MITSUBISHI MOTORS

Eclipse Cross
2019 Model Year

AdBlue system
4N14 diesel with SCR



training Academy

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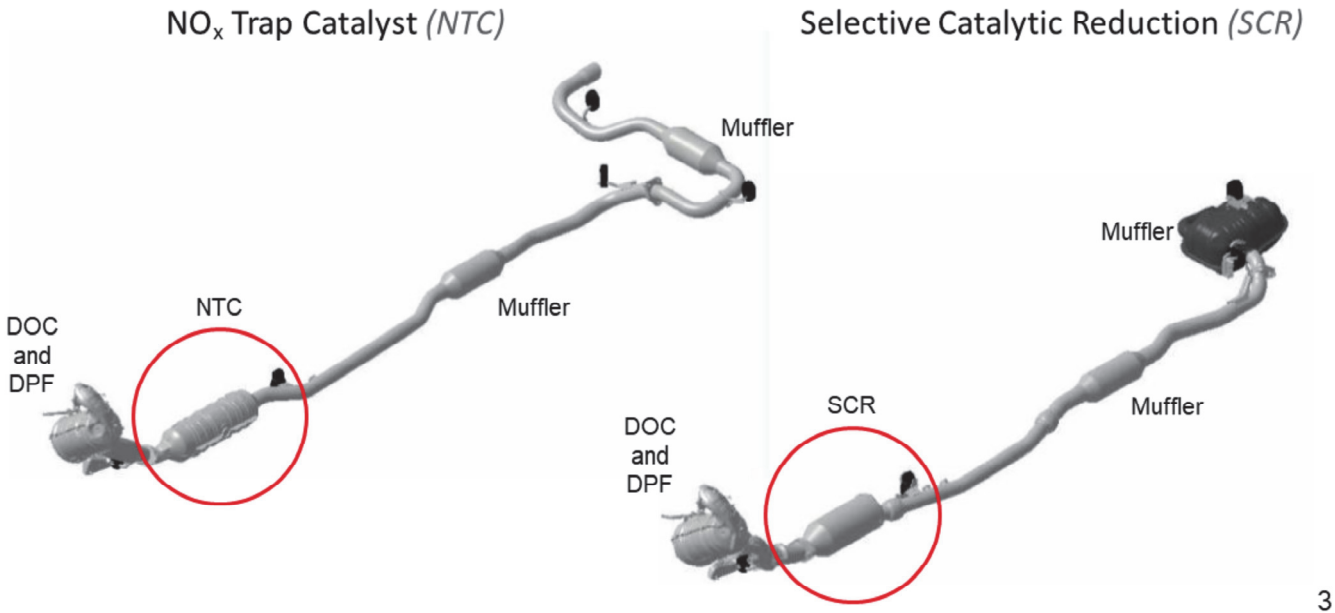
ECLIPSE CROSS

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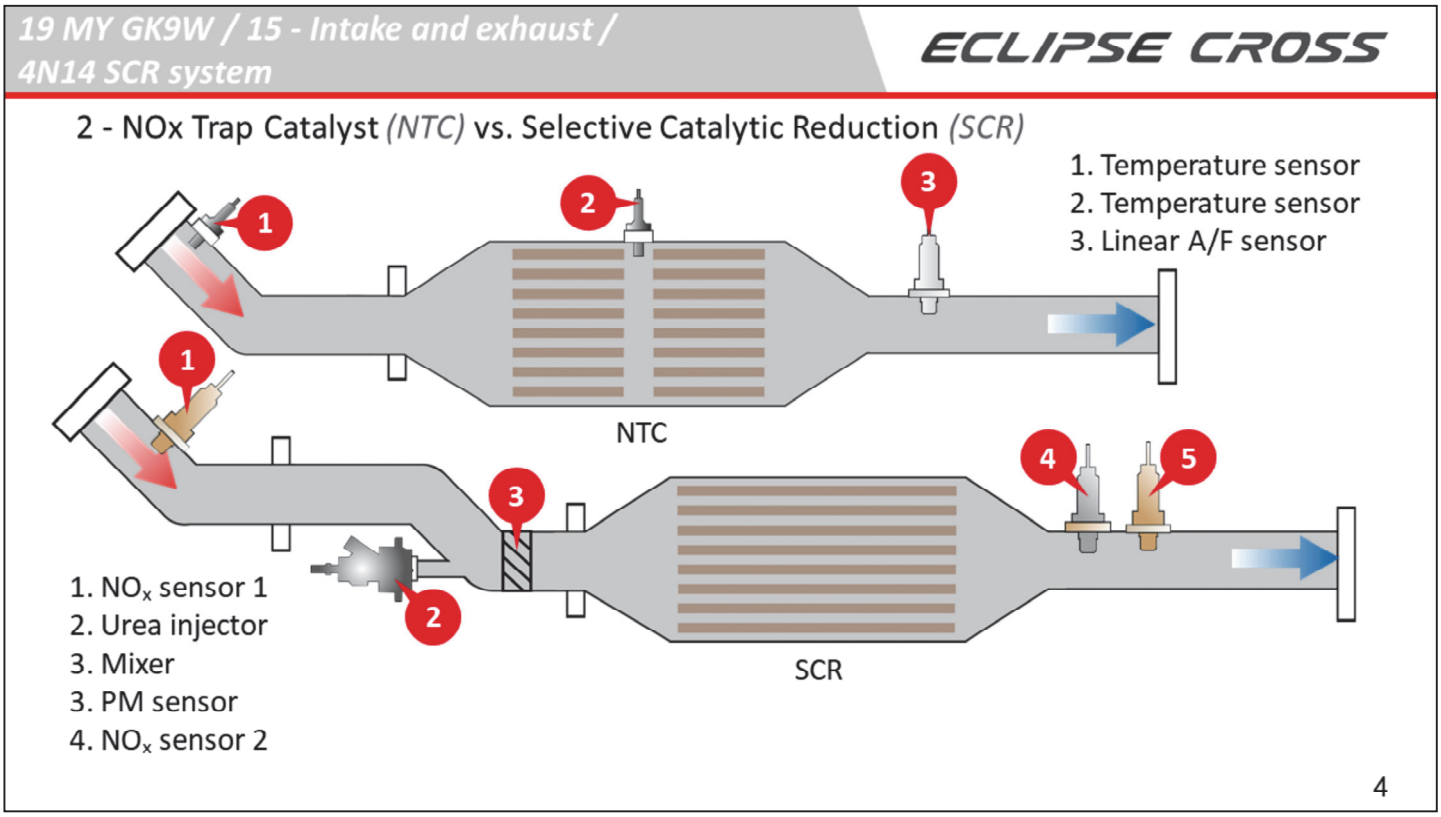
1 - 4N14 NO_x after treatment system



With the 16 MY ASX and Outlander diesel we introduced the NOx trap catalyst in order to comply with the Euro 6 emission requirements for NO_x of 80mg/km during the laboratory test, the so-called NEDC.

From September 2018, all type approvals need to comply with the new Euro 6d-temp. Euro6d-temp introduces a new test cycle, the WLTP, with heavier loads compared to the previous test cycle. Also a Real Driving Emission test is added where it is necessary to comply with a strict NOx limit of 168g/km until 2020 and 120g/km from 2021.

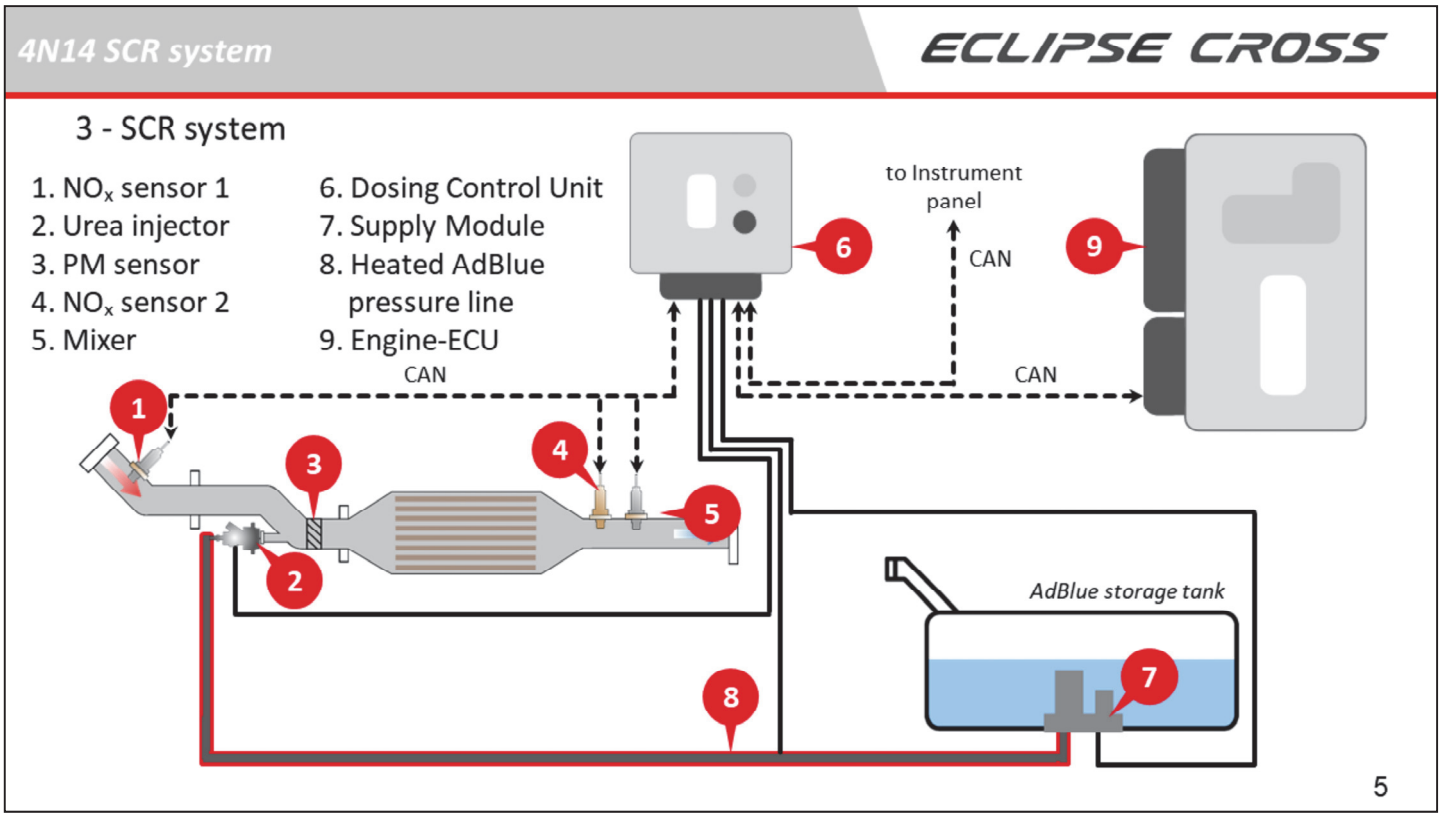
Therefore the new Eclipse Cross 4N14 diesel engine is equipped with a Selective Catalytic Reduction (SCR) system replacing the NO_x Trap Catalyst (NTC).



Above you can see the layout of the NO_x Trap catalyst with it's related sensors installed.
With the SCR system the NTC catalyst has been replaced for the SCR catalyst and the
Linear A/F sensor and temperature sensor have been removed.

A NO_x sensor and Urea injector are installed before the SCR catalyst.
After the SCR catalyst a PM sensor and a second NO_x Sensor are installed.
The connecting exhaust pipe to which the Urea injector is attached is a separate part
fitted between the flange connection of the DPF and the flange connection of the SCR catalyst.

This liquid reductant agent is AdBlue or Diesel Exhaust Fluid (DEF), which is a mixture of 32.5% urea and 67,5% de-ionized water. In the chemical process this is converted to ammonia for reduction of NO_x in the SCR catalyst.



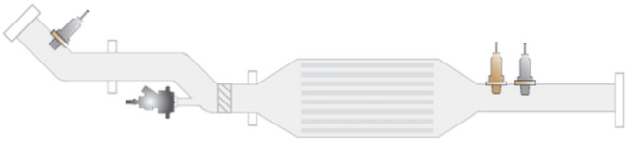
The SCR system is far more complex compared to the previous NOx after treatment system on the 4N14 engine.

Since AdBlue freezes at a temperature of -11 degrees Celcius the pressure line to the Urea injector is heated. Also the supply module in the AdBlue tank contains a dedicated tank heater. Under normal operation no AdBlue will remain in the pressure line when the ignition switch is turned OFF. After the ignition switch is turned OFF, the supply module drains the AdBlue from the pressure line into the tank.

Sensors before and after the SCR catalyst enable closed-loop control of the NO_x emissions. After cold start the SCR catalyst first needs to warm-up. From a catalyst temperature of approximately 200 degrees Celcius the injection of AdBlue and conversion from No_x to N_2 and H_20 is possible.

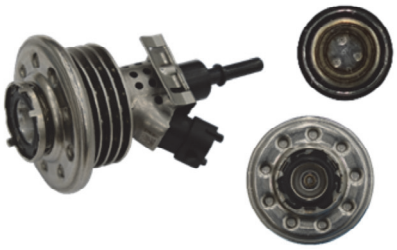
With this system configuration using NO_x sensors before and after the SCR catalyst A(n 80 to) 90% reduction of NO_x in the exhaust gasses is achieved.

4 - Components & function (1/2)





NO_x Sensor 1 & 2
to determine No_x and O_2 levels up- and downstream of the SCR catalyst



Urea injector
an air-cooled module with 3-hole nozzle to inject the AdBlue into the exhaust

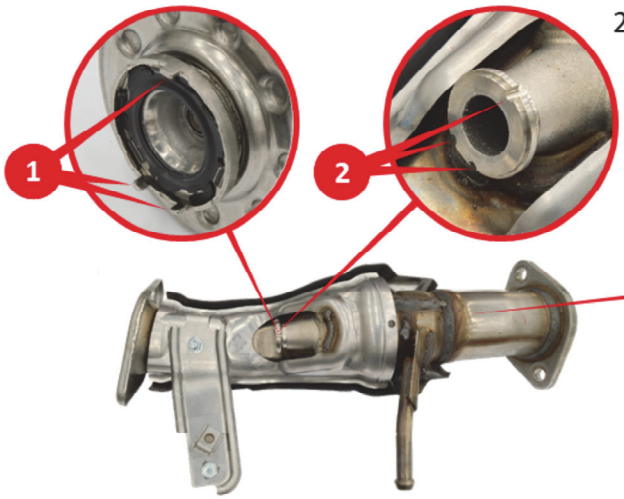


PM Sensor
to determine the soot level and therefore performance of the DPF

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4 - Components & function (2/3)

1. Dosing Module alignment points
2. Exhaust pipe alignment points



Exhaust pipe upstream of SCR catalyst
were the Urea injector and mixer are installed

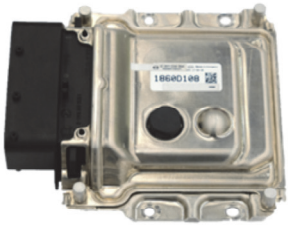


Mixer
the mixer improves the mixture of AdBlue with the exhaust gas

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4 - Components & function (3/3)





Dosing Control Unit *(DCU)*
the Dosing Control Unit is used to monitor and control all functions and components of the SCR-aftertreatment system.

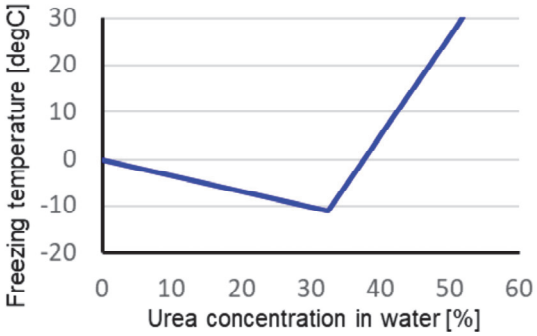




Supply Module
the Supply Module is used to supply the AdBlue to the Urea injector, to determine the AdBlue quantity, quality, temperature and pressure and to warm-up the AdBlue in case of low temperatures.

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AdBlue is a harmless mixture consisting of 32,5% urea and 67,5% de-ionized water. It is a non-toxic biodegradable colourless fluid which is used in the SCR system for producing ammonia which in turn is used to break down NOx in the SCR catalyst.

If the remaining driving range of the AdBlue is 2400km, a warning message will pop-up in the information display to recommend the driver to fill up the AdBlue tank.

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The regular shelf-life of AdBlue is 12 months when stored at a temperature of up to 30℃.
It should should be avoided to expose AdBlue directly to sunlight.
In case of spilling AdBlue on metal or clothes, just rinse with water.

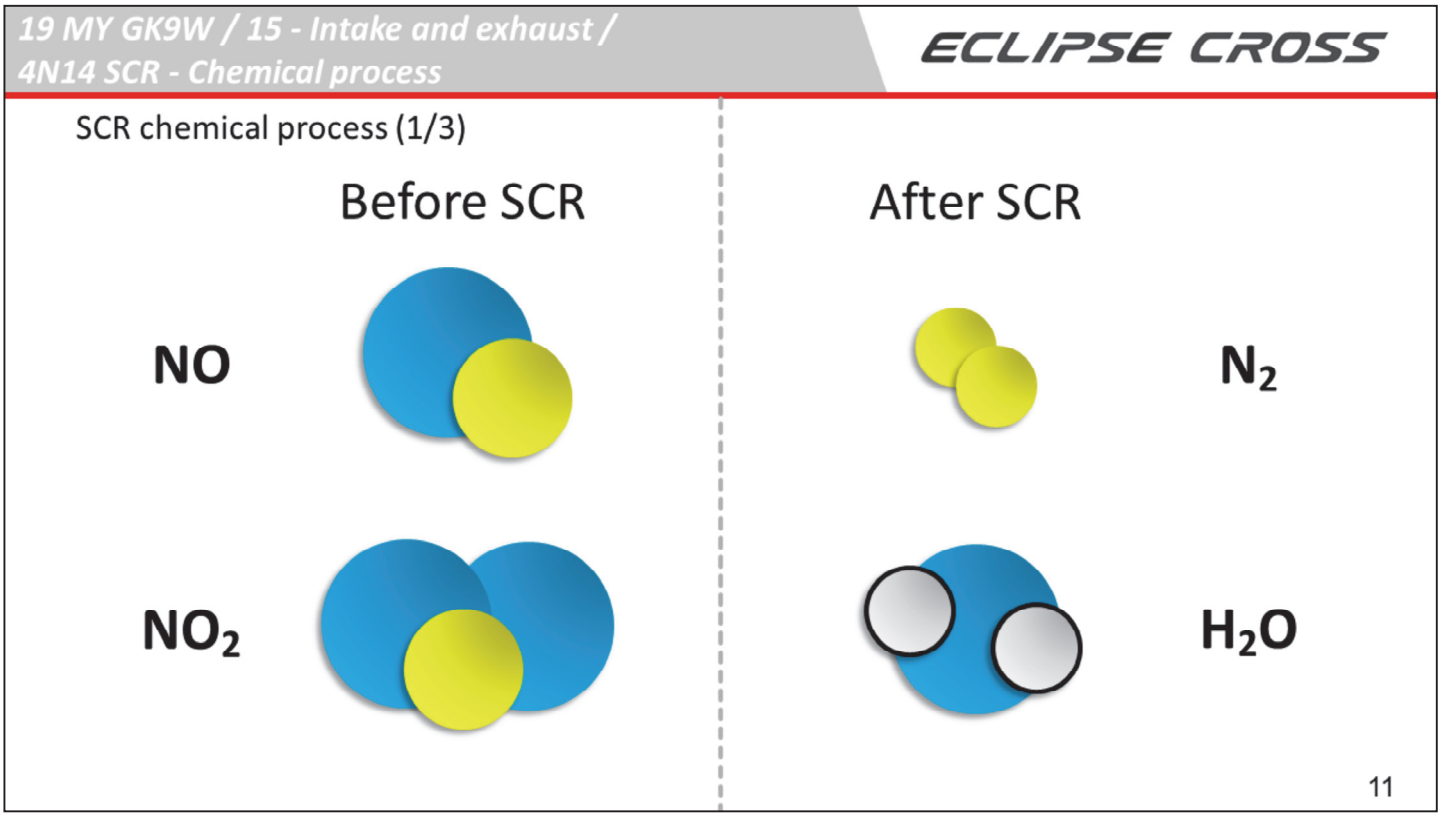
The concentration of urea in water is important because it affects the freezing temperature.
In the graph you can see the 32,5% concentrations is most optimal. Please note urea in water is a liquid form. Pure urea is solid and has a melting temperature of 133 degC.

AdBlue temperature	Description
-11°C and below	At -11°C AdBlue will freeze. Therefore the SCR system has an AdBlue pressure line which is heated, plus a heating element in the AdBlue tank.
-10°C to 30°C	At a temperature of between -10°C and 30°C AdBlue can be kept and/or stored without degrading
30°C to 80°C	In the range of 30°C to 80°C the AdBlue will start to decompose. This is the worst condition which affects the AdBlue quality.
over 80°C	At a temperature of over 80°C the AdBlue will decompose into toxic ammonia. This is the case with regular operation with the SCR system

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When the frozen AdBlue defrosts, the quality of the fluid reamains.

Exposure to high concentrations of ammonia in air causes immediate burning of the eyes, nose, throat and respiratory tract and can result in blindness, lung damage or death.



Selective Catalytic Reduction (SCR) uses a chemical process with catalytic material to break down the toxic NO and NO_x to N2 (nitrogen) and H20 (water).

SCR chemical process (2/3)

The urea-water mixture is injected into the exhaust. Because of the hot exhaust gas the water evaporates to gas and the urea becomes solid.

Due to the high exhaust gas temperature the solid urea breaks down further to Ammonia and Isocyanic Acid (HNCO)

The isocyanic acid (HNCO) reacts with the water vapour from the combustion process breaking it down to Ammonia and CO2.

NH_2-CO-NH_2 (liquid)



H_2O (liquid)



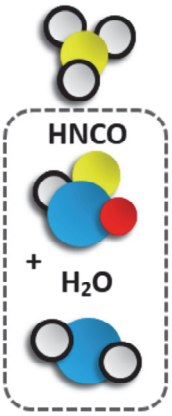
NH_2-CO-NH_2 (solid)



H_2O (gas)



NH_3 (Ammonia)



NH_3 (Ammonia)

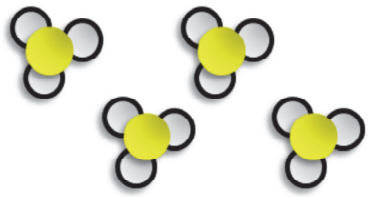
CO_2



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SCR chemical process (3/3)

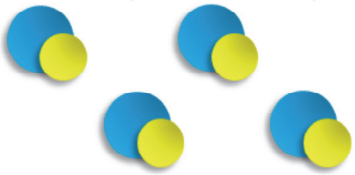
$4NH_3$ (Ammonia)



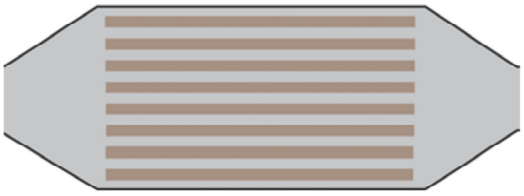
O_2 (Oxygen)



4NO (Nitric Oxide)

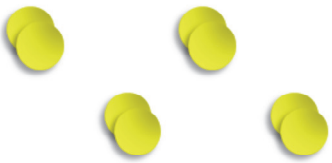


The Ammonia is used for the chemical process in the SCR catalyst reducing the amount of NOx.

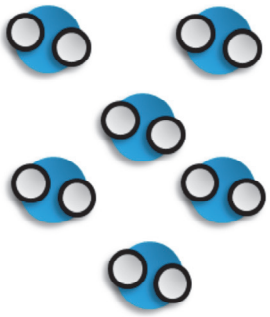


Ammonia, Oxygen and Nitric Oxide are converted to Nitrogen and Water.

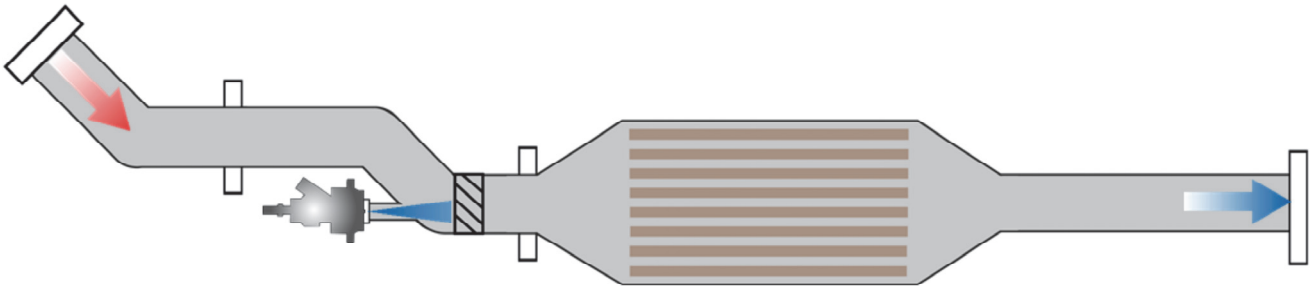
4 N_2 (Nitrogen)



6 H_2O (Water)



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Step 1

The NO_x contaminated exhaust gas flows downstream the exhaust. The NO_x level in the exhaust gas is determined by NO_x sensor 1.

Step 2

The Dosing Control Unit *(DCU)* calculates the necessary amount of AdBlue, which is injected by the urea injector in order to reduce the amount of NO_x.

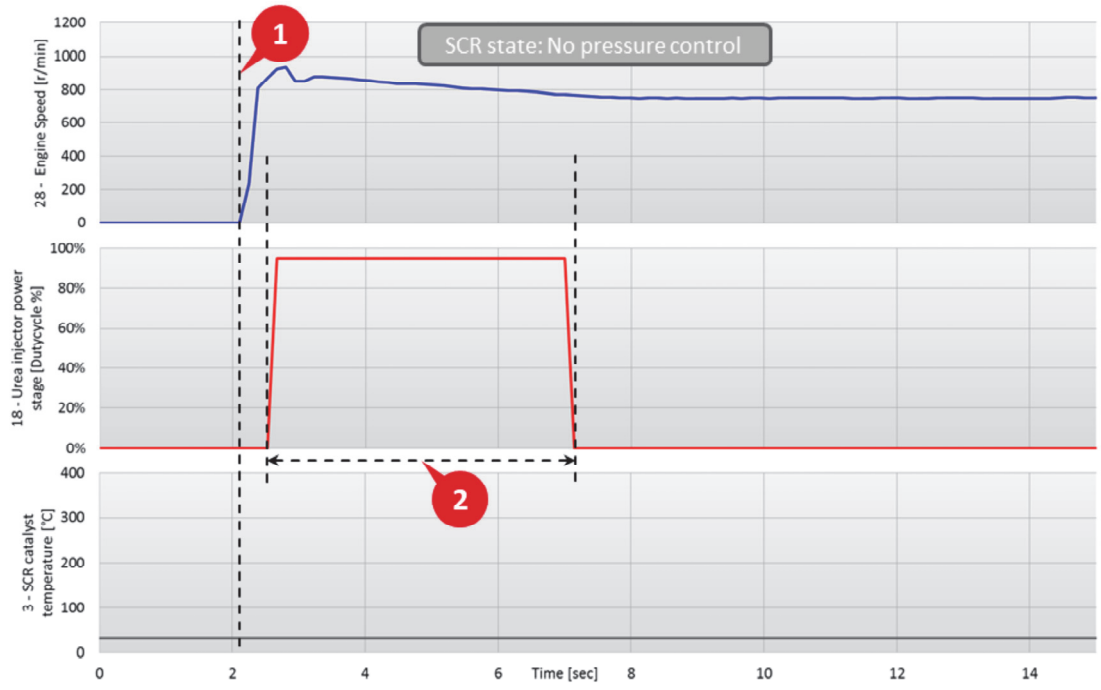
Step 3

In the SCR catalyst the ammonia breaks down the NO_x. After the SCR catalyst NO_x sensor 2 measures the NO_x level again. The Dosing Control Unit determines the NO_x reduction rate, and adjusts the control.

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By measurement of the NO_x and O_2 level before and after the SCR catalyst the Dosing Control Unit can determine the amount of NO_x reduction.

When ammonia would pass the SCR catalyst without chemical conversion, this is called ammonia slip. Since ammonia is toxic we should prevent ammonia slip. Therefore the NO_x reduction rate is limited to ~90%, to ensure maximum use of ammonia and minimum ammonia slip.



1: the engine is started

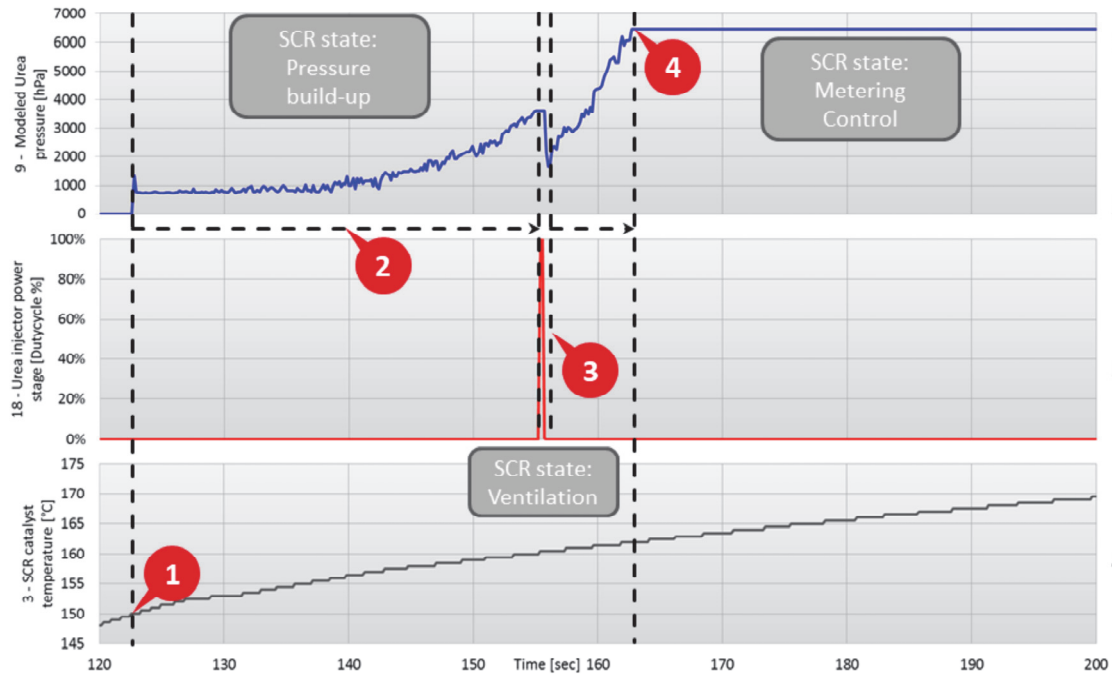
2: the Urea injector is opened by a 95% duty-cycle for ~4.5sec.

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For diagnostics the function of the urea injector is checked with every initialization at engine start. This has no effect for the SCR system since there is no AdBlue supplied.

At each engine stop the heated pressure line is drained and the AdBlue is recovered from the pressure line and stored in the AdBlue tank.

A duty-cycle of 100% could also mean a short circuit to +.
Therefore the duty-cycle is controlled at 95% when initializing at engine start.



1: the SCR catalyst temperature reaches 150C

2: the supply module builds up the pressure for AdBlue supply to the Urea injector.

3: the air in the AdBlue heated pressure line is released by control of the Urea injector

4: The AdBlue supply target pressure has been reached

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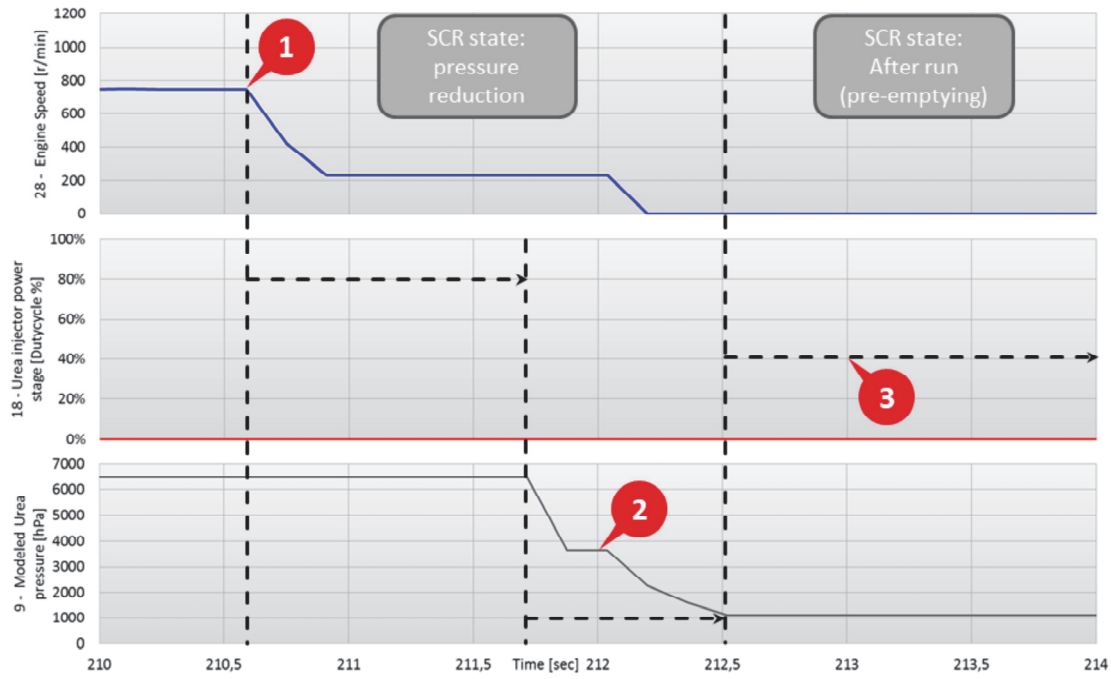
After a cold start the SCR-system is not immediately active. First the exhaust gas temperature and catalyst will need to warm-up until the operating temperatures have been reached.

When the catalyst temperature is near the operating temperature the supply module is activated and AdBlue pressure will build-up in the heated pressure line. The heated pressure line was filled with air. During pressurization the Urea injector is shortly opened to release the compressed air. This process is called **“ventilation”** and can be found by datalist item **6 SCR sub state machine**.

After releasing the air, the pressure is further increased until the normal operating pressure has been reached. Normally this threshold is at approximately 6000hPa or 6 bar.

19 MY GK9W / 15 - Intake and exhaust / 4N14 SCR - Control at engine stop (1/2)

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1: at engine stop datalist item 3: SCR state machine changes to pressure reduction.

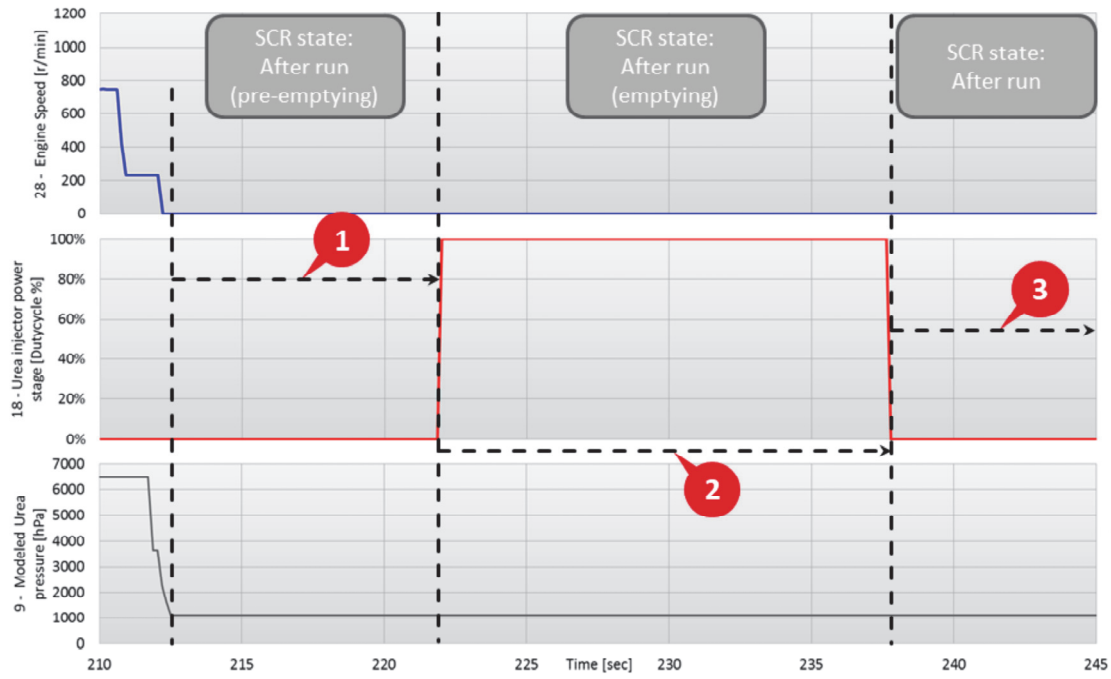
2: the AdBlue is recovered from the heated pressure line and the pressure is reduced

3: the SCR status changes to after run (pre-emtpying)

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19 MY GK9W / 15 - Intake and exhaust / 4N14 SCR - Control at engine stop (2/2)

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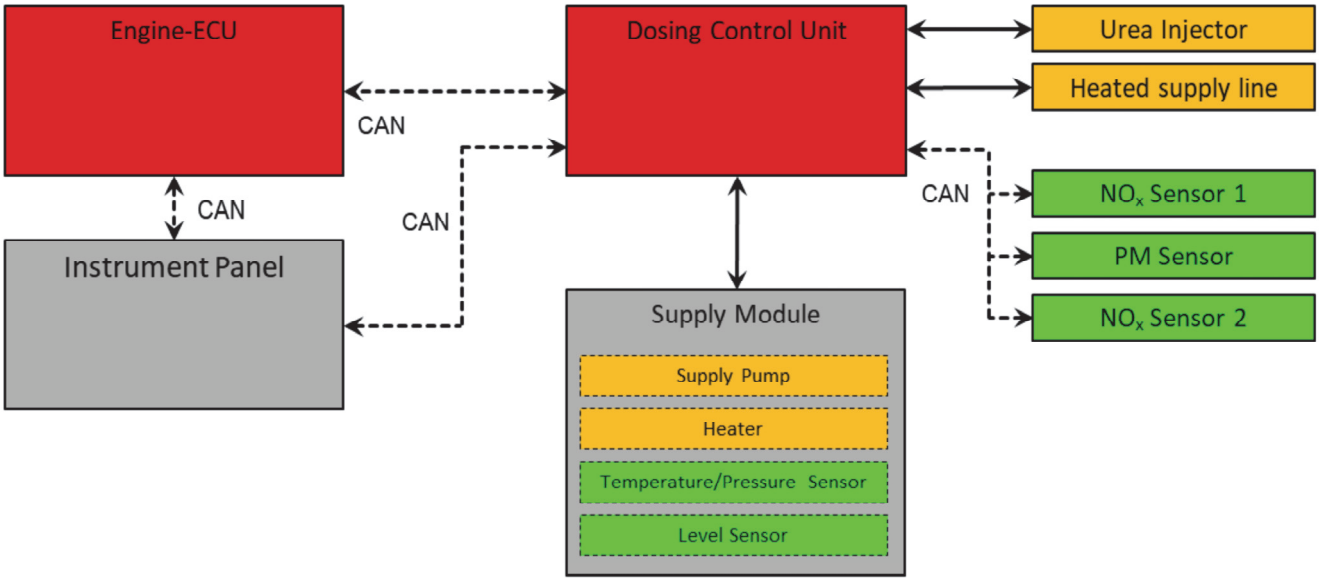
1: 10 seconds after the pressure reduction was completed the Urea injector is controlled.

2: the urea injector is fully opened by a 100% duty-cycle for approximately 15 sec.

3: the stop sequence for the SCR-system is completed.

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Wiring Diagram



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The Eclipse Cross SCR system includes two levels of warnings:

- Driver Warning
- Driver Enforcement

Driver Warning

The system informs the driver of a warning by visual alarms. A warning lamp is installed on the bottom of the RPM dial and a relevant message is shown on the Multi-Information-Display *(MID)*.

- if the level of AdBlue in the tank is getting low
- the quality of the AdBlue has deteriorated significantly
- irregularities with AdBlue injection monitoring.
- abnormal behaviour of NO_x monitoring



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Level of AdBlue

The Driver Warning will be activated when the remaining driving range is 2400km before the AdBlue tank runs empty. The intensity of the warnings will escalate when the AdBlue tank approaches empty and the Driver Enforcement comes into effect. The minimum required refill needs to be equivalent to a 2400km driving range to deactivate this warning.

After any of the following three warning messages have been set and no appropriate countermeasures are taken, after 50km the Driver Enforcement System will be activated:

AdBlue quality

- If the sensor in the AdBlue tank can detects a deviation of the quality of the liquid.

AdBlue injection monitoring

- When there is a deviation of over 50% between actual and demanded average AdBlue consumption for a period of over 30 minutes.
- In case of unforeseen interruption of the AdBlue injection.



Driver Enforcement

Driver Enforcement occurs to prevent vehicle operation with an empty AdBlue tank or in case of malfunction of the SCR system.

If this system is activated the remaining driving range is 600km and counting down. After 600km the engine will be disabled and will no longer start. Also the maximum speed of the vehicle will be limited to 64km/h.



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Depending on the cause of activation there are two ways to deactivate the enforcement system:

In case of an empty AdBlue tank :

The refill needs to be equivalent to a 2400km driving range to deactivate the enforcement system. If we consider 10.000km range based on 15,6L AdBlue this would mean a refill of at least : 2400/10.000 * 15,6L = 3,74L.

In case of malfunction :

After repair of the SCR-system, the OBD system needs re-initialization.
When the OBD system is re-initialized the vehicle will operate for a maximum of 50 km to allow for validation of the repair. If after 50km the fault still persists the enforcement system will be fully reactivated.

The capacity of the AdBlue tank is 15,6L. This is estimated to be enough to travel about 10.000km. If we assume a fuel consumption of 5.8L/100km we come to the following consumption of AdBlue:



Diesel consumption

5.8L/100km over 10.000km	= 580L diesel consumption
5.8L/100km	= 17,24km/L

AdBlue consumption

15,6L divided by 10.000km	= 0,00156L is 1,56mL of AdBlue per kilometer
17,24 x 1,56	= 26,89 mL per liter diesel.

In this example the consumption of AdBlue is 2,689 % of the fuel consumption.

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The range you can drive with a full AdBlue tank can deviate depending on the driver and driving conditions. Two main components of the combustion process are responsible for the production of NOx and indirectly also for the amount of injected AdBlue for NOx reduction.

Combustion temperature [Thermal NOx]

Ambient air contains Nitrogen and Oxygen and is used for the air-fuel mixture of the diesel engine. Between the gasoline and diesel engines there is as significant difference in the amount of air used for the combustion process. A diesel engine relies on excess air, therefore during the combustion process a much higher amount of ambient air is involved.

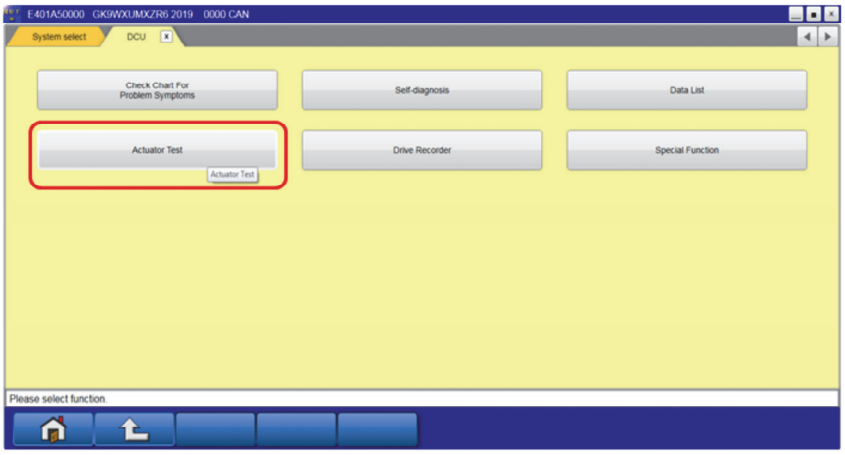
The combustion temperatures which are very high, cause the Nitrogen and Oxygen in the air/fuel mixture to react and form NOx. The excess air for the combustion causes the higher level of NOx output from a diesel engine compared to a gasoline engine.

Fuel [Fuel NOx]

Diesel also contains a certain concentration of Nitrogen. This Nitrogen can form NOx by oxidation during the combustion when the temperatures are over 800 degC.

A more aggressive driving style requires more air/fuel and will result in higher combustion temperatures. This will lead to a higher AdBlue consumption and a shortened driving range.

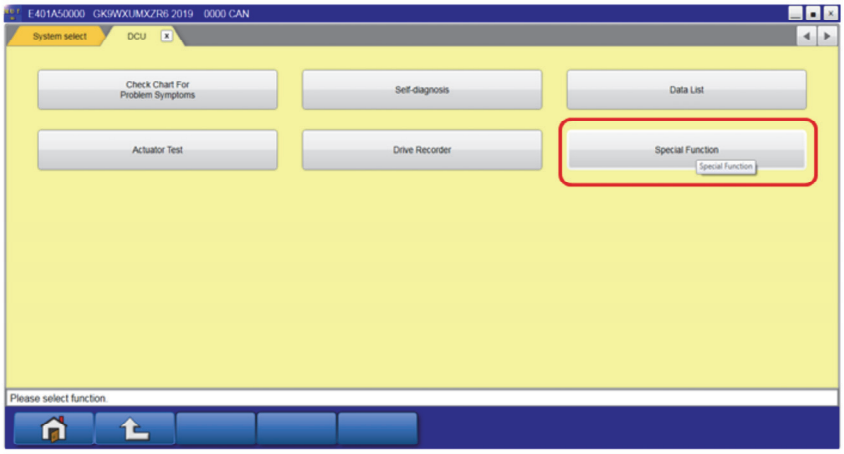
Actuator tests
- Urea injector (% dutycycle)
- Heated pressure line (ON/OFF)
- Urea tank heater (ON/OFF)
- Back flow pump (% dutycycle)
- Supply Pump (ON/OFF)



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[Note]

Keep in mind that both heaters are using 4 to 8 amperes and when you perform the actuator test. Keeping these actuator test running for a long time might drain the battery.



Special functions:
- Emptying test
- Leak detection test
- Pressure preparation test
- Backflow pump test
- Dosing quantity test
- Dynamic dosing quantity test from calibration
- Static dosing quantity test from calibration
- Spray test
- Engine test for dosing valve dry actuation
- First filling
- SCR system test

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Several Special Functions can be performed after after turning ON the ignition switch and the following conditions are met :

5 SCR state machine = No pressure control

6 SCR sub state machine = Invalid

These special functions are:

- Emptying test
- Leak detection test
- Pressure preparation test
- Backflow pump test
- Engine test for dosing valve dry actuation
- First filling
- SCR system test

Component	Possible faults
AdBlue tank	AdBlue tank leaking / cracked
Urea / water mixture	Urea /water mixture decomposed Misfuelling Water evaporated
NOx sensors	Sensor / controller failure Sensor drift
Urea injector	Nozzle contaminated Injector failure
SCR catalytic converter	NOx conversion insufficient
AdBlue tank	AdBlue tank leak / cracked
Supply module	Supply / backflow pump failure Sensor failure

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