APPENDIX 3 – TEST RESULTS

INDEX

1. VEHICLE 1

1.1 Vehicle data

Vehicle N°	**1**
Partner	**DEKRA**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	ca. 2000
Communication protocol	ISO 9141 2
EGR (yes/no)	NO
Air injection(yes no)	YES
Transmission (manual/automatic)	manual
Egr valve (yes/no)	NO
motorised throttle (yes/no)	YES
manifold pressure sensor (yes/no)	NO
pre-catalyst (yes/no)	NO
main catalyst (yes/no)	YES
secondary air injection valve (yes/no)	YES
mileage (km)	28200

1.2 Failure description

The vehicle was tested with the following failures:

- Simulation of lambda sensor malfunction
- Resistor build in line with the injectors (see the sketch)
- Catalyst with weaker performance
- Sensors disconnected respectively connection with a resistor in line

1.2.1 Simulation of lambda sensor malfunction

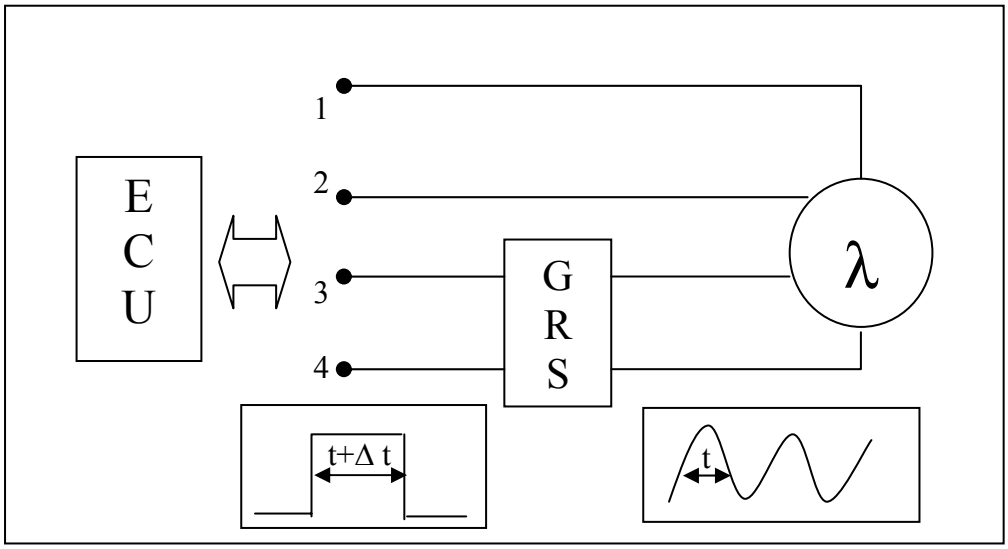
The electronic “Simulation of Lambda Sensor Deterioration” (**GRS**) simulates the behaviour of OBD sensors (artificially slowed-down or shifting sensors) in connection with a potential-free sensor. The GRS is connected between an intact lambda sensor and the ECU (see sketch). The setting of the GRS permits to manipulate the characteristics of the lambda sensor so that a lambda control can be implemented.

As in the standard production, the sensor signal is connected in this GRS via the resistance (51 kΩ) and a constant opposing voltage source (450 mV). As long as the internal resistance of the lambda- sensor remains sufficiently high impedance, the voltage is determined by the opposing voltage source. Thus a cold sensor can be recognised by a firmly defined window width of 350 mV and 550 mV. In this case the sensor input in the ECU remains open.
When the temperature of the sensor rises, is internal resistance drops and the sensor voltage dominates against the opposing voltage source. When the voltage rises or drops beyond this range, the output of the GRS is switched via a reed relay at the sensor input of the ECU. In

order to avoid a response of the warm/cold recognition as long as the sensor signal moves within the window width, a mono-flop with a life of 1s is connected in series.

A rich shift is reached by delaying the lean/rich jump of the sensor voltage by a timer switched in series. With a multi-turn potentiometer , this time can be set continuously variably.

The vehicle was tested with the simulation of malfunction within the O_2 Sensor.
The sketch shows the way of connecting the upstream oxygen sensor with the GRS.



sketch: Oxygen sensor with GRS, (1 and 2 heater, 3 and 4 signal sensor

The output of the GRS is a rectangular signal. In the used attitude the high voltage lasts additional 0.8 seconds.

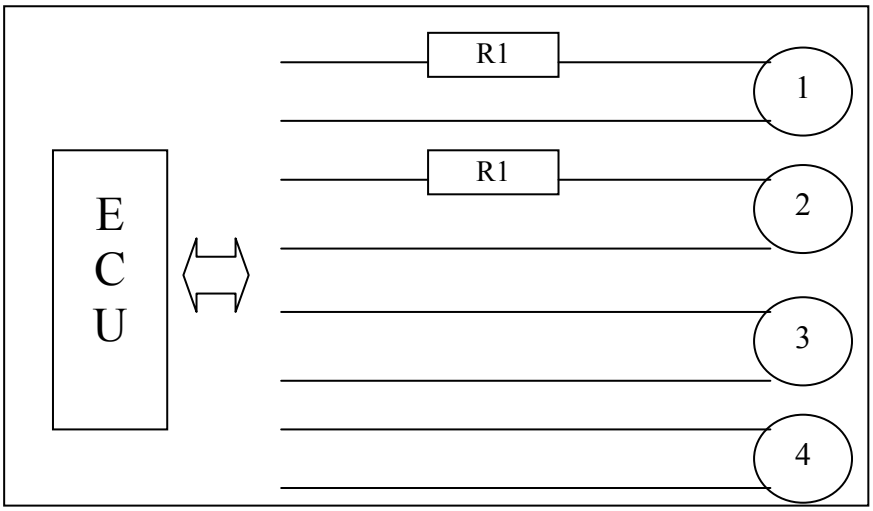
1.2.2 Catalyst with weaker performance

The catalytic converter is build up by a support consisting of a ceramic monolithic honeycomb structure which creates the general high geometric surface to the catalyst. In case of the manipulated catalyst half of the ceramic monolith wasn't covered with catalytic components (Pt, Pd, Rh, Fe...). Furthermore, the covered part of the monolith was partially destroyed, so that the efficiency was going to be weaker.

1.2.3 Injectors out of tune

The resistors connected according the sketch produces a different behaviour of the fuel mixture in the opposite to the normal connected injectors. Following, the whole composition of the raw exhaust emissions isn't consistency.

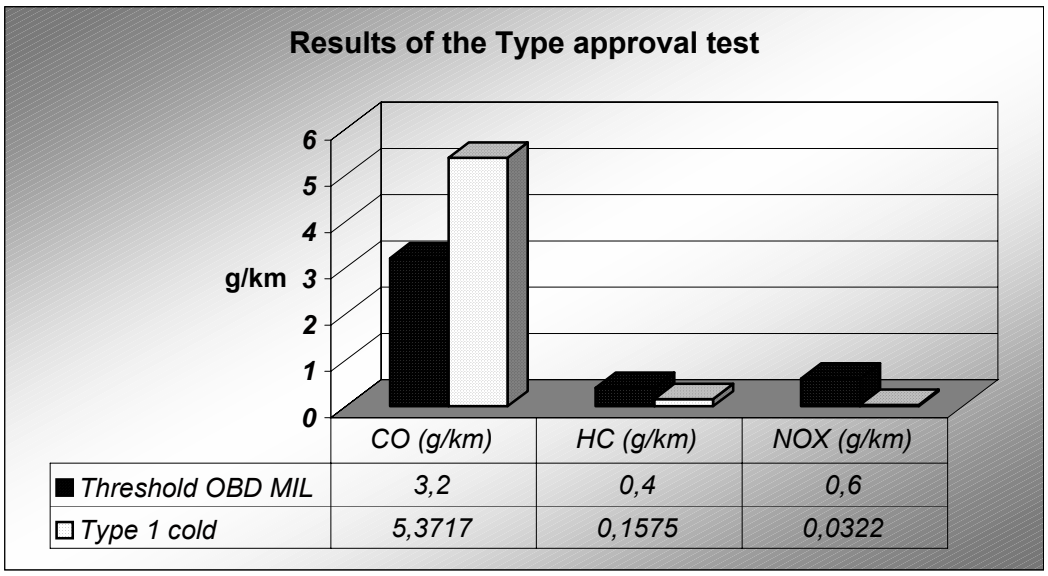
sketch: injectors resistor R1 30 Ω, injectors are signet with 1,2... .



1.3 Test Results

1.3.1 Test results of the type 1 test

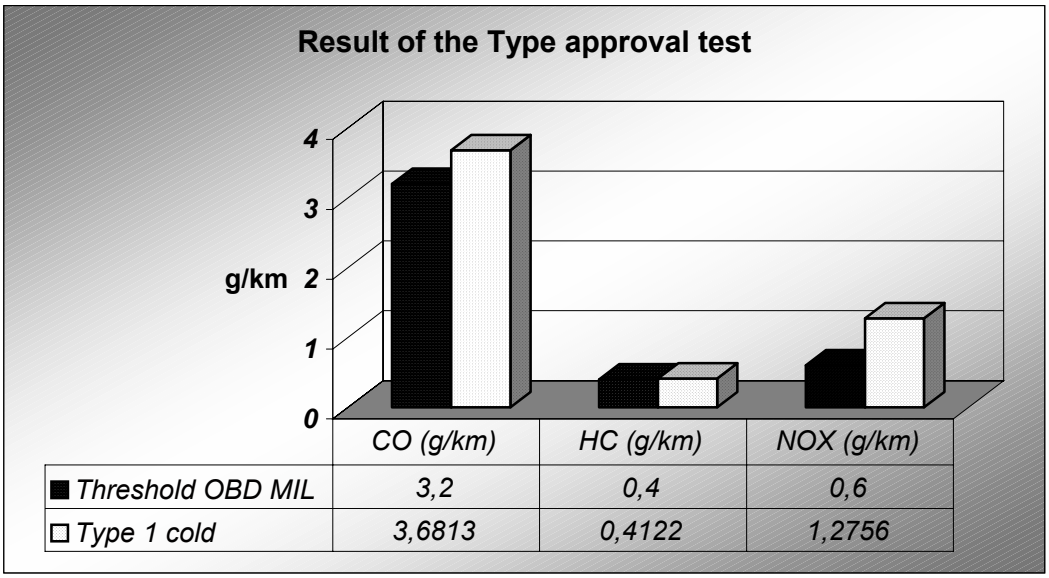
1.3.1.1 Test with a simulation of lambda sensor malfunction



**Threshold OBD MIL: Annex XI 96/69 EG chapter 3.3.2*

The influence of the simulation tool is significant. The catalytic converter isn't able to convert CO during the changed conditions. HC and NOX are increased according to the reference measuring but the thresholds are not exceed.

1.3.1.2 Test with combination of a altered catalyst and lambda irregularity

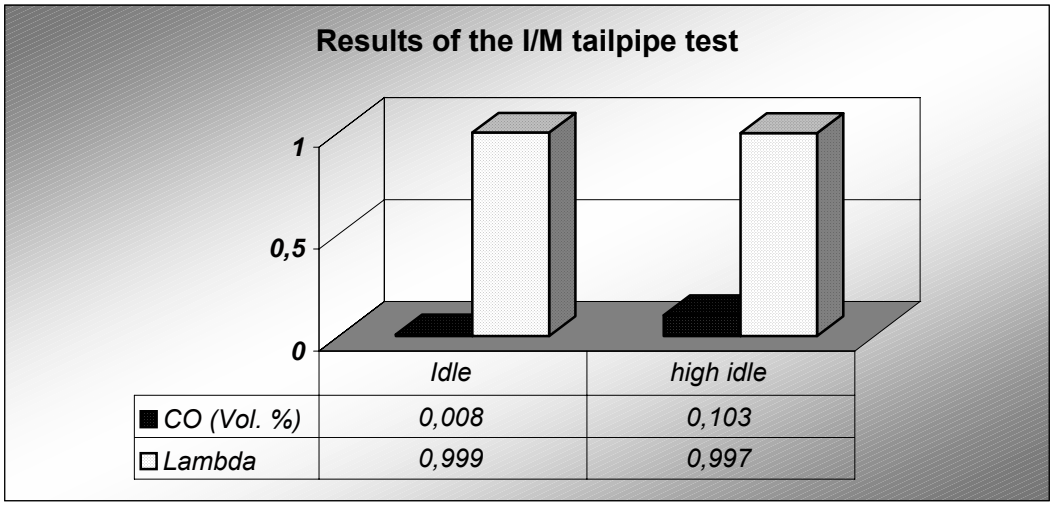


**Threshold OBD MIL: Annex XI 98/69 EG chapter 3.3.2*

The influence of the failure combination is significant. The damaged catalytic converter wasn't able to convert all the three components at the existing inconsistent lambda conditions.

1.3.2 Results of the I/M test

1.3.2.1 Test with a simulation of lambda sensor deterioration

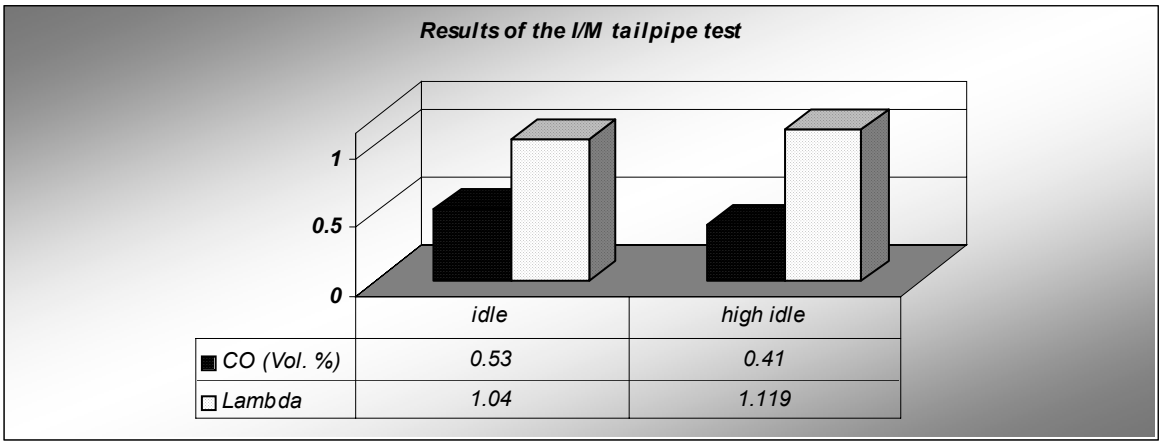


**high idle at 2800 1/min*

The influence of the changed frequency resulting of the simulation Tool hasn't been a significant influence of exhaust emission concentration at idle speed.

The influence of the changed frequency resulting of the simulation Tool has become more importance at high idle. Otherwise the values are below the current threshold according to 96/96/EU

1.3.2.2 I/M test with combination of an altered catalyst and lambda irregularity



**high idle at 2780 1/min*

The influence of the failure combination on the I/M tailpipe test is significant at low idle. The low performance to convert CO occurs at the type approval test as well as at the tailpipe test. Lambda exceeds simultaneously CO exists, that's an indication for the inconsistent lambda conditions.
The effects at high idle are significant as well. Both, lambda and CO cross the current threshold according to 96/96/EG. In all, the air fuel mixture is lean but on the other hand CO exists.

1.3.3 Table of test results

Test results EUDC TYPE 1 and I/M			
kind of modification	***without failure as reference***	***combination of a altered catalyst and lambda irregularity***	***Simulation of lambda sensor deterioration***
mileage	28237	28212	28168
EUDC results			
CO (g/km)	0	1,6904	4,8694
CO2 (g/km)	149	141	142
HC (g/km)	0,0041	0,2016	0,0517
Nox (g/km)	0,0077	1,4495	0,0036
Type 1 results			
CO (g/km)	0,8861	3,6813	5,3717
CO2 (g/km)	197	186	189
HC (g/km)	0,0936	0,4122	0,1575
Nox (g/km)	0,0602	1,2756	0.0322
I/M results			
CO low idle Vol. %	0	0,53	0,008
CO high idle Vol. %	0,02	0,41	0.103
lambda low idle	0,999	1,04	0,999
lambda high idle	1	1,119	0.997
CO2 low idle Vol. %	15,2	13,8	15
CO2 high idle Vol. %	15,2	12,9	14,8
HC low idle ppm	25	186	45
HC high idle ppm	28	168	78
O2 low idle Vol. %	0,05	1,38	0,05
O2 high idle Vol. %	0,05	2,66	0,05

1.4 Results reading out the OBD system

The MIL lamp illuminates when ignition is on and engine off. Further the MIL indicates failures like disconnection of sensors respectively actuators and most of simulated electrical failures with resistances.

1.4.1 Table of Sensor and actuator failures

Table: sensor failures

Sensors	kind of simulation	MIL Status / P0 CODE	exhaust emission relevant effects
Coolant temperature sensor	disconnecting resistor	ON P0 116	emergency program be regulated
Air mass flow sensor	disconnecting resistor	ON P0 101 P0 111 OFF NO	emergency program be regulated
Upstream lambda sensor	disconnecting resistor	ON P0 130 ON P0 131	emergency program increase of emission
Downstream lambda sensor	lambda shift simulator connecting up- and downstream	OFF NO ON P0 420	increase of emission normal emission
Throttle position sensor	disconnecting putting a resistor in line	ON P0 120 OFF NO	limp home mode be regulated

Table: Actuator failures

Actuators	kind of simulation	MIL / P0 Code	exhaust emission relevant effects
1. Secondary air injection	take currant at the valve	ON P0 410	be regulated
2.Idle speed actuator	disconnecting	ON P0 505	limp home mode
3. Injectors	disconnecting	ON P0 201	limp home mode
4. ignition / sparks	disconnecting misfire generator	ON P0 300 ON P0 300	limp home mode limp home mode
5. catalyst conversion	thermically work of destruction combined with lambda differences	ON P0 420 OFF NO	no effects increase of emission

Most of the failures described above were recorded by the OBD system either by the MIL or by a DTC saved in the ECU.

1.4.2 OBD values and available data of vehicles compared to 98/69/EU

1.4.2.1 Readiness CODE:

	available at the vehicles
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	YES
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

1.4.2.2 Freeze - Frame:

If trouble codes happen, the ECU should save the following data:

	available at the vehicle
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 1
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	NO
Status fuel system	YES

**98/69/EU 6.5.1.1*

The ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 1**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	NO
Ignition timing advance	YES
Intake manifold pressure	NO
Air flow rate	NO
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

1.5 Measuring protocol

Vehicle N°	**1**
Partner	**DEKRA**
Inertia	**1420 kg**
Power absorbed at 80 km/h	**7,5 KW**
Air temperature	**295,52 K**
Atmospheric pressure	**1006,02 hPa**
Humidity	**42,32 %**

2. VEHICLE 2

2.1 Vehicle data

Vehicle N°	**2**
Partner	**DEKRA**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	1600
Communication protocol	ISO 9141 2
EGR (yes/no)	YES
Air injection(yes no)	NO
Transmission (manual/automatic)	manual
Egr valve (yes/no)	YES
motorised throttle (yes/no)	YES
manifold pressure sensor (yes/no)	YES
pre-catalyst (yes/no)	YES
main catalyst (yes/no)	YES
pre-muffler	YES
main muffler	YES
mileage (km)	6650

2.2 Failure description

The vehicle was tested with the following failures:

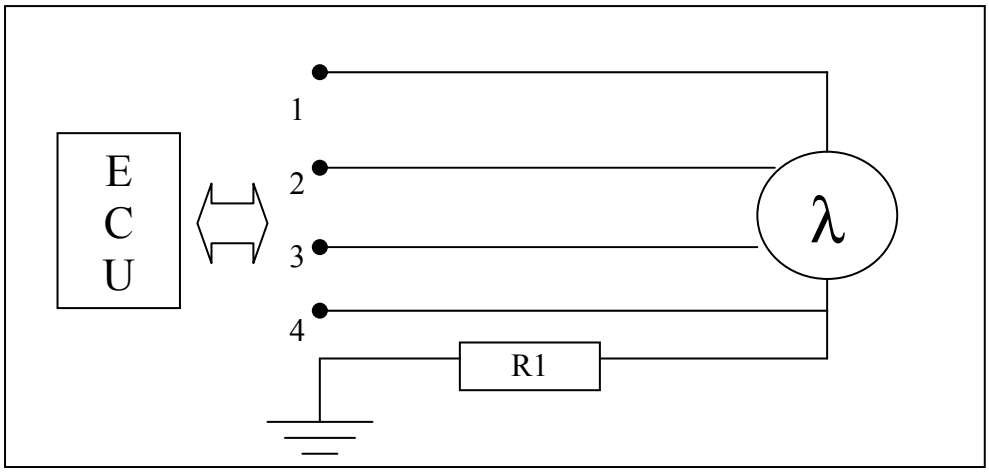
- Simulation of an aged O_2 Sensor

2.2.1 Simulation of an aged O_2 Sensor

To simulate an aged oxygen sensor, the sensors ability to respond with a lower voltage were reached by a build in resistor. The sketch shows in which way the downstream oxygen sensor is connected with the resistor. Further, this failure should also emerge when the wire is defect and the lead wire has been contact to the chassis ground.

A dead sensor will prevent the ECU from making the necessary air/fuel corrections, causing the air /fuel mixture to run rich in the “closed loop” operation, resulting in much higher emissions.

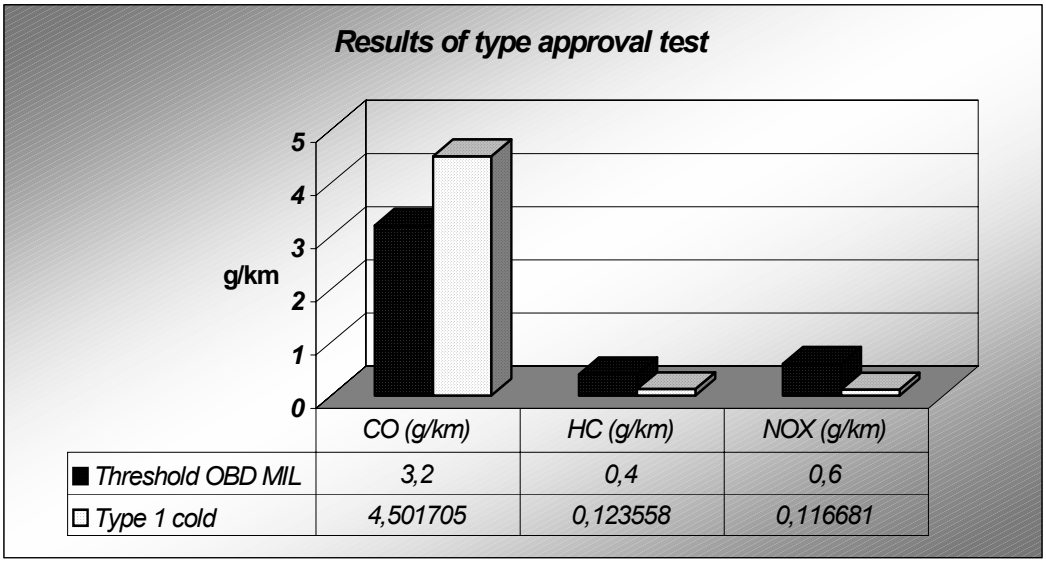
sketch: Oxygen sensor with resistor R1, (1 and 2 heater, 3 and 4 signal sensor)



2.3 Test Results

2.3.1 Results of the type 1 test

2.3.1.1 Simulation of an aged O_2 sensor



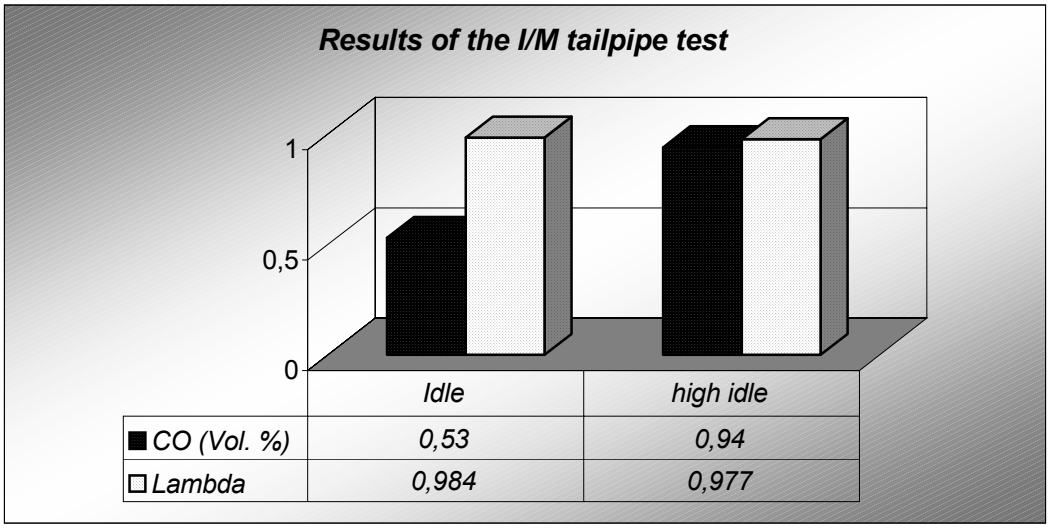
**Threshold OBD MIL: Annex XI to 98/69 EG break 3.3.2*

The lower sensor voltage has already influence for the air fuel mixture respectively for the exhaust gas composition.

The catalytic converter isn't able to convert CO during the changed conditions. HC and NOX are increased according to the limits of EURO 4 but the thresholds for the MIL are not exceeded.

2.3.2 Results of the I/M test

2.3.2.1 Simulation of an aged O_2 sensor



high idle 2800 1/min

The influence of the lower sensors voltage is significant at the tailpipe test at low idle speed as well as at high idle speed. Lambda is significant below the soichiometric air fuel ratio accordingly CO increased.

The exhaust emissions cross all demands according to 96/96/EG.

2.3.3 Results of the HOT EUDC and TYPE 1 tests

Test results EUDC TYPE 1 and I/M		
kind of modification	**without failure as reference**	**Simulation of an aged O_2 sensor**
mileage	6649	6688
EUDC results		
CO (g/km)	0,018	3,68
CO2 (g/km)	132	130
HC (g/km)	0,000282	0,038089
Nox (g/km)	0,008851	0,146682
Type 1 results		
CO (g/km)	0,264	4,501
CO2 (g/km)	167	162
HC (g/km)	0,051086	0,123558
Nox (g/km)	0,064912	0,116681
I/M results		
I/M CO low idle Vol. %	0	0,53
I/M CO high idle Vol. %	0	0,94
I/M lambda low idle	0,998	0,984
I/M lambda high idle	0,999	0,977
I/M CO2 low idle Vol. %	15,3	14,5
I/M CO2 high idle Vol. %	15,4	14,2
I/M HC low idle ppm	13	100
I/M HC high idle ppm	12	28
I/M O2 low idle Vol. %	0,01	0,1
I/M O2 high idle Vol. %	0	0,1

2.4 Results reading out of the OBD system

2.4.1 Table of sensor and actuator failures

Sensors	kind of simulation	MIL Status / P0 Code	exhaust emission relevant effects
1. Coolant temperature sensor	disconnecting resistance	ON P0 116 OFF	emergency program be regulated
2. Intake manifold air pressure	disconnecting resistor	ON P0 101/ P0 111 OFF NO	emergency program be regulated
3. Upstream lambda sensor	disconnecting resistor	ON P0 ON P0 131	emergency program be regulated

4. Downstream lambda sensor	disconnecting resistor	ON P0 143 OFF NO	emergency program increase of emission

Actuators	kind of simulation	MIL / P0 Code	exhaust emission relevant effects
1. EGR valve	a built in valve dummy	ON P0 401	increase of emission
2. ignition / spark	disconnect	ON P0 302	emergency program
3. Injectors	disconnect resistor	ON P0 201 OFF NO	emergency program be regulated

2.4.2 OBD values and available data of vehicles compared to 98/69/EU

2.4.2.1 Readiness CODE:

	available at the vehicle 2
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	YES
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

2.4.2.2 Freeze - Frame:

If trouble codes happen the ECU should save the following data:

	available at the vehicle 2
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 2
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	NO
Status fuel system	YES

**98/69/EU 6.5.1.1*

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 2**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

2.5 Measuring protocol

Vehicle N°	**2**
Partner	**DEKRA**
Inertia	**1470 kg**
Power absorbed at 80 km/h	**7,32 KW**
Air temperature	**295,35 K**
Atmospheric pressure	**1003,45 hPa**
Humidity	**49,59 %**

3. VEHICLE 3

3.1 Vehicle data

Vehicle N°	**3**
Partner	**DEKRA**
Verification of the Approval 98/69	YES
Engine type	V6
Engine capacity	ca. 2800
Communication protocol	SAE J1850 VPM
EGR (yes/no)	YES
Transmission (manual/automatic)	automatic
Egr valve (yes/no)	YES
throttle (yes/no)	YES
motorised throttle (yes/no)	YES
manifold pressure sensor (yes/no)	YES
pre-catalyst (yes/no)	NO
main catalyst (yes/no)	YES
secondary air injection valve (yes/no)	NO
mileage (km)	14300

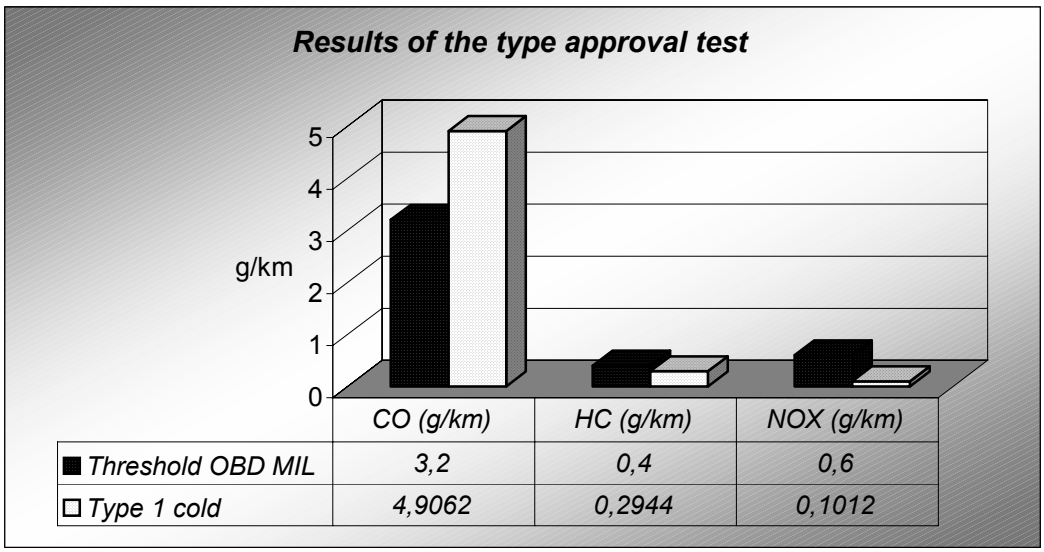
3.2 Failure description

The vehicle was tested with a leaking exhaust system. The lambda sensor in front of the catalytic converter was coming lose. Therefore this leak was able to let atmospheric O_2 pass and dilute the exhaust composition. So lambda is regulated within the lambda sensor and would be changed of the additional O_2.

3.3 Test results

3.3.1 Results of the type 1 test

3.3.1.1 Simulation of a lacking exhaust system



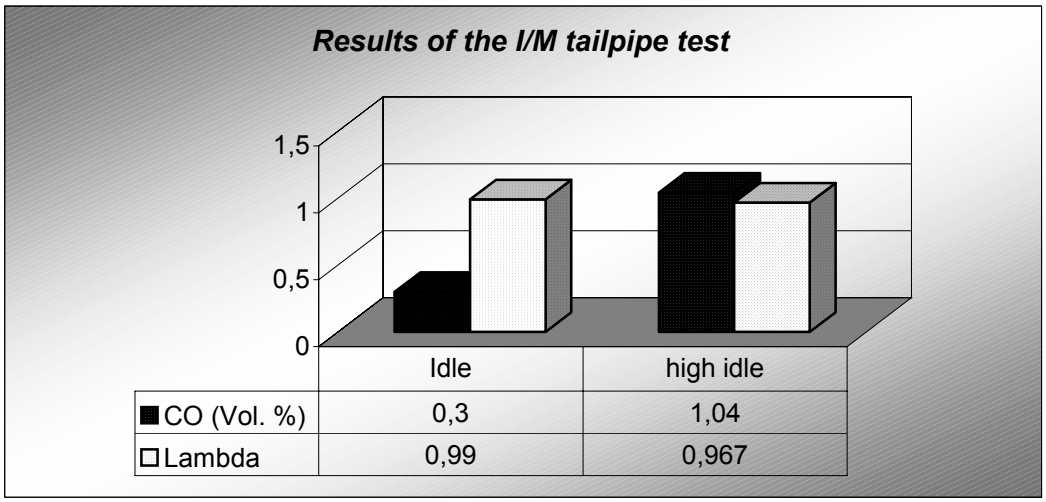
**Threshold OBD MIL: Annex XI to 98/69 EG break 3.3.2*

The influence of the leak at the exhaust system is during the type 1 test significant. The increasing CO emissions might be the result of unstable air fuel compositions.

The catalytic converter isn't able to convert CO during the changed conditions. HC increased according to the limit of EURO 3 but the thresholds for the MIL are not exceeded.

3.3.2 Results of the I/M test

3.3.2.1 Simulation of a lacking exhaust system



** high idle 2800 1/min*

The influence of the leaking exhaust system is during the tailpipe test at idle speed significant.

as well as during the high idle speed test. Even the thresholds CO at high idle of 96/96/EG are increased more then 3 times.

3.3.3 Table of test results

Test results EUDC TYPE 1 and I/M		
Test	**First T1 reference**	**loosen O_2 sensor**
mileage	14277	14320
EUDC results		
CO (g/km)	0,0730	2,9192
CO2 (g/km)	177,0080	176,0630
HC (g/km)	0,0103	0,0881
Nox (g/km)	0,0935	0,1007
Type 1 results		
CO (g/km)	0,58	4,91
CO2 (g/km)	236	232
HC (g/km)	0,0855	0,2944
Nox (g/km)	0,0916	0,1012
I/M results		
I/M CO low idle Vol. %	0,01	0,3
I/M CO high idle Vol. %	0,008	1,04
I/M lambda low idle	1,0	0,99
I/M lambda high idle	1,0	0,967
I/M CO2 low idle Vol. %	15,2	14,7
I/M CO2 high idle Vol. %	15,3	14,3
I/M HC low idle ppm	9	24
I/M HC high idle ppm	5	128
I/M O2 low idle Vol. %	0,01	0
I/M O2 high idle Vol. %	0	0,03

3.4 Results of the OBD-system

3.4.1 Table of sensor and actuator failures

Sensors	kind of simulation	MIL Status	exhaust emission relevant effects
1. Coolant temperature sensor	disconnecting resistance	ON P0 116 OFF	emergency program be regulated
2. Intake manifold air pressure	disconnecting resistor	ON P0 109 OFF NO	emergency program be regulated
3. Upstream lambda sensor	disconnecting resistor	ON P0 130 ON P0 174	emergency program increase of emission
4. Downstream lambda sensor	disconnecting build out coming loose	ON P0 136 ON P0 174 OFF NO	emergency program increase of emission increase of emission

Actuators	kind of simulation	MIL / P0 Code	exhaust emission relevant effects
1. ignition / spark	misfire	ON P0 304	emergency program increase of emission

3.4.2 OBD values and available data of vehicles compared to 98/69/EU

3.4.2.1 Readiness CODE:

	available at the vehicle 3
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	YES
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

3.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle 3
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 3
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	NO
Status fuel system	YES

*98/69/EU 6.5.1.1

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 3**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

3.5 Measuring protocol

Vehicle N°	**3**
Partner	**DEKRA**
Inertia	**1590 kg**
Power absorbed at 80 km/h	**8,48 KW**
Air temperature	**295,05 K**
Atmospheric pressure	**1003,78 hPa**
Humidity	**51,48 %**

4. VEHICLE 4

4.1 Vehicle data

Vehicle N°	**4**
Partner	**RWTÜV**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	ca. 1000
Communication protocol	ISO 9141 2
EGR (yes/no)	NO
Air injection(yes no)	NO
Transmission (manual/automatic)	manual
Egr valve (yes/no)	NO
motorised throttle (yes/no)	NO
manifold pressure sensor (yes/no)	NO
pre-catalyst (yes/no)	NO
main catalyst (yes/no)	YES
secondary air injection valve (yes/no)	NO
mileage (km)	20720

4.2 Failure description

4.2.1 Coolant temperature sensor

Simulation of 10 °C coolant-temperature at ambient temperature (20 - 30 °C)

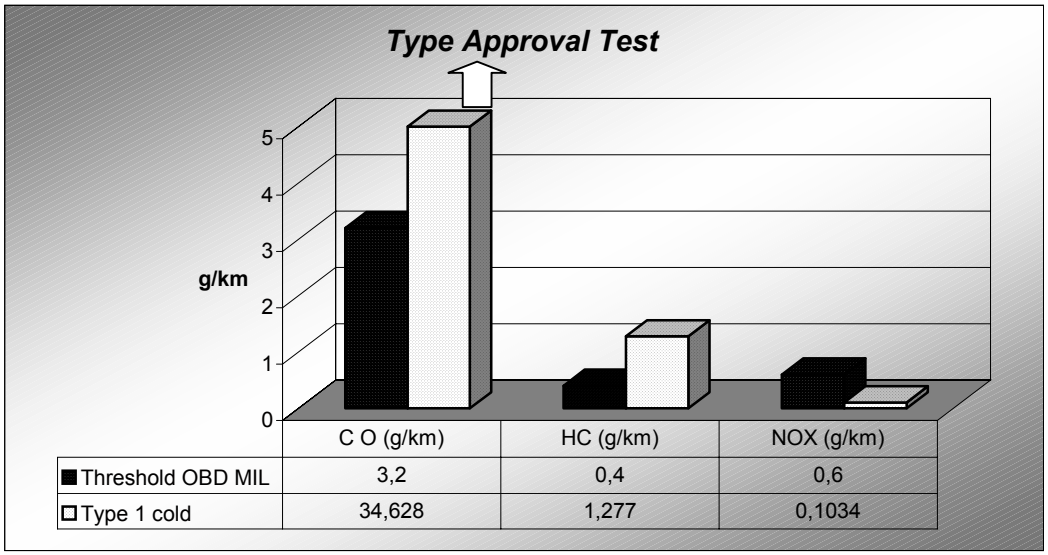
4.2.2 Air flow sensor signal

Changed length of the cable between air flow sensor and control unit

4.3 Test Results

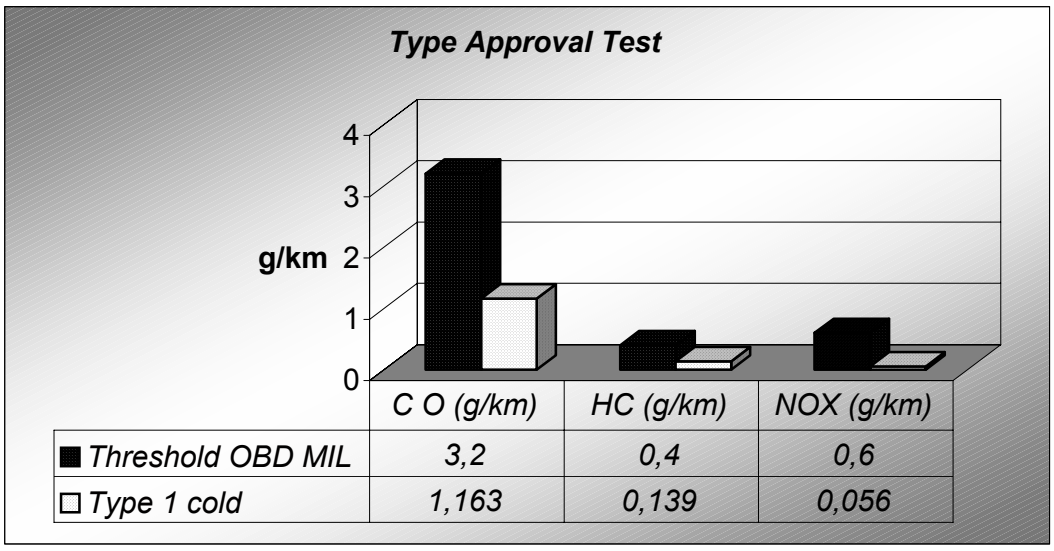
4.3.1 Results of the type 1 test

4.3.1.1 Failure simulation: Coolant temperature sensor

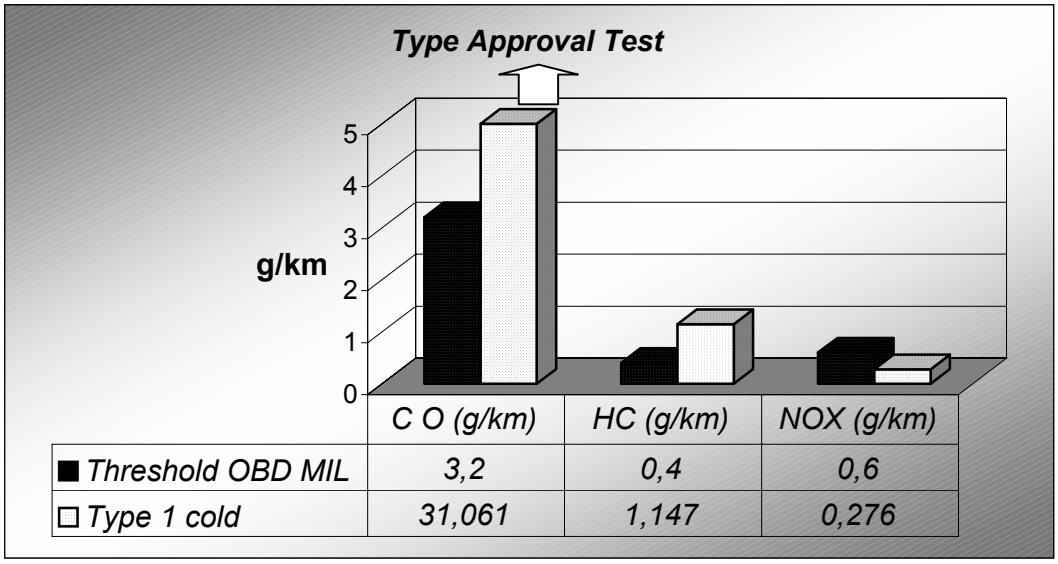


The effect of the build in resistor is very impressive, CO rise up more the ten times over the MIL threshold. Also HC increases about more the three times over the MIL threshold.

4.3.1.2 Failure simulation: Air flow sensor signal

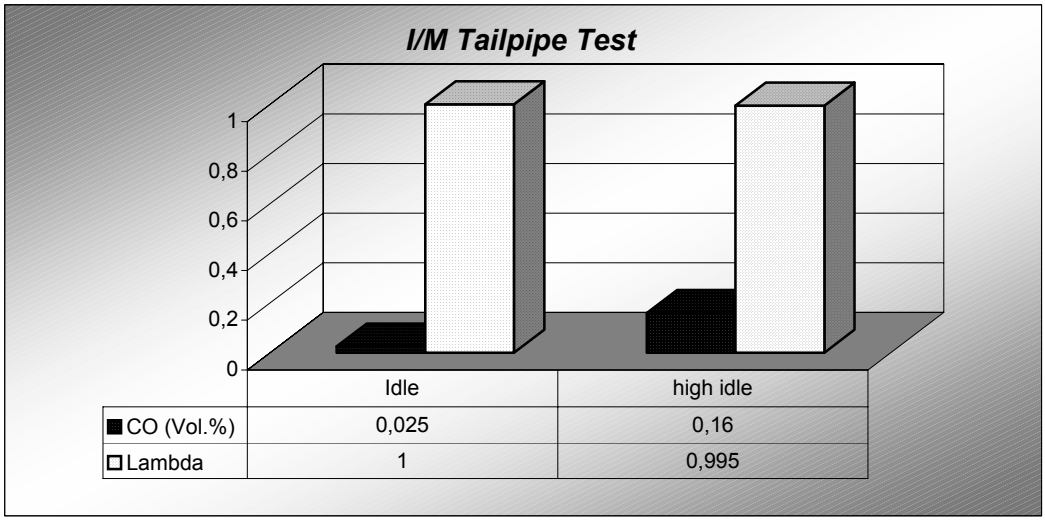


4.3.1.3 Failure simulation: Coolant temperature sensor and airflow sensor signal

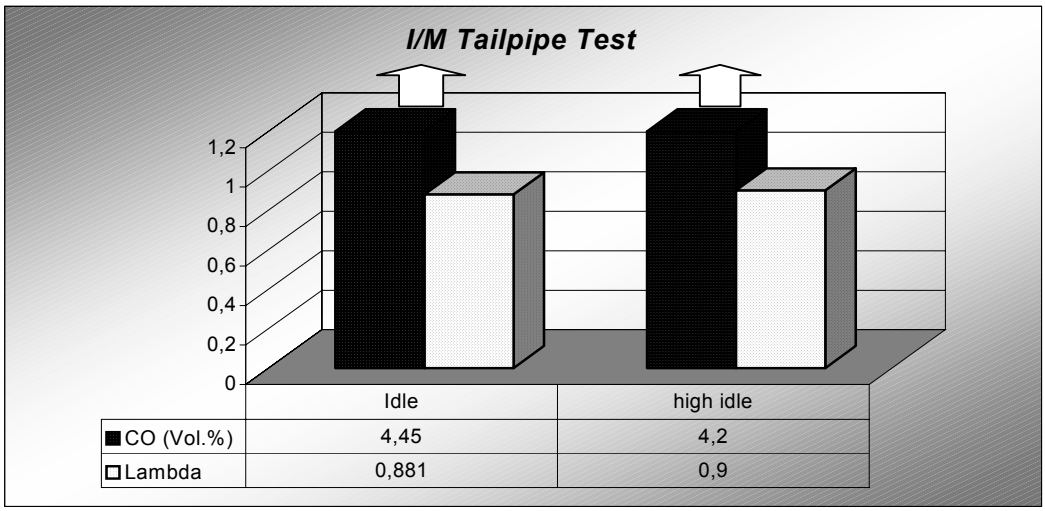


4.3.2 Results of the tailpipe test

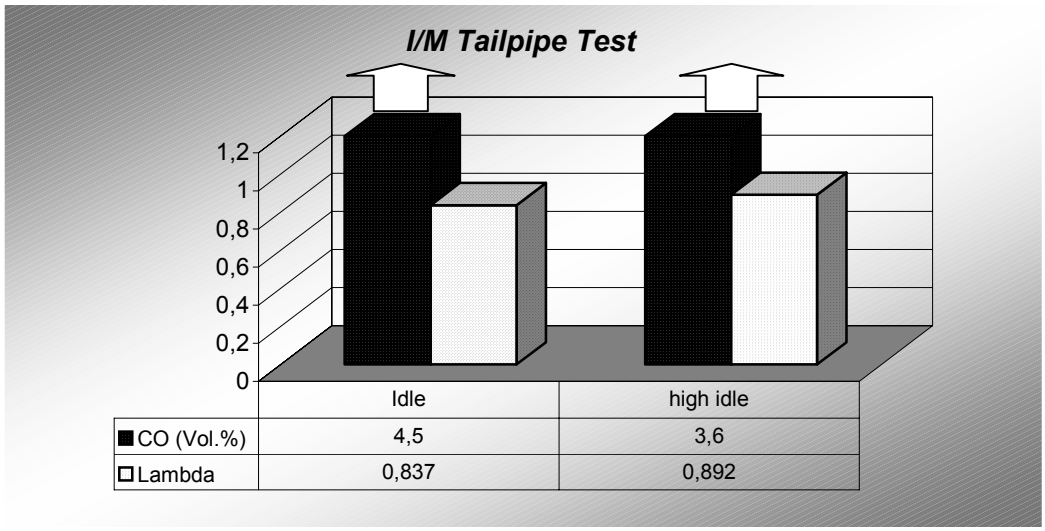
4.3.2.1 Failure simulation: Coolant temperature sensor



4.3.2.2 Failure simulation: Air flow sensor signal



4.3.2.3 Failure simulation: Coolant temperature sensor and airflow sensor signal



4.3.3 Table of the test results

Test results EUDC TYPE 1 and I/M				
kind of modification	**without failure as reference**	**Coolant temperature-sensor**	**Air flow sensor signal**	**Coolant temperature sensor and air flow sensor signal**
mileage	20720	20861	20909	20954
EUDC results				
CO (g/km)	0,0897	26,801	0,127	18,301
CO2 (g/km)	129	113,045	129,587	87,879
HC (g/km)	0,0102	0,767	0,011	0,59
Nox (g/km)	0,0317	0,1487	0,038	0,374
Type 1 results				
CO (g/km)	0,9526	34,628	1,163	31,061
CO2 (g/km)	151,2799	141,932	152,277	123,698
HC (g/km)	0,1068	1,277	0,139	1,147
Nox (g/km)	0,0465	0,1034	0,056	0,276
I/M results				
CO low idle Vol. %	0	4,45	0,025	4,5
CO high idle Vol. %	0,002	4,20	0,16	3,6
lambda low idle	1	0,881	1	0,873
lambda high idle	1,004	0,9	0,995	0,892
CO2 low idle Vol. %	14,1	12,4	15,5	12,3
CO2 high idle Vol. %	15	12,6	15,3	12,9
HC low idle ppm	0	213	7	190
HC high idle ppm	1	190	10	134
O2 low idle Vol. %	0	0,21	0	0
O2 high idle Vol. %	0,12	0,12	0	0

4.4 Results of the OBD System

4.4.1 Table of sensor and actuator tested failures

Sensors	**kind of simulation**	**MIL Status / P0 CODE**	**exhaust emission relevant effects**
Coolant temp. sensor	disconnection	P0115	
Air flow sensor	disconnection	P0100 P0110	
Injection system	disconnection	P0300 P0302	

4.4.2 OBD values and data available compared to 98/69/EU

4.4.2.1 Readiness CODE:

	available at the vehicle 4
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

4.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle 4
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 4
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	NO

**98/69/EU 6.5.1.1*

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 4**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	NO
Air flow rate	YES
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

4.5 Measuring protocol

Vehicle N°	**4**
Partner	**RWTÜV**
Inertia	**910**
Power absorbed at 80 km/h	**7,46**
Air temperature	**24**
Atmospheric pressure	**1025**
Humidity	**35**

5. VEHICLE 5

5.1 Vehicle data

Vehicle N°	**5**
Partner	**RWTÜV**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	ca.2000
Communication protocol	ISO 9141 2
EGR (yes/no)	YES
Air injection(yes no)	NO
Transmission (manual/automatic)	manual
Egr valve (yes/no)	YES
motorised throttle (yes/no)	YES
manifold pressure sensor (yes/no)	NO
pre-catalyst (yes/no)	NO
main catalyst (yes/no)	YES
secondary air injection valve (yes/no)	NO
mileage (km)	2022

5.2 Failure Description

5.2.1 Coolant temperature sensor

Simulation of 15 °C coolant temperature at ambient temperature (20 - 30 °C).

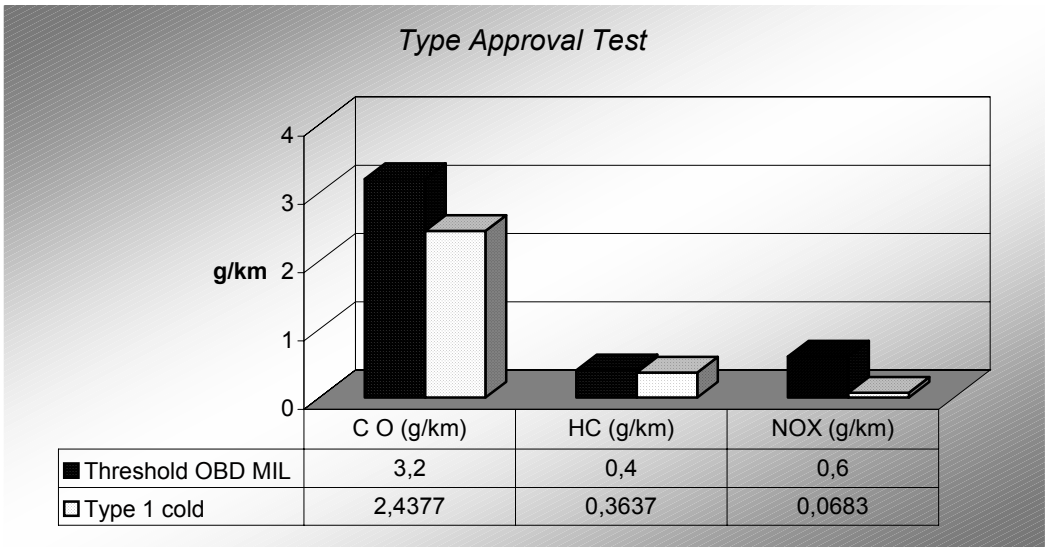
5.2.2 Evaporative Emission Control System

Simulation loaded charcoal canister and failure of the solenoid valve.

5.3 Test Results

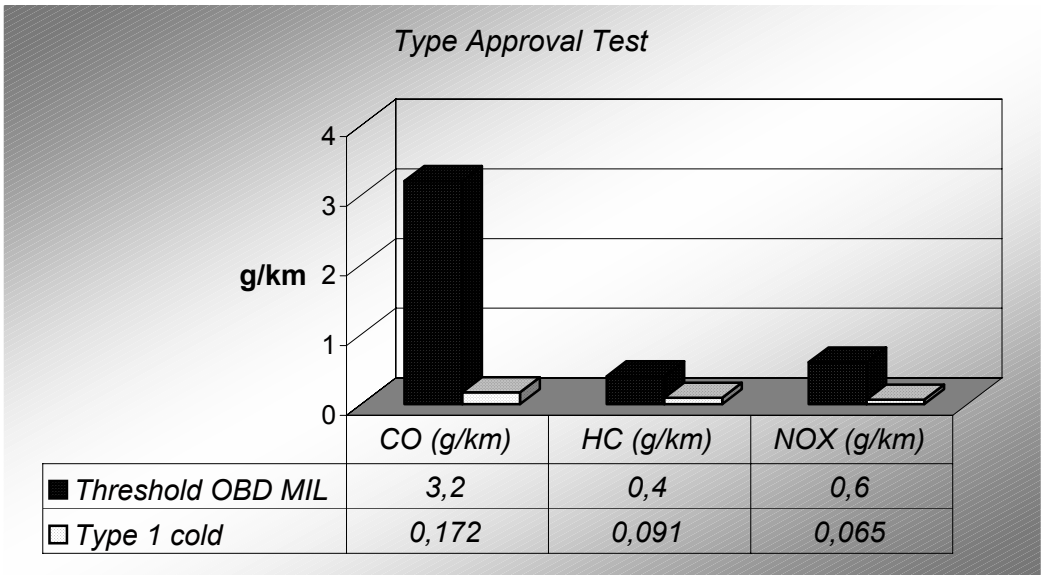
5.3.1 Results of the type 1 test

5.3.1.1 Failure simulation: Coolant temperature sensor



	C O (g/km)	HC (g/km)	NOX (g/km)
Threshold OBD MIL	3,2	0,4	0,6
Type 1 cold	2,4377	0,3637	0,0683

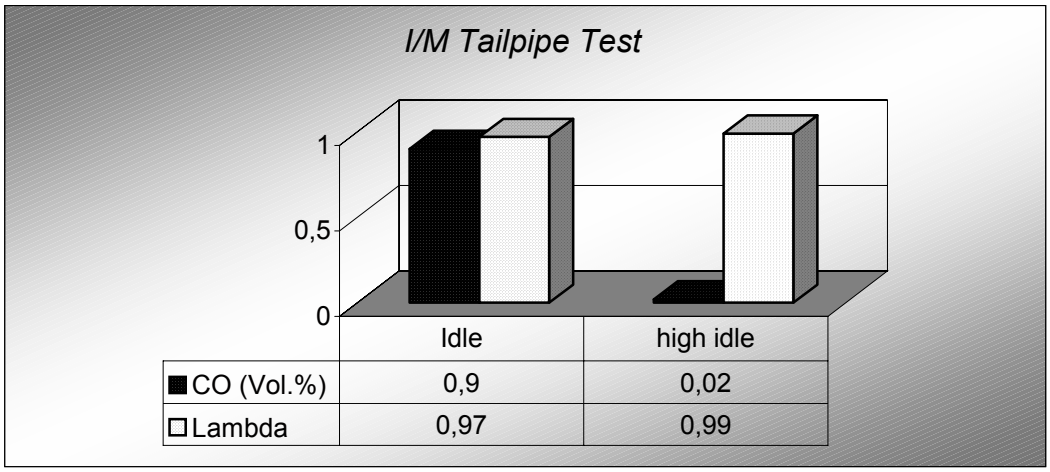
5.3.1.2 Failure simulation: EVAP System



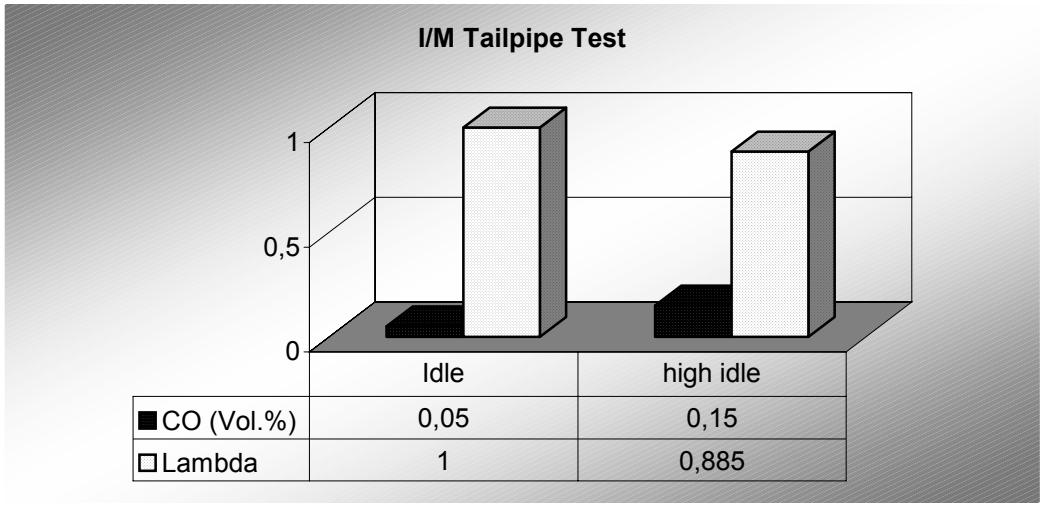
	CO (g/km)	*HC (g/km)*	*NOX (g/km)*
Threshold OBD MIL	*3,2*	*0,4*	*0,6*
Type 1 cold	*0,172*	*0,091*	*0,065*

5.3.2 Results of the I/M test

5.3.2.1 Failure simulation: Coolant temperature sensor



5.3.2.2 Failure simulation: EVAP System



5.3.3 Table of the test results

Test results EUDC TYPE 1 and I/M			
kind of modification	**without failure as reference**	**Coolant temperature sensor**	**EVAP System**
mileage	2022	2183	2344
EUDC results			
CO (g/km)	0,0134	1,729	0,05
CO2 (g/km)	139,01	143,7244	139,094
HC (g/km)	0,0023	0,0011	0001
Nox (g/km)	0,0673	0,0014	0,05
Type 1 results			
CO (g/km)	0,1311	2,4377	0,172
CO2 (g/km)	179,5698	191,1155	179,144
HC (g/km)	0,0981	0,3637	0,091
Nox (g/km)	0,081	0,0683	0.065
I/M results			
CO low idle Vol. %	0,003	0,90	0,05
CO high idle Vol. %	0,004	0,02	0,15
lambda low idle	1	0,97	1
lambda high idle	1	0,999	0,885
CO2 low idle Vol. %	15,4	15,4	15,4
CO2 high idle Vol. %	15,4	15,4	15,2
HC low idle ppm	4	115	0
HC high idle ppm	7	12	53
O2 low idle Vol. %	0	0	0
O2 high idle Vol. %	0	0	0

5.4 Results of the OBD System

5.4.1 Table of sensor and actuator tested failures

Sensors	kind of simulation	MIL Status / P0 CODE	exhaust emission relevant effects
Coolant temp. sensor	disconnection	P0115	
EVAP	disconnection	P0441	

5.4.2 OBD values and available data compared to 98/69/EU

5.4.2.1 Readiness CODE

	available at the vehicles 5
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

5.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle 5
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 5
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	NO
Status fuel system	YES

**98/69/EU 6.5.1.1*

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 5**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	NO
Air flow rate	YES
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

5.5 Measuring protocol

Vehicle N°	**5**
Partner	**RWTÜV**
Inertia	**1360**
Power absorbed at 80 km/h	**7,31**
Air temperature	**24**
Atmospheric pressure	**996**
Humidity	**35**

6. VEHICLE 6

6.1 Vehicle data

Vehicle N°	**6**
Partner	**RWTÜV**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	ca. 1500
Communication protocol	ISO 9141 2
EGR (yes/no)	YES
Air injection(yes no)	NO
Transmission (manual/automatic)	manual
Egr valve (yes/no)	YES
motorised throttle (yes/no)	YES
manifold pressure sensor (yes/no)	YES
pre-catalyst (yes/no)	YES
main catalyst (yes/no)	YES
secondary air injection valve (yes/no)	NO
mileage (km)	1022

6.2 Failure description

6.2.1 Oxygen sensor

Simulation of a wrong signal with a resistor
see 1.2.2.1 Signal: 0,75 V

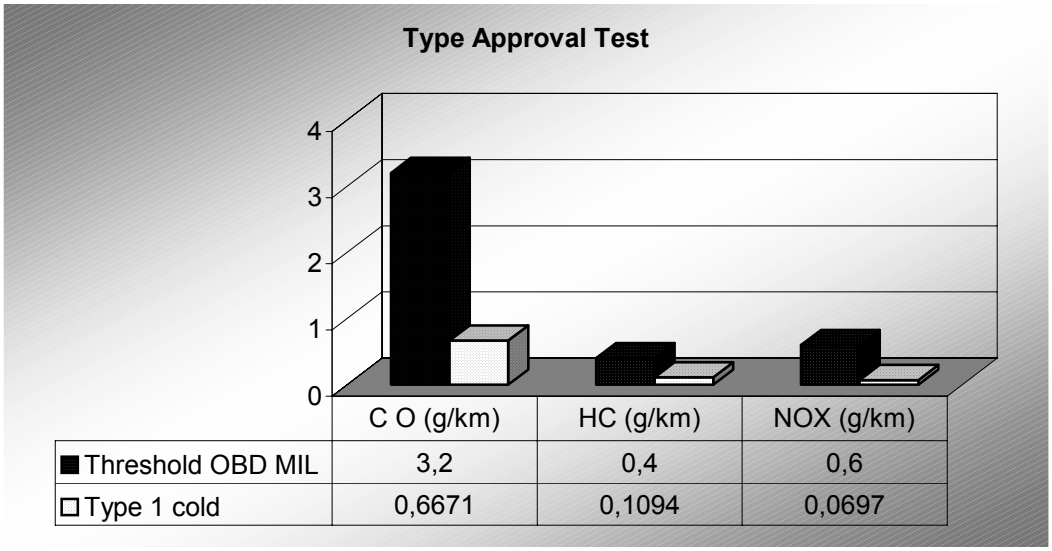
6.2.2 Oxygen sensor

Signal: 0,68 V

6.3 Test Results

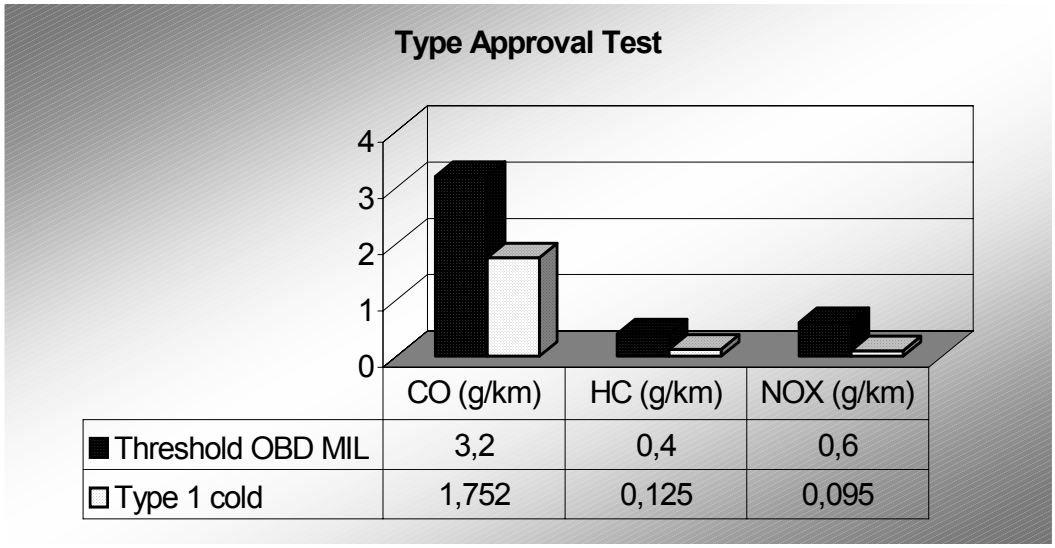
6.3.1 Results of the type 1 test

6.3.1.1 Signal: 0,75 V



	C O (g/km)	HC (g/km)	NOX (g/km)
Threshold OBD MIL	3,2	0,4	0,6
Type 1 cold	0,6671	0,1094	0,0697

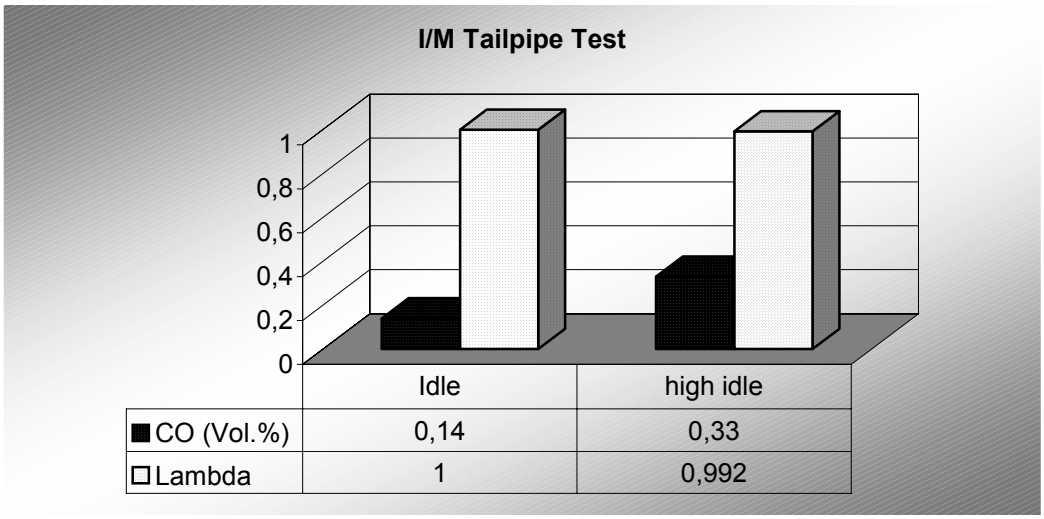
6.3.1.2 Signal: 0,68 V



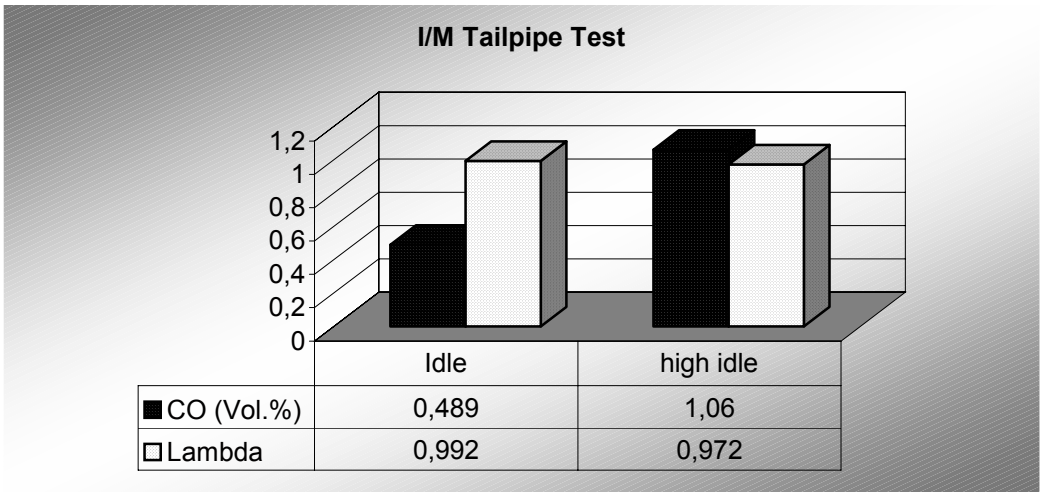
	CO (g/km)	HC (g/km)	NOX (g/km)
Threshold OBD MIL	3,2	0,4	0,6
Type 1 cold	1,752	0,125	0,095

6.3.2 Results of the I/M test

6.3.2.1 Signal: 0,75 V



6.3.2.2 Signal: 0,68 V



6.3.3 Table of the test results

Test results EUDC TYPE 1 and I/M			
kind of modification	**without failure as reference**	**Signal 0,75 V**	**Signal 0,68 V**
mileage	1022	1437	1471
EUDC results			
CO (g/km)	0,0062	0,0351	0,951
CO2 (g/km)	131,397	132,07	123,343
HC (g/km)	0,0012	0,0016	0,031
Nox (g/km)	0,004	0,0366	0,11
Type 1 results			
CO (g/km)	0,308	0,6671	1,752
CO2 (g/km)	166,2698	168,936	166,465
HC (g/km)	0,0748	0,1094	0,125
Nox (g/km)	0,0246	0,0697	0,095
I/M results			
CO low idle Vol. %	0,002	0,14	0,489
CO high idle Vol. %	0,004	0,33	1,06
lambda low idle	1,001	1	0,992
lambda high idle	1	0,992	0.972
CO2 low idle Vol. %	15,4	15,3	15,2
CO2 high idle Vol. %	15,4	15,2	15
HC low idle ppm	2	14	135
HC high idle ppm	3	28	40
O2 low idle Vol. %	0	0	0
O2 high idle Vol. %	0	0	0

6.4 Results of the OBD System

6.4.1 Table of sensor and actuator tested failures

Sensors	kind of simulation	MIL Status / P - CODE	exhaust emission relevant effects
O_2 sensor	disconnection	P1115 P1116 P1237 P1238	

6.4.2 OBD values and available data compared to 98/69/EU

6.4.2.1 Readiness CODE:

	available at the vehicles 6
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	YES
ARG system	YES
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

6.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle 6
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES
Fuel trim	YES
Intake manifold pressure	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 6
Fuel pressure	NO
Vehicle speed	YES
Status fuel system	YES

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 6**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

6.5 Measuring protocol

Vehicle N°	**6**
Partner	**RWTÜV**
Inertia	**1250**
Power absorbed at 80 km/h	**7,2**
Air temperature	**24**
Atmospheric pressure	**1002**
Humidity	**51**

7. VEHICLE 7

7.1 Vehicle data

Vehicle N°	**7**
Partner	**RWTÜV**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	ca. 1500
Communication protocol	ISO/DIS 14230 4
EGR (yes/no)	NO
Air injection(yes no)	NO
Transmission (manual/automatic)	manual
Egr valve (yes/no)	NO
motorised throttle (yes/no)	NO
manifold pressure sensor (yes/no)	YES
pre-catalyst (yes/no)	NO
main catalyst (yes/no)	YES
secondary air injection valve (yes/no)	NO
mileage (km)	2137

7.2 Failure description

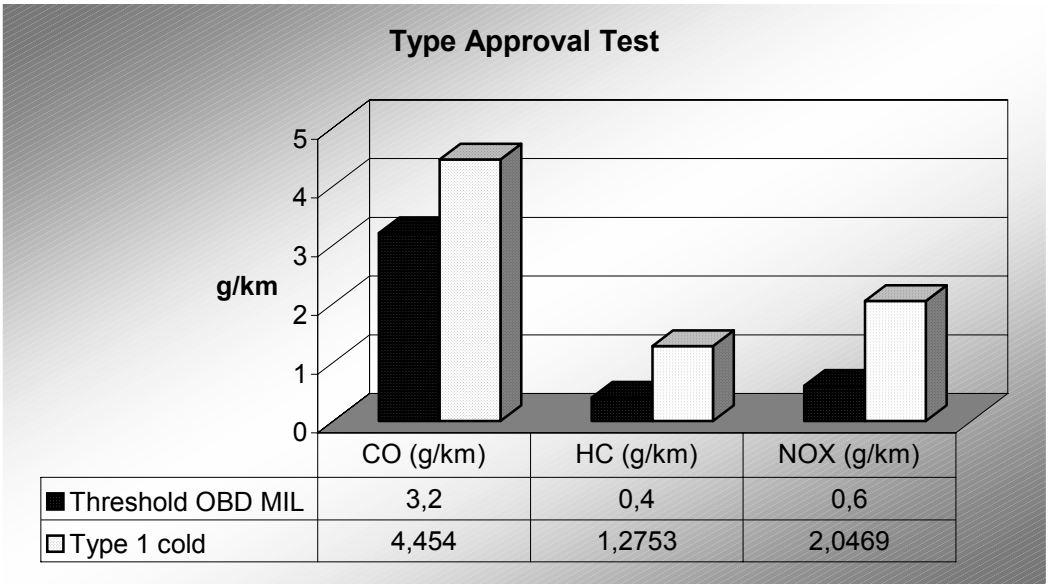
7.2.1 Catalyst

Simulation of a catalyst without monolith.

7.3 Test results

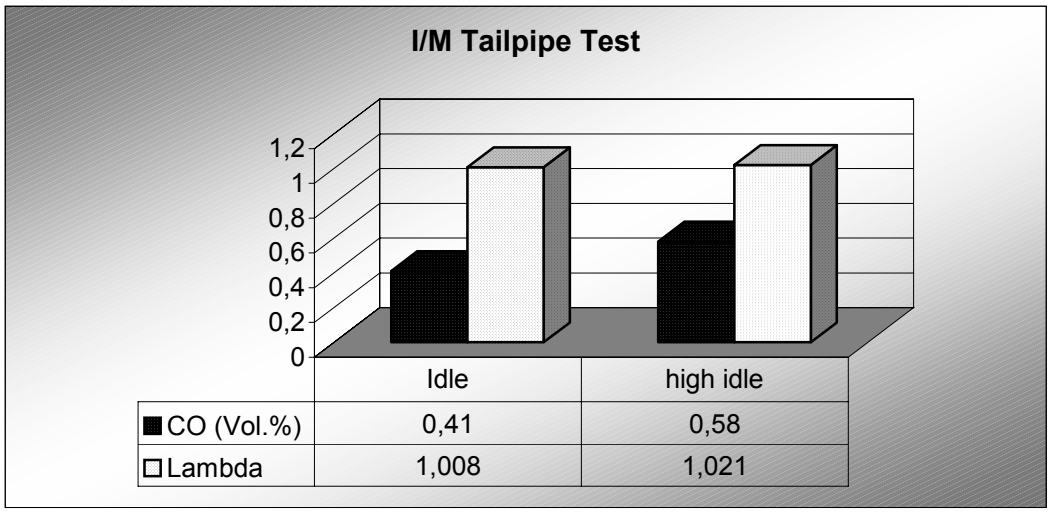
7.3.1 Results of the type 1 test

7.3.1.1 Simulation of a catalyst without monolith



7.3.2 Results of the I/M test

7.3.2.1 Simulation of a catalyst without monolith



7.3.3 Table of the test results

Test results EUDC TYPE 1 and I/M		
kind of modification	**without failure as reference**	**with failure**
mileage	2137	2304
EUDC results		
CO (g/km)	0,5467	3,5131
CO2 (g/km)	133,593	127,0657
HC (g/km)	0,0293	0,8943
Nox (g/km)	0,023	2,4165
Type 1 results		
CO (g/km)	0,5783	4,454
CO2 (g/km)	159,487	150,045
HC (g/km)	0,0588	1,2753
Nox (g/km)	0,0268	2,0469
I/M results		
CO low idle Vol. %	0,035	0,41
CO high idle Vol. %	0,063	0,58
lambda low idle	1	1,008
lambda high idle	0,998	1,021

7.4 Results of the OBD System

7.4.1 Table of actuator and sensor failures

	Fault code	Fuel system status	MIL status Freeze frame	MIL
Upstream O_2 sensor disconnect	P0130	OL, not ready CL	On	off
Upstream O_2 sensor heater disconnect	P0141 P0135	OL, not ready CL	On	off
MAP sensor disconnect	P0105		On	off

7.4.2 OBD values and available data compared to 98/69/EU

7.4.2.1 Readiness CODE:

	available at the vehicles 7
Catalyst	NO
Catalyst heater	YES
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	YES
Evaporation system	YES
ARG system	YES
Air condition	NO
misfiring	YES
fuel system	YES
Components	NO

7.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle
Fuel trim	YES
Fuel pressure	YES
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle x**
Coolant temperature	NO
Status fuel system	NO
Fuel trim	NO
Intake air temperature	NO
Ignition timing advance	NO
Intake manifold pressure	NO
Air flow rate	NO
Engine speed	YES
Throttle position	NO
Status secondary air injection	NO
Calculated load	NO
Vehicle speed	NO
Fuel pressure	NO

7.5 Measuring protocol

Vehicle N°	**7**
Partner	**RWTÜV**
Inertia	**1020**
Power absorbed at 80 km/h	**4,3**
Air temperature	**24**
Atmospheric pressure	**1002**
Humidity	**52**

8. VEHICLE 8 (the same type like vehicle 7)

8.1 Vehicle Data

Vehicle N°	**8**
Partner	**GOCA**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	1360 cm3
Communication protocol	KW 2000
EGR	NO
Air injection	NO
Transmission	Manual 5
motorised throttle	NO
Manifold pressure sensor	YES
pre-catalyst	NO
main catalyst	YES
mileage	2365 km

8.2 Failure description

This vehicle has been tested with the following failures:

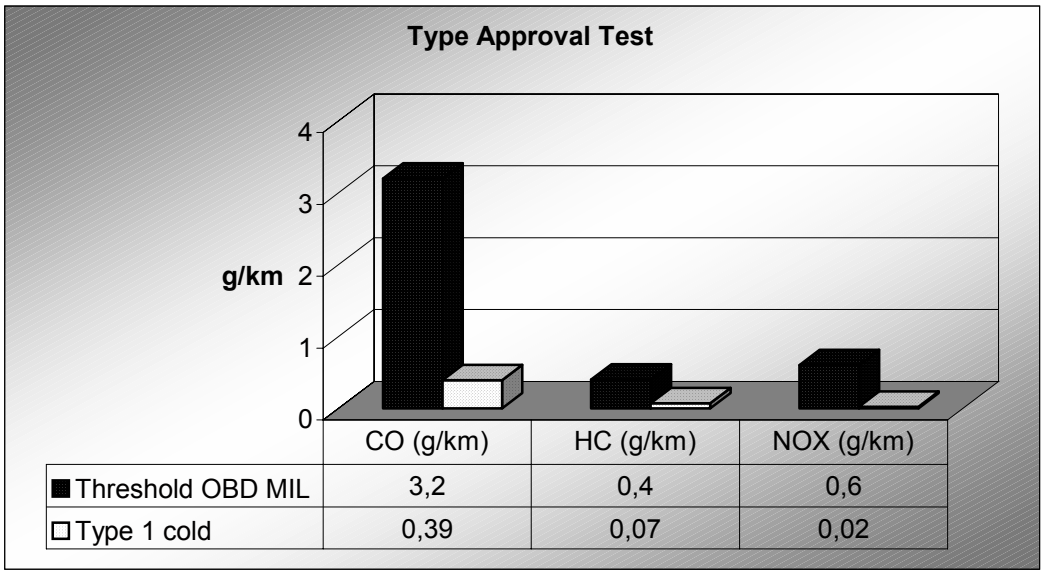
- Misfire: misfires were generated by building in sparkplugs in one cylinder with slight air gap. Air gaps of 0,1 mm to 0,3 mm give different frequencies of misfires and different changes in emissions
- Upstream O_2 sensor disconnect
- Upstream O_2 sensor malfunction: (+0,3V offset and 30% attenuation; 3K3 resistor) O_2 sensor aging creates:
  - a positive offset on the sensor output voltage
  - attenuation of the signal
  - slower response(+0,3V offset and 30% attenuation; 3K3 resistor)

  Electro-thermal or electro-chemical alterations in the sensor and connecting hardware can create negative offset voltages and attenuation. In this test constant voltages were added to or substracted from the sensor output voltage signal and the signal was attenuated.
- Upstream O_2 sensor heater disconnect
- MAP sensor disconnect
- Catalytic converter malfunction
  The cat was replaced by a canister containing flow obstructions and acting as a filter to the exhaust flow and composition variations.

During the tests, the vehicle driveability was always correct.

8.3 Test results

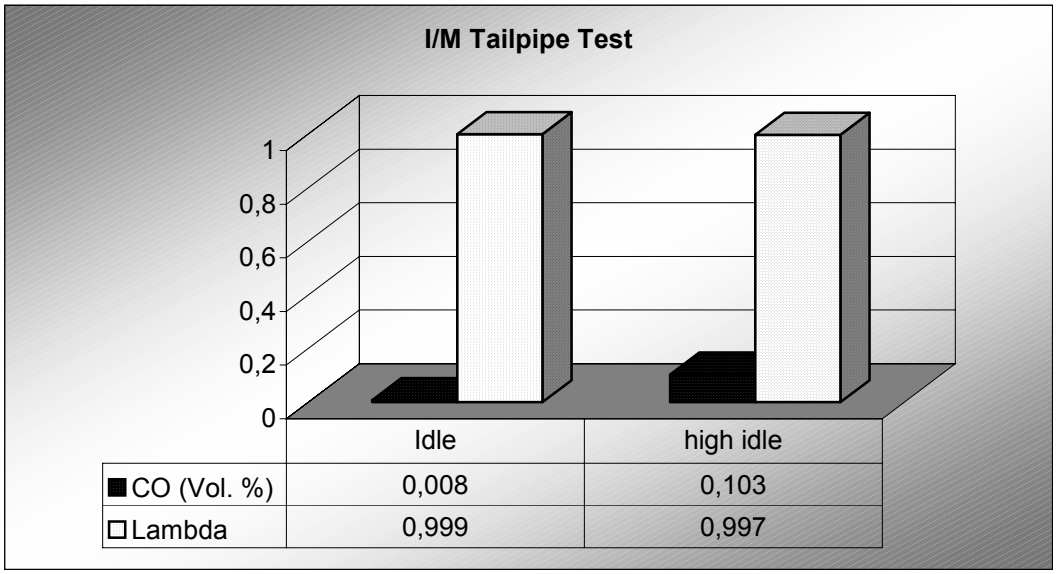
8.3.1 Results of the TYPE 1 tests



		CO	HC	NOx	CO2	Fault code	MIL
		g/km	g/km	g/km	g/km		
Initial	EU DC	0.18	0.01	0.01	145.60	no P code	off
Initial	Cold	0.39	0.07	0.02	170.02	no P code	off
Misfire	EU DC	0.21	0.01	0.01	145.83	P0300	off
Misfire	Cold	0.6	0.13	0.01	171.46	P0300	off
Ageing O_2 sensor	EU DC	0.78	0.06	0.47	143.00	no P code	off
Cat converter malfunction	EU DC	3.84	0.93	2.76	135.05	no P code	off
Limits		3.20	0.40	0.60	-		

With the EUDC/T1 test the failure “Cat converter malfunction“ is clearly detected.
Since the value for the CO, HC and NOx concentrations for the hot EUDC test with the ageing failure for the upstream O_2 sensor are considerably higher than the concentrations with no failure, the T1 test may come in the neighbourhood of the EOBD limit values.

8.3.2 Results of the I/M tests



8.3.3 Table of test results

Test results EUDC TYPE 1 and I/M		
kind of simulation	***without failure as reference***	***Misfire:spark plug gap 0,3 mm***
MIL Status	NOT ON	NOT ON
mileage	2365	2272
EUDC results		
CO (g/km)	0,18	0,21
CO2 (g/km)	145,60	145,83
HC (g/km)	0,01	0,01
Nox (g/km)	0,01	0,01
TYPE 1 results		
CO (g/km)	0,39	0,6
CO2 (g/km)	170,02	171,46
HC (g/km)	0,07	0,13
Nox (g/km)	0,02	0,01
I/M results		
I/M CO low idle Vol. %	0,01	0,2
I/M CO high idle Vol. %	0,05	0,13
I/M lambda low idle	1	1,001
I/M lambda high idle	0,998	0,993
I/M CO2 low idle Vol. %	15	15
I/M CO2 high idle Vol. %	15	15,2
I/M HC low idle ppm	2	41
I/M HC high idle ppm	8	17

I/M O2 low idle Vol. %	0,01	0,11
I/M O2 high idle Vol. %	0	0
I/M Nox low idle	/	/
I/M Nox high idle	/	/

	CO idle	CO high idle	Lambda	Fault code	MIL
	%	%	%		
Initial	0.01	0.05	0.998	no P code	off
Misfire	0.2	0.13	0.993	P0300	off
Ageing O_2 sensor	0	0	1.04	no P code	off
Cat converter malfunction	0.47	0,72	1.02	no P code	off
Limits	0.5	0.3	0.97 - 1.03		

With the I/M test the failure “Cat converter malfunction“ was clearly detected.
The I/M test with the upstream O_2 sensor malfunction just exceeded the lambda limit.

8.4 Results of the OBD system

The MIL lamp did go on when the ignition was switched on, with the engine off, and after starting the engine, he did go off.

The simple failures, such as disconnection of sensors as specifically required by the directive, were detected by the EOBD system.

8.4.1 Table of sensor and actuator failures

	Fault code	Fuel system status	MIL status Freeze frame	MIL
Upstream O_2 sensor disconnect	P0130	OL, not ready CL	On	off
Upstream O_2 sensor heater disconnect	P0141 P0135	OL, not ready CL	On	off
MAP sensor disconnect	P0105		On	off

Nevertheless the MIL lamp never lighted up.

Setting and resetting the readiness codes*:*

The readiness codes were reset in this vehicle after the ignition was disconnected for more than two minutes or after a « clear fault codes » instruction from the scan tool. It is impossible to establish after a reset how the readiness codes were reset. In practice consequently means that this kind of vehicle which had to switch-off the ignition for more than two minutes immediately prior to a technical inspection, for example when queuing, presents itself with reset fault codes. It is impossible to establish whether fault codes were not reset immediately before the test. Fraud is consequently not excluded.
Stored fault codes and freeze frames remain in memory even after turning off ignition for more than 2 minutes.

The vehicle does not have an EGR, no heated catalytic converter and no secondary air injection. However readiness codes are supported for these components.

It is noticeable in this table that on replacement of the catalytic converter by a faulty catalytic converter the vehicle emissions increase significantly but this fault is not diagnosed by the OBD system.

Misfire was detected by the EOBD system, by the freeze frames, but not by the MIL lamp.

The upstream O_2 malfunction isn't detected by the EOBD system. The T1 and I/M test for these failure are around the limit values.

In general it may be stated that the faults which result in a significant increase in emissions, could be found by means of the 4-gas method. The added value of the OBD system consists of giving an indication of where the fault is located.

8.4.2 OBD Values and available data compared to 98/69/EU

8.4.2.1 Readiness CODE:

	available at the vehicle 8
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	YES
ARG system	NO
Air condition	YES
misfiring	YES
fuel system	YES
Components	YES

8.4.2.2 Freeze - Frame:

If trouble codes happen, the ECU should save the following data:

	available at the vehicle
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	Available at the vehicle 8
Fuel trim	NO
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

The ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 8**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	NO
Intake air temperature	NO
Ignition timing advance	NO
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	NO
Throttle position	□□
Status secondary air injection	NO
Calculated load	NO
Vehicle speed	NO
Fuel pressure	NO

8.5 Measuring Protocol

Vehicle N°	**8**
Partner	**GOCA**
Inertia	1130 kg
Power absorbed at 80 km/h	6,29 kW
Air temperature	296 °K
Atmospheric pressure	100,7 kPa
Humidity	47,2 %

9. VEHICLE 9

9.1 Vehicle Data

Vehicle N°	**9**
Partner	**GOCA**
Verification of the Approval 98/69	YES
Engine type	4
Engine capacity	1948 cm3
Communication protocol	ISO 9141
EGR	NO
Air injection	YES
Transmission	Automatic 5
motorised throttle	NO
Manifold pressure sensor	YES
pre-catalyst	NO
main catalyst	YES
mileage	15947 km

9.2 Failure description

This vehicle has been tested with the following failures:

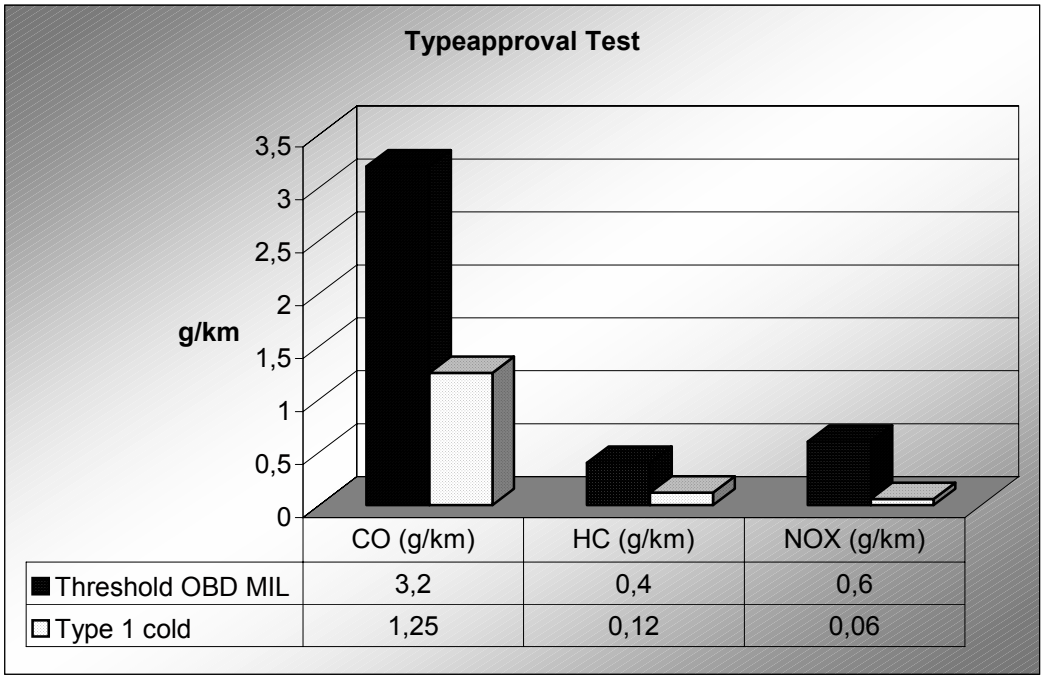
- Upstream O_2 sensor disconnect
- Upstream O_2 sensor heater disconnect
- Upstream O_2 sensor malfunction : (+0,3V offset and 30% attenuation; 3K3 resistor) O_2 sensor aging creates:
  - a positive offset on the sensor output voltage
  - attenuation of the signal
  - slower response(+0,3V offset and 30% attenuation; 3K3 resistor)

  Electro-thermal or electro-chemical alterations in the sensor and connecting hardware can create negative offset voltages and attenuation. In this test constant voltages were added to or substracted from the sensor output voltage signal and the signal was attenuated (+0,3V offset and 30% attenuation; 3K3 resistor). The λ control operates normally but the voltage of the downstream sensor was slightly lower than under normal conditions)
- Misfire: misfires were generated by building in sparkplugs in one cylinder with slight air gap of 0,2 mm .
- Catalytic converter malfunction
  The cat was replaced by a canister containing flow obstructions and acting as a filter to the exhaust flow and composition variations.
- Coolant temperature malfunction: the coolant temperature NTC resistor was replaced by a 2K2 ohm resistor simulating a constant coolant temperature of 23°C. As this is the only coolant temperature sensor, one radiator fan was connected directly to the battery and a thermocouple was installed to keep the engine from overheating.
- Coolant temperature sensor disconnect: the coolant temperature was disconnected.

During the tests, the vehicle driveability was always correct.

9.3 Test results

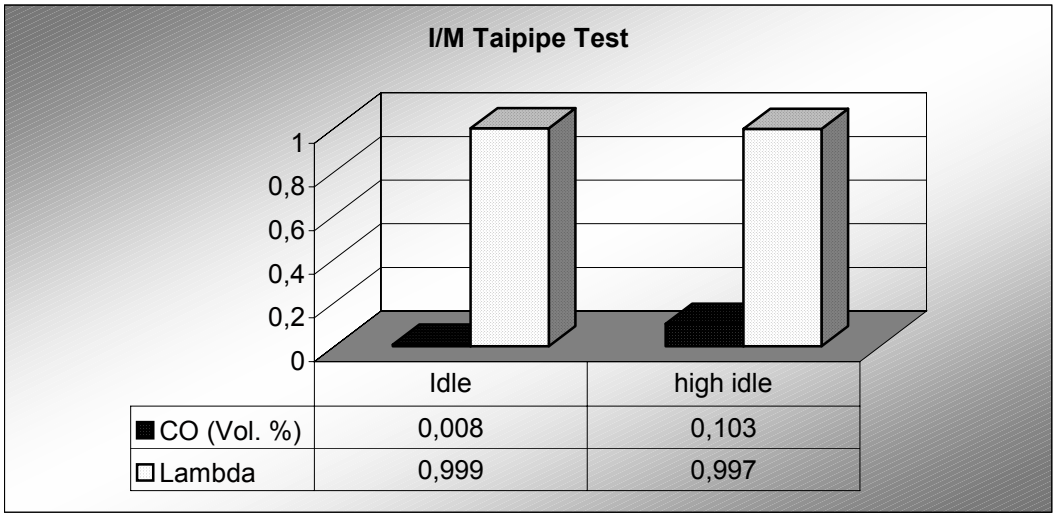
9.3.1 Results of the TYPE 1 tests



		CO	HC	NOx	CO2	Fault code	MIL
		g/km	g/km	g/km	g/km		
Initial	EUDC	0.05	0.0	0.02	162.38	no P code	off
Initial	Cold	1.25	0.12	0.06	228.75	no P code	off
Ageing O_2 sensor	EUDC	0.01	0.0	0.03	157.24	no P code	off
Misfire	EUDC	0.09	0.0	0.02	161.67	P0304	on
Misfire	Cold	1.7	0.13	0.07	230.79	P0304	on
Cat converter malfunction	EUDC	4.49	0.51	2.95	156.49	P0420	on
Coolant temp sensor malfunction	EUDC	9.69	0.27	0.0	172.71	no P code	off
Limits		3.20	0.40	0.60	-		

With the EUDC/T1 test the failures “Cat converter malfunction“ and „Coolant temperature sensor malfunction“ are clearly detected.

9.3.2 Results of the I/M tests



9.3.3 Table of test results

Test Results EUDC TYPE 1 and I/M		
kind of modification	***without failure as reference***	***Misfire: spark plug gap 0,2 mm***
	MIL OFF	MIL ON (READ OFF)
mileage	16999	16977
EUDC results		
CO (g/km)	0,05	0,09
CO2 (g/km)	162,38	161,67
HC (g/km)	0	0
Nox (g/km)	0,02	0,02
Type 1 results		
CO (g/km)	1,25	1,7
CO2 (g/km)	228,75	230,79
HC (g/km)	0,12	0,13
Nox (g/km)	0,06	0,07
I/M results		
I/M CO low idle Vol. %	0,01	0,29
I/M CO high idle Vol. %	0,01	0,02
I/M lambda low idle	1,003	1,06
I/M lambda high idle	1	0,998
I/M CO2 low idle Vol. %	15,3	14
I/M CO2 high idle Vol. %	15,3	15,4
I/M HC low idle ppm	1	200
I/M HC high idle ppm	4	24
I/M O2 low idle Vol. %	0,08	1,8-2
I/M O2 high idle Vol. %	0,01	0
I/M Nox low idle	/	/
I/M Nox high idle	/	/

	CO idle	CO high idle	Lambda	Fault code	MIL
	%	%	%		
Initial	0.01	0.01	1	no P code	off
Ageing O_2 sensor	0.03	0.0	0.999	no P code	off
Misfire	0.29	0.02	0.998	P0304	on
Cat converter malfunction	0.64	0.6	0.999	P0420	on
Coolant temp sensor malfunction	0.2	0,28	0.992	no P code	off
Limits	0.5	0.3	0.97 - 1.03		

With the I/M test the failure “Cat converter malfunction“ was clearly detected.
The I/M test with the failure “Coolant temperature sensor malfunction detect a much higher CO values, but they do not pas the limits of the 96/96/CE.

9.4 Results reading out the OBD system

The MIL lamp did go on when the ignition was switched on, with the engine off, and after starting the engine, he did go off.

The simple failures, such as disconnection of sensors as specifically required by the directive, were detected by the EOBD system;

9.4.1 Table of sensor and actuator failures

	Fault code	Fuel system status	MIL status Freeze frame	MIL
Upstream O_2 sensor disconnect	P0030	OL, not ready CL	Off	On
Upstream O_2 sensor heater disconnect	P0130	OL, not ready CL	Off	On
Coolant temperature sensor disconnect	P0118	OL, not ready CL	Off	On

For the fault of the upstream O2 sensor disconnected the fault code P0030 (instead of P0130?) and for the upstream O2 sensor heater disconnected the fault code P0130 (instead of P0135?) ware set.

In general when a P code is set, the MIL went on but the freeze frame status mentioned MIL status off.

Setting and resetting the readiness codes
This vehicle only supports one readiness code. In addition it was always set when taking a reading. This makes the readiness codes entirely unusable, as with the vehicle 8, fraud is not excluded during technical inspection.

The OBD system performs as expected in the area of fault detection. The added value of the OBD system is also rather limited here.

The faults are stored in two stages. Firstly the fault is considered a temporary (fault code with a + suffix), then they are confirmed if they persist in a second test. This works correctly but the parameter « Fault codes stored amount » does not correctly represent the number of different faults. All, and only, confirmed faults should be counted.

By the replacement of the catalytic converter by a faulty catalytic converter the vehicle emissions increase significantly and this fault is diagnosed by the OBD system and detected by the T1 and I/M test.

Misfire was detected by the EOBD system. There are higher CO emissions on the T1 and I/M test, but they do not passes the present used limits

The upstream O_2 malfunction isn't detected by the EOBD system, the T1 and I/M test.

The coolant temperature sensor malfunction will be detected by the T1 test. The MIL didn't went on, but the fuel system status was in an open loop "OL, not ready CL". For the I/M test there are higher values, but they do not pass the 96/96CE limit.

9.4.2 OBD values and available data compared to 98/69/EU

9.4.2.1 Readiness CODE:

	available at the vehicle 9
Catalyst	YES
Catalyst heater	YES
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	YES
Evaporation system	YES
ARG system	NO
Air condition	YES
misfiring	YES
fuel system	YES
Components	YES

9.4.2.2 Freeze - Frame:

If trouble codes happen, the ECU should save the following data:

	available at the vehicle 9
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 9
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

The ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 9**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	NO
Ignition timing advance	NO
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	ÝES
Throttle position	NO
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

9.5 Measuring Protocol

Vehicle N°	**9**
Partner	**GOCA**
Inertia	1470 kg
Power absorbed at 80 km/h	4,29 kW
Air temperature	295,6 °K
Atmospheric pressure	101,4 kPa
Humidity	53,4 %

10. VEHICLE 10

10.1 Vehicle Data

Vehicle N°	**10**
Partner	**GOCA**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	1997 cm3
Communication protocol	ISO 9141
EGR	NO
Air injection	YES
Transmission	Manual 5
motorised throttle	NO
Manifold pressure sensor	YES
pre-catalyst	YES
main catalyst	YES
Mileage	2270 km

10.2 Failure description

This vehicle has been tested with the following failures:

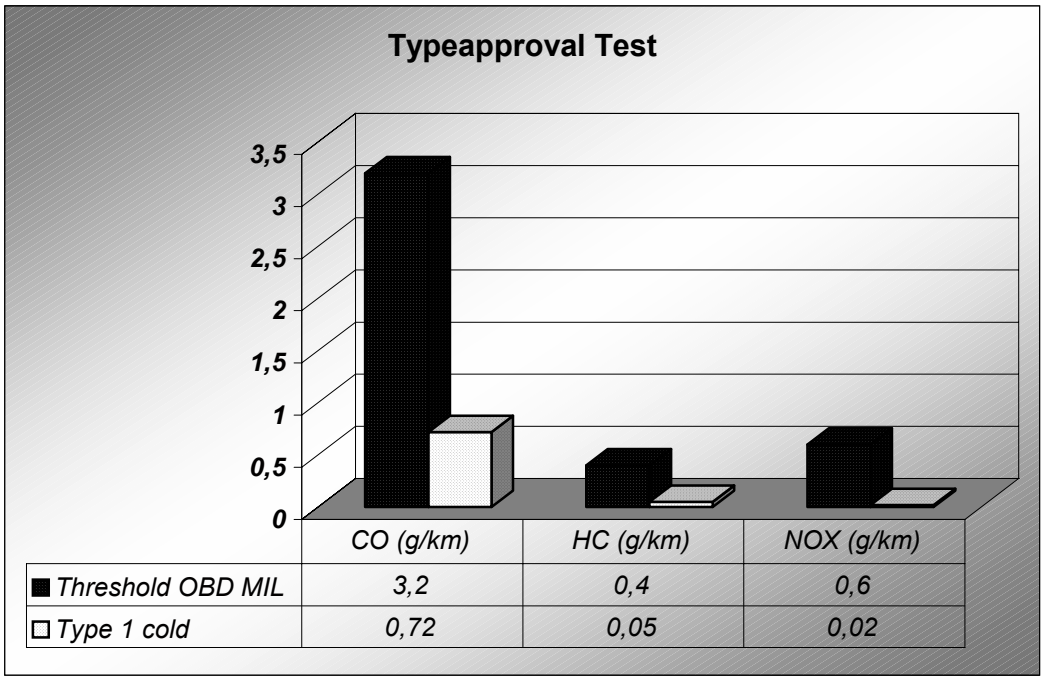
- Upstream O_2 sensor disconnect
- Upstream O_2 sensor heater disconnect
- Upstream O_2 sensor malfunction (+0,4V offset and 25% attenuation; resistor divider 820 ohm and 2200 ohm – The λ control operates normally but the voltage of the downstream sensor was slightly lower than under normal conditions)
- Upstream O_2 sensor malfunction : (+0,4V offset and 25% attenuation; resistor divider 820 ohm and 2200 ohm) O_2 sensor aging creates:
  - a positive offset on the sensor output voltage
  - attenuation of the signal
  - slower response

  Electro-thermal or electro-chemical alterations in the sensor and connecting hardware can create negative offset voltages and attenuation. In this test constant voltages were added to or substracted from the sensor output voltage signal and the signal was attenuated (+0,4V offset and 25% attenuation). The λ control operates normally but the voltage of the downstream sensor was slightly lower than under normal conditions)
- Misfire: misfires were generated by building in sparkplugs in one cylinder with slight air gap of 0,2 mm.
- Catalytic converter malfunction
  The cat was replaced by a canister containing flow obstructions and acting as a filter to the exhaust flow and composition variations.
- Coolant temperature malfunction: the coolant temperature NTC resistor was replaced by a 2K2 ohm resistor simulating a constant coolant temperature.
- Coolant temperature sensor disconnect: the coolant temperature sensor was disconnected.

During the tests, the vehicle driveability was always correct.

10.3 Test Results

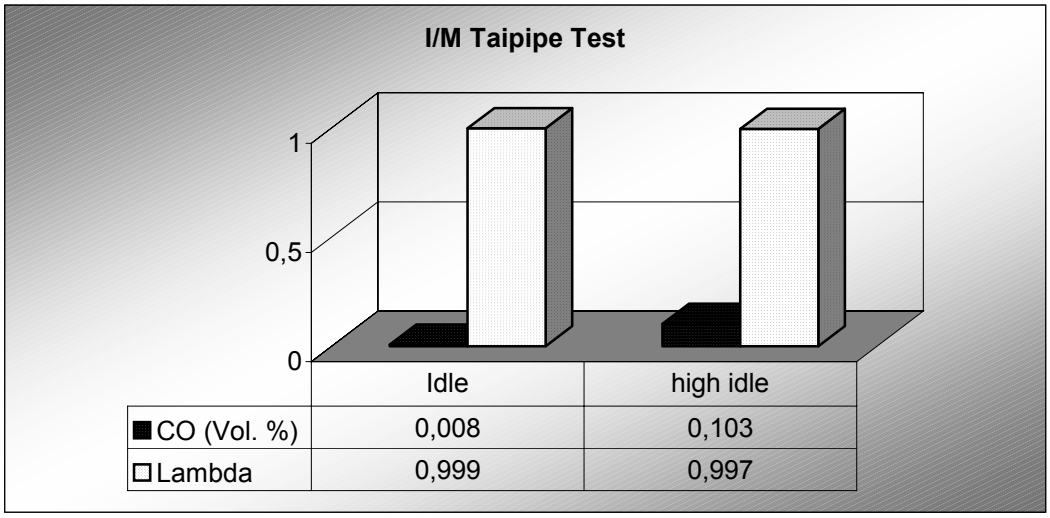
10.3.1 Results of the TYPE 1 tests



		CO	HC	NOx	CO2	Fault code	MIL
		g/km	g/km	g/km	g/km		
Initial	EUDC	0.07	0.0	0.01	185.42	no P code	off
Initial	Cold	0.72	0.05	0.02	234.11	no P code	off
Ageing O_2 sensor	EUDC	0.0	0.0	0.4	181.14	P0133	on
Misfire	EUDC	0.08	0.0	0.01	186.46	no P code	off
Misfire	Cold	0.75	0.11	0.02	237.76	no P code	off
Cat converter malfunction	EUDC	0.25	0.03	0.01	181.74	P0421	on
Coolant temp sensor malfunction	EUDC	0.07	0.0	0.01	182.66	no P code	off
Limits		3.20	0.40	0.60	-		

The failures give in some cases an increase of the measured values. Especially misfire and ageing upstream O2 sensor gives some increase, but they stay far from the EOBD limits.

10.3.2 Results of the I/M tests



10.3.3 Table of test results

Test Results EUDC TYPE 1 and I/M		
kind of modification	***without failure as reference***	***Misfire: spark plug gap 0,2 mm***
MIL	NOT ON	NOT ON
mileage	3128	3128
EUDC results		
CO (g/km)	0,07	0,08
CO2 (g/km)	185,47	186,46
HC (g/km)	0	0
Nox (g/km)	0,01	0,01
Type 1 results		
CO (g/km)	0,72	0,75
CO2 (g/km)	234,11	237,76
HC (g/km)	0,05	0,11
Nox (g/km)	0,02	0,02
I/M results		
I/M CO low idle Vol. %	0	0,05
I/M CO high idle Vol. %	0	0,02
I/M lambda low idle	1	1,027
I/M lambda high idle	0,999	0,999
I/M CO2 low idle Vol. %	15,5	15,1
I/M CO2 high idle Vol. %	15,5	15,4
I/M HC low idle ppm	1	0
I/M HC high idle ppm	1	1
I/M O2 low idle Vol. %	0,01	0,57
I/M O2 high idle Vol. %	0	0
I/M Nox low idle	/	/
I/M Nox high idle	/	/

	CO idle	CO high idle	Lambda	Fault code	MIL
	%	%	%		
Initial	0.0	0.0	0.999	no P code	off
Ageing O_2 sensor	0.0	0.0	0.999	P0133	on
Misfire	0.05	0.02	0.999	no P code	off
Cat converter malfunction	0.0	0.0	0.999	P0421	on
Coolant temp sensor malfunction	0.0	0.01	0.999	no P code	off
Limits	0.5	0.3	0.97 – 1.03		

With the I/M test no failures could be detected.

10.4 Results reading out the OBD system

The MIL lamp did go on when the ignition was switched on, with the engine off, and after starting the engine, he did go off.

The simple failures, such as disconnection of sensors as specifically required by the directive, were detected by the EOBD system;

10.4.1 Table of sensor and actuator failures

	Fault code	Fuel system status	MIL status Freeze frame	MIL
Upstream O_2 sensor disconnect	P0135	OL, Drive condition	On	On
Upstream O_2 sensor heater disconnect	P0135	OL, not ready CL	On	On
Coolant temperature sensor disconnect	P0115	OL, Drive condition	On	On

For the fault of the upstream O2 sensor disconnected the fault code P0135 (instead of P0130 ?) was set.

10.4.2 OBD values and available data compared to 98/69/EU

10.4.2.1 Readiness codes

	available at the vehicle 10
Catalyst	YES
Catalyst heater	YES
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	YES
Evaporation system	YES
ARG system	YES
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

The OBD system in this vehicle supports all readiness codes of the components present, except for the air-conditioning. The readiness codes are reset by the scan tool, which also resets any fault codes, and set while driving. In this way it is possible to be certain at the inspection that, if the readiness codes are set and no fault code is present, the OBD system considers the vehicle to be in order.

The faults were stored in two stages. Firstly the fault was considered temporary (mode 7, fault code with a + suffix), then it is confirmed if it persists during a second test (mode 3). This worked correctly but the parameter « Fault codes stored amount » does not indicate the correct number of different faults. All, and only, confirmed faults should be counted.

The vehicle tested is equipped with two new catalytic converters. This explains why considerably increased emissions were not established on failure of the first catalytic converter. The OBD system did diagnose the Upstream O2 sensor ageing and the cat replacement by a canister.

10.4.2.2 Freeze frame

If trouble codes happen, the ECU should save the following data:

	available at the vehicle 10
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 10
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

The ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 10**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	NO
Ignition timing advance	NO
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	NO
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

10.5 Measuring Protocol

Vehicle N°	**10**
Partner	**GOCA**
Inertia	1590 kg
Power absorbed at 80 km/h	7,49 kW
Air temperature	298,6 °K
Atmospheric pressure	101,1 kPa
Humidity	56,4 %

11. VEHICLE 11

11.1 Vehicle data

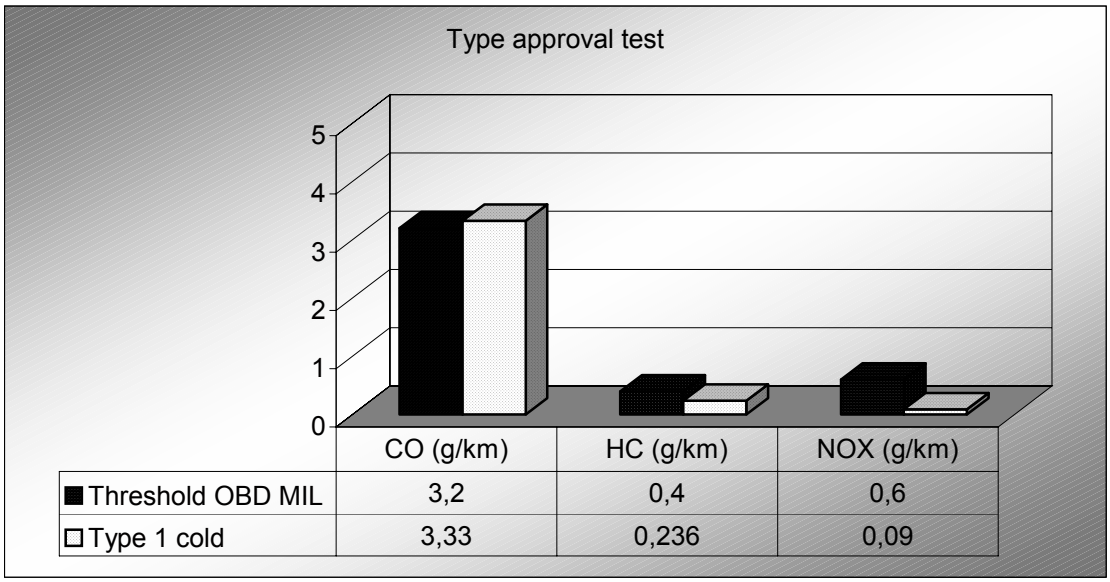
Vehicle N°	**11**
Partner	**VI**
Verification of the Approval 98/69	Yes
Engine type	V6
Engine capacity	2500
Communication protocol	ISO 9141
EGR	No
Air injection	No
Transmission (manual/automatic)	Automatic
Motorised throttle	No
manifold pressure sensor (yes/no)	Yes
pre-catalyst (yes/no)	Yes
main catalyst (yes/no)	Yes
EGR valve	No
Secondary air injection valve	No
mileage (km)	22296 miles

11.2 Failure description

Sensor	Simulate failure by	Effect of failure
1. Coolant Temperature Sensor	Putting 1.5KΩ resistor into sensor wiring	ECU receives a temperature value 60°C too low. Over fuels vehicle.
2. Inlet air Temperature Sensor	Putting 3.88KΩ resistor into sensor wiring	ECU receives a temperature value 55°C too low. Incorrect fuelling.
3. Barometric pressure/ Manifold Absolute Pressure Sensor	Disconnect one barometric pressure sensor wire.	ECU receives no pressure Information and reverts to default values. P 0107 fault code (low input) (but MIL not on)
4. Pre catalyst Oxygen sensor heater circuit	Putting 11.2Ω resistor into heater wiring	Reduces heating of oxygen sensor Affects time to closed loop control of fuelling.

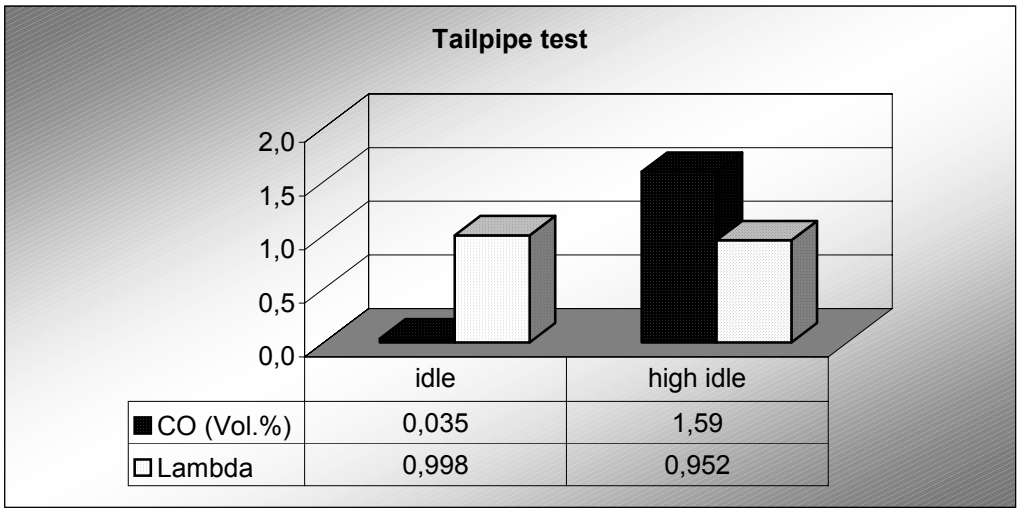
11.3 Test results

11.3.1 Results of the type 1 test



The CO result exceeds EOBD and Euro III limits. The HC result exceeds the Euro III limits.

11.3.2 Results of the tailpipe test



The vehicle fail the I/M test. CO at high idle exceeds the limit value.

11.3.3 Table of the test results

Test results EUDC TYPE 1 and I/M		
kind of modification	***without failure as reference***	***Coolant temperature sensor***
mileage	22296 miles	22528 miles
EUDC results		
CO (g/km)	0.236	1.659
CO2 (g/km)	215.9	227.4
HC (g/km)	0.010	0.017
Nox (g/km)	0.048	0.028
Type results		
CO (g/km)	0.608	3.330
CO2 (g/km)	282.6	340.9
HC (g/km)	0.081	0.236
Nox (g/km)	0.114	0.090
I/M results		
I/M CO low idle %	0,002	0,035
I/M CO high idle %	0,002	1,590
I/M lambda low idle	1,000	0,998
I/M lambda high idle	1,000	0,952
I/M CO2 low idle %	15,2%	15,2
I/M CO2 high idle %	15,2	14,5
I/M HC low idle ppm	14	36
I/M HC high idle ppm	6	168
I/M O2 low idle %	0,05	0,00
I/M O2 high idle %	0,00	0,00
I/M Nox low idle	not measured	not measured
I/M Nox high idle	not measured	not measured

11.4 Results reading out OBD system

11.4.1 Table of sensor and actuator failures

Sensors	kind of simulation	MIL Status / P0 CODE	exhaust emission relevant effects
1. Coolant temperature	1.5KΩ resistor in line with sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
2. Inlet air temperature	3.88KΩ resistor in line with sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
3.Combined barometric pressure/Manifold Absolute Pressure	Disconnect one barometric pressure sensor wire	MIL Off No registered fault codes	Increased regulated emissions
Pre-catalyst oxygen sensor heater circuit	11.2Ω resistor in line with sensor wiring	MIL Off No registered fault codes	Increased regulated emissions

11.4.2 OBD values and available data compared to 98/69/EC

11.4.2.1 Readiness CODE:

	available at the vehicle 11
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

11.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle 11
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 11
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 11**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

11.5 Measuring protocol

Vehicle N°	**11**
Partner	**VI**
Inertia	**1700**
Power absorbed at 80 km/h	**7.804kW**
Air temperature	**23 C**
Atmospheric pressure	**750.75 mm Hg**
Humidity	**29%**

12. VEHICLE 12

12.1 Vehicle data

Vehicle N°	**12**
Partner	**VI**
Verification of the Approval 98/69	yes
Engine type	4 cylinder
Engine capacity	1,6
Communication protocol	J1850 PWM
EGR (yes/no)	no
Air injection(yes no)	no
Transmission (manual/automatic)	Manual
Egr valve (yes/no)	no
Motorised throttle	no
manifold pressure sensor (yes/no)	yes
pre-catalyst (yes/no)	no
main catalyst (yes/no)	yes
secondary air injection valve (yes/no)	no
mileage	2520 miles

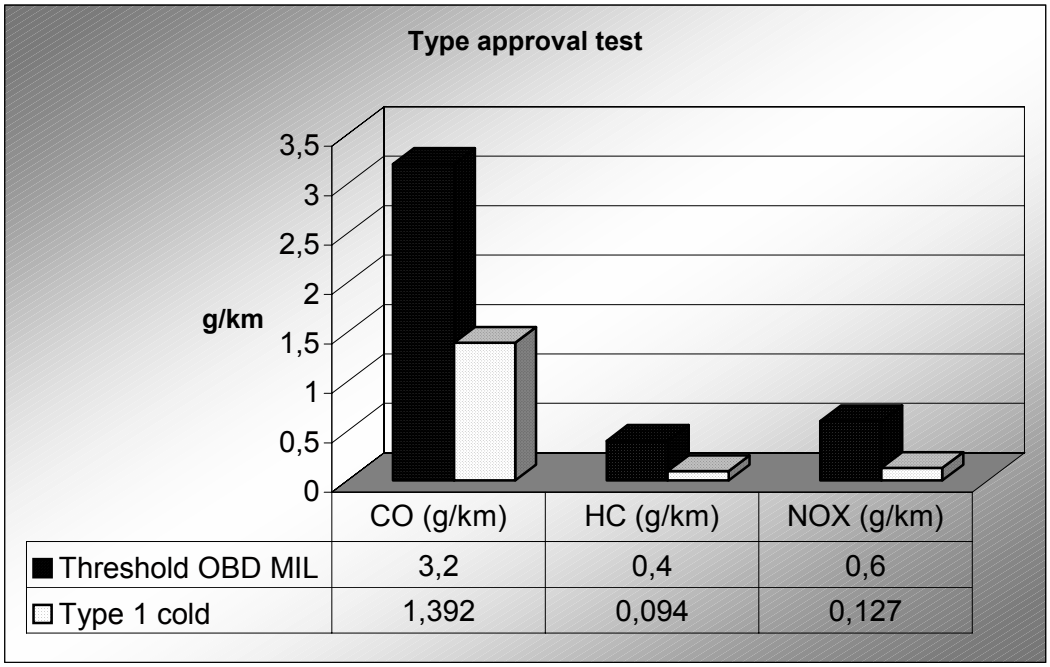
12.2 Failure description

Sensor	Simulate failure by	Effect of failure
1. Cylinder Head Temperature Sensor	Putting 14.8KΩ resistor into sensor wiring	ECU receives a temperature value 60°C too low. Over fuels vehicle.
2. Manifold Absolute Pressure Sensor	Putting 14.8KΩ resistor into sensor wiring	Increases Idle MAP value by 7kPa (28kPa to 35 kPa) Effects Fuelling and ignition timing.
3.Inlet air Temperature Sensor	Putting 3.88KΩ resistor into sensor wiring	ECU receives a temperature value 50°C too low. Incorrect fuelling.
4. Throttle Position Sensor	Putting 1.195Ω resistor into heater wiring	TPS value increased by 20% at idle. Retards ignition timing 23 degrees at idle.

12.3 Test Results

12.3.1 Results of the type 1 test

12.3.2 Test with a modified Manifold Absolute Pressure Sensor

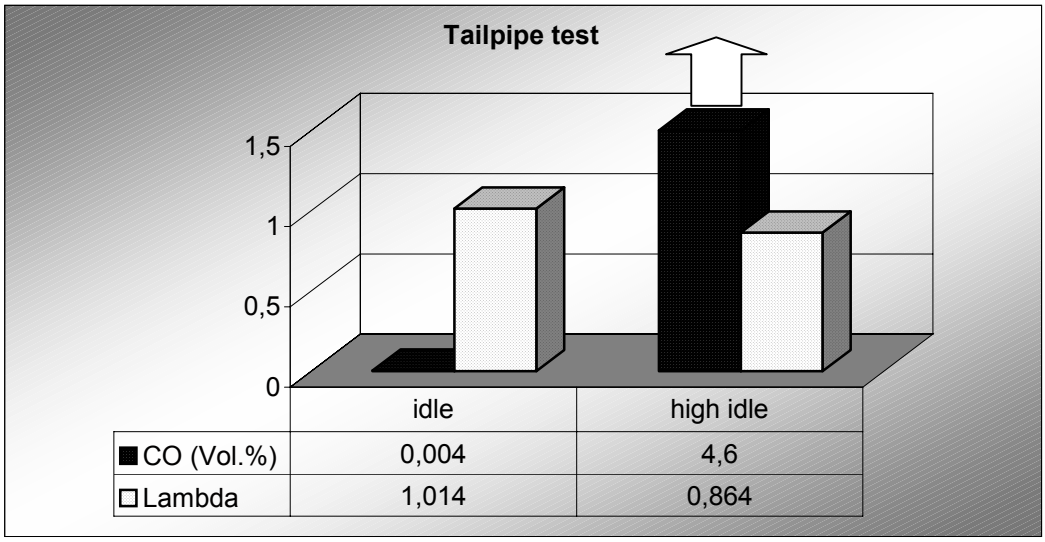


	CO (g/km)	HC (g/km)	NOX (g/km)
Threshold OBD MIL	3,2	0,4	0,6
Type 1 cold	1,392	0,094	0,127

Increased emissions but within Euro III limits.

12.3.3 Results of the I/M test

12.3.3.1 Manifold Absolute Pressure Sensor



	idle	high idle
CO (Vol.%)	0,004	4,6
Lambda	1,014	0,864

Fails I/M test. CO at high idle exceeds limit value. Lambda at high idle remain under the limit.

12.3.4 Table of the test results

Test results EUDC TYPE 1 and I/M		
kind of modification	***without failure as reference***	***MAP sensor***
mileage	2520 miles	2678 miles
EUDC results		
CO	0.164 g/km	0.563 g/km
CO2	157.2 g/km	146.0 g/km
HC	0.016 g/km	0.012 g/m
Nox	0.02 g/km	0.111 g/km
Type results		
CO	0.384 g/km	1.392 g/km
CO2	187.5 g/km	174.9 g/km
HC	0.059 g/km	0.094 g/km
Nox	0.058 g/km	0.127 g/km
I/M results		
I/M CO low idle	0,027%	0,004%
I/M CO high idle	0,007%	4,600%
I/M lambda low idle	1,000	1,014
I/M lambda high idle	1,000	0,864
I/M CO2 low idle	14,9%	15,0%
I/M CO2 high idle	15,1%	12,5%
I/M HC low idle	16 ppm	68 ppm
I/M HC high idle	0 ppm	174 ppm
I/M O2 low idle	0,08%	0,25%
I/M O2 high idle	0,00%	0,00%
I/M Nox low idle	not measured	not measured
I/M Nox high idle	not measured	not measured

12.4 Results reading out the OBD system

12.4.1 Table of sensor and actuator failures

Sensors	kind of simulation	MIL Status / P0 CODE	exhaust emission relevant effects
1. Cylinder head temperature sensor	14.8KΩ resistor in line with sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
2. Manifold Absolute pressure sensor	14.8KΩ resistor in line with sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
3. Inlet air temperature sensor	3.88KΩ resistor in line with sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
4. Throttle Position sensor	1.195Ω resistor in line with sensor wiring	MIL Off No fault codes registered	Increased regulated emissions

12.4.2 OBD values and available data compared to 98/69/EU

12.4.2.1 Readiness CODE:

	available at the vehicle 12
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

12.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle 12
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 12
Fuel trim	YES
Fuel pressure	YES
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 12**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	NO
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

12.5 Measuring protocol

Vehicle N°	**12**
Partner	**VI**
Inertia	**1250**
Power absorbed at 80 km/h	**6.647**
Air temperature	**24 C**
Atmospheric pressure	**755.25 mm Hg**
Humidity	**37%**

13. VEHICLE 13

13.1 Vehicle data

Vehicle N°	**13**
Partner	**VI**
Verification of the Approval 98/69 (yes/no)	Yes
Engine type	4 cylinder
Engine capacity	1,2
Communication protocol	KWP 2000 FAST
EGR (yes/no)	Yes
Air injection(yes no)	No
Transmission (manual/automatic)	Manual
EGR valve	Yes
Motorised throttle	Yes
manifold pressure sensor	Yes
pre-catalyst	No
main catalyst	Yes
Mileage	249 miles

13.2 Failure description

Sensor	Simulate failure by	Effect of failure
1. Coolant Temperature Sensor	Putting 3.8KΩ resistor into sensor wiring	Put MIL on during test P0115 Engine coolant temperature circuit malfunction. P0115+TRN Engine temperature circuit malfunction
	Putting 14.8KΩ resistor into sensor wiring	ECU receives a temperature value 60°C too low. Over fuels vehicle.
2. Inlet air temperature sensor	Putting 2.7KΩ resistor into sensor wiring	ECU receives a temperature value 30°C too low. Incorrect fuelling.
3. Air Mass Meter	Putting 180Ω resistor into sensor wiring	Initially halved idle air mass readings, but corrected by ECU learning.
4. Oxygen Sensor Heater circuit	Putting 11.3Ω resistor into heater wiring	Sensor heating reduced to half normal value. Lambda control effected.

Effect of sensor disconnections.

Unplug sensor from wiring loom and monitor effect of induced fault with EOBD reader

Coolant Temperature sensor.
Ignition on . Engine cooling fan runs permanently
Start Engine. MIL on within 5 seconds.
Fault codes P0115 Coolant temperature circuit malfunction
Freeze Frame / Data P0115
Engine cooling fan runs until sensor re-connected to loom.
Reset fault code to put MIL out.

Effect of sensor disconnections.
Unplug sensor from wiring loom and monitor effect of induced fault with EOBD reader

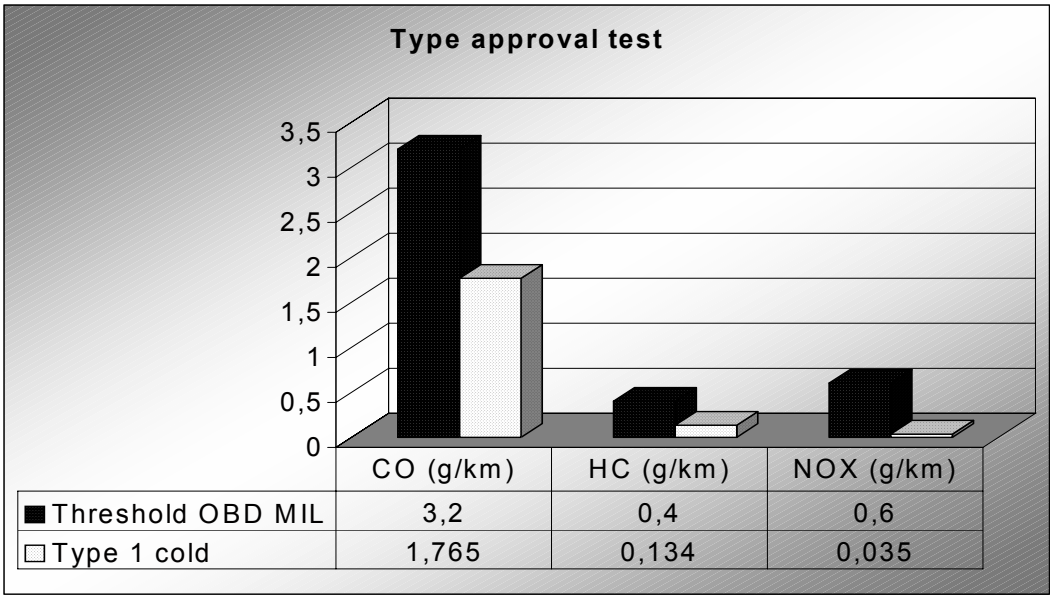
Air Mass Meter.
Puts MIL on at second engine start.
Fault code P0100 Mass or volume air flow circuit malfunction.
Freeze Frame / Data P0100.
Raised idle speed from 725rpm to 920 rpm.
Negative fuel trims.
Records air intake temperature as –40C (from +90 C)
Records mass air flow as 0.0 g/s

Throttle Position Sensor.
(Vehicle has a motorised throttle)
Live readings on EOBD reader TPS 100%
No throttle response, vehicle undrivable.
No fault codes, MIL off.

Purge valve.
MIL illuminates on second engine start.
Fault code P0443 Purge control valve malfunction.

13.3 Test Results

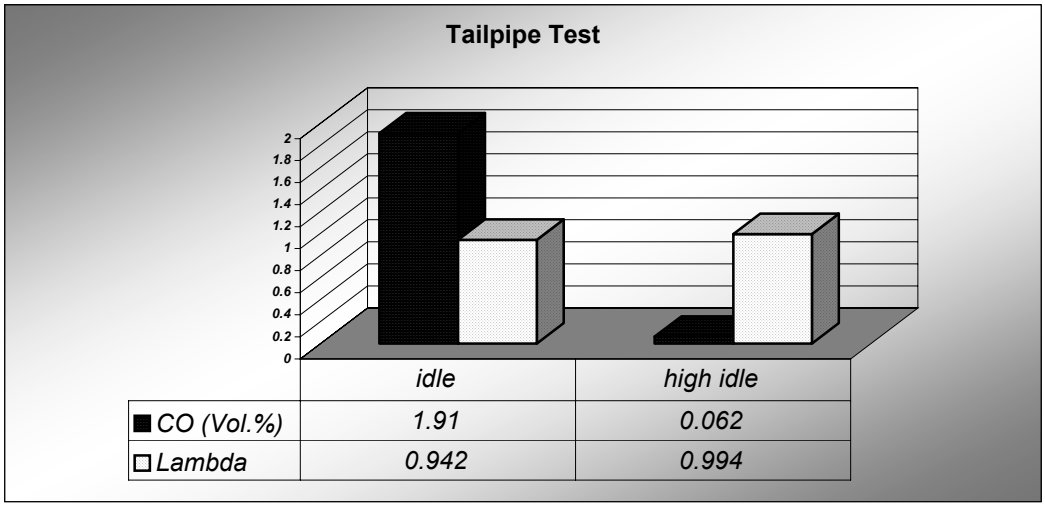
13.3.1 Results of the Type 1 test



	CO (g/km)	HC (g/km)	NOX (g/km)
Threshold OBD MIL	3,2	0,4	0,6
Type 1 cold	1,765	0,134	0,035

CO and HC exceed the EURO IV limits valid to this vehicle.

13.3.2 Results of the I/M test



CO at low idle speed exceeds the limit value. The vehicle fails the I/M test.

13.3.3 Table of the test results

Test results EUDC TYPE 1 and I/M		
kind of modification	***Without failure as reference***	***Coolant Temperature***
mileage	249 miles	415 miles
EUDC results		
CO	0.070 g/km	0.132 g/km
CO2	127.1 g/km	134.5 g/km
HC	0.010 g/km	0.007 g/km
Nox	0.012 g/km	0.043 g/km
Type 1 results		
CO	0.681 g/km	1.765 g/km
CO2	154.9 g/km	164.2 g/km
HC	0.075 g/km	0.134 g/km
Nox	0.011 g/km	0.035 g/km
I/M results		
I/M CO low idle	0,026%	1,910%
I/M CO high idle	0,009%	0,062%
I/M lambda low idle	1,000	0,942
I/M lambda high idle	0,998	0,994
I/M CO2 low idle	15,1%	14,1%
I/M CO2 high idle	15,2%	15,1%
I/M HC low idle	66 ppm	154 ppm
I/M HC high idle	22 ppm	39 ppm
I/M O2 low idle	0,09%	0,06%
I/M O2 high idle	0,00%	0,00%
I/M Nox low idle	Not measured	Not measured
I/M Nox high idle	Not measured	Not measured

13.4 Results reading out the OBD system

13.4.1 Table of sensor and actuator failures

Sensors	kind of simulation	MIL Status / P0 CODE	exhaust emission relevant effects
1.Coolant temperature	3.8KΩ resistor into sensor wiring	Put MIL on during test. P0115 and P0115+TRN	Increased regulated emissions
2. Coolant temperature	14.8KΩ resistor into sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
3. Inlet air temperature	2.7KΩ resistor into sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
4. Air mass meter	180KΩ resistor into sensor wiring	MIL Off No fault codes registered	Increased regulated emissions
5. Oxygen sensor heater	11.3Ω resistor into sensor wiring	MIL Off No fault codes registered	Increased regulated emissions

13.4.2 OBD values and available data compared to 98/69/EU

13.4.2.1 Readiness CODE:

	available at the vehicle 13
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

13.4.2.2 Freeze - Frame:

If trouble codes happen the ECU saved this data:

	available at the vehicle 13
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 13
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	NO
Status fuel system	YES

**98/69/EU 6.5.1.1*

Further the ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 13**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	NO
Air flow rate	YES
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

13.5 Measuring protocol

Vehicle N°	**13**
Partner	**VI**
Inertia	**1020**
Power absorbed at 80 km/h	**6.004**
Air temperature	**26 C**
Atmospheric pressure	**755.60 mm Hg**
Humidity	**52%**

14. VEHICLE 14

14.1 Vehicle Data

Vehicle N°	**14**
Partner	**UTAC**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	1600 cm3
Communication protocol	ISO 9141 2
EGR	NO
Air injection	NO
Transmission	Manual 5
Manifold pressure sensor	YES
motorised throttle	NO
pre-catalyst	NO
main catalyst	YES
mileage	1830 km

14.2 Failure description

This vehicle has been tested with three failures :

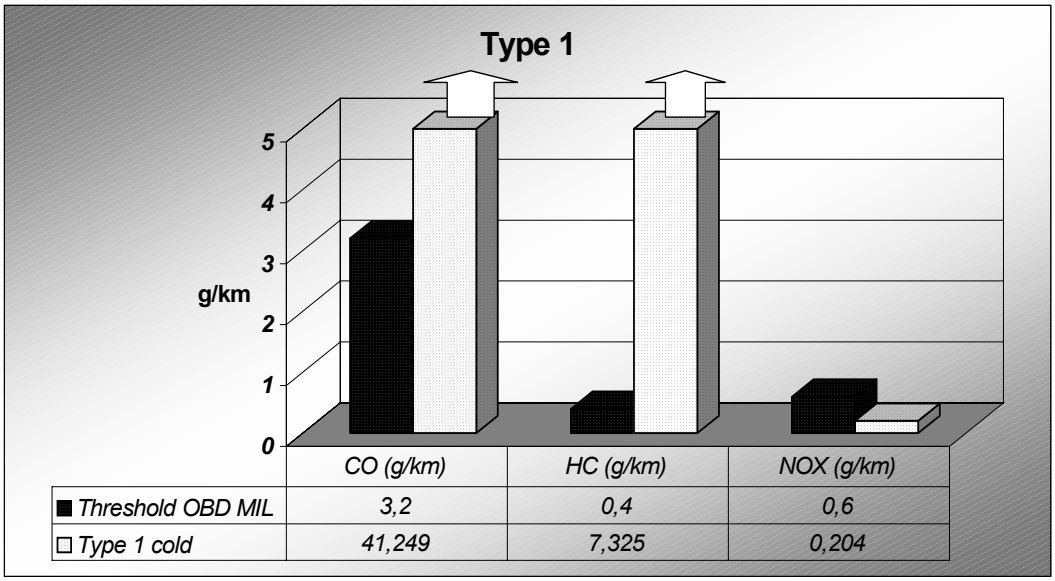
- ageing manifold air pressure (MAP) sensor
- ageing throttle position
- misfire

During the tests, the vehicle driveability was always correct.

Sensor	Simulate failure by	Effect of failure
1. Manifold air pressure	A resistor is added into the signal wiring, the pressure signal goes from 30 to 70 kPa at idle.	The manifold air pressure signal is too high, incorrect fuelling
2. Throttle position	A resistor is added into the signal wiring, the position goes from 12 to 35% at idle.	ECU receives an incorrect throttle position, incorrect fuelling during transient phases.
3. Misfire	One spark plug has a gap at 0,15 mm instead of 1 mm, there is no control on the misfiring level.	Combustion problems

14.3 Test Results

14.3.1 Results of the type 1 test

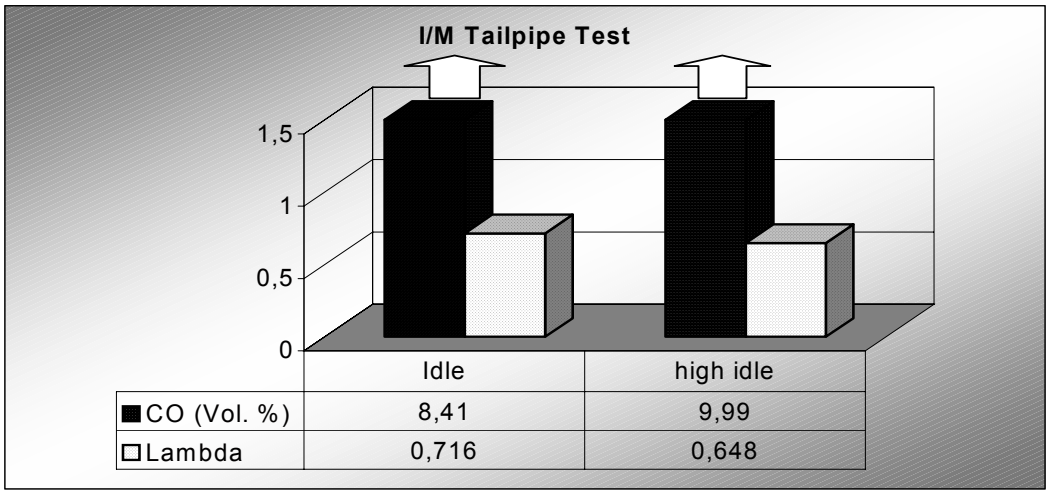


For the final type I test, the failures were MAP sensor and misfire. The throttle position did not show a relevant effect on the previous tests.

		CO	HC	NOYES	CO2	Fault code	MIL
		g/km	g/km	g/km	g/km		
Initial	Froid	0,660	0,116	0,031	158,0		off
Fault 1+3	Froid	41,249	7,325	0,204	156,0	P0105	off
Final	Froid	0,651	0,102	0,039	160		off
Limits		3.20	0.40	0.60	-		

The fault code P0105 indicate a detection of a failure on the MAP sensor, but the MIL was still off.

14.3.2 Results of the I/M test



14.3.3 Table of test results

Test Results EUDC TYPE 1 and I/M		
kind of modification	***without failure as reference***	***Map sensor + misfiring***
mileage	1831 km	1880
EUDC results		
CO	0,030	17,240
CO2	130,2	131,6
HC	0,003	1,815
Nox	0,019	0,265
Type 1 results		
CO	0,660	41,249
CO2	158,0	156,0
HC	0,116	7,325
Nox	0,031	0,204
I/M results		
I/M CO low idle Vol. %	0,00	8,41
I/M CO high idle Vol. %	0,00	9,99
I/M lambda low idle	0,998	0,716
I/M lambda high idle	0,999	0,648
I/M CO2 low idle Vol. %	15,5	9,7
I/M CO2 high idle Vol. %	15,5	6,5
I/M HC low idle ppm	15,0	2550
I/M HC high idle ppm	21,0	1973
I/M O2 low idle Vol. %	0,0	0,0
I/M O2 high idle Vol. %	0,0	0,0
I/M Nox low idle	Not measured	not measured
I/M Nox high idle	not measured	not measured

		CO idle	CO high idle
		%	%
Initial	Cold	0,0	0,0
Fault 1+3	Cold	8,41	> 9,99
Limits		0,3	

With the I/M test the failures were clearly detected.

14.4 Results of reading out the OBD system

14.4.1 Table of sensor and actuator failures

Sensors	kind of simulation	MIL Status / P0 CODE	exhaust emission relevant effects
Manifold air pressure	Disconnecting	Off – P0105	No relevant effects
	Resistor	Off – P0105	Increase of emissions
Throttle position	Resistor	Off – none	No relevant effects

Actuators	kind of simulation	MIL / P0 Code	exhaust emission relevant effects
Spark plug	Gap too small	Off - none	Increase of emissions

14.4.2 OBD values and available data compared to 98/69/EU

14.4.2.1 Readiness CODE:

	available at the vehicles
Catalyst	Yes
Catalyst heater	No
O2 sensor	Yes
O2 sensor heater	NO
Secondary air injection	NO
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	Yes
fuel system	NO
Components	NO

14.4.2.2 Freeze - Frame:

If trouble codes happen, the ECU should save the following data:

	available at the vehicle
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

The ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 14**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

14.5 Measuring protocol

Vehicle N°	**14**
Partner	**UTAC**
Inertia	**1130 kg**
Power absorbed at 80 km/h	**4,3 kW**
Air temperature	**24 °C**
Atmospheric pressure	**750 mm Hg**
Humidity	**44 %**

15. VEHICLE 15

15.1 Vehicle Data

Vehicle N°	**15**
Partner	**UTAC**
Verification of the Approval 98/69	Yes
Engine type	4 cylinder
Engine capacity	1300 cm3
Communication protocol	ISO 14230
EGR	No
Air injection	No
Transmission	Manual 5
Manifold pressure sensor	YES
motorised throttle	No
pre-catalyst	No
main catalyst	YES
mileage	114 km

15.2 Failure description

This vehicle has been tested with three failures :

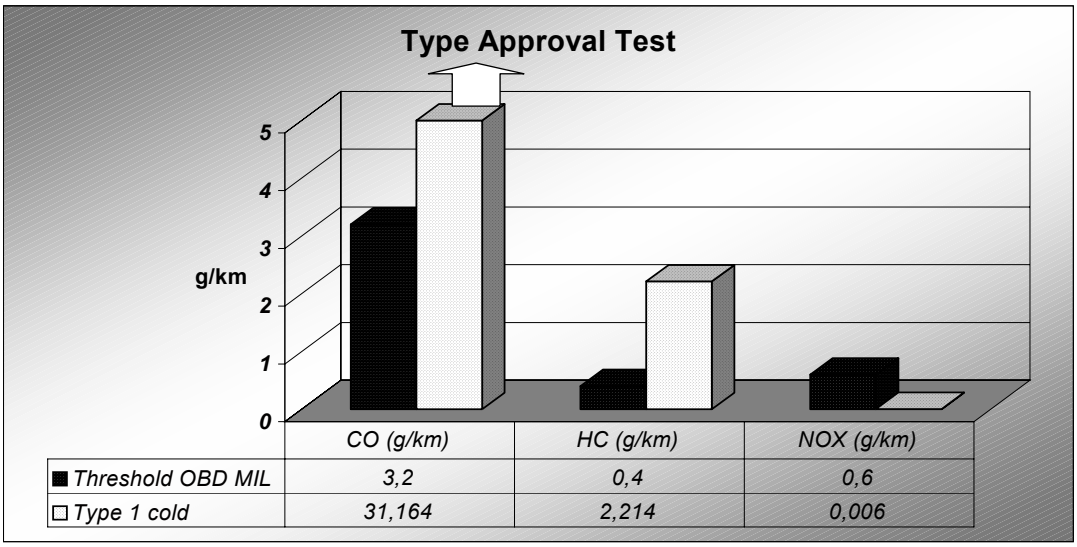
- ageing manifold air pressure (MAP) sensor
- ageing downstream lambda sensor
- misfire

During the tests, the vehicle driveability was always correct.

Sensor	Simulate failure by	Effect of failure
1. Manifold air pressure	A resistor has been added into the signal wiring, the pressure signal goes from 30 to 70 kPa at idle.	The manifold air pressure signal is too high, incorrect fuelling
2. Ageing downstream lamda sensor	A resistor of 1 Mohm has been added into the signal wiring. The voltage goes from 0 to 0,015 volts.	Shift of the signal
3. Misfire	One spark plug has a gap at 0,15 mm instead of 1 mm, there is no control on the misfiring level.	Combustion problems

15.3 Test results

15.3.1 Results of the type 1 test

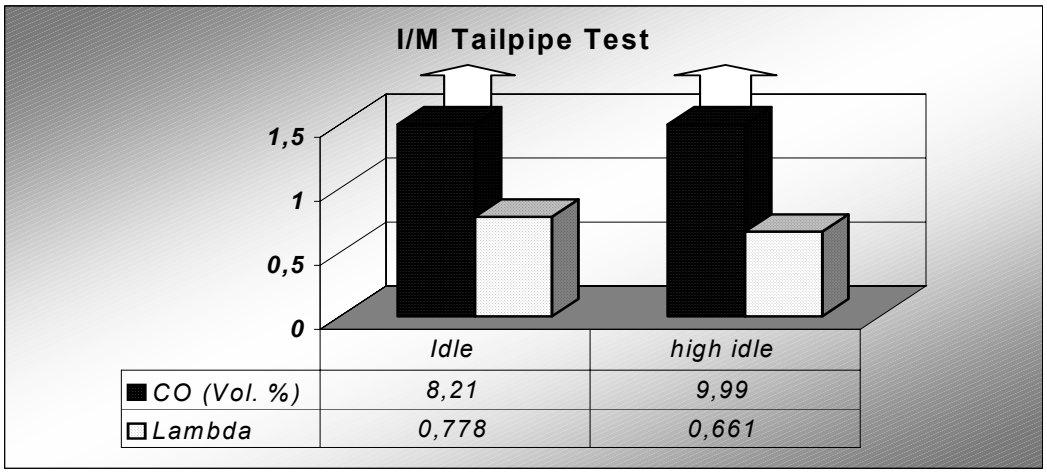


For the final type I test, the failures were MAP sensor and misfire. The throttle position did not show a relevant effect on the previous tests.

		CO	HC	NOx	CO2	Fault code	MIL
		g/km	g/km	g/km	g/km		
Initial	Cold start	0,294	0,055	0,017	147,2		off
Fault 1+3	Cold start	31,164	2,214	0,006	145,3	P0170	off
Final	Cold start	0,468	0,142	0,031	145,6		off
Limits		3.20	0.40	0.60	-		

The fault code P0170 indicate a detection of a failure on the correction of the fuel alimentation. This code appear because due to the failure, the correction of the fuel alimentation is out of the manufacturer limits.

15.3.2 Results of the I/M test



15.3.3 Table of test results

Test Results EUDC TYPE 1 and I/M		
kind of modification	***without failure as reference***	***Map + Lambda sensors***
mileage	114	410
EUDC results		
CO (g/km)	0,098	12,862
CO2 (g/km)	126,9	120,1
HC (g/km)	0,011	0,684
Nox (g/km)	0,004	0,001
Type 1 results		
CO (g/km)	0,294	31,164
CO2 g/km)	147,2	145,3
HC (g/km)	0,055	2,214
Nox (g/km)	0,017	0,006
I/M Results		
I/M CO low idle Vol. %	0,0	8,21
I/M CO high idle Vol. %	0,0	9,99
I/M lambda low idle	1,098	0,778
I/M lambda high idle	1,008	0,661
I/M CO2 low idle Vol. %	14,0	10,7
I/M CO2 high idle Vol. %	15,2	8,0
I/M HC low idle ppm	0,0	659
I/M HC high idle ppm	2	2900
I/M O2 low idle Vol. %	0,0	0,04
I/M O2 high idle Vol. %	0,0	0,0
I/M Nox low idle	Not measured	not measured
I/M Nox high idle	not measured	not measured

		CO idle	CO high idle
		%	%
Initial	Froid	0,0	0,0
Fault 1+3	Froid	8,21	> 9,99
Limits		0,3	

With the I/M test the failures were clearly detected.

15.4 Results reading out the OBD system

15.4.1 Table of sensor and actuator failures

Sensors	kind of simulation	MIL Status / P0 CODE	exhaust emission relevant effects
Manifold air pressure	Resistor	Off – P0170	Increase of emissions
Ageing downstream lamda sensor	Resistor	Off – none	Small increase of emissions

Actuators	kind of simulation	MIL / P0 Code	exhaust emission relevant effects
Spark plug	Gap too small	On – P0301	Increase of emissions

15.4.2 OBD values and available data compared to 98/69/EU

15.4.2.1 Readiness CODE:

	available at the vehicles
Catalyst	YES
Catalyst heater	NO
O2 sensor	YES
O2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
ARG system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

15.4.2.2 Freeze - Frame:

If trouble codes happen, the ECU should save the following data:

	available at the vehicle
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle
Fuel trim	YES
Fuel pressure	NO
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

The ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 15**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	NO
Engine speed	YES
Throttle position	YES
Status secondary air injection	NO
Calculated load	YES
Vehicle speed	YES
Fuel pressure	NO

15.5 Measuring Protocol

Vehicle N°	**15**
Partner	**UTAC**
Inertia	955 kg
Power absorbed at 80 km/h	4,2 kW
Air temperature	23°C
Atmospheric pressure	99,6 kPa
Humidity	39%

The setting of the chassis dynamometer was made from an equivalent vehicle data.

16. VEHICLE 16

16.1 Vehicle Data

Vehicle N°	**16**
Partner	**IBSR/BIVV**
Verification of the Approval 98/69	YES
Engine type	4 cylinder
Engine capacity	1970 cm3
Communication protocol	91/441/CEE
EGR	NO
Air injection	YES
Transmission	Automated 5 speed
Manifold pressure sensor	YES
motorised throttle	YES
pre-catalyst	YES (2)
main catalyst	YES
Secondary air injection valve	NO
Lambda sensors	3
mileage	747 km

16.2 Failure description

This vehicle has been tested with the following failures:

- Misfire (spark plug with 0,1 mm and 0,15mm gaps in cylinder 2)
- Upstream O_2 sensor disconnect
- Upstream O_2 sensor ageing malfunction (+0,4V offset and 25% attenuation)
- Upstream O_2 sensor heater disconnect
- Coolant temperature sensor malfunction
- Catalytic converter malfunction (cat replaced by a canister)

During the tests, the vehicle driveability was always correct.

16.2.1 Upstream O_2 sensor ageing malfunction

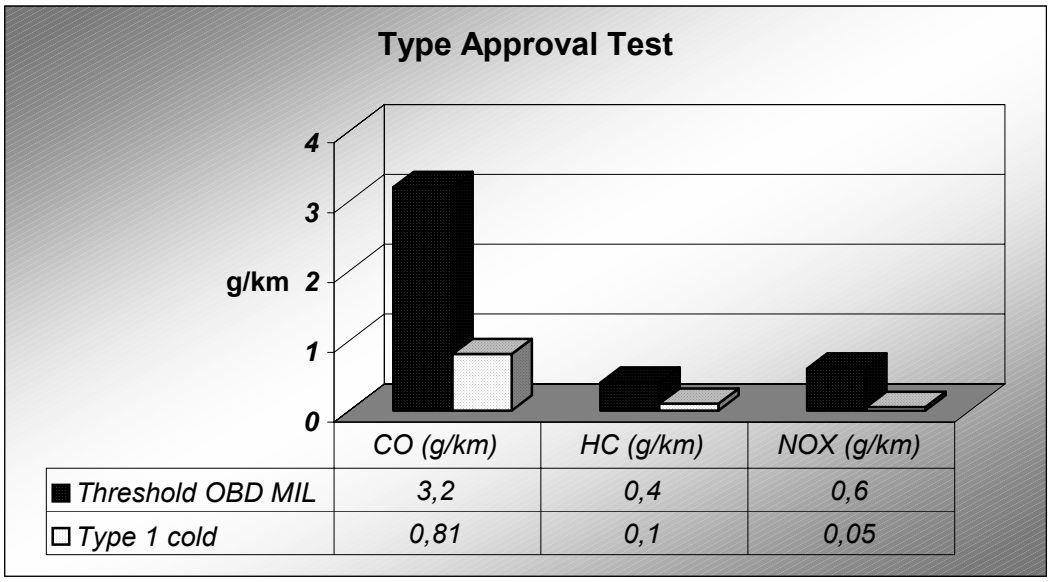
O2 sensor ageing creates

-a positive offset on the sensor output voltage;
-attenuation of the signal;
-slower response

This vehicle is equipped with 2 upstream lambda sensors; 2 fuel controllers and 2 catalysts. Exhaust streams meet after the first catalyst. In this test , the sensor output signal was attenuated by 25 % and shifted upwards by +0,4 V offset. Obviously, with one lambda sensor and fuel controller working normally, the effect of a failure in the other lambda sensor on the emissions is reduced.

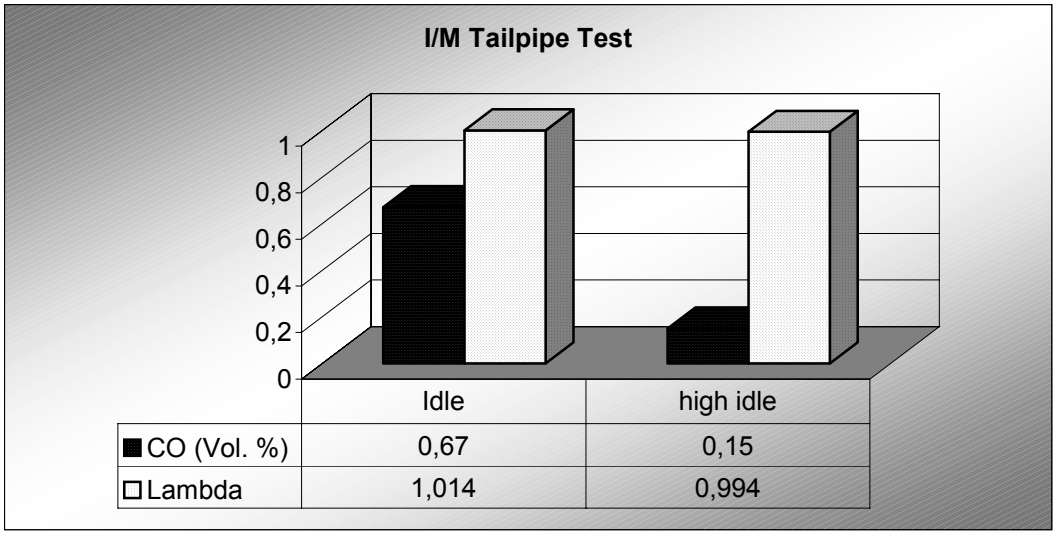
16.3 Test Results

16.3.1 Results of the HOT EUDC and TYPE 1 tests



		CO	HC	NOx	CO2	Fault code	MIL
		g/km	g/km	g/km	g/km		
Initial	Cold UDC+EUDC	0.50	0.09	0.04	249.95	no P code	off
Initial	Hot EUDC	0.36	0.01	0.02	199.50	no P code	off
Misfire	Cold UDC+EUDC	0.81	0.10	0.05	261.68	P0302	on
Misfire	Hot EUDC	0.47	0.03	0.04	208.25	P0302	on
Upstream cats = canister	Hot EUDC	0.44	0.04	0.09	190.05	No P code	off
Ageing O_2 sensor	Hot EUDC	0.02	0.02	1.38	200.96	P0130	on
Cat converter malfunction	Hot EUDC	0.44	0.04	0.09	190.05	no P code	off
Coolant. temper sensor malfunction	Hot EUDC	0.10	0.01	0.01	202.91	P0115	on
Limits		3.20	0.40	0.60	-		

16.3.2 Results of the I/M tests



16.3.3 Table of test results

Test Results EUDC TYPE 1 and I/M		
kind of modification	***without failure as reference***	***spark plug 0,2 mm***
Partner	BIVV/IBSR	
	easy	Rapport ETE/N5069/PEC-114
mileage	2368 km	2319 km
EUDC results		
CO	0,14	0,47
CO2	199,5	208,25
HC	0,01	0,03
Nox	0,02	0,04
Type 1 results		
CO	0,5	0,81
CO2	249,95	261,68
HC	0,09	0,1
Nox	0,04	0,05
I/M results		
I/M CO low idle Vol. %	0	0,67
I/M CO high idle Vol. %	0	0,15
I/M lambda low idle	1	1,014
I/M lambda high idle	0,999	0,994
I/M CO2 low idle Vol. %	15,6	14,7
I/M CO2 high idle Vol. %	15,4	15,4
I/M HC low idle ppm	0	36
I/M HC high idle ppm	1	49
I/M O2 low idle Vol. %	0	0,82
I/M O2 high idle Vol. %	0	0
I/M Nox low idle	Not measured	not measured
I/M Nox high idle	Not measured	not measured

	CO idle	CO high idle	Lambda	Fault code	MIL
	%	%			
Initial	0.01	0.01	0,999	no P code	off
Misfire	0.21	0.12	0,995	P0302	on
Upstream cats= canister	0.00	0.01	0.999	No P code	off
Upstream O2 Sensor disconn.	0.00	0.00	1.018	P0135	on
Ageing O_2 sensor	0.01	0.00	1.011	P0130	on
Upstream O2 sensor heater disc.	0.01	0.04	0.998	P0135	on
Cat converter malfunction	0.00	0.01	0.999	no P code	off
Coolant temper. Sensor malfunction	0.00	0.01	0.999	P0115	on
Limits	0.5	0.3	0.97 - 1.03		

None of the I/M tests were out of tolerance. The OBD system however perceived error codes and put on the MIL.It could be concluded that the OBD diagnostic is effectively complementary to I/M. However I/M measurements are very low related to the limits (except for misfiring)

Defaults on lambda regulation
Obviously with one lambda sensor and fuel controller working normally, the effect of failure in the other lambda sensor on the emissions is reduced. So I/M measurements remain under the limits but readiness codes are set.

16.4 Results reading out OBD system

16.4.1 Table of sensor and actuator failures

	Fault code	Fuel system status	MIL status Freeze frame	MIL
Upstream cats= canister	none	CL Using H0S2	Off	Off
Upstream O_2 sensor disconnect	P0135,should be P0130 ?	OL, not ready OL	On	On
Upstream O_2 sensor heater disconnect	P0135	OL, not ready OL	On	On
Upstream O2 sensor malfunction	P0130	OL fault	On	On
Misfire	P0302	CL Using H0S2	On	On
Coolant temper. Sensor malfunction	P0115	CL Using H0S2	On	On

16.4.2 OBD values and available data compared to 98/96/EU

Upstream O2 sensor malfunction
During 15 km driving in rural area the lambda control does not operate normally. It frequently switches between 4 states : CL, OL driving condition, OL not ready CL and OL fault. Fault code P0130 was stored in 2 steps. First the fault code is stored with a + suffix (temporary fault, mode 7).In the live readings and in the readiness codes menus, 0 fault codes are then reported. Then, if the fault remains during a second or third trip, the fault is confirmed without the + suffix (mode 3)This happens correctly and the parameter " Fault codes stored amount " represents correctly the number of apparent faults .
Once fault is reported, the MIL lights up and a freeze frame is stored. All and only confirmed faults are counted. In some cases, fault codes with a + suffix were automatically cleared while driving, even with persisting fault conditions.

Catalytic convertor malfunction
Both upstream cats were replaced by a canister containing flow obstructions and acting as a filter to the exhaust flow and composition variations. Although the voltage of the downstream lambda sensors increased from an average of 0.44 V to 0.71 V, the OBD system did not recognize the failing catalyst.

Remarks :

-Readiness codes are only cleared by resetting fault codes and set by driving. For this vehicle setting of the readiness codes required unrealistic long driving cycles
-To reset fault codes it is necessary to turn off ignition.;
-Stored fault codes and freeze frames remain in memory even after turning of ignition.;
- In some cases fault codes with a + suffix were automatically cleared while driving even with persisting fault condition.

16.4.2.1 Readiness CODE:

	available at the vehicles 16
Catalyst	YES
Catalyst heater	NO
O_2 sensor	YES
O_2 sensor heater	YES
Secondary air injection	NO
Evaporation system	NO
EGR system	NO
Air condition	NO
misfiring	YES
fuel system	YES
Components	YES

16.4.2.2 Freeze - Frame:

If trouble codes happen, the ECU should save the following data:

	available at the vehicle 16
Calculated load	YES
Engine speed	YES
Coolant temperature	YES
Error which caused the freeze-frame storage	YES

**98/69/EU 6.5.1.1*

Furthermore, the following data should be stored if it is accessible by the ECU:

	available at the vehicle 16
Fuel trim	YES
Fuel pressure	YES
Vehicle speed	YES
Intake manifold pressure	YES
Status fuel system	YES

**98/69/EU 6.5.1.1*

The ECU has also to transmit other data if available, during normal operation of the engine:

Error code (DTC)	**available at the vehicle 16**
Coolant temperature	YES
Status fuel system	YES
Fuel trim	YES
Intake air temperature	YES
Ignition timing advance	YES
Intake manifold pressure	YES
Air flow rate	YES
Engine speed	YES
Throttle position	YES
Status secondary air injection	□□
Calculated load	YES
Vehicle speed	YES
Fuel pressure	YES

16.5 Measuring protocol

Vehicle N°	**16**
Partner	**IBSR/BIVV**
Inertia	1360 kg
Power absorbed at 80 km/h	7,29 kW
Air temperature	294,6°K
Atmospheric pressure	100,9 kPa
Humidity	51,8 %

17. VEHICLE 17

17.1 Vehicle data

Vehicle number	**17**
Partner	**VI**
Verification of the Approval 98/69 (yes/no)	yes
Engine type	4 cylinder turbo
Engine capacity	2000
Communication protocol	ISO9141
EGR (yes/no)	No
Air injection(yes no)	No
Transmission (manual/automatic)	Manual
EGR valve	No
Motorised throttle	Yes
manifold pressure sensor	Yes
pre-catalyst	Yes
main catalyst	Yes
Mileage	8395 miles

17.2 Failure description

Attempts were made to set sensor faults that caused a rise in emissions but did not trigger the MIL or effect the drivability of the car.

Sensors examined

Airflow meter
Combined inlet air temperature/pressure sensor
Mass air flow sensor
Evaporative canister purge valve
Coolant temperature sensor
Turbo boost pressure control valve
Oxygen sensors.

Extension looms were installed between the plug and socket of the following sensors:
- coolant temperature
- combined inlet air temperature
- mass air flow.

Resistor values used to induce faults

Sensor	***Simulate failure by Resistance of***	***Effect***
Coolant temperature sensor.	1.5kohm	reduces coolant temperature by 50° C. raises idle speed from 900 rpm to 1130 rpm
Inlet air temperature	560 ohm	reduces inlet air temperature by 35°C
MAP sensor	47 ohm	alters pressure reading from 39kPa at engine idle to 53kPa

This preparation work was carried out prior to the vehicle being installed on the chassis dynamometer. When resistor values were added to induce sensor faults the engine was only run at idle and the vehicle was not driven.

The vehicle was then installed on the chassis dynamometer. The engine was stopped between conditioning cycles.
When the vehicle was driven with any sensor faults introduced that had enough effect to cause a rise in emissions, the vehicles diagnostic systems detected this and the engine went into limp home mode.

We could not complete the three conditioning runs required by the protocol to set a sensor fault without the MIL illuminating, for any of the induced sensor faults that were tried.

The scan tool registered the following fault codes.

P0101+TRN ECU:11
Mass or volume air flow circuit
range/performance problem

P1260+TRN ECU:11
Fuel and air metering

These fault codes were cleared with the scan tool and another EUDC was driven.

This set a fault code P1260 +TRN ECU:11

The scan tool would clear this fault code, but driving the car on the chassis dynamometer would reset the code and the MIL would illuminate just after the second engine start.

The vehicle was taken, on a trailer, to a main dealer and examined with a factory scan tool.

The diagnosis was that the vehicle was locked into limp home mode and was missing fuelling values from the ECU and using default values.

The vehicle has a throttle cable that normally operates a potentiometer, which provides inputs to the electronic (motorised) throttle.
In the event of the vehicle going into limp home mode, a mechanical linkage is triggered that connects the throttle cable to the throttle. This converts throttle operation from electronic to mechanical control. It will stay in limp home mode with the MIL on until the system is reset by a dealer, allowing the vehicle to be inspected and any emissions control equipment faults to be rectified.

To reset the system to electronic control, the mechanical linkage was reset, and then the fault codes were cleared and the fuelling values reset with the manufacturer's scan tool.

A comparison was made of the emissions from the vehicle in limp home mode (with fault code P1260 set) to those for the normal vehicle, and the results were also compared with the Euro III gasoline (Type Approval) limits and the EOBD limits.

17.3 Test Results

17.3.1 Type 1 Results

Cold Start Type 1 tests on a chassis dynamometer for regulated emissions and fuel consumption with the engine in normal and limp home modes.

Test results EUDC TYPE 1 and I/M		
Engine condition	***normal***	***limp home***
MIL Status	NOT ON	NOT ON
mileage		
EUDC results		
EUDC (l/100km)	7.5	8.86
TYPE 1 results		
CO (g/km)	0.61	0.810
CO2 (g/km)	243	280.1
HC (g/km)	0.05	0.180
Nox (g/km)	0.01	0.032
Consumption (l/100km)	10.2	12.07
I/M results		
I/M CO low idle Vol. %	0.007	0.009
I/M CO high idle Vol. %	0.008	0.005
I/M lambda low idle	0.998	1.000
I/M lambda high idle	1.000	1.000
I/M CO2 low idle Vol. %	15.1	15.2
I/M CO2 high idle Vol. %	15.1	15.2
I/M HC low idle ppm	16	11
I/M HC high idle ppm	8	10
I/M O2 low idle Vol. %	0.00	0.00
I/M O2 high idle Vol. %	0.00	0.00
I/M Nox low idle	-	-
I/M Nox high idle	-	-

Within the high idle measuring the runs 2800 rpm. In limp home mode the vehicle is still within the I/M limits for in-service testing.

As expected the emissions are higher with the engine running in limp home, but they are still within the Euro III limits and the EOBD limits.

17.4 Results reading out the OBD system

17.4.1 OBD values and available data compared to 98/69/EU

17.4.1.1 Readiness Code

	Available at vehicle 17
Catalyst	**YES**
Catalyst heater	**NO**
O2 sensor	**YES**
O2 sensor heater	**YES**
Secondary air injection	**NO**
Evaporation system	**NO**
ARG system	**NO**
Air conditioning	**NO**
Misfiring	**YES**
Fuel system	**YES**
Components	**YES**

17.4.1.2 Freeze Frame

	Available at vehicle 17
Calculated load	**YES**
Engine speed	**YES**
Coolant temperature	**YES**
Error which caused the freeze-frame storage	**YES**

17.4.1.3 Data stored by ECU

	Available at vehicle 17
Fuel trim	**YES**
Fuel pressure	**NO**
Vehicle speed	**YES**
Intake manifold pressure	**YES**
Status fuel system	**NO**

17.5 Measuring Protocol

Vehicle N°	**17**
Partner	**VI**
Inertia	**1470**
Power absorbed at 80 km/h	**7.304**
Air temperature	**24 C**
Atmospheric pressure	**745 mm Hg**
Humidity	**57 %**