando and Chevrolet Cruze. In the Volvo XC90, there was a technical error during the earlier measurement, which led to the significantly increased emissions. In the retest, this turned out to be no longer the case. For these vehicles, the investigation is now closed.
- For the following vehicles, it has not yet been sufficiently demonstrated that the reduced operation of the emission control system due to a lower ambient temperature or higher engine load is necessary to protect the engine: Jeep Grand Cherokee. Here, extra investigation is required to examine whether it is possible to update the software to achieve better emission performances. This category includes vehicles for which it has not been demonstrated that the reduced operation of the emission control system is necessary for engine protection: Suzuki Vitara. Despite the fact that several tests must still be conducted to obtain a more accurate picture of the time-dependent control system, it seems that it involves a prohibited defeat device and, on completion of those tests, the investigation will be passed on to the Public Prosecution Service. The efficiency of the emission control system may not be reduced under conditions to be expected during normal use of the vehicle unless this is necessary in order to protect the engine. This need has not yet been demonstrated for these two vehicles.

The future

This report describes how light motor vehicles were admitted on the basis of the then applicable laws and regulations. Looking ahead, it can be stated that the new Real Driving Emissions (RDE) test, which will be compulsory for new types of vehicles from 1 September 2017, must result in the reduction of emissions in practice. This additional test with a mobile emission measurement system (PEMS) obliges the manufacturer to ensure that during a test drive on the road, under broadly-defined conditions, the vehicle complies with the emission requirements at all times.

2. Background and working method

Background

In September 2016, RDW published the report ‘RDW Emission Test Programme’. As part of this programme, thirty vehicles from eight manufacturers were tested: Isuzu, Volvo, Hyundai, Kia, Suzuki, Opel, Chevrolet and Jeep. During these indicative emission tests, non-standard emission behaviour was detected in sixteen vehicles. During the tests at the RDW Test Centre, (significantly) higher NO_x emissions were measured in these vehicles at particular speeds, times, distances or external temperatures. Each manufacturer was then supplied with the report ‘RDW Emission Test Programme’, with additional information for each manufacturer.

Measures taken

The reported findings led RDW to take the following measures after coordinating with the Ministry of Infrastructure and the Environment:
1. With support from TNO, a follow-up laboratory investigation was conducted for vehicles with non-standard emission behaviour. This was aimed at gaining a more accurate picture of the detected deviations.
2. The relevant manufacturers had to supply RDW with additional information and demonstrate that the detected emission behaviour is covered by the permitted exceptions.
3. Depending on the information that the manufacturers supplied, RDW asked additional questions and held (multiple) surveillance interviews with them.
4. Based on this additional information and on the measurement results from the laboratory and the surveillance interviews, RDW drew up its conclusions and shared them with the manufacturers. Where necessary, RDW asked external parties for an expertise assessment.
5. Where necessary and possible, the relevant manufacturers implemented improvements. RDW is now checking these updates. By mutual agreement, the improvements should be implemented as soon as possible into the ongoing production process. Where possible, the adjustments will also be offered for existing vehicles. This is part of RDW’s regular surveillance process.

Surveillance interviews

During the surveillance interviews, all the manufacturers had to provide RDW with an explanation of the emission behaviour that was measured for the relevant vehicle. They also had to explain how their emission control system operates in practice. Based on that information, RDW assessed whether the manufacturer’s arguments were sufficient to explain the emission behaviour of the vehicle. If this was not the case, RDW asked for additional information. RDW assessed the emission behaviour of the vehicles on the basis of the information supplied, the manufacturer’s explanation and the measurement results from the laboratory. Where necessary, RDW asked external parties for an expertise assessment, including an assessment whether it (legitimately) involved protection of the engine.

If RDW thought that the manufacturer’s justification and explanation were inadequate, improvements need to be made to vehicles that are still in production. RDW will assess the proposed improvements. The aim of the adjustments is to reduce the NO_x emissions of the vehicles in practice. The improvements should be implemented as soon as possible. In addition, the manufacturers must also investigate whether improvements can be implemented in existing vehicles that are no longer in production.

Timeline

These follow-up activities were performed by RDW in the period from October 2016 to June 2017. The timetable is outlined below.

September 2016	Publication report 'RDW Emission Test Programme'
August / November 2016	Implementation of laboratory tests
October 2016	Test programme results sent to manufacturers
November 2016	Additional information supplied by manufacturers
December 2016	First round of surveillance interviews at RDW head office
January – February 2017	Additional measures by RDW and manufacturers
March – May 2017	Subsequent rounds surveillance interviews
June 2017	Subsequent rounds surveillance interviews
July 2017	Publication of report 'Surveillance Manufacturers'

3. Vehicles

The following overview displays the sixteen vehicles that were investigated by RDW. RDW supervises manufacturers and not individual brands. Different car manufacturers produce different brands. The interviews were therefore held with each manufacturer and different brands and vehicles were discussed. It relates to the following vehicles, sorted by manufacturer and in the order in which the surveillance interviews were held.

The third column displays the European emission standard; this is the European Union emission standard for vehicles. The emission standard is becoming increasingly stricter: vehicles are obliged to emit increasingly fewer hazardous substances. The standard is expressed in Euro, followed by a number. From September 2016 onward, all new types of vehicles must satisfy the Euro 6b standard.

BRAND	TRADE NAME	EMISSION CODE	MANUFACTURER
Volvo	XC90	Euro 6	Volvo Car Corporation
Volvo	XC90	Euro 6	Volvo Car Corporation
Hyundai	I40	Euro 5	Hyundai / KIA Motor Group
KIA	Cee'd	Euro 5	Hyundai / KIA Motor Group
KIA	Optima	Euro 5	Hyundai / KIA Motor Group
KIA	Sorento	Euro 6	Hyundai / KIA Motor Group
Suzuki	Vitara	Euro 6	Suzuki Motor Corporation Japan / motor FCA
Suzuki	SX4	Euro 5	Suzuki Motor Corporation Japan / motor FCA
Opel	Mokka	Euro 5	Adam Opel GmbH / motor General Motors Corporation
Opel	Mokka	Euro 6	Adam Opel GmbH / motor General Motors Corporation
Chevrolet	Aveo	Euro 5	General Motors Corporation
Chevrolet	Orlando	Euro 5	General Motors Corporation
Chevrolet	Cruze	Euro 5	General Motors Corporation
Jeep	Grand Cherokee	Euro 5	Fiat Chrysler Automobiles (FCA)
Jeep	Wrangler Unlimited Van	Euro 5	Fiat Chrysler Automobiles (FCA)
Jeep	Wrangler Unlimited Van	Euro 5	Fiat Chrysler Automobiles (FCA)

Of the sixteen vehicles in which non-standard emission behaviour was detected, five were admitted in accordance with the Euro 6 standard. These vehicles are still being produced and can be sold as new. The other vehicles are no longer being produced and have not been sold as new for a number of years.

From a surveillance perspective, this means that any corrective measures in the Euro 5 group relate only to vehicles that have already been registered and are being driven on the public roads. In case of a Euro 6 approval, measures can also relate to the production process in the factory.

4. Operation of emission control system – interpretation

The interviews with manufacturers have produced a great deal of information about the operation of the systems. This chapter describes the development and operation of emission control systems.

Exhaust gas limit values Euro 5 / Euro 6

Since 2005, various studies and investigations have shown that diesel vehicles emit many fine dust particles and NO_x. This is why stricter requirements were stipulated for Euro 5 and later Euro 6 in the European legislation that includes the emission requirements. One of the refinements involved the need to include a soot filter (DPF) in diesel-fuelled light motor vehicles. Combined with the stricter limit values and improved test methods, this was aimed at further reducing the emissions of fine dust. For NO_x, the limit for Euro 5 had to be significantly reduced. For Euro 6, with the introduction of new emission control systems the limit ultimately dropped to 80 mg/km for diesel light motor vehicles. For Euro 6, the manufacturers decided not to use the Selective Catalytic Reduction (SCR) emission control system and continued to use EGR, supplemented with a Lean NO_x Trap (LNT) and in that way managed to achieve the Euro 6 limit during the approval test. Field investigations have demonstrated, however, that for Euro 5 and Euro 6 using just EGR – where relevant, supplemented with LNT – the NO_x emissions remained high in practice, around the level before the introduction of Euro 5.

Systems for NO_x reduction

On the way towards the Euro 6 standard (September 2014), the NO_x emissions during the approval tests had to be reduced from 180 mg/km to 80 mg/km. There are various technologies available to reduce the emissions of NO_x. The following is a brief summary of the best-known systems:

- Exhaust Gas Recirculation (EGR): this technology recirculates dirty exhaust gases from the engine back to the engine intake. It lowers the combustion temperature of the engine and in that way reduces the emissions of NO_x. The amount of exhaust gas that is recirculated to the engine is regulated with an EGR valve. The disadvantage of this technology is that the engine can become very polluted under certain conditions. This can even lead to the failure of and damage to the engine. For most Euro 5 vehicles, High Pressure EGR is used with an EGR cooler (to cool the temperature of the recirculated gas) and sometimes a bypass of the EGR cooler to ensure that the recirculated exhaust gas temperature is not overcooled in case of a low ambient temperature.
- Selective Catalytic Reduction (SCR): this technology uses a catalytic converter to remove NO_x from exhaust gases using a urea solution (such as AdBlue). The engine can run efficiently at a high combustion temperature, which results in low CO_2 emissions and low fuel consumption. The SCR catalytic converter reduces the high NO_x emissions by converting them to mainly nitrogen and water. The disadvantage for the consumer is that urea sometimes has to be refilled between regular servicing and is not always available at petrol stations. The network of urea filling points has not yet been adapted for use by light motor vehicles and is still only suitable for large-scale users such as lorries.
- Lean NO_x Trap (LNT): when this technology is used, the NO_x exhaust gases are collected in the catalytic converter and reduced to harmless substances, if possible. This works effectively inside a particular bandwidth of the temperature of the LNT. When the LNT is full, the NO_x is converted to nitrogen by means of a catalytic reaction. The disadvantage of this is that the catalytic converter can only collect a limited amount of NO_x. If more NO_x is emitted before the catalytic reaction takes place, the catalytic converter becomes supersaturated and stops working until successful reduction takes place.

Modulation of the EGR system

Exhaust gas recirculation (EGR) was a frequently-used technology in the period 2006-2010. This technology ensures that dirty exhaust gases are recirculated to the engine intake. This reduces the NO_x, but also pollutes the engine. This pollution can damage diesel engines, causing the recirculation channel to clog up, for example. This turned out to be dangerous in a number of (investigative) situations. There are examples of situations where the engine jams and the vehicle stops suddenly. Space has been created in the regulations for the protection of the engine. Amongst other things, this protection is provided by incrementally switching off the EGR system. This more limited use of the system, depending on the conditions, is called modulation. The system programming determines the extent to which this occurs – based on engine load, the revolutions per minute and ambient and engine temperature, for example. If the modulation is too high, it leads to high emissions. If the modulation is too low, it leads to engine damage.

No large-scale introduction of SCR

When Euro 6 was introduced in September 2014, the SCR technology was not used on a large scale in light motor vehicles. The technology is complex, which means the system is relatively expensive. The necessary use and availability of the urea solution are a limitation. For light motor vehicles, there are still no refuelling facilities at regular petrol stations. There are only small jerry-cans (10 litres) available, so it is necessary to top up between servicing intervals in order to use the system effectively. Furthermore, due to the use of cheaper technologies such as exhaust gas recirculation, manufacturers were also able to comply with the specified requirements during the test.

The alternative: the Lean NO_x Trap (LNT)

Partly due to the decision of manufacturers not to use SCR technology with a urea solution, other technologies, such as the Lean NO_x Trap have been further developed. In practice, these technologies were found to work less effectively than during the admission test. The reason for this was the dependency on the temperature of the LNT and the limited storage capacity of the catalytic converter, depending on the format. This technology is often combined with an EGR system.

The original test procedure

At the time, the test procedure for the admission test was described in detail; this was aimed at developing a universally reproducible test that can be implemented for everybody at any time. The global requirements of the test were:

- A fixed route (speed / distance)
- A fixed duration (around 20 minutes)
- An ambient temperature of between 20°C and 30°C.

With the introduction of new technologies and more extensive software, manufacturers started using the test procedure as a specification for adjusting their emission systems. As a result, the system was mainly developed to comply with the test, which was still possible without the use of SCR. Financial considerations may have played a role in this.

The Real Driving Emission test

From 2005 onward, investigations increasingly showed that passenger vehicles had higher emissions in practice than during the approval test. From the perspective of the regulator, that is undesirable. After all, the emission requirements were drawn up with the aim of producing vehicles that are also clean on the public roads. To reduce the emissions in practice, in 2010, the development of the Real Driving Emissions (RDE) test began. This test makes it compulsory for vehicles to be tested not only in the laboratory but also in the field under much more varied conditions. In order to use this test, a mobile measurement system is required for this test. The technology has developed so quickly that there are now different brands of mobile measurement systems available. These mobile measurement systems were not yet available when the Euro 5 vehicles were being developed at the start of this century. Due to their size, the systems were only available for lorries. It is only since 2007 that the use of mobile emission measurement systems has been studied in depth[2].

2. Joint Research Centre, Analyzing on-road emissions of light-duty vehicles with Portable Emissions Measurement Systems (PEMS) (2011) page 7.

5. Laboratory tests

The indicative tests conducted by RDW at the RDW Test Centre differ from the approval test in the laboratory in terms of the conditions. RDW wanted to avoid a situation in which manufacturers would call into question the approach to testing on the test track developed together with TNO. After all, this is not a legally established test. RDW and TNO therefore repeated a number of tests in an accredited laboratory in Germany. In this way, the RDW field tests were validated.

In a laboratory, the conditions can be controlled. In principle, the measurement conditions are then the same as those for an admission test. The external influences (the weather, condition of the road surface, number of bends, type of test driver) are then ruled out as much as possible. In the laboratory, the vehicles were also driven according to the alternative tests that were drawn up by RDW and conducted on the road. This included driving 10% faster or slower or driving the type-approval route in reverse sequence. When a vehicle exhibited temperature-dependent emission behaviour, for example, tests were conducted outside the temperature windows of the standard test conditions.

Not all sixteen vehicles were retested in the laboratory. A selection of vehicles was chosen that adequately reflects the results of each manufacturer. Some vehicles exhibited analogous emission behaviour and/or had a comparable engine.

RDW retested the following vehicles in the laboratory:

Brand	Trade name	Emission code
Chevrolet	Aveo	Euro 5
Chevrolet	Orlando	Euro 5
Jeep	Grand Cherokee	Euro 5
Jeep	Wrangler Unlimited Van	Euro 5
KIA	Optima	Euro 5
KIA	Sorento	Euro 6
Opel	Mokka	Euro 6
Suzuki	SX4	Euro 5
Suzuki	Vitara	Euro 6
Volvo	XC90	Euro 6

RDW deemed the road tests that were reported in September 2016 to be indicative. Based on the laboratory tests that were conducted, no new facts were discovered in relation to the measurements conducted by RDW on the test track. The difference between the results of the field tests and the results of the laboratory tests was less than expected. This also turned out to be the case later in the interviews with manufacturers. None of the manufacturers took exception to the measurement results that were collected using this approach.

6. Deviations in emission behaviour

During the indicative tests, the vehicles were subjected to ten different test cycles. First, the type-approval test according to the New European Driving Cycle (NEDC) was conducted for the vehicle, but then on the test track instead of in the laboratory. Then, during the field tests, the engine temperature, speed, load, duration and sequence of the test were varied.

When the vehicle displayed unexplainable emission behaviour in one of the tests, specific retests were conducted in the laboratory to illustrate this.

Based on the indicative tests conducted by RDW, the following deviations in emission behaviour are possible:

Use of cold start recognition

Every vehicle is conditioned for the approval test and prepared for the test conditions. The vehicle recognises that the engine has been cold started.
When the vehicle performs less well during a test with a warm start than a test with a cold start, this can indicate a dependency. What may be happening here is that the oil and/or coolant temperature are being used as a parameter to protect the engine against damage.

Use of a temperature window

The vehicle recognises the ambient temperature so that it can adjust the way the EGR system is controlled. During the NEDC, the temperature should be between 20 °C and 30 °C. In this programme, field tests were also conducted outside the window of 20 °C to 30 °C. Below or above these temperatures, vehicles will display different emission behaviour. This can be seen in all road tests conducted by RDW unless the ambient temperature is between 20 °C and 30 °C.

Use of a speed window

The vehicle deviates from the standard if the speed does not correspond with the required speeds in the NEDC. This is shown by the NEDC +10% and the RDE tests. Substantially higher values in only these tests compared to the laboratory test indicate a speed dependency. Because the engine load also significantly increases with the speed, the engine load may also be an important factor.

Use of a distance window

In the NEDC +10% and the RDE cycles, the driven distance is greater. If this is a reason for activating a defeat device, in the NEDC +10% it is only visible over the last 10% of the trip. This is not distinctive enough. For the RDE cycles, this is indeed visible because here, the driven distance is much higher than during the type-approval test. It is difficult to make the distinction with a time window.

Use of a time window

The specific effect of a time window is illustrated when the trip takes longer than 20 minutes. This is the case with the RDE tests that take approx. 90 minutes. A substantial increase in the NO_x/km in the RDE indicates a time window (or a distance window).

7. Surveillance interviews

This chapter lists the results of the surveillance interviews for each manufacturer.
The following RDW staff were present at the interviews:

- Manager Admission and Surveillance Vehicles (TTV)
- Manager TTV Assessment and Surveillance
- Manager TTV Product Assessment
- Operational Manager TTV Product Assessment Light Vehicles
- Operational Manager TTV Assessment and Surveillance - Surveillance Manufacturers
- Operational Manager TTV Assessment and Surveillance - Surveillance Technical Services
- Senior Adviser Emissions and Energy, Development Vehicle Regulation
- Adviser Innovation

RDW conducted surveillance interviews and follow-up interviews with the relevant manufacturers in the period from December 2016 up to and including June 2017. During these interviews, RDW discussed the test results with the manufacturers, after which the manufacturers explained RDW's results. This was followed by a discussion about the operation of the emission control system and possible improvements in the vehicle. To conclude, follow-up activities were specified and, where necessary, additional information was requested and a follow-up interview was planned.

Guide to this document

Below, the reason for the follow-up investigation is displayed for each manufacturer and for each vehicle based on the results in the 'RDW Emission Test Programme' report and on the laboratory tests that were conducted. The deviations in emission behaviour detected by RDW are also displayed. The manufacturer's justification for these figures is explained in detail and assessed by RDW. Then a short summary of the surveillance interview with the manufacturer is included. This is followed by RDW's follow-up activities, assessment and conclusion. Lastly, any outstanding points are dealt with in detail.

8. Results for each manufacturer

Volvo

In its 'RDW Emission Test Programme' report, RDW stated that it detected unexplainable very high emission behaviour in one of the two variants of the Volvo XC90. To verify this, extra tests were conducted for this variant on the roller dynamometer. Volvo was asked to explain the emission behaviour of the vehicle.
The following persons took part in the interview on behalf of Volvo:

- Senior Director, Complete Powertrain Engineering
- Senior Manager, Environmental Certification
- Attribute Leader Emissions
- Manager Diesel After-Treatment Control
- Manager Diesel Combustion Control
- Marketing Director Volvo Nederland
- Technical Specialist & Competence Development Volvo Nederland
- Manager Customer Service Volvo Nederland

Volvo XC90

Tests
Two variants of the Volvo XC90 with a Euro 6 2.0L 4-cylinder diesel engine were tested. The variants that were tested are the D4204T11 and D4204T14. These engines use an emission control system based on High Pressure Exhaust Gas Recirculation and a Lean NO_x Trap.

The test results (RDW Test Centre and Laboratory) for the Volvo XC90 are displayed in the following table:

Test type	**Field test XC90**	**D4204T11**	**Field test XC90**	**D4204T14**	**Laboratory test XC90**	**D4204T14**
	NO_x measured	CF	NO_x measured	CF	NO_x measured	CF
1 NEDC cold (T ambient ≥ 25)	271	3,4	428	5,4	65	0,8
2 NEDC hot	286	3,6	289	3,6	93	1,2
3 NEDC hot + load	376	4,7	307	3,8		
4 NEDC hot + 10%	488	6,1	503	6,3	106	1,3
5 NEDC hot -10%	231	2,9	328	4,1		
6 NEDC hot back	325	4,1	389	4,9		
7 RDE	453	5,7	n/a	n/a		
8 NEDC cold (T ambient <20)	350	4,4	422	5,3	226	2,8
9 NEDC hot (T ambient <20)	396	5,0	1157	14,5	143	1,8
10 NEDC hot + 10%	690	8,6	644	8,1		
11 NEDC hot back	355	4,4	426	5,3		
12 NEDC hot - no start	277	3,5	354	4,4		
13 RDE	393	4,9	481	6,0		

Based on the tests that were conducted at the RDW Test Centre, RDW detected the following non-standard emission behaviour:

Deviation in emission behaviour	Yes	No
Use of cold start recognition	X	
Use of a temperature window	X	
Use of a speed window (engine load)	X	
Use of a distance window		X
Use of a time window		X

The tested Volvo XC90 vehicles do not display any major differences when the engine has been switched on for a longer time. The vehicle is not retested in the laboratory on the basis of a time and/or distance window.

Unexplainable differences with a higher engine load (NEDC +10%) were detected. In addition, the vehicle displays a significant increase during the transition from NEDC to the NEDC hot. Moreover, the vehicle seems to be displaying temperature-dependent emission behaviour.

Based on these results, RDW conducted five additional tests in the laboratory. The values in the laboratory were many times lower than the results of the field tests.

RDW asked Volvo to explain the measured values and the differences between the field and laboratory tests.

Surveillance interview

During the surveillance interview, Volvo stated that it never used control mechanisms in the emission control system that recognise that an approval test is being conducted.

Volvo endorsed RDW's test method. Volvo also conducted its own field tests of the Euro 6b during which it measured emission values comparable to RDW's results. The emission values that were measured are the result of a combination of the chosen technology, the parts that were used and the system settings. The results of the tests were discussed in detail during the interview. Volvo provided a detailed justification of the deviations in the field test compared to the admission test.

Volvo used modulation of the EGR system, where the system is only briefly switched off in a temperature range between 0°C and 30°C. This was demonstrated with extensive road tests at different temperatures. In addition, Volvo displayed graphs with results of the scope of the EGR system.
The system works in the same way on the roller dynamometer as on the road, but there are factors that affect the operation of the EGR system. According to Volvo, the following factors affect the NO_x emissions in practice:

- Preparation of the vehicle
- Higher resistance due to driving on the road
- Weather and ambient conditions
- The driving behaviour of the driver during the test.
- Vehicle status, maintenance history and fuel used.

In practice, the progression of the measured NO_x emissions for the lighter vehicles (Volvo V40) is logical given the higher engine load and the modulation of the EGR system deployed at lower temperatures.
A number of peaks are probably due to the influence of weather conditions and variations in the tests.

In the heavier vehicles (Volvo XC90), the increase in NO_x is greater due to the higher resistance and the vehicle mass compared to the lighter vehicles. The absence of a speed-related control was explained in detail by Volvo by mapping out the relationship between the NEDC tests and the RDE test. This is not a trend, because the data is comparable.

What Volvo was not able to justify was the inexplicably very high emission behaviour of the Volvo XC90 D4204T14 tested by RDW. According to Volvo, this could have been attributable to a possible technical defect in the vehicle and/or the measurement equipment. RDW said that it will retest a Volvo XC90 at the RDW Test Centre.

Below, the test results of a different randomly selected Volvo XC90 D4204T14 are displayed:

Test type	**Field tests Volvo XC90** No_x measured	**D4204T14** CF
1 NEDC cold (T ambient ≥ 25)	525	3,4
2 NEDC hot	500	3,6
3 NEDC hot + load	464	4,7
4 NEDC hot + 10%	719	6,1
5 NEDC hot -10%	379	2,9
6 NEDC hot back	463	4,1
7 RDE	n/a	n/a
8 NEDC cold (T ambient <20)	548	4,4
9 NEDC hot (T ambient <20)	506	5,0
10 NEDC hot + 10%	678	8,6
11 NEDC hot back	508	4,4
12 NEDC hot - no start	530	3,5
13 RDE	404	4,9

When the new Volvo XC90 was retested at the RDW Test Centre, the NO_x emissions were higher across the board than the type-approval limit. During earlier field tests, a peak was measured during the NEDC hot test. During the retest, RDW did not detect this peak again, so this confirmed Volvo's suspicion that the earlier vehicle had a broken sensor.

The higher measured values during the tests at the RDW Test Centre compared to the laboratory tests can be explained by the relatively heavy engine load and the weather conditions[3]. The ambient temperature was relatively low during the tests (7°C to 11°C). This shows that the EGR system was modulated on the basis of the ambient temperature.

To summarise, the higher NO_x emissions in the field were the result of different factors such as the speed and temperature, and it is for this reason that the results of the field tests deviate significantly from the admission test. In addition, the combination of vehicle mass and the behaviour of the test driver and drive line affect the NO_x emitted in the field.

3. By weather conditions is meant the external temperature, wind speed and precipitation.

Conclusion

Volvo has adequately demonstrated that regulation of the EGR system is necessary in order to protect the engine. No corrective measures or recall campaigns are necessary.

The NO_x value measured earlier for the Volvo XC90 was not reproducible. In the laboratory and at the RDW Test Centre, no unexplainable non-standard emission behaviour was detected in the new Volvo XC90.

No follow-up steps are necessary, so the file for these vehicles is closed.

Outstanding points

All outstanding points have been dealt with.

Hyundai and KIA

During the surveillance interviews with RDW, the Hyundai and KIA brands were represented by the same persons. This is because the parent company uses the same development department for both brands. In addition, the vehicles use the same engines and drive lines.

In its ‘RDW Emission Test Programme’ report, RDW stated that it detected unexplainable non-standard emission behaviour in various Hyundai and KIA vehicles. This involves the Hyundai i40 and the KIA Cee´d, Optima and Sorento (Euro 6). The Hyundai I40 and KIA Cee’d were not retested given that they use engines from the same engine family as the Optima and Sorento and the emission behaviour of the vehicles is comparable. The vehicles particularly exhibited non-standard emission behaviour at a temperature lower than 20 °C.

During the interview, the following persons attended on behalf of Hyundai and KIA:

- Head of Powertrain, Hyundai Engine Europe Technical Center
- Senior Powertrain Engineer, Hyundai Engine Group Korea
- Advisor Regulation & Certification Team, Hyundai Engine Group Korea
- Advisor Hyundai Brussels office
- Director for After Sales, Hyundai Motor Nederland

Below, for each vehicle type we focus in detail on the findings of the tests and the results of the interviews.

KIA Sorento Tests
For the test, a KIA Sorento with a Euro 6 2.2L 4-cylinder diesel engine with engine code D4HB was used. This engine uses an emission control system based on High Pressure Exhaust Gas Recirculation and an integrated Diesel Oxidation Catalyst (oxidation of exhaust gases) and Diesel Particle Filter (soot filter).

The test results of the KIA Sorento are displayed in the following table:

Test type	**Field tests KIA Sorento**	**Laboratory test KIA Sorento**		
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	292	3,7	52	0,7
2 NEDC hot	272	3,4		
3 NEDC hot + load	371	4,6		
4 NEDC hot + 10%	408	5,1	166	2,1
5 NEDC hot -10%	263	3,3		
6 NEDC hot back	258	3,2		
7 RDE	n/a	n/a		
8 NEDC cold (T ambient <20)	224	2,8	331	4,1
9 NEDC hot (T ambient <20)	184	2,3		
10 NEDC hot + 10%	451	5,6		
11 NEDC hot back	175	2,2		
12 NEDC hot - no start	270	3,4		
13 RDE	499	6,2		

Based on the tests that were conducted at the RDW Test Centre and in the laboratory, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	**Yes**	**No**
Use of cold start recognition		X
Use of a temperature window	X	
Use of a speed window (engine load)	X	
Use of a distance window		X
Use of a time window		X

Er zijn geen grote verschillen zichtbaar tussen testen met een koude en warme motor. Ook schakelt het voertuig niet anders wanneer de motor voor langere tijd is ingeschakeld.

There are no major differences visible between tests with a cold and a warm engine. In addition, the vehicle does not change gears differently when the engine has been switched on for a longer time.

However, the vehicle does have high NO_x emissions with a higher engine load. The NO_x emissions during the indicative tests with a higher engine load (NEDC + 10%) are around CF ~5. The vehicle also reacts more strongly to lower ambient temperatures that are just outside the test conditions. To further investigate this emission behaviour, three tests were conducted in the laboratory: the standard type-approval test, a test with a heavier engine load (NEDC + 10%) and a standard type-approval test at an ambient temperature of 14 °C. The results of the laboratory tests exhibit a CF of ~4 in the tests with a lower ambient temperature and the two other tests show a lower CF than tested at the RDW Test Centre.

RDW has asked Hyundai and KIA to explain the measured values.

KIA Optima Tests

For the test, a KIA Optima with a Euro 5 1.7L 4-cylinder diesel engine with engine code D4FD was used. This engine uses an emission control system based on High Pressure Exhaust Gas Recirculation and an integrated Diesel Oxidation Catalyst (oxidation of exhaust gases) and Diesel Particle Filter (soot filter).

The test results of the KIA Optima are displayed in the following table. When there are two values, it means that a test was conducted several times:

Test type	**Field tests KIA Optima**	**Laboratory test KIA Optima**		
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	266	1,5	182	1,0
2 NEDC hot	n/a	n/a	485	2,7
3 NEDC hot + load	292	1,6		
4 NEDC hot + 10%	413	2,3		
5 NEDC hot -10%	313	1,7		
6 NEDC hot back	355	2,0		
7 RDE	n/a	n/a		
8 NEDC cold (T ambient <20)	951	5,3	1230	6,8
9 NEDC hot (T ambient <20)	n/a	n/a	192	1,1
10 NEDC hot + 10%	444	2,5		
11 NEDC hot back	267	1,5		
12 NEDC hot - no start	297	1,7		
13 RDE	n/a	n/a		

Based on the tests that were conducted at the RDW Test Centre and in the laboratory, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	**Yes**	**No**
Use of cold start recognition		X
Use of a temperature window	X	
Use of a speed window (engine load)		X
Use of a distance window		X
Use of a time window		X

Various tests on the KIA Optima were conducted twice in the laboratory. This because half-way through the test programme it was found that the vehicle had a defective battery, which had to be replaced with another battery. Because of this, two NEDC cold tests and an NEDC hot test were declared invalid and excluded from the report. The battery voltage was found to influence the control behaviour of the engine, which meant that the NO_x and CO_2 emissions were not stable. Given the results, this vehicle reacts quite strongly to ambient temperatures under the test conditions. In addition, no major differences were detected between tests with a cold and warm engine. In addition, the vehicle does not change gears differently when the engine has been switched on for a longer time.

However, the vehicle does have high NO_x emissions at a lower ambient temperature. The NO_x emissions during the indicative tests at a lower ambient temperature NEDC cold (T ambient ≤ 20) are around CF ~5. To further investigate this emission behaviour, three tests were conducted in the laboratory: a standard type-approval test, a standard type-approval test with a warm engine and a standard type-approval test with an ambient temperature of 14°C. The results of the laboratory tests show a CF of ~7 in the tests at a lower ambient temperature.
RDW has asked Hyundai and KIA to explain the measured values.

Surveillance interview

During the interview, Hyundai and KIA endorsed RDW's test results. Hyundai and KIA said that the measured emission values are the result of a combination of the chosen technology, the parts that were used and the system settings.

According to Hyundai and KIA, the difference between the values measured at the RDW Test Centre and those in the test laboratory was due, amongst other things, to the test conditions and the ambient temperature.

Hyundai and KIA explained the emission strategy for the vehicles. An increased engine load results in increased NO_x emissions, which leads to different results for the various tests. Hyundai and KIA said that the reduction in the ratio of the exhaust gas recirculation is used to achieve the requisite sustainability of the EGR system in cold air. In all the vehicles, the components are positioned on the warm side of the system to ensure the optimal performance of the EGR system. In addition, Hyundai and KIA say that during the field tests there are various factors that affect the NO_x emissions. Hyundai and KIA mentioned wind, driving behaviour and engine load, amongst other things. According to RDW, the explanation given in the first interview was not sufficiently substantiated. Additional information that was supplied should have been better substantiated.

Hyundai and KIA then gave RDW a more detailed explanation of the way the EGR system is regulated in the range from 0 °C to 30 °C. Hyundai and KIA explained this regulation in detail and it was assessed by RDW. The system has been set up in such a way that it is not switched off within a temperature range of 0 °C to 30 °C but is modulated to protect the engine against pollution. Hyundai and KIA demonstrated this using graphs and diagrams with a detailed illustration of the way the EGR system is modulated.

Conclusion

Hyundai and KIA have adequately demonstrated that it is necessary to regulate the EGR system in order to protect the engine. For the KIA Sorento, the KIA Optima and vehicles in the same engine family (Hyundai i40 and KIA Cee'd), it was demonstrated that there is no unauthorised non-standard emission behaviour. No follow-up steps are necessary, so the file for these vehicles is closed.

Outstanding points

All outstanding points have been dealt with.

Suzuki

In its 'RDW Emission Test Programme' report, RDW stated that it detected unexplainable non-standard emission behaviour in two Suzuki vehicles. These vehicles are the Suzuki SX4 (Euro 5) and Suzuki Vitara (Euro 6). Particularly at temperatures that are different to the admission test, there is non-standard emission behaviour in both vehicles. RDW suspects that in the Suzuki Vitara the time for which the engine is running influences the operation of the emission control system. This is unacceptable.
The following persons took part in the interview on behalf of Suzuki:

- Managing Officer, Suzuki Engine Corporation Japan
- Director Automobile Engineering, Suzuki Engine Corporation Japan
- European liaison officer, Suzuki Engine Corporation Japan
- Powertrain Engineering Vice President Fiat Chrysler Automotive Italy
- Emissions & After-treatment Coordination Fiat Chrysler Automotive Italy

Suzuki SX4

One Suzuki SX4 with a Euro 5 1.6L 4-cylinder diesel engine was tested. It involves the D16AA variant. This engine uses an emission control system based on High Pressure EGR.

The table below displays the test results (RDW Test Centre and Laboratory) for the Suzuki SX4:

Test type	**Field tests Suzuki SX4**		**Laboratory test Suzuki SX4**	
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	457	2,5	190	1,1
2 NEDC hot	722	4	466	2,6
3 NEDC hot + load	693	3,9		
4 NEDC hot + 10%	691	3,8		
5 NEDC hot -10%	614	3,4		
6 NEDC hot back	453	3,6		
7 RDE	715	4,0		
8 NEDC cold (T ambient <20)	1059	5,9	221	1,2
9 NEDC hot (T ambient <20)	785	4,4	409	2,3
10 NEDC hot + 10%	820	4,6		
11 NEDC hot back	808	4,5		
12 NEDC hot - no start	757	4,2	487	2,7
13 RDE	739	4,1		

Based on the tests that were conducted at the RDW Test Centre, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	**Yes**	**No**
Use of cold start recognition	X	
Use of a temperature window	X	
Use of a speed window (engine load)		X
Use of a distance window		X
Use of a time window		X

The Suzuki SX4 exhibited no major differences when the engine has been switched on for a longer time. The vehicle is not retested in the laboratory on the basis of a time and/or distance window. In addition, the engine load has no significant deviant effect on the measured NO_x emissions in practice.

There are unexplainable differences at a lower temperature, which means that an extra test in the laboratory is necessary. To map out the emission behaviour properly, the effect on the emissions with a warm engine at a low temperature is also investigated. Partly because the Suzuki Vitara, which has the same engine as the Suzuki SX4, is exhibiting non-standard emission behaviour based on the time and/or distance, the Suzuki SX4 will also be tested with a longer activation duration.

Based on these conclusions, RDW conducted five tests in the laboratory. The values in the laboratory were many times lower than in the field tests. The differences between the type-approval test at 25°C and 14 °C and tests with a warm engine and after a longer activation duration were relatively large, however.

RDW asked Suzuki to explain the values that were measured and the differences between the field and laboratory tests.

Surveillance interview

Suzuki explained the emission strategy for the vehicles. Suzuki asked the engine manufacturer (Fiat Chrysler Automotive – FCA) to take part in the surveillance interview to explain how the engine operates.

RDW also asked Suzuki and FCA to explain the emission control system and confirm whether it is using a regulator for the EGR system. Suzuki and FCA said that this system does not switch off on the basis of the ambient temperature. But it does use modulation on the basis of the ambient temperature. There is also modulation based on the cooling water temperature, which explains the higher emissions with a warm engine. This switch-off takes place to protect the engine. The manufacturer was surprised about the results during the NEDC cold test. The values should not be so high (CF 5.1). To compare: information was supplied about different tests that were conducted on the Suzuki SX4 by other European approval bodies. The tests were conducted at different ambient temperatures. FCA then also decided to conduct its own tests at lower ambient temperatures and in that way simulate the behaviour of the vehicle. The results of these tests were shared with the RDW. RDW's assessment of the information obtained is that the vehicle modulates the EGR system on the basis of the ambient temperature in order to protect the engine.

Conclusion

For the Suzuki SX4, Suzuki and FCA have demonstrated sufficiently plausibly that modulation of the EGR system at lower ambient temperatures and on the basis of the cooling water temperature is necessary to protect the engine. For RDW, this concludes the investigation of the Suzuki SX4.

Outstanding points

There are no outstanding points for this vehicle.

Suzuki Vitara

One Suzuki Vitara with a Euro 6 1.6L 4-cylinder diesel engine was tested. It involves the D16AA variant. This engine uses an emission control system based on high and low pressure EGR in combination with LNT.

Test type	Field tests Suzuki Vitara No_x measured	 CF	Laboratory test Suzuki Vitara No_x measured	 CF
1 NEDC cold (T ambient ≥ 25)	145	1,8	90	1,1
2 NEDC hot	181	2,3		
3 NEDC hot + load	192	2,4		
4 NEDC hot + 10%	204	2,6		
5 NEDC hot -10%	180	2,3		
6 NEDC hot back	149	1,9		
7 RDE	n/a	n/a		
8 NEDC cold (T ambient <20)	290	3,6	377	4,7
9 NEDC hot (T ambient <20)	213	2,7		
10 NEDC hot + 10%	195	2,4		
11 NEDC hot back	148	1,9		
12 NEDC hot - no start	361	4,5	274	3,4
13 RDE	517	6,5		

Based on the tests that were conducted at the RDW Test Centre, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	Yes	No
Use of cold start recognition		X
Use of a temperature window	X	
Use of a speed window (engine load)		X
Use of a distance window	X	
Use of a time window	X	

During the field tests, the Suzuki Vitara displays no non-standard emission behaviour based on the engine temperature or engine load. Based on the ambient temperature, there is an increase, but it remains under the specified CF5.

With a longer activation duration of the engine (NEDC hot – no start and RDE), the vehicle displays non-standard emission behaviour. In the laboratory, tests are being conducted on the basis of a time and/or distance window to explain the results. Given the unexplainable differences in the Suzuki SX4 at low temperatures, the influence of the ambient temperature on the emissions is also being examined.

Based on these conclusions, RDW conducted three tests in the laboratory. The differences between the type-approval test at 25 °C and 14 °C and tests with a warm engine and after a longer activation duration are relatively large (CF ~5). In addition, the activation duration of the engine also displays a relatively significant difference (CF ~3) compared to the normal NEDC test.

RDW asked Suzuki to explain the values that were measured and the differences between the field and laboratory tests.

Surveillance interview

During the interview, Suzuki endorsed RDW's test results. Suzuki explained that the measured emission values are the result of a combination of the chosen technology, the parts that were used and the adjustment of systems.

Suzuki explained the emission strategy for the vehicles. Suzuki asked the engine manufacturer (Fiat Chrysler Automotive – FCA) to take part in the surveillance interview to explain how the engine operates. FCA was unable to explain the finding that the duration for which the engine is switched on affects the operation of the EGR system. FCA contradicted this and said that there is a time-related switch in the vehicle. RDW said that the time for which the engine is running cannot be an element to protect the engine and that this is unacceptable. FCA also said that the Italian Ministry of Transport, which is responsible for the type-approval that was issued, conducted tests and did not detect any time-related switch.

RDW also asked Suzuki and FCA to explain the emission control system and confirm whether the EGR system is regulated. Suzuki and FCA said that this system does not switch off on the basis of the ambient temperature. But it does use modulation on the basis of the ambient temperature.

Although Suzuki and FCA believe that there is no need to adapt the vehicles, Suzuki did say that a software update for various vehicles, including the Suzuki Vitara, is available and will be implemented in the ongoing production process and rolled out for the existing fleet of vehicles. RDW then said that it wants to test this update in order to assess the consequences for the actual NO_x emissions. It is also important to determine after the update whether the time for which the engine is running does or does not influence emission behaviour.

In January 2017, RDW tested a vehicle in FCA's test laboratory in Italy with the proposed software update. This test was then repeated in the Netherlands with a random vehicle in which the software update had been installed. This test was conducted at the RDW Test Centre.

Test type	**Field tests Suzuki Vitara**		**Laboratory test Suzuki Vitara**	
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	824	10,3	38	0,5
2 NEDC hot	601	7,5		
3 NEDC hot + load	537	6,7		
4 NEDC hot + 10%	681	8,5		
5 NEDC hot -10%	554	6,9		
6 NEDC hot back	601	7,5		
7 RDE	n/a	n/a		
8 NEDC cold (T ambient <20)	484	6,1		
9 NEDC hot (T ambient <20)	370	4,6		
10 NEDC hot + 10%	509	6,4		
11 NEDC hot back	560	7,0		
12 NEDC hot - no start	657	8,2	92 / 98	1,2 / 1,2
13 RDE	831	10,4		

In the laboratory in Italy, 3 tests were conducted on a Suzuki Vitara with a software update in which the engine was no longer restarted after the first test. The aim of these tests is to confirm under the tested conditions that there is no reason to assume the presence of a time-related EGR modulation. The CF of 1.2 measured in the two NEDC hot – no start tests was to be expected.

The tests at the RDW Test Centre were conducted at a low ambient temperature that varied from 4 °C to 9 °C. The influence of the ambient temperature on the NO_x emissions is clearly visible. As Suzuki also states, the EGR system is modulated on the basis of the ambient temperature.
In the tests, no link was found between the NO_x emissions in practice and the effect of the time for which the engine is running on the emission control system. This is evident from the results of the NEDC hot – no start and RDE, which are not significantly higher than the other test results. No time-dependent emission control system was detected in the relevant vehicles in question.

Conclusion

Suzuki regulates the EGR system on the basis of the ambient temperature. The system is not switched off but is modulated to protect the engine against pollution.

The indicative road tests show that the emissions made by the Suzuki Vitara increase when the test takes longer than the usual emission test. This may indicate that the operation of the emission control system is time-dependent. After the software update, it could no longer be demonstrated that the time for which the engine is running affects the operation of the emission control system. The cause was therefore removed and the vehicle now complies with the admission requirements. The update was implemented in the ongoing production process and supplied as a service update, and is now available to all the relevant vehicle holders through the Suzuki dealer network.
This will be checked as part of the regular surveillance conducted by RDW.

RDW considers a time-dependent emission control system to be unacceptable. It may be that a punishable offence has been committed. This will be assessed by the Public Prosecution Service. RDW will conduct further investigations on the Suzuki Vitara to find out whether unauthorised emission manipulation may have taken place. Where necessary, RDW will notify the Public Prosecution Service. In addition, RDW is in close contact with the European Commission and its fellow approval authorities.

Outstanding points

All outstanding points have been dealt with from the perspective of the admission process.

RDW will start setting up an additional test programme with a Suzuki vehicle fitted with the software from before the service update. RDW will also investigate whether the low ambient temperature during the control test of the software update may have had an effect. Criminal responsibility for this file lies with the Public Prosecution Service. RDW and the Public Prosecution Service are consulting on the matter.

Opel and Chevrolet

RDW has registered the manufacturers Adam Opel GmbH (Opel) and GM Korea Company (Chevrolet) for surveillance interviews. The vehicles use the same drive lines and are therefore represented by the same persons.
In its ‘RDW Emission Test Programme’ report, RDW stated that it detected unexplainable non-standard emission behaviour in various Opel and Chevrolet vehicles. This relates to the Chevrolet Aveo, Cruze and Orlando and the Opel Mokka (Euro 5 and Euro 6). Only the Chevrolet Orlando and Aveo and the Opel Mokka (Euro 6) were retested; this is because the Chevrolet Cruze and the Opel Mokka (Euro 5) use engines from the same engine family as the Chevrolet Orlando and Aveo and the emission behaviour of those vehicles is comparable. Non-standard emission behaviour was detected at temperatures that deviated from the admission test.

During the interview, the following persons attended on behalf of Opel and Chevrolet:

- Executive Director Global Propulsion Systems Embedded Controls
- Vice President GM Global Propulsion Systems – Europe
- Director EU Affairs, Head of Brussels Office
- Director GME Regulations & Certification

Chevrolet Orlando Tests
For the test, a Chevrolet Orlando with a Euro 5, 2.0L 4-cylinder diesel engine with engine code Z20D1 was used. This engine uses an emission control system based on High Pressure Exhaust Gas Recirculation and an integrated Diesel Oxidation Catalyst (oxidation of exhaust gases) and Diesel Particle Filter (soot filter).

The test results for the Chevrolet Orlando are displayed in the following table:

Test type	**Field tests Chevrolet Orlando**		**Laboratory test Chevrolet Orlando**	
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	1242	6,9	202	1,1
2 NEDC hot	1521	8,5	526	2,9
3 NEDC hot + load	1772	9,8		
4 NEDC hot + 10%	1422	7,9		
5 NEDC hot -10%	1391	7,7		
6 NEDC hot back	1468	8,2		
7 RDE	n/a	n/a		
8 NEDC cold (T ambient <20)	809	4,5	1696	9,4
9 NEDC hot (T ambient <20)	479	2,7	1481	8,2
10 NEDC hot + 10%	700	3,9		
11 NEDC hot back	720	4,0		
12 NEDC hot - no start	679	3,8		
13 RDE	1265	7,0		

Based on the tests that were conducted at the RDW Test Centre and in the laboratory, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	**Yes**	**No**
Use of cold start recognition		X
Use of a temperature window	X	
Use of a speed window (engine load)		X
Use of a distance window		X
Use of a time window		X

Given the results, this vehicle is exhibiting relatively high values over the entire range. In addition, no major differences were detected between tests with a cold and warm engine. In addition, the vehicle does not change gears differently when the engine has been switched on for a longer time.
To further investigate this emission behaviour, four tests were conducted in the laboratory: a standard

type-approval test, a standard type-approval test with a warm engine, a standard type-approval test with an ambient temperature of 14 °C and a standard type-approval test with a warm engine and an ambient temperature of 14 °C. The tests were conducted with a different
vehicle to the vehicle with which the indicative tests were conducted. The results of the laboratory tests exhibit a high CF in the tests with a lower ambient temperature.

RDW has asked Opel and Chevrolet to explain the measured values.

Chevrolet Aveo

For the test, a Chevrolet Aveo with a Euro 5, 1.2L 4-cylinder diesel engine with engine code A13DTE was used. This engine uses an emission control system based on High Pressure Exhaust Gas Recirculation and an integrated Diesel Oxidation Catalyst (oxidation of exhaust gases) and Diesel Particle Filter (soot filter).

The test results for the Chevrolet Aveo are displayed in the following table:

Test type	**Field tests Chevrolet Aveo**		**Laboratory test Chevrolet Aveo**	
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	293	1,6	156	0,9
2 NEDC hot	485	2,7	123	0,7
3 NEDC hot + load	518	2,9		
4 NEDC hot + 10%	623	3,5		
5 NEDC hot -10%	329	1,8		
6 NEDC hot back	448	2,5		
7 RDE	417	2,3		
8 NEDC cold (T ambient <20)	1191	6,6	692	3,8
9 NEDC hot (T ambient <20)	1122	6,2	747	4,1
10 NEDC hot + 10%	1209	6,7		
11 NEDC hot back	1052	5,8		
12 NEDC hot - no start	1107	6,2		
13 RDE	961	5,3		

Based on the tests that were conducted at the RDW Test Centre and in the laboratory, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	**Yes**	**No**
Use of cold start recognition		X
Use of a temperature window	X	
Use of a speed window (engine load)		X
Use of a distance window		X
Use of a time window		X

The vehicle that was tested during the indicative tests has high NO_x emissions at a lower ambient temperature. The NO_x emissions during the indicative tests with a lower ambient temperature NEDC cold (T ambient ≤ 20) are around CF ~6. In addition, no major differences were detected between tests with a cold and warm engine. In addition, the vehicle does not change gears differently when the engine has been switched on for a longer time.

To further investigate this emission behaviour, four tests were conducted in the laboratory: a standard type approval test, a standard type approval test with a warm engine, a standard type-approval test with an ambient temperature of 14°C and a standard type approval test with a warm engine and an ambient temperature of 14°C. The results of the laboratory tests exhibit a high CF in the tests with a lower ambient temperature.

RDW has asked Opel and Chevrolet to explain the measured values.

Opel Mokka (Euro 6)

For the test, an Opel Mokka with a Euro 6, 1.6L 4-cylinder diesel engine with engine code B16DTH was used. This engine uses an emission control system based on High Pressure Exhaust Gas Recirculation, Lean NO_x Trap and an integrated Diesel Oxidation Catalyst (oxidation of exhaust gases) and Diesel Particle Filter (soot filter).

The test results for the Opel Mokka are displayed in the following table:

Test type	Field tests Opel Mokka		Laboratory test Opel Mokka	
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	287	3,6	125 /192	1,6 / 2,4
2 NEDC hot	316	4,0	509	6,4
3 NEDC hot + load	451	5,6		
4 NEDC hot + 10%	353	4,4		
5 NEDC hot -10%	286	3,6		
6 NEDC hot back	159	2,0		
7 RDE	338	4,2		
8 NEDC cold (T ambient <20)	435	5,4	278	3,5
9 NEDC hot (T ambient <20)	412	5,2	287	3,6
10 NEDC hot + 10%	392	4,9		
11 NEDC hot back	326	4,1		
12 NEDC hot - no start	343	4,3		
13 RDE	n/a	n/a		

Based on the tests that were conducted at the RDW Test Centre and in the laboratory, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	Yes	No
Use of cold start recognition		X
Use of a temperature window		X
Use of a speed window (engine load)	X	
Use of a distance window		X
Use of a time window		X

Given the results of the indicative tests, this vehicle is not particularly responsive to ambient temperatures that are just outside the test conditions. In addition, no major differences were detected between tests with a cold and warm engine. In addition, the vehicle does not change gears differently when the engine has been switched on for a longer time.

However, the vehicle does have high NO_x emissions with a higher engine load. The NO_x emissions during the indicative tests with a higher engine load (NEDC + 10%) are appreciably higher than the CF 5. To further investigate this emission behaviour, four tests were conducted in the laboratory: two standard type-approval tests at 25°C, a standard type-approval test at 25°C with a warm engine and a standard type-approval test at 14°C. The result of the standard type-approval test at 25°C with a warm engine still cannot be explained. The other values exhibit a lower CF than the indicative values that were measured at the RDW Test Centre. The NO_x emissions at a lower ambient temperature of 14°C are considerably higher than the values measured at an ambient temperature of 25°C.

RDW has asked Opel and Chevrolet to explain the measured values.

Surveillance interview

During the interview, Opel and Chevrolet endorsed RDW's test results. Opel and Chevrolet said that the measured emission values are the result of a combination of the chosen technology, the parts that were used and the fine-tuning of systems.

Opel and Chevrolet explained the emission strategy for the vehicles. According to RDW, the explanation given in the first interview was unsatisfactory. Modulation of the EGR system was not discussed. Opel and Chevrolet were therefore asked to supply more information and provide extensive justification of the regulation of the EGR system from 0°C to 30°C.

Opel and Chevrolet explained the emission control strategy in the 0°C to 30°C range to RDW. The results were discussed in detail during a follow-up interview. RDW was not yet fully convinced of the need to protect the engine at 14°C and 18°C, respectively. RDW asked Opel and Chevrolet for a letter that responds to at least the following items:

1. A description of why little or no use is made of exhaust gas recirculation outside the test temperature range of the NEDC for the three tested vehicles.
2. A description of the improvements that can be made in the EGR system outside the test temperature range of the NEDC for the EU5 vehicles.
3. A description of the developments in the NO_x reduction systems from 2007 and the impact on the actual NO_x emissions during use.
4. An explanation of why Opel and Chevrolet believe that they comply with Article 3, definition number 10 and Article 5, item 2 of 715/2007/EC.
5. The information specified in the last section of Article 3, item 9 of 692/2008/EC as shared during the meeting.

In response, Opel and Chevrolet said that they make limited use of exhaust gas recirculation. The EGR system is switched off at particular temperatures within the temperature range of 0 °C to 30 °C (depending on the engine type at 14°C or 18°C). The reason for this switch-off is the quality of the parts that were used and the influence of the temperature on the emission control system. RDW carefully studied the information supplied by Opel and Chevrolet. In RDW's view, Opel and Chevrolet should have made more use of the EGR system. In the follow-up interview, it was found that Opel and Chevrolet do not consider it to be reasonably possible to update existing vehicles and keep complying with the type-approval values. Adjustment of the modulation would lead to more engine damage. This was plausibly demonstrated by Opel and Chevrolet using data about defects in the engine and various parts. Because of this, any adjustment realises just marginal improvements in emission behaviour. The focus for Opel and Chevrolet is on continuing to develop software and hardware and in that way meet the requirements set for the RDE test. RDW has carefully assessed the information and has also requested an external expertise assessment.

Conclusion

The emission behaviour only satisfies the specified requirements within a narrow temperature range. However, after supplying all the requested additional information, Opel and Chevrolet plausibly demonstrated to a sufficient degree that the regulation of the EGR system is necessary to protect the engine. Engine protection on the basis of the ambient temperature is therefore permitted for these vehicles.

Outstanding points

All outstanding points have been dealt with.

Fiat Chrysler Automobiles (FCA)

In the report 'RDW Emission Test Programme', RDW stated that it had detected unexplainable non-standard emission behaviour in two vehicle types for which RDW issued emission certificates to FCA. These two vehicle types were the Jeep Wrangler (two variants) and the Jeep Grand Cherokee. At higher driven speeds and different temperatures to the admission test, there was non-standard emission behaviour.

In December 2016, March 2017 and May 2017, surveillance interviews were held on this subject, where the following persons visited RDW on behalf of Fiat Chrysler Automobiles (FCA):

- Powertrain Engineering Vice President FCA
- Powertrain Calibration Engineer FCA
- General Counsel FCA

For each vehicle type, the findings and the results of the interviews will be dealt with in greater detail.
Jeep Wrangler Tests
Two variants of the Jeep Wrangler with a Euro 5 2.8L 4-cylinder diesel engine were tested. This engine is produced by VM Motori in Cento, Italy. Since 2013, VM Motori has been fully owned by Fiat Group Automobiles, later FCA. The variants that were tested are the VM10D and the VM11D. These engines use an emission control system based on High Pressure Exhaust Gas Recirculation and an integrated Diesel Oxidation Catalyst (oxidation of exhaust gases) and Diesel Particle Filter (soot filter).

(See diagram next page)

The test results of the Jeep Wrangler are displayed in the following table:

Test type	Field tests Wrangler	VM11D	Field tests Wrangler	VM10D	Laboratory test	VM10D
	NO_x	CF	NO_x	CF	NO_x	CF
1 NEDC cold (T ambient ≥25)	385	2,1	509	2,8	191	1,1
2 NEDC hot	534	3,0	533	3,0		
3 NEDC hot + load	471	2,6	847	4,7		
4 NEDC hot + 10%	916	5,1	880	4,9	1085	6,0
5 NEDC hot -10%	492	2,7	577	3,2		
6 NEDC hot back	689	3,8	575	3,2		
7 RDE	n/a	n/a	n/a	n/a		
8 NEDC cold (T ambient <20)	755	4,2	619	3,4		
9 NEDC hot (T ambient <20)	464	2,6	579	3,2		
10 NEDC hot + 10%	893	5,0	909	5,1		
11 NEDC hot back	561	3,1	822	4,6		
12 NEDC hot - no start	507	2,8	461	2,6		
13 RDE	696	3,9	n/a	n/a		

Based on the tests that were conducted at the RDW Test Centre and in the laboratory, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	Yes	No
Use of cold start recognition		X
Use of a temperature window		X
Use of a speed window (engine load)	X	
Use of a distance window		X
Use of a time window		X

Given the results, this vehicle is not particularly responsive to ambient temperatures that are just outside the test conditions. In addition, no major differences were detected between tests with a cold and warm engine. In addition, the vehicle does not change gears differently when the engine has been switched on for a longer time.

However, the vehicle does have high NO_x emissions with a higher engine load. The NO_x emissions during the indicative tests with a higher engine load (NEDC + 10%) are around CF ~5. To further investigate this emission behaviour, two tests were conducted in the laboratory: a standard type approval test and a test with a heavier engine load (NEDC + 10%). The results of the laboratory tests display a CF of 6 in the tests with heavier load.

RDW has asked FCA to explain the measured values.

Surveillance interview

FCA said that the measured NO_x emissions are the result of a combination of the chosen technology, the parts that were used and the system settings.

According to FCA, the deviations under different conditions to the regular admission test were due to the modulation of the EGR system. During the first surveillance interview, RDW is of the opinion that FCA provided an unsatisfactory explanation of the modulation of the emission control system, so it was not possible to assess it. RDW asked for additional information and follow-up interviews were held.

In these follow-up interviews, FCA showed that it is possible to modulate the emission control system on the basis of the following factors:

- Ambient temperature
- External air pressure
- Engine temperature
- Cooling water temperature
- Vehicle speed
- Acceleration
- Revolutions per minute of the engine
- Amount of fuel (engine load)

To protect the engine, the emission control system is modulated under different conditions.

FCA was asked to demonstrate that modulation is necessary to protect the engine.

At FCA, the emission control system is controlled on the basis of the operation of the engine and ambient factors. They include the revolutions per minute, engine load, cooling water temperature and various engine settings. The specified ambient factors are the temperature and the air pressure. According to FCA, this control is necessary to protect the engine against pollution.

FCA explained the operation of the emission control system and the parameters in detail with graphs displaying the results of emission tests, calculations of the engine load, spreadsheets displaying the extent of exhaust gas recirculation with different ambient factors and photographs of damage to the engine[4] due to the use of a EGR system under particular conditions that can cause engine damage – for example, an intensive engine load. In addition, FCA says that short, intensive city trips can lead to high soot emissions and the generation of hydrocarbons (damp soot), which progressively leads to the failure of engine parts. The EGR system has been adjusted so that there is enough protection to ensure that no acute engine damage can occur in these situations. The aim of this protection is to guarantee that the vehicle systems continue to perform under all conditions.

FCA itself also tested a Jeep Wrangler vehicle in the laboratory and arrived at NO_x values that were 40% lower than the RDW during the laboratory tests. To explain this, the CO_2 values were also examined. These display CO_2 values that are 20% lower compared to the tests conducted by RDW in the laboratory. The lower CO_2 values correspond more with the type-approval value. During the interview, the possible cause of this difference was discussed in detail.

The reasons for the difference in measured values are (partly) due to the condition of the vehicle and the chosen settings of the roller dynamometer. When conducting a laboratory test, different settings are possible for a roller dynamometer. During the test, RDW used table values because they were also used during the type-approval. These table values do not take the condition of the vehicle into account. When coast down values are used for the roller dynamometer settings, the settings are corrected to match the settings at the time of the type-approval. This takes the condition of the vehicle into account, but this is not the case when table values are used. FCA tested a vehicle that more closely corresponds with the vehicle at the time of the type-approval, which results in lower emissions.

4. Diesel Particulate Filter, EGR valve, inlet valves, Lambda sensor and inlet manifold.

The high NO_x emissions with a higher engine load was justified by FCA in the following way:
The combination of vehicle mass and energy requirement that leads to a particular engine load in order to drive a constant speed has a direct influence on the control of the EGR system. The heavier load of the diesel engine means that a larger amount of fuel is injected, so there is less space for diffusion with air. As a consequence, less use is made of the EGR system. This is necessary to generate stable combustion and minimise the precipitation of dirt in the engine. The consequence of this control is that the NO_x emissions are significantly increased with a higher engine load.

Conclusion

FCA has demonstrated sufficiently plausibly that modulation of the EGR system at lower ambient temperatures and higher engine capacities is necessary to protect the engine. For RDW, this concludes the investigation into the Jeep Wrangler.

Outstanding points

There are no outstanding points for this vehicle.

Jeep Grand Cherokee Tests

A Jeep Grand Cherokee with a Euro 5 3.0L V6 diesel engine was tested. This engine is produced by VM Motori in Cento, Italy. Since 2013, VM Motori has been fully owned by Fiat Group Automobiles, later FCA. The test vehicle was fitted with AT5 automatic transmission, which was replaced by the AT8 in 2013.

These engines use an emission control system based on High Pressure Exhaust Gas Recirculation and an integrated Diesel Oxidation Catalyst (oxidation of exhaust gases) and Diesel Particle Filter (soot filter). The test results of the Jeep Grand Cherokee are displayed in the following table:

Test type	**Field tests Grand Cherokee**		**Laboratory test Grand Cherokee**	
	No_x measured	CF	No_x measured	CF
1 NEDC cold (T ambient ≥ 25)	1249	6,9	220	1,2
2 NEDC hot	1874	10,4	1630	9,1
3 NEDC hot + load	2083	11,6		
4 NEDC hot + 10%	2062	11,5	1646	9,1
5 NEDC hot -10%	1972	11		
6 NEDC hot back	1914	10,6		
7 RDE	1889	10,5		
8 NEDC cold (T ambient <20)	1283	7,1		
9 NEDC hot (T ambient <20)	1935	10,8		
10 NEDC hot + 10%	2195	12,2		
11 NEDC hot back	1953	10,9		
12 NEDC hot - no start	2062	11,5		
13 RDE	1672	9,3		

Based on the tests that were conducted at the RDW Test Centre and in the laboratory, the following non-standard emission behaviour was detected:

Deviation in emission behaviour	Yes	No
Use of cold start recognition	X	
Use of a temperature window		X
Use of a speed window (engine load)	X	
Use of a distance window		X
Use of a time window		X

During the road tests, the Jeep Grand Cherokee exhibits high NO_x values across the board. However, when measured with a cold engine, this is half the value when measured with a warm engine. The further investigation therefore focuses on modulation of the EGR system on the basis of the engine temperature and engine load.

The standard NEDC (Cold 25) test in the emission laboratory comes close to the limit of 180 mg/km NO_x (CF=~1.2). On the road, a CF=6.9 was confirmed for the standard NEDC. The values for the other tests with a warm engine and higher load exhibit much higher NO_x emissions, both on the road and in the laboratory.

Follow-up interviews with FCA focused on the fact that the absolute emissions are so much higher than the limit value (CF ~9). RDW has asked FCA to explain the measured values.

Surveillance interview

FCA said that the Grand Cherokee in the RDW test was one of the first vehicles in the production series. The engine has five gears, and there were problems with the engine's vortex valve. Initially, the modulation of the EGR system was carefully deployed to prevent the engine from becoming polluted. The experience gained since then with the control of the EGR system now offers more possibilities for a less cautious strategy. It was agreed that FCA will supply additional information and draw up a statement about the high emissions in practice. FCA also said it would come up with an improvement to the way the EGR system is adjusted.

The justification that FCA gave for the Jeep Wrangler in terms of the emission control system also applies to the Jeep Grand Cherokee.

FCA added that the vehicle approved by RDW was adjusted as a precaution. Further investigation into the operation of the engine and EGR system will make it possible to improve the actual emissions of these vehicles. During the third interview, FCA proposed a calibration update. According to FCA, this update greatly reduces the emissions, and the initial type-approval data has been taken into consideration as much as possible. FCA also says that the calibration update means that the expected conformity factor will be around six. This is the maximum that is feasible with the existing hardware and without having too great an effect on the initial type-approval data such as the consumption and capacity. The calibration update can be ready to be rolled out in July 2017. Before that time, RDW will test the software update to validate the adapted calibration.

Conclusion

After a number of interviews and the supply of various items of information, FCA has explained the operation of the EGR system and what needs to be done to protect the engine. For the Jeep Grand Cherokee, the NO_x emissions are many times higher when the NEDC test is started with a warm engine than when the same test is started with a cold engine. The need for engine protection in this case has not yet been adequately demonstrated. The Public Prosecution Service (OM) has been informed about this case. RDW believes that the results in practice are too high and that an update needs to be implemented for the Jeep Grand Cherokee to reduce emissions in practice. The proposed calibration update shows that improvements are nevertheless attainable despite the existing hardware.

Outstanding points

FCA's proposed calibration update should be validated in a vehicle. RDW will provide a suitable test vehicle in which FCA will install the calibration update. The calibration update will be available in July 2017 and, after approval by RDW, can be rolled out through the dealer channel in the 25,644 vehicles registered in Europe. FCA issued a statement about the calibration update. In this statement, FCA says that the vehicle complies with the approval requirements but that improvements are possible and will be implemented after approval by RDW.

9. Conclusions

This report follows on from the 'RDW Emission Test Programme' (September 2016) in which thirty vehicles from eight manufacturers were tested: Isuzu, Volvo, Hyundai, Kia, Suzuki, Opel, Chevrolet and Jeep. In response to the results of this programme, a follow-up investigation was carried out to determine the extent to which the detected deviations were permitted in 16 vehicles. In the follow-up investigation, manufacturers were informed by RDW that vehicles should be adapted, where possible, in order to improve emission performances in practice. RDW will monitor the adjustments implemented by the manufacturers. Based on these steps, the investigation can be concluded as far as the admission aspects are concerned.

Conclusions by manufacturer

To conclude, the vehicles can be divided into two categories:

1. Vehicles for which it has been plausibly demonstrated that the reduced operation of the emission control system is necessary for engine protection:

Hyundai i40
KIA Cee'd, KIA Optima, KIA Sorento
Jeep Wrangler Unlimited Van (2 variants)
Volvo XC90 (2 variants)
Suzuki SX4
Opel Mokka (Euro 5 en Euro 6)
Chevrolet Aveo, Chevrolet Orlando en Chevrolet Cruze

   In the Volvo XC90, there was a technical error during the earlier measurement, which led to the significantly increased emissions. In the retest, this turned out to be no longer the case. For these vehicles, the investigation is now closed.

2. Vehicles for which it has not yet been (sufficiently) demonstrated that the reduced operation of the emission control system due to lower ambient temperature or higher engine load is necessary in order to protect the engine: Jeep Grand Cherokee Van and Suzuki Vitara.

   For these vehicles, extra investigation is necessary to find out whether the software can be updated in order to improve the emission performances.

   Although more tests must be conducted to obtain a clearer picture of the time-dependent control system, this would seem to involve a prohibited defeat device and when those tests have been completed, the investigation will be handed over to the Public Prosecution Service.

Volvo

Volvo uses modulation of the EGR system, where the system briefly switches off within a temperature range of 0°C to 30°C. Compared to other manufacturers, this is a very broad temperature range. RDW's findings could not be reproduced properly for all vehicles. A different (random) Volvo XC90 vehicle was retested, and the results were better than during the same tests with another vehicle. The Volvo XC90 tested earlier probably had a broken sensor during the test. Other questions were answered by Volvo to RDW's satisfaction, and no follow-up steps are necessary.

Hyundai/KIA

Hyundai and KIA modulate the EGR system. Hyundai and KIA have adequately demonstrated that this modulation is necessary to protect the engine. No follow-up steps are necessary.

Suzuki

At Suzuki, the justification was found to be sufficient, except for the reduced emission performances when the test takes longer than the usual emission test. This may indicate the use of a time-dependent emission control system. When a time-dependent control system is close to the test limits, engine protection is not plausible. When this is the case, RDW considers it to be unacceptable. It is the task of the Public Prosecution Service to decide whether this is a punishable offence. RDW has therefore informed the Public Prosecution Service about this case. RDW tested an update that was offered by Suzuki, and a time-dependent emission control system could no longer be detected in the relevant vehicles after the update. This update is currently being rolled out. Further investigation will be conducted to determine whether the original vehicles included the time-dependent control of the emission control system.

Opel and Chevrolet

This manufacturer's EGR system is completely switched off at 14°C and 18°C. Opel and Chevrolet have said that they do not think it is possible to improve this without damaging the engine even more. After holding in-depth interviews and assessing many additional items of information, RDW has concluded that this extent of modulation is necessary to protect the engine. This was confirmed by TNO. The fact that the emission behaviour satisfies the specified requirements in just a narrow temperature range is therefore permitted. From an admission perspective, no follow-up steps are necessary.

Fiat Chrysler Automobiles (FCA)

FCA modulates the EGR system. For the Jeep Wrangler, FCA has plausibly demonstrated that extensive modulation is necessary in order to protect the engine. The NO_x emissions in the Jeep Grand Cherokee are many times higher when the NEDC test is started with a warm engine than when the same test is started with a cold engine. The need for engine protection in this case has not yet been adequately demonstrated. The Public Prosecution Service (OM) has been informed about this case. Given the high values in the Jeep Grand Cherokee, at RDW's request, FCA explored improvements in the shape of an update. The proposed update will be available in July 2017 and will be assessed by RDW. The aim of the update is to reduce the emissions in practice.
From an admission perspective, this case is therefore closed.

General conclusions

Causes
The interviews clarify many of the reasons and rationale for the choices that were made. With the introduction of the new Euro 6 standard, manufacturers made as few adjustments as possible to their engines at the time, which meant they were only just able to comply with the specified approval requirements. The test requirements functioned as development specifications. In addition, there were still no mobile emission measurement systems for light motor vehicles when Euro 5 vehicles were being developed.

Differences between manufacturers

Due to the broad spectrum of manufacturers (Sweden, Japan, Italy, Germany, Korea and the United States), an accurate picture has been created of the technical options and the choices that were made by each manufacturer. This is particularly evident by the way the exhaust gas recirculation was regulated by the manufacturers. Some manufacturers decided that the system would operate between 0°C and 30°C, and others decided that the system should switch off completely under 18°C to prevent engine damage. While engines were being developed, manufacturers made choices in terms of the materials and engine protection that had a major effect on the emissions in practice.

The approach

The approach to first take indicative and broad measurements on the test track and then retest in the laboratory in specific cases has worked well. The measurements in the laboratory have confirmed the indicative measurements on the test track and this is one of the reasons why none of the manufacturers called the results into question.

The surveillance interviews

A large number of intensive surveillance interviews were held. Often with a very diverse international group. In most cases, it was found in the first interview that more documentation and justification was required from the manufacturers. In addition, follow-up tests were conducted for almost every manufacturer to check updates or validate results. Sometimes at RDW, sometimes on location. For almost all the manufacturers, the file is closed from an admission perspective.

Follow-up steps

For two vehicles, this supplementary investigation has not (yet) led to sufficient justification for non-standard emission behaviour. For the Jeep Grand Cherokee, the manufacturer did not plausibly demonstrate that the non-standard emission behaviour is necessary to protect the engine. RDW believes that additional tests must be conducted in order to form an opinion about the emission behaviour of these vehicles. For the Suzuki Vitara (FCA engine), the manufacturer has not plausibly demonstrated that the emission behaviour is necessary to protect the engine. According to RDW, this may involve an unauthorised manipulation instrument. RDW will conduct a number of additional tests to gain a clearer impression of the way the emission control system operates in this vehicle.

Public Prosecution Service

In the case of deviations from the type-approval, i.e. a non-conformity, it is RDW's task to surveillance the process of removing this deviation and ensuring that the vehicle again complies with the applicable requirements.

It is the task of the Public Prosecution Service (OM) to assess whether it actually involves a punishable offence and to proceed with a prosecution, where relevant. All information obtained during this investigation was transferred to the OM.

It is not permitted to operate the emissions system under different conditions, except if this is necessary to protect the engine. In the end, this was plausibly demonstrated in almost all the situations that were encountered. At Suzuki (FCA engine), a time-dependent emission control system may have been detected. RDW considers a time-dependent emission control system to be unacceptable. A punishable offence may have been committed (see Appendix 2: Legal Framework). It is the task of the OM to assess this. RDW has notified the OM about the case. The OM can then later decide whether the manufacturers should be subjected to a criminal investigation.

The future

This report looks back at how the admission process was conducted on the basis of the regulations at the time. Looking ahead, it can be stated that the new Real Driving Emissions (RDE) test, which will be compulsory for new types of vehicles from 1 September 2017, will reduce the emissions by testing vehicles in practice.

The test specifies broader requirements, such as:

- A much more varied time period (from 20 to 85 minutes)
- More varied driving conditions (take measurements in the field in addition to using the roller dynamometer)
- A more varied temperature window (from 20°C - 30°C to 5°C - 30°C)

For lorries, the RDE was made mandatory at an earlier date. This has had good results. RDW will continue to closely monitor developments. The investigation into the NO_x emissions in practice will be concluded with this report.

Appendix 1: Vehicles with non-standard emission behaviour

Vehicles that exhibit non-standard emission behaviour, as confirmed by RDW in its first investigation:

Brand	Trade name	Engine	WVTA	Emission certificate
Chevrolet	Aveo	Euro 5	e4*2007/46*0270*09	e4*715/2007*692/2008A*0298*00
Chevrolet	Orlando	Euro 5	e4*2007/46*0224*04	e4*715/2007*692/2008A*00193*03
Chevrolet	Cruze	Euro 5	e4*2001/116*0140*13	e4*715/2007*692/2008F*0268*03
Hyundai	I40	Euro 5	e4*2007/46*0263*03	e4*715/2007*692/2008A*0274*00
Jeep	Grand Cherokee	Euro 5	e4*NKS*0042*01	e4*715/2007*692/2008A*0242*00
Jeep	Wrangler Unlimited Van	Euro 5	e4*NKS*0044*00	e4*715/2007*692/2008A*0136*00
Jeep	Wrangler Unlimited Van	Euro 5	e4*2001/116*0116*13	e4*715/2007*692/2008A*0137*00
KIA	Cee'd	Euro 5	e4*2007/46*0496*00	e4*715/2007*566/2011J*5652*00
KIA	Optima	Euro 5	e4*2007/46*0255*02	e4*715/2007*692/2008A*0271*00
KIA	Sorento	Euro 6	e4*2007/46*0894*01	e4*715/2007*136/2014W*0544*01
Opel	Mokka	Euro 5	e4*2007/46*0537*04	e4*715/2007*630/2012J*0345*01
Opel	Mokka	Euro 6	e4*2007/46*0537*11	e4*715/2007*136/2014W*0644*02
Suzuki	SX4	Euro 5	e4*2007/46*0779*00	e4*715/2007*630/2012J*0432*00
Suzuki	Vitara	Euro 6	e4*2007/46*0928*02	e4*715/2007*136/2014W*0658*00

Appendix 2: Legal framework

For the further implementation of Regulation 715/2007, the Decree type approval motor vehicles air pollution was amended (Government Gazette 2014, No. 120, 19 March 2014.) The explanatory memorandum of this Decree describes how the stipulations in the specified regulation were transposed into national law.

In order to implement Article 13 of this Regulation, the new Article 2 of the Decree type approval motor vehicles air pollution stipulates that it is prohibited to act in contravention of the requirements specified in Regulation 715/2007. It specifies Articles

4, eerste, tweede en derde lid,
5, eerste en tweede lid
6, eerste, vierde tot en met zevende lid
7, tweede lid

The Decree is based on the Environmental Management Act 9.5.1 and 9.5.6. The enforcement of these articles in the Environmental Management Act is regulated in the Economic Offence Act, Article 1a, under 2° and Article 2. These articles in the Economic Offence Act state that violation of the stipulations specified in the Environmental Management Act will be regarded as an economic offence. According to Article 6, a crime is punishable with a prison sentence of a maximum of 2 years, community service or a fine of the fourth category (maximum € 19,500). If there is no intent, the same fine can be imposed, but the prison term will be a maximum of 6 months. In accordance with Article 17, first clause, under 1, enforcement of the Economic Offence Act is the task of the police.