Contents

Note:
The Hatz diagnose software, error message list and the workshop is absolutely necessary for diagnose and repair work at the Hatz engine

Specifications

Design type of the engine	Liquid-cooled 4-cylinder four-stroke diesel engine
Injection system	Bosch Off-Highway Common Rail
Charging system	Turbocharger with intercooler
Exhaust system	gAGR, DOC, DPF
Bore x stroke (mm)	84 x 88
Displacement (ccm)	1952
Compression ratio	17,5 : 1
Engine power (KW)	54,9
Idle speed (U/min)	1100
Max. speed (U/min)	2600
Amaunt of oil (l)	7,0

Specifications

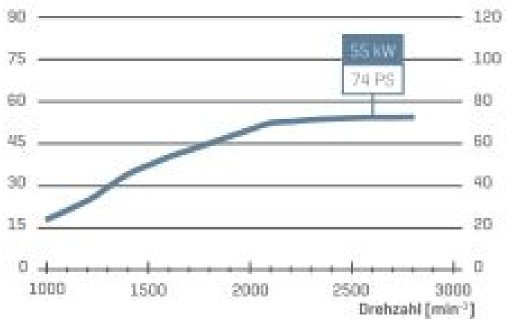
Oil consumption	0,5% vom Kraftstoffverbrauch bei Vollast
Engine oil pressure (bar)	2,5 bis 4,5
Max. injection pressure (bar)	1800
Direction of rotation	Left (looking at the fly-wheel)
Valve clearance	Automatic compensation (maintenance free)
Engine oil quality	ACEA6, API CJ-4
Coolant	H50-Coolant min. 40 / 60
Fuel	EN590, BS2689A1/A2, ASTM D 975-09a 1-D S15 oder 2-D S15, JIS K2204

Hako Group

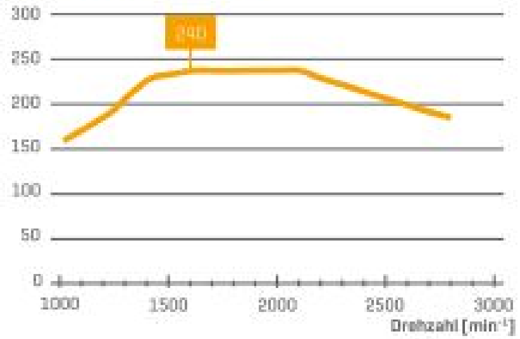
Specifications

4H50TICD² | 4H50TIC

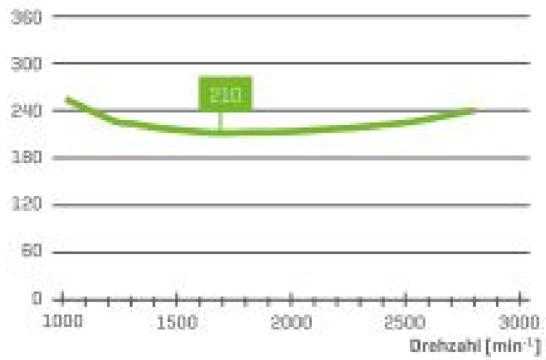
Engine power (KW/PS)



Drehmoment (Nm)



Fuel consumption (g/kwh)



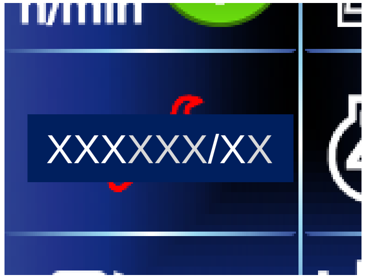
Engine Type Plate

Serial number (S/N)
AAA BB CC DDDDDD

AAA = Engine typ = 165
BB = Series = 10 (and higher)
CC = Construction year
DDDDDD = running number

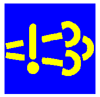
The engine type plate is located on the crankcase and contains the following engine information:	
1	Model designation of the engine
2	Engine serial number
3	Serial rating (kW) at nominal speed (rpm)
4	Displacement (liters)
5	Information for US emission certification (EPA/CARB)
6	EU type approval
7	EU country of origin (Germany)
8	Model year (month/year)
9	ECE - type approval numbers
10	Code for type plate variants
11	Barcode (engine serial number)

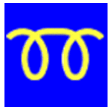
Display indications

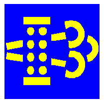


Error message as SPN / FMI code
SPN 3-6-digit / FMI 1-2-digit
Error message s. Chapter 9.0.6

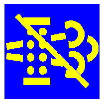
 Engine or drive foult

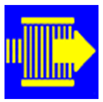
 Error in the DPF

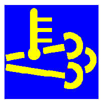
 (flashing) engine foult

 DPF regeneration required

 Limb Home Modus aktivated

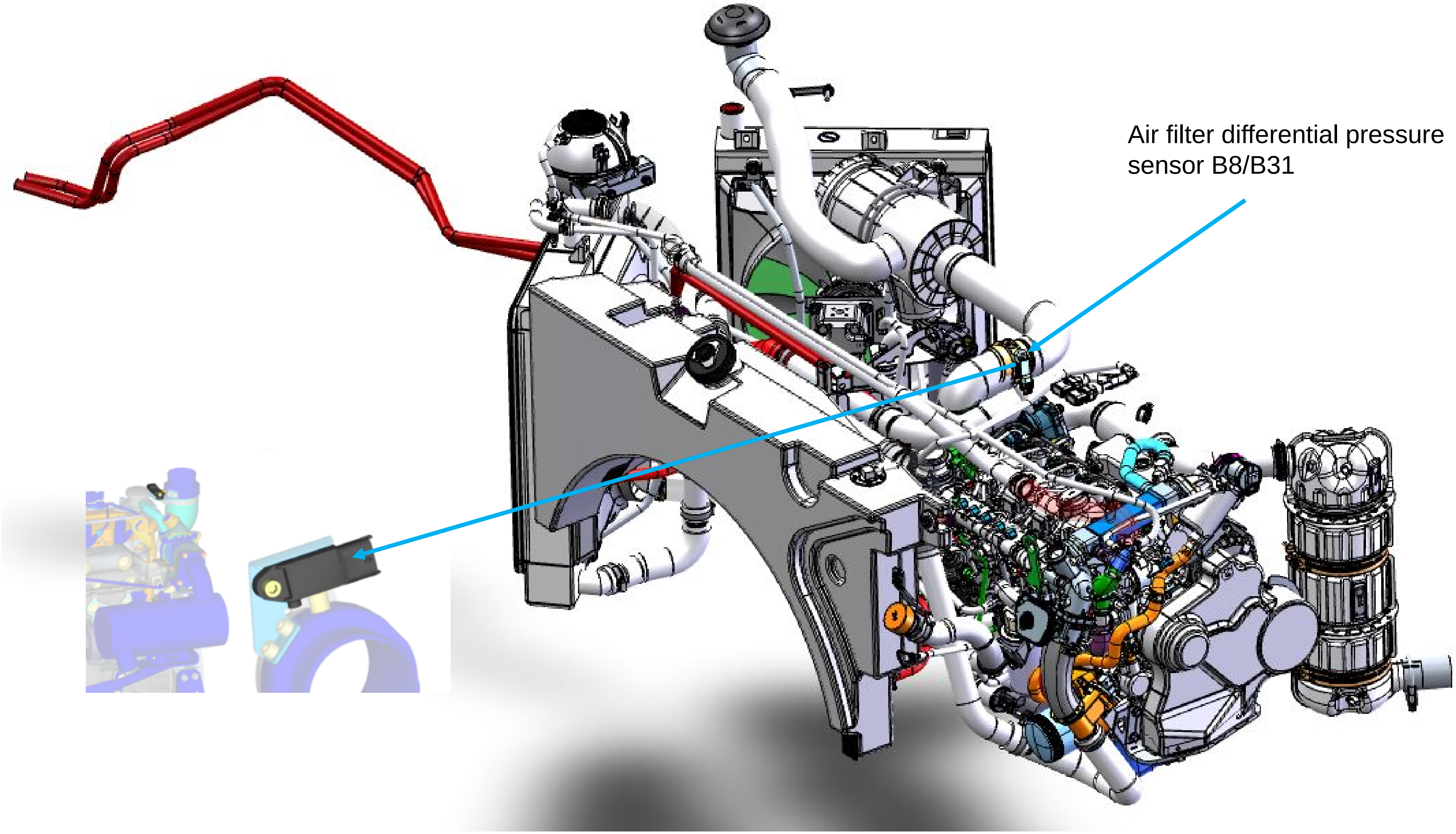
 Regeneration locked

 Warning air filter clogged

 Active regeneration is running

Overview engine parts

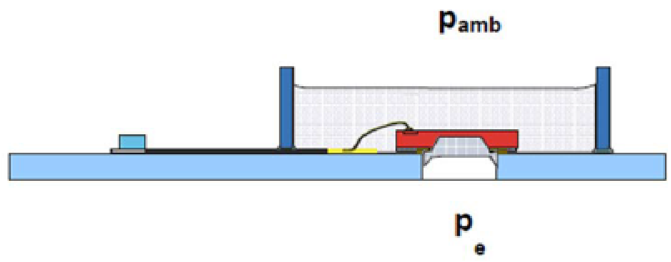
Engine system complete

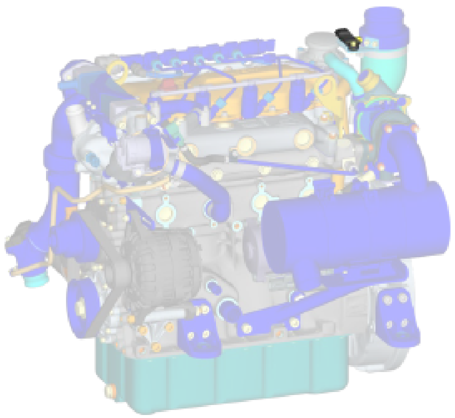


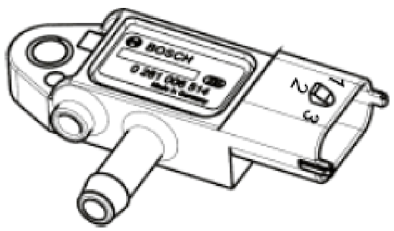
Overview engine parts

Air Filter Differential Pressure Sensor (relative pressure sensor):

The piezoresistive pressure sensor element and suitable electronics for signal amplification and temperature compensation are integrated on a silicon chip. The pressure pe acts on the back of the silicon membrane. The ambient pressure Pamb acts as a reference pressure from above on the active side of the silicon membrane.







Steckerbelegung
Connector Details

1. Spannungsversorgung 5 Volt
   Voltage supply 5 volts
2. Masse
   Ground
3. Ausgangssignal
   Output signal

Function:
This sensor is currently used for air filter/intake vacuum monitoring only and has no influence on combustion-related components such as EGR, injection, etc. Excessive intake pressure could lead to turbocharger damage, altered emissions, loss of performance, etc.

The normal operation of the sensor can be divided into 3 areas:

- No exceeding of warning or error threshold => normal engine operation
- Exceeding the warning threshold => Entry into fault memory, no power reduction, the operator is only requested to change the air filter (lamp)
- Exceeding the error threshold => Entry into fault memory, power reduction/emergency run, the operator is “forced” to react.

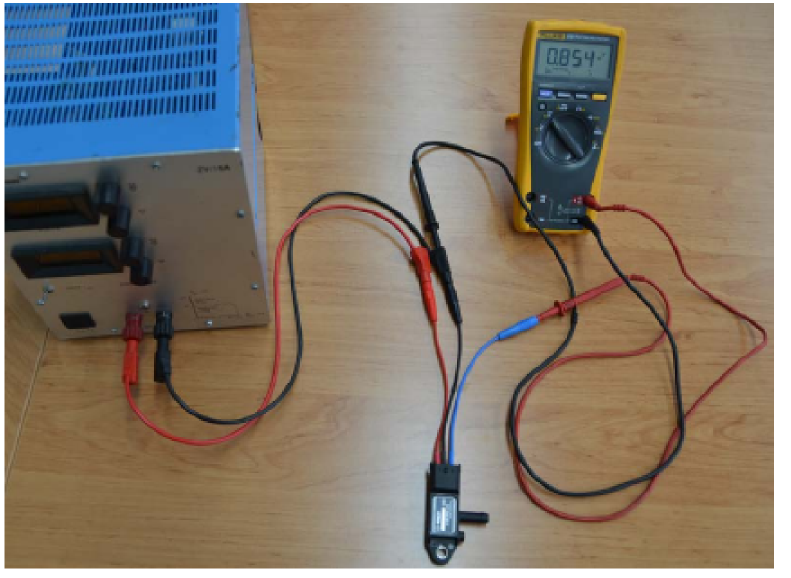
These warning thresholds are only activated when the engine is warm. They are in relation to the operating point of the characteristic fields and recorded in the control unit. An automatic sensor calibration was applied in the software, which takes place in the so called “run-up process” of the control unit. Furthermore, the sensor is also checked for the voltage limits (broken wire/ short circuit).If they are out of range, an entry is made in the fault memory and the error reaction (limp home/engine shut down) takes place
according programming/customer requirements.

Dynamic check of Air Filter Differential Pressure Sensor

Step	Description
1	Full adaption of the Sensor
2	Switch the Ignition ON
3	Measure Voltage between Pin 2 (GND) and Pin 3 (Output Signal)
4	If this Voltage value is between 0.5V and 4.5V → Sensor OK → Air Filter OK (eg. Room Pressure relatively = 0.00 bar → Voltage value approx. 0.8V)

Static check of Air Filter Differential Pressure Sensor

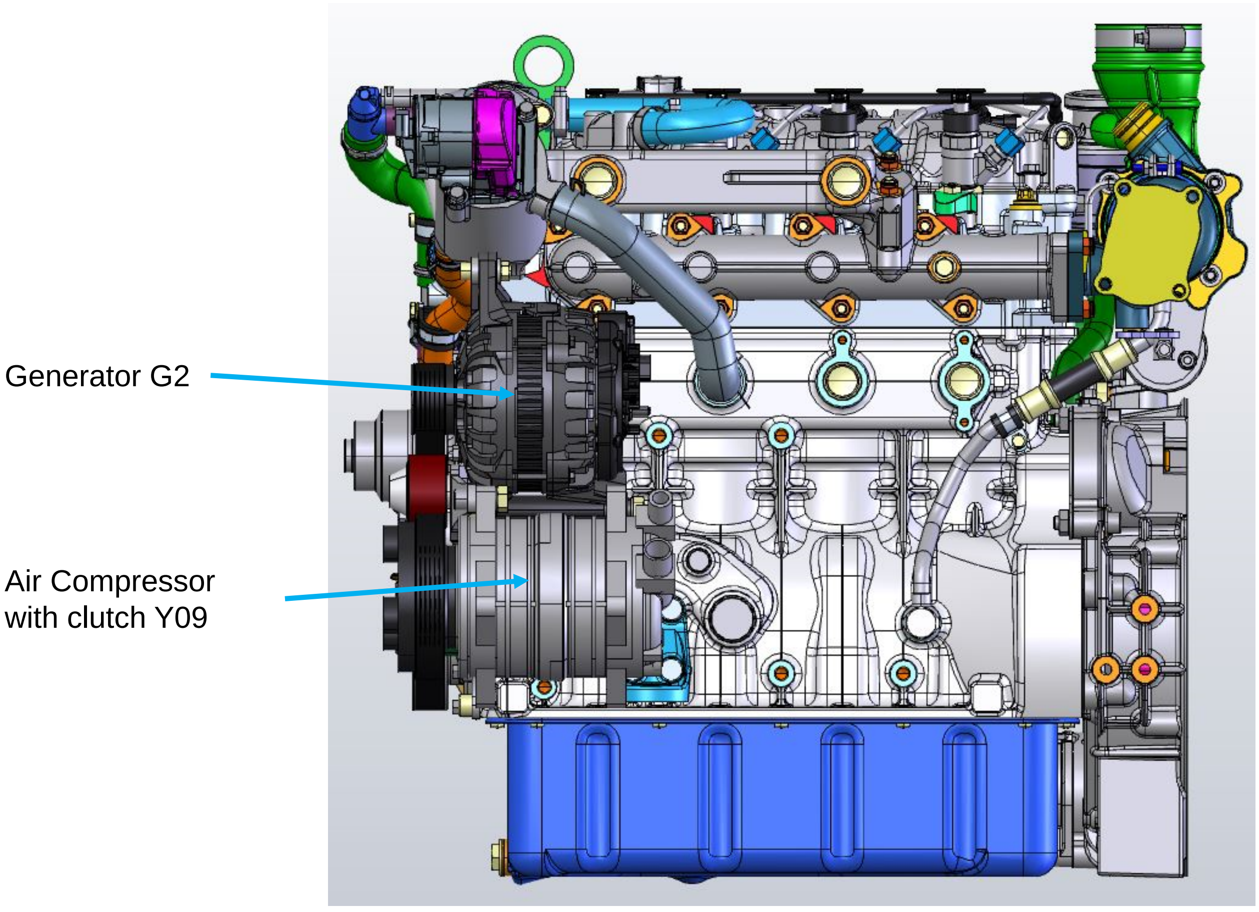
Step	Description
1	Voltage supply (5V) of the Sensor via Pin 1 (B+) and Pin 2 (GND)
2	Measure Voltage between Pin 2 (GND) and Pin 3 (Output Signal) If this Voltage value is between 0.5V and 4.5V → Sensor OK → Air Filter OK (eg. Room Pressure relatively = 0.00 bar → Voltage value approx. 0.8V)
3	Compare measured Value with figures provided in the Temperature Table (refer Table below for Static Verification of Temperature Sensor).



Druck Pressure P_{rel}			Signalausgangsspannung Signal Output Voltage U_{out}
Bar	kPa	psi	V
-0,11	-11	-1,60	4,5
-0,10	-10	-1,45	4,2
-0,09	-9	-1,31	3,8
-0,08	-8	-1,16	3,5
-0,07	-7	-1,02	3,2
-0,06	-6	-0,87	2,8
-0,05	-5	-0,73	2,5
-0,04	-4	-0,58	2,2
-0,03	-3	-0,44	1,8
-0,02	-2	-0,29	1,5
-0,01	-1	-0,15	1,2
0,00	0	0	0,8
0,01	1	0,15	0,5

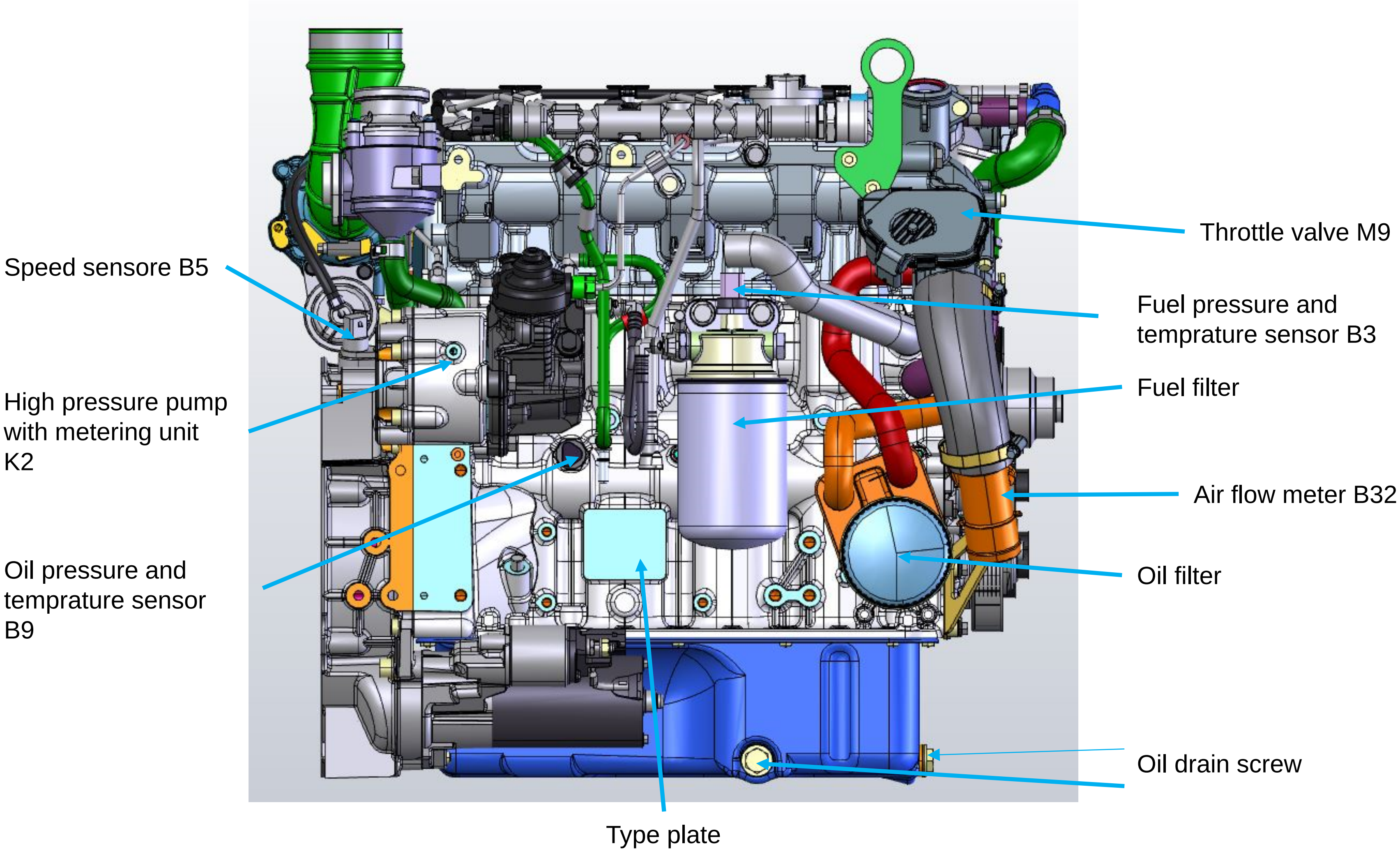
Overview engine parts

View from the right (direction of travel)



Overview engine parts

View from the left (direction of travel)

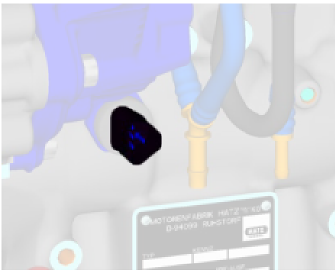


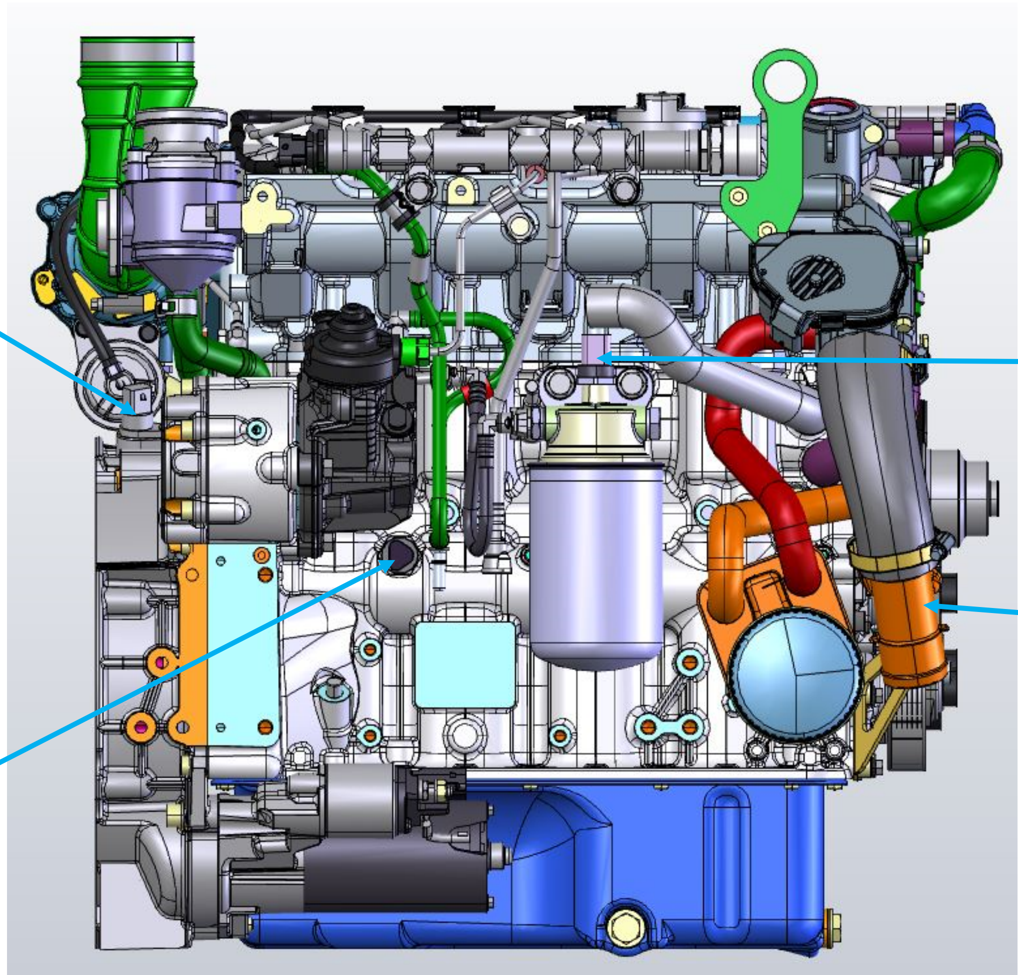
Overview engine parts

View from the left (direction of travel)

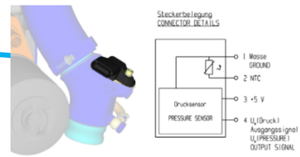
B5

B9



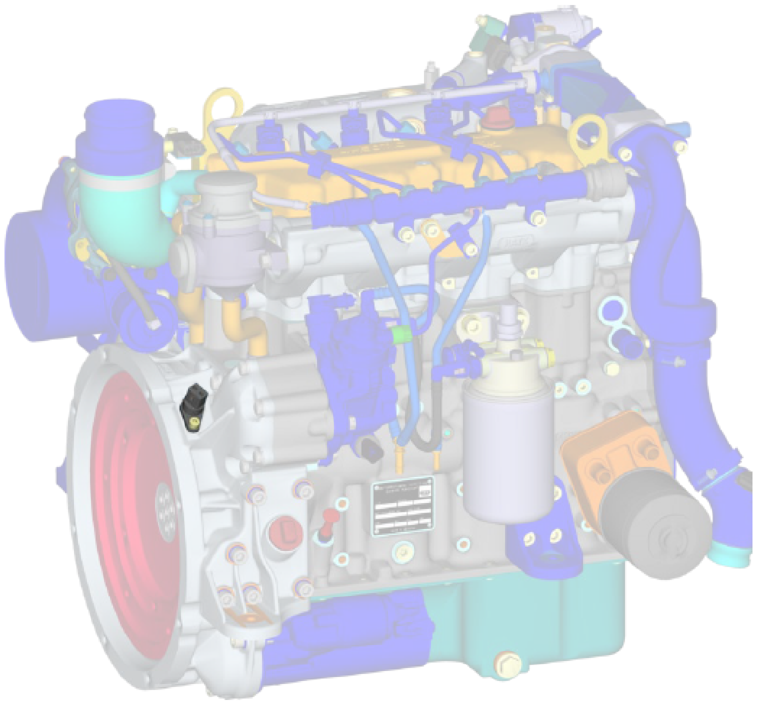


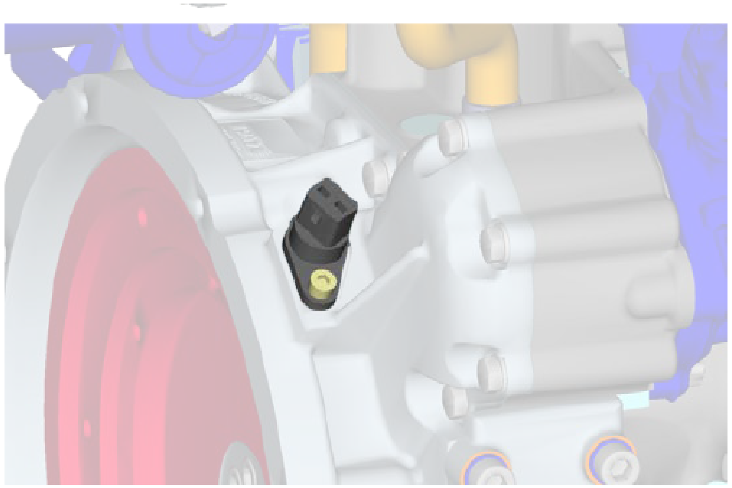
B3



B32

Speed Sensor (Crankshaft):
The soft core of the sensor, which is surrounded by a winding, is mounted directly against a rotating encoder wheel, separated by an air gap. The soft iron core is connected to a permanent magnet. The magnetic field extends from the permanent magnet via the pole pin of stainless steel into the ferromagnetic encoder wheel. The magnetic flux through the coil depends on whether a gap or a tooth opposes the pole core. A tooth bundles the stray flux of the magnet in such a way that it is passed as a useful flow through the pole core and thus the coil. A gap, on the other hand, weakens the flow through the coil (see Figure 1). The magnetic flux changes of the useful flux induce a sinusoidal wave that is proportional to the rate of change in the sensor coil Output Voltage.





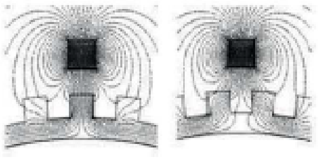


Figure 1: Path of the Magnetic Field Lines

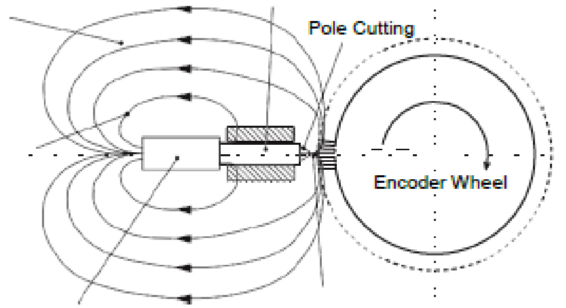
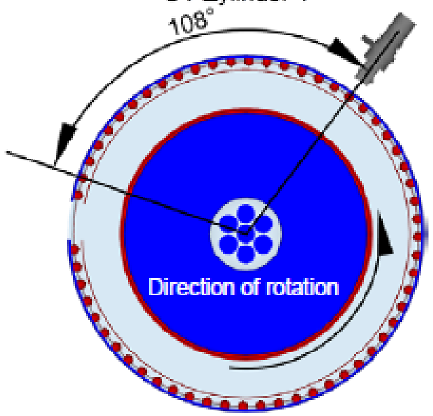


Figure 2: DG6 Magnetic circuit with the Trigger Wheel

Arrangement of the Speed Sensor:

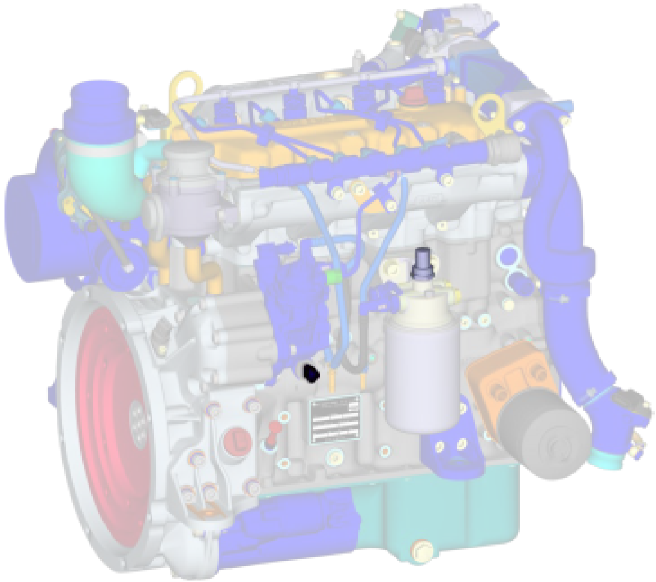


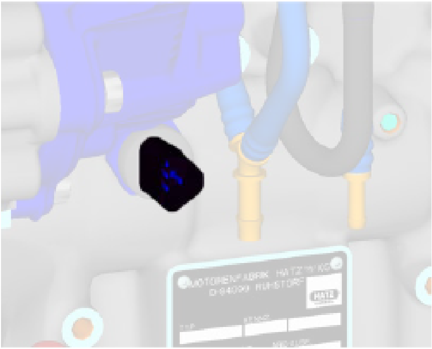
Pressure Sensor (Fuel and Oil):

A piezoresistive sensor element and an appropriate electronics for signal amplification and temperature compensation are on a micro-mechanical chip. The pressure of the measured medium is via a pressure supports on the underside of the membrane sensor element. The ambient pressure is used as a reference on a ventilation in the housing on the front side of the silicon membrane.

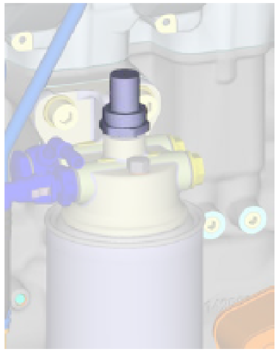
Fuel Temperature Sensor / Oil / Coolant / Charge Air (NTC):

The temperature sensor is a sensor that a temperature in an electrical resizes. This temperature sensor is a thermistor (NTC), i.e. it reduces its resistance with increasing temperature.





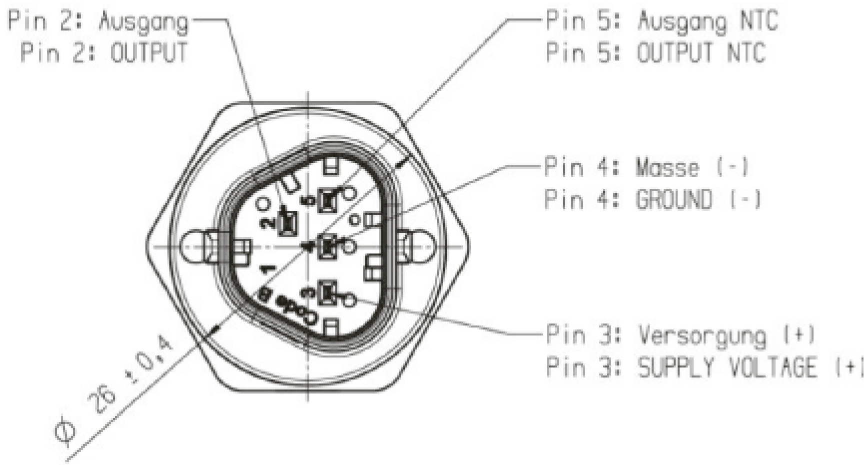
Oil



Fuel

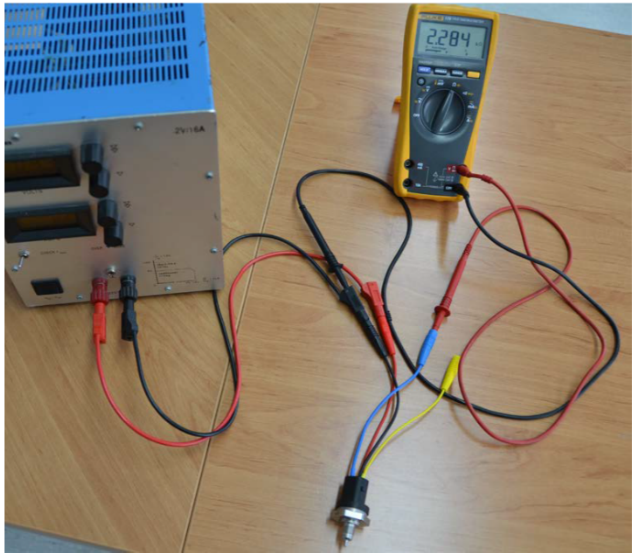
Dynamic checking of the Temperature Sensor (Fuel / Oil)

Step	Description
1	Primary Ignition of the Sensor
2	Switch the Ignition ON
3	Measure Resistor between Pin 4 (GND) and Pin 5 (Output NTC)
4	Compare measured Value with figures provided in the Temperature Tabl (refer Table below for Static Verification of Temperature Sensor). (eg. Room Temperature = 20 - 25°C → Value approx. 2300 Ω) → Sensor



Dynamic Testing of the Pressure Sensor (Fuel / Oil)

Step	Description
1	Full adaption of the Sensor (see Table below for Dynamic check of the Temperature Sensor).
2	Switch the Ignition ON
3	Measure Voltage between Pin 4 (GND) and Pin 2 (Output)
4	Compare measured Value with figures provided in the Pressure Table (refer Table below for Static Verification of Pressure Sensor). (eg. Room Pressure relatively = 0.00 bar → Voltage value approx. 0.5V) → sensor OK



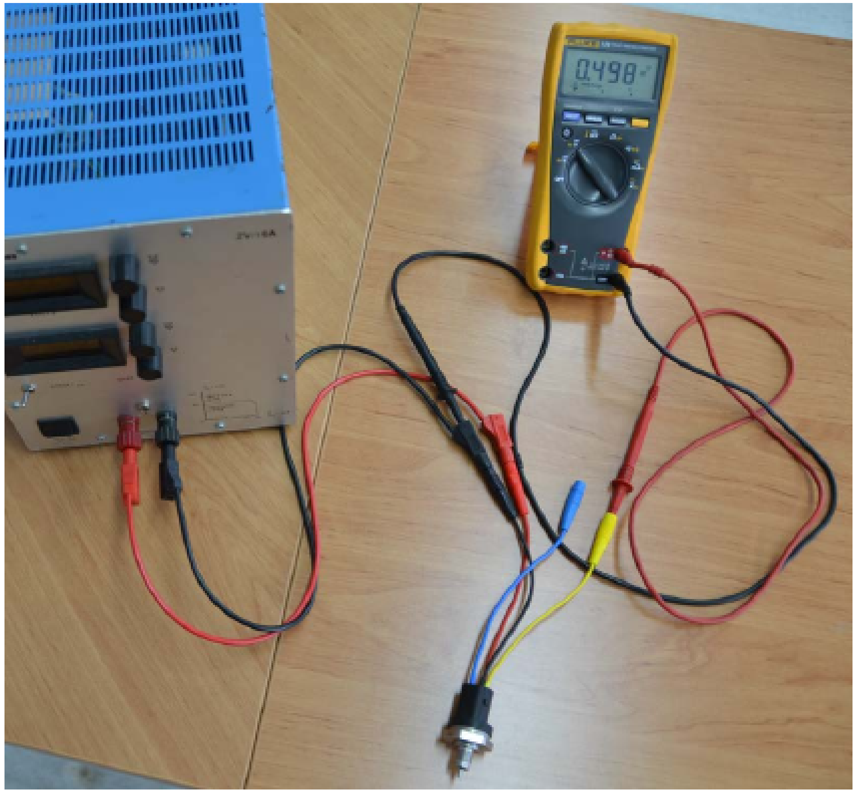
Static Verification of the Temperature Sensor (Fuel / Oil)

Step	Description
1	Voltage supply (5V) of the Sensor via Pin 3 (B) and Pin 4 (GND)
2	Measure Resistor between Pin 4 (GND) and Pin 5 (Output NTC)
3	Compare measured Value with figures provided in the Temperature Table (refer Table below for Static Verification of Temperature Sensor). (eg. Room Temperature = 20 - 25°C → Value approx. 2300 Ω) → Sensor OK

Temperatur Temperature **T**		Widerstand Resistance **R** in Ω	
°C	**°F**	Min.	Max.
-40	-40	39236	51354
-30	-22	22546	28929
-20	-4	13430	16919
-10	14	8265	10238
0	32	5239	6390
10	50	3412	4102
20	68	2278	2702
25	77	1877	2213
30	86	1555	1823
40	104	1084	1256
50	122	770	884
60	140	557	633
70	158	410	462
80	176	306	342
90	194	232	257
100	212	178	196
110	230	137	152
120	248	107	119
130	266	85	95
140	284	68	76

Statische Überprüfung des Drucksensors (Kraftstoff / Öl)

Schritt	Beschreibung
1	Spannungsversorgung (5V) des Sensors über Pin 3 (B+) und Pin 4 (Gnd)
2	Spannungswert zwischen Pin 4 (Gnd) und Pin 2 (Output) messen.
3	Wert mit der Tabelle vergleichen. (z.B. Raumdruck relativ = 0,00 bar → Spannungswert ca. 0,5 V) → Sensor i.O.



Druck Pressure P_{rel}			Signalausgangsspannung Signal Output Voltage U_{out}
Bar	**kPa**	**psi**	**V**
0,0	0	0	0,5
0,5	50	7	0,7
1,0	100	15	0,9
1,5	150	22	1,1
2,0	200	29	1,3
2,5	250	36	1,5
3,0	300	44	1,7
3,5	350	51	1,9
4,0	400	58	2,1
4,5	450	65	2,3
5,0	500	73	2,5
5,5	550	80	2,7
6,0	600	87	2,9
6,5	650	94	3,1
7,0	700	102	3,3
7,5	750	109	3,5
8,0	800	116	3,7
8,5	850	123	3,9
9,0	900	131	4,1
9,5	950	138	4,3
10,0	1000	145	4,5

Fuel pressure and temperature sensors:

Fuel pressure: The minimum requirement of low fuel pressure is 1.5 bar at speeds from 900 rpm to 1500 rpm. From a speed of 1500 rpm, the minimum requirement increases up to a speed of max. 3000 min-1 linear to 2 bar.

Fuel temperature: The maximum fuel temperature up to fault detection is 80° C, but in normal operation the power is reduced as low as 70 ° C. In certain cases of failure (e.g., defective metering unit), power is reduced as the fuel temperature rises above 50 ° C. In this case, no error entry regarding the fuel temperature will take place (error entry due to ZME).

The limit value for the error entry "fuel temperature" remains at 80 ° C.
Note: A density correction is also made in the permitted temperature range.

Oil pressure Temperature Sensor:

Oil pressure: The oil pressure limits for activating the oil pressure lamp are linear at speeds of 900 min-1 to 2800 min-1 from 0.8 to 1.5 bar. The limits for ctivating the selected error replacement reaction, or engine shutdown, are linear from 0.25 to 0.8 bar at speeds of 900 rpm to 2800 rpm.

Oil temperature: The maximum oil temperature up to fault detection is 130 ° C. Furthermore, based on the oil temperature, the internal friction of the engine is calculated and adjusted so the injected fuel quantity. This makes it possible for the engine to always deliver the desired power regardless of the engine / oil temperature and to avoid any mechanical damage.

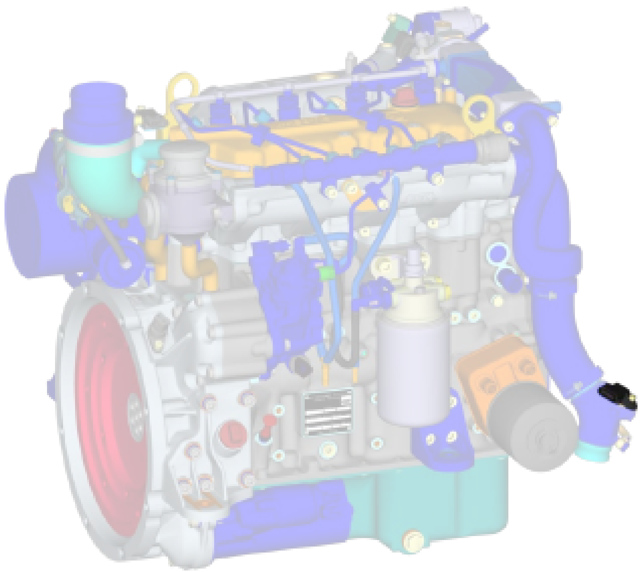
Note: In the event of a coolant temperature failure, the oil temperature serves as a substitute value.

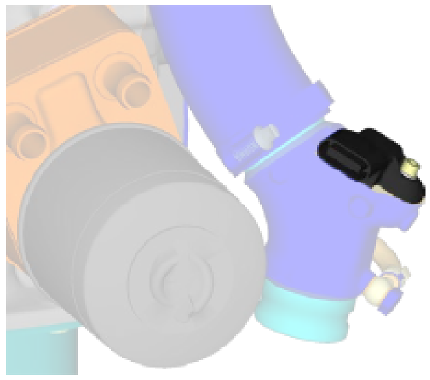
Turbocharging Pressure Sensor:

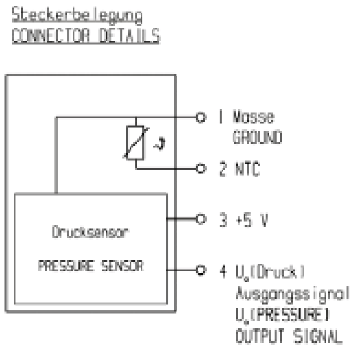
The piezoresistive pressure sensor element and suitable electronics for signal amplification and temperature compensation are integrated on a silicon chip. The measured pressure acts from above on the active side of the silicon membrane.

Fuel Temperature Sensor / Oil / Coolant / Charge Air (NTC):

The temperature sensor is a sensor that converts a temperature into an electrical variable. This temperature sensor is a thermistor (NTC), i.e. It reduces its resistance with increasing temperature.





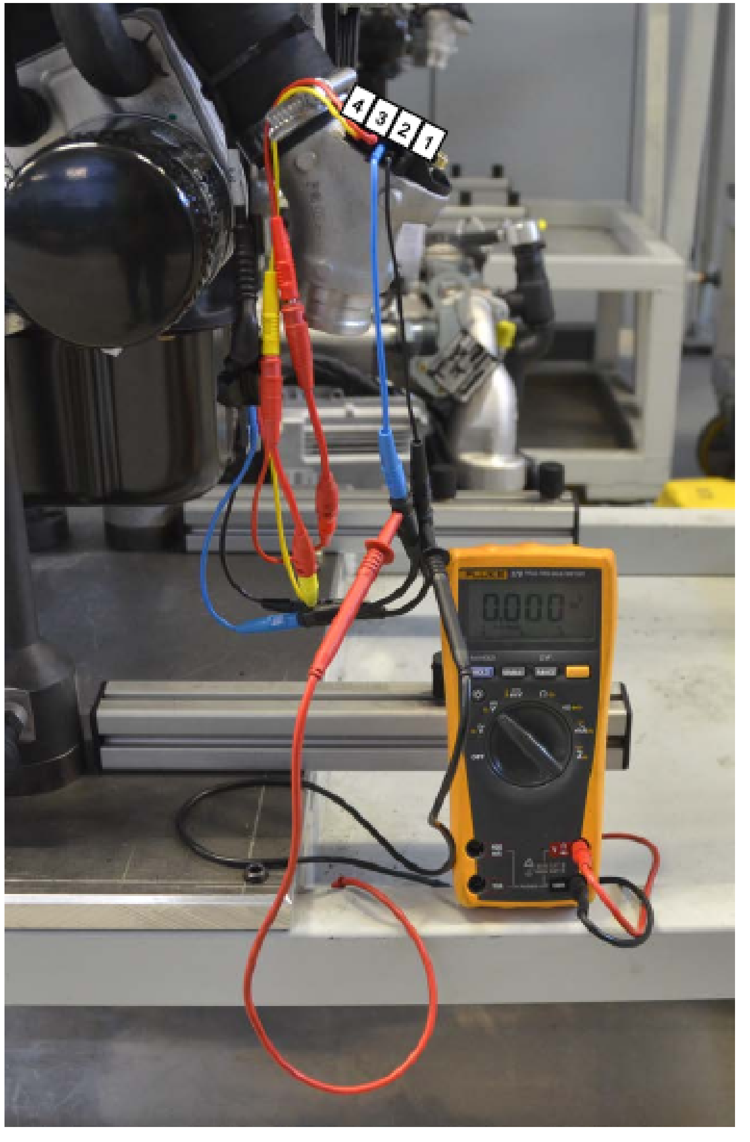


Function
This sensor is required for the calculation of the air mass flow and for the control of combustion-relevant characteristics, such as: injection pattern, rail pressure, begin of delivery, EGR rate, injection quantity.
A too low load pressure (depending by operating stage) is currently not declared as an error. However, there may be a reduction in the injection quantity / performance if there is insufficient boost pressure to maintain exhaust emissions (smoke limitation).

The sensor values are monitored for the physical value and the voltage limits. If these limits are out of range, an entry is made in the error memory and error reaction (limp home / engine shut down), depending on customer requirements.

Dynamische Überprüfung des Ladetemperatursensors

Schritt	Beschreibung
1	Volladaption des Sensors.
2	Zündung Ein
3	Pin 1 (Gnd) und Pin 2 (NTC) messen.
4	Wenn dieser Spannungswert zwischen 0,5V und 4,5V liegt → Sensor i.O (z.B. Raumtemperatur 20 – 25°C → Spannungswert ca. 3V)


4
3
2
1
0.000

Dynamic check of the Load Pressure Sensor

Step	Description
1	Full adaption of the Sensor
2	Switch the Ignition ON
3	Measure Voltage between Pin 1 (GND) and Pin 4 (NTC)
4	Room Pressure → 40mV

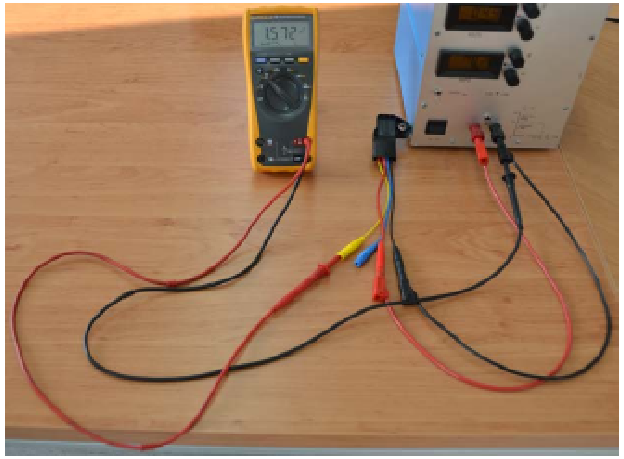
Static check of the Boost Pressure Sensor

Step	Description
1	Measure Resistor between Pin 1 (GND) and Pin 2 (Output NTC)
2	Compare measured Value with figures provided in the Temperature Table (refer Table below for Static Verification of Temperature Sensor). (eg. Room Temperature = 20 - 25°C → Value approx. 2200 Ω) → Sensor OK

Temperatur Temperature **T**		Widerstand Resistance **R** in Ω	
°C	**°F**	Min.	Max.
-40	-40	40730	50314
-30	-22	23603	28829
-20	-4	14055	16970
-10	14	8595	10261
0	32	5420	6403
10	50	3504	4100
20	68	2323	2690
25	77	1916	2207
30	86	1591	1827
40	104	1100	1254
50	122	783	887
60	140	561	632
70	158	412	461
80	176	306	340
90	194	231	256
100	212	178	196
110	230	137	151
120	248	107	118
130	266	85	94

Static verification of the Turbocharging Pressure Sensor

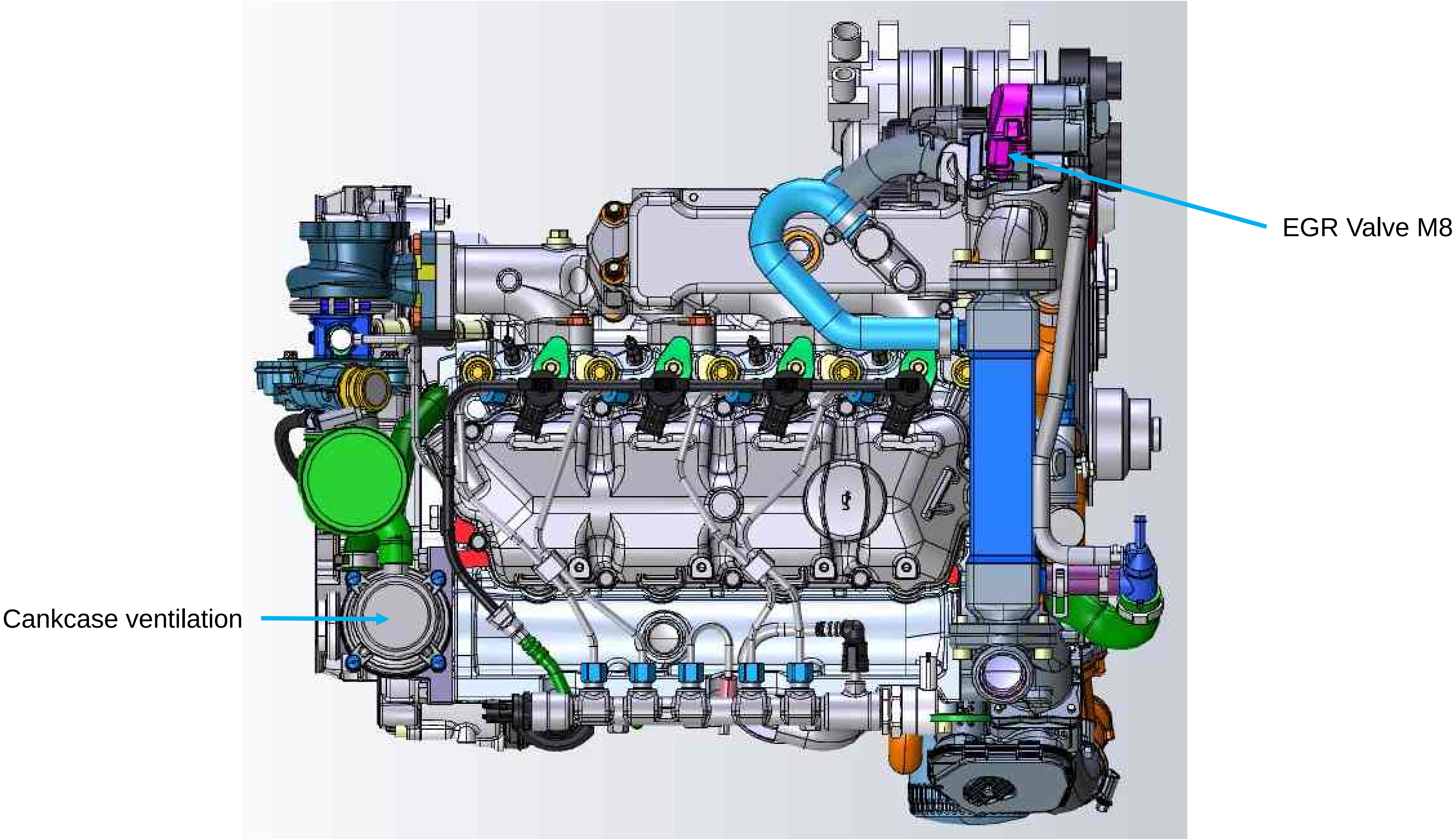
Step	Description
1	Voltage supply (5V) of the Sensor via Pin 1 (GND) and Pin 3 (B+)
2	Measure the Signal Output Voltage between Pin 4 (U_O) und Pin 1 (GND).
3	Compare measured Value with figures provided in the Pressure Table (refer Table below for Static Verification of Pressure Sensor). (eg. Room Pressure relatively = 1 bar → Voltage value approx. 1.6V) → sensor OK



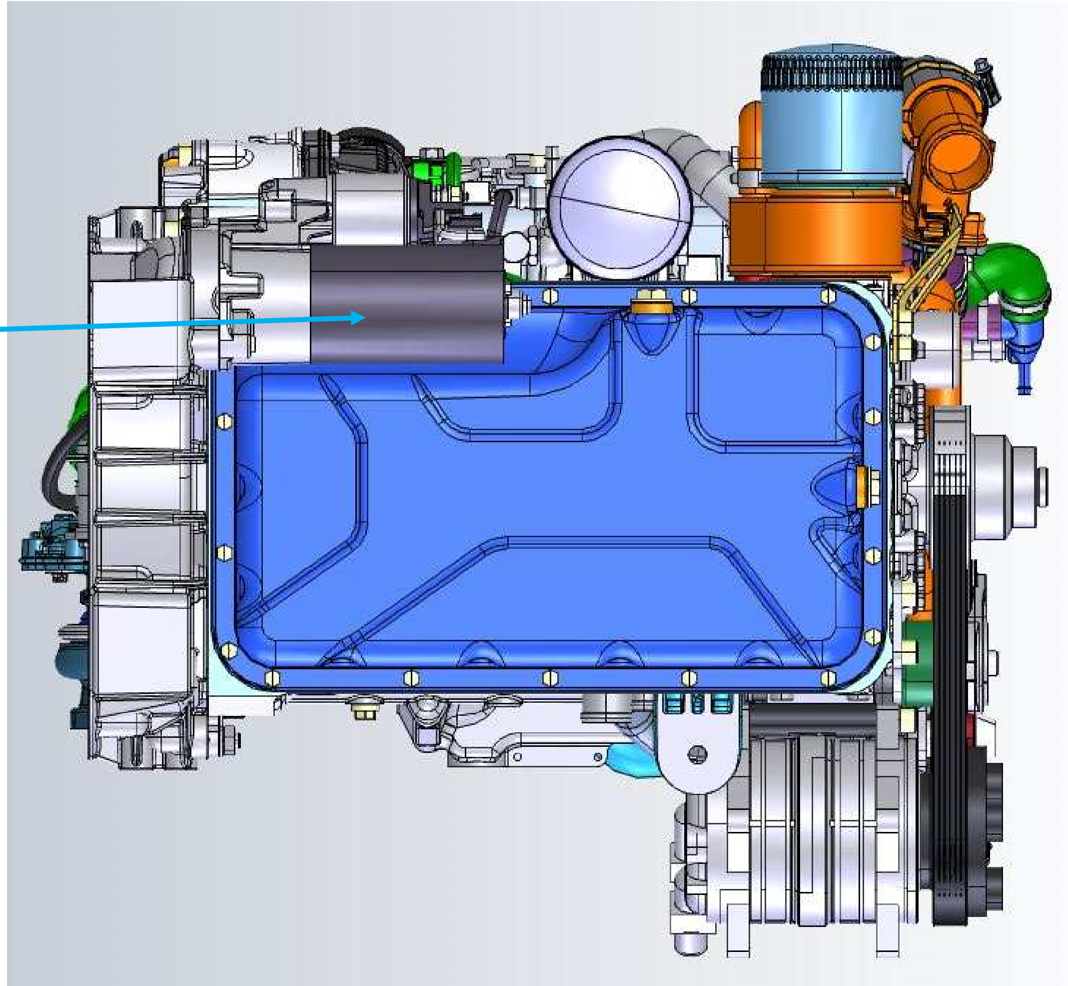
Absolutdruck Absolute Pressure P_{abs}			Signalausgangsspannung Signal Output Voltage U_{out}
Bar	kPa	psi	V
0,2	20	3	0,4
0,4	40	6	0,7
0,6	60	9	1,0
0,8	80	12	1,3
1,0	100	15	1,6
1,2	120	17	1,9
1,4	140	20	2,2
1,6	160	23	2,5
1,8	180	26	2,8
2,0	200	29	3,1
2,2	220	32	3,4
2,4	240	35	3,7
2,6	260	38	4,0
2,8	280	41	4,4
3,0	300	44	4,7

Overview engine parts

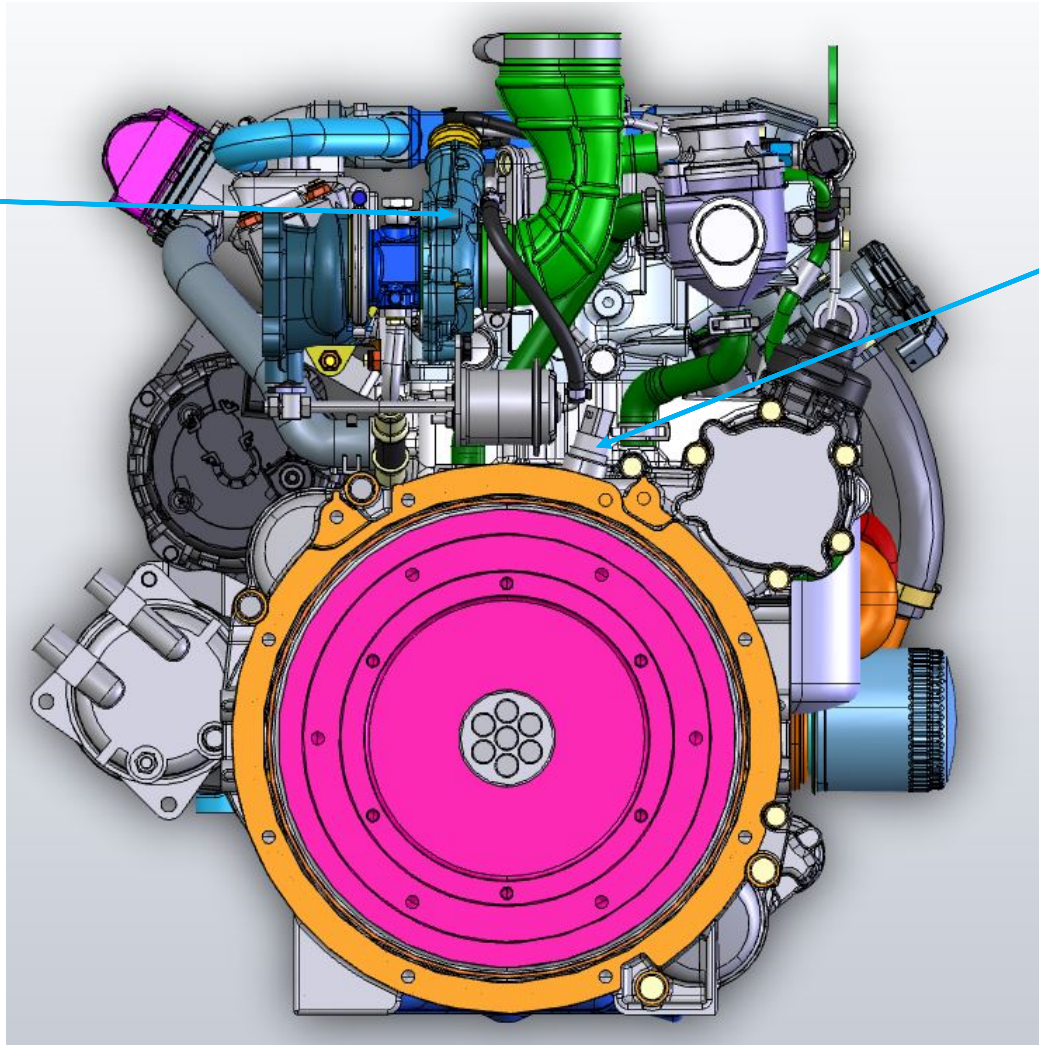
View from the top



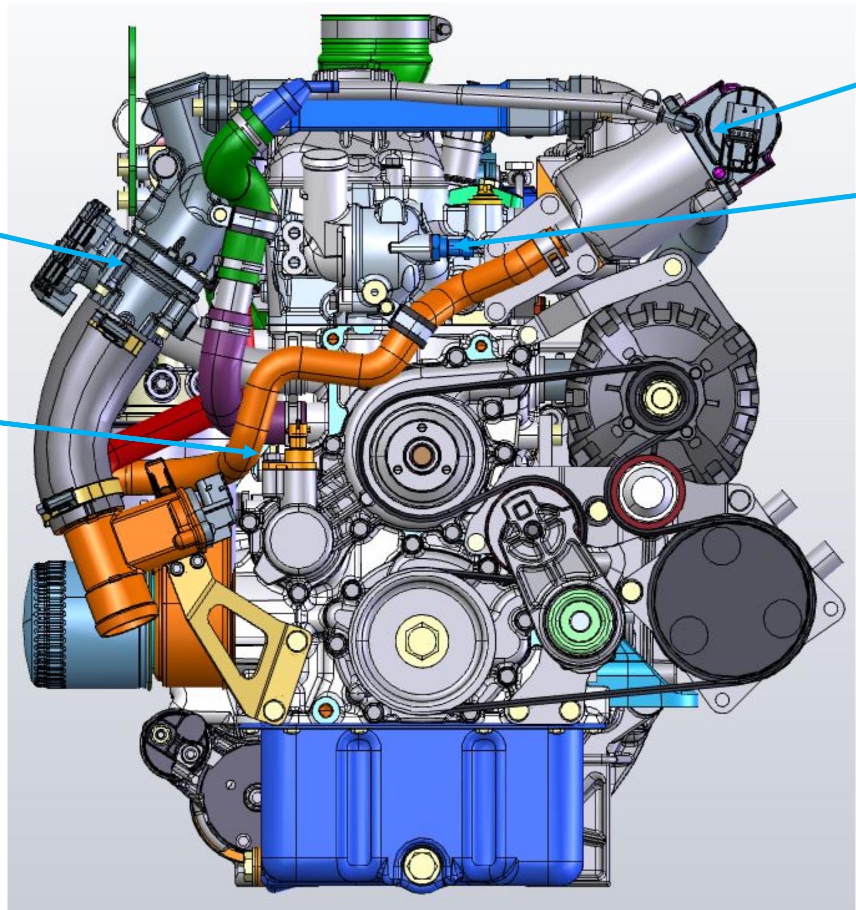
Hatz Motor Übersicht der Bauteile
Ansicht von unten

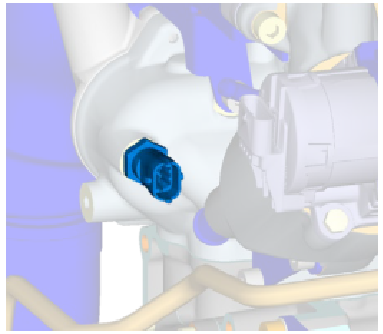


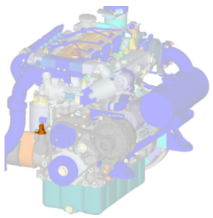
Overview engine parts

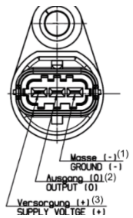


Hatz Motor Übersicht der Bauteile
Ansicht von hinten

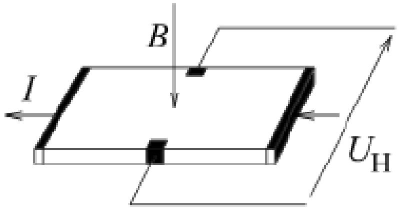


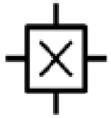






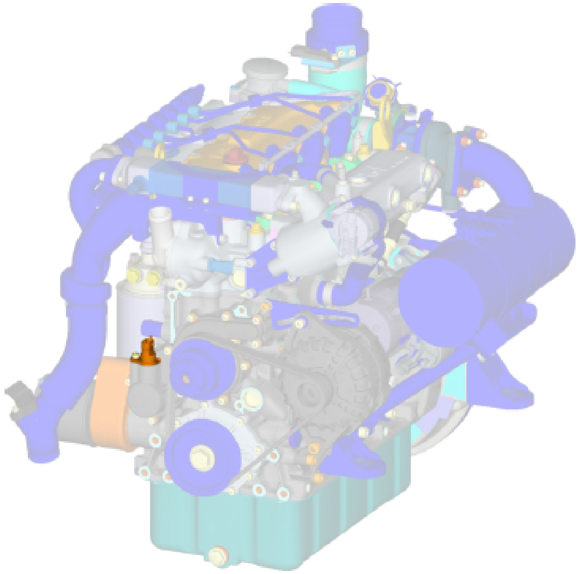
Principle of the Hall-Sensor

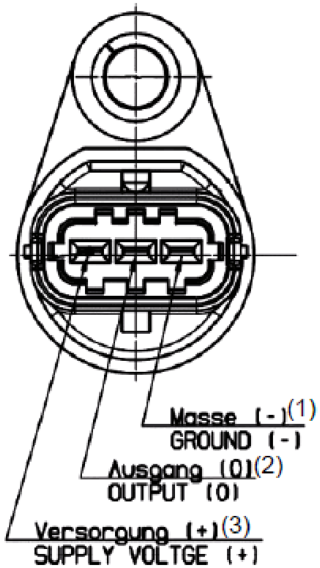




Switch Symbol

Due to a current I and a magnetic flux density B, the Hall voltage UH is produced A Hall sensor (also Hall probe or Hall sensor, according to Edwin Hall) uses the Hall effect for the measurement of magnetic fields.
If a simple Hall sensor is traversed by a current and brought into a perpendicular magnetic field, it provides an output voltage that is proportional to the product of magnetic field strength and current (Hall effect). The signal is also temperaturedependent.
A Hall sensor also provides a signal when the magnetic field in which it is located is constant. This is the decisive advantage compared to a sensor consisting of magnet and coil. As soon as the magnet and the coil are not moved together, the voltage induced in the coil is zero and the magnet is not detected.





Function of the Phase Detector

The phase detector is an active Hall sensor, which must be supplied with a DC voltage. The camshaft is reduced by 1: 2 against the crankshaft. Their positionindicates whether an engine piston moving toward the top dead center is in the compression or ejection stroke. The phase sensor on the camshaft (also referred to as a phase detector) outputs this information to the control unit. An impulse wheel with segments made of ferromagnetic material rotates with the camshaft. The Hall IC is located between the rotor and a permanent magnet. The permanent magnet provides a magnetic field perpendicular to the Hall element. If a segment passes the current-carrying sensor element (semiconductor wafer) of the rod sensor, it changes the field strength of the magnetic field perpendicular to the Hall element. Thus, the electrons driven by a longitudinal voltage applied to the element are more deflected perpendicular to the current direction. This results in a voltage signal (Hall voltage)

Which is in the millivolt range and is independent of the relative speed between the sensor and the pulse wheel. The integrated evaluation electronics in the Hall IC of the sensor prepares the signal and outputs it as a square-wave signal.

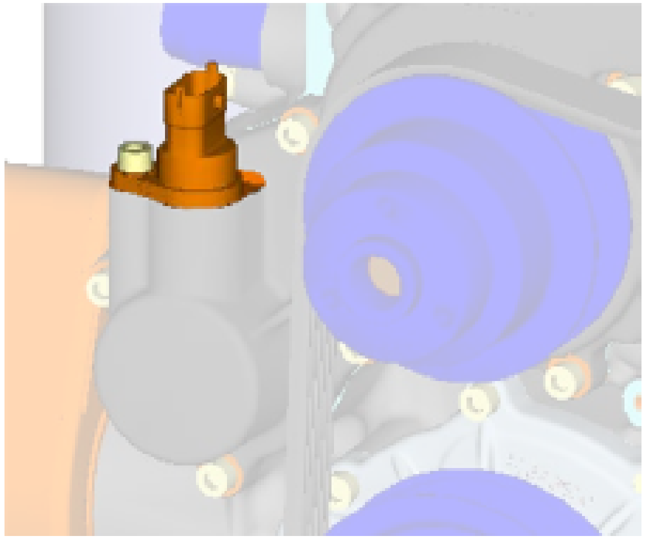
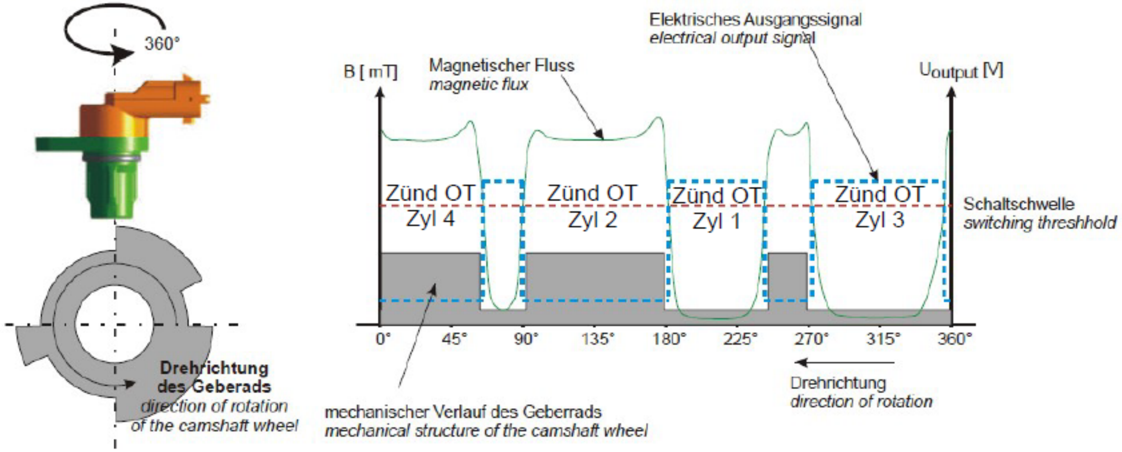


Illustration of an encoder wheel with quick start function

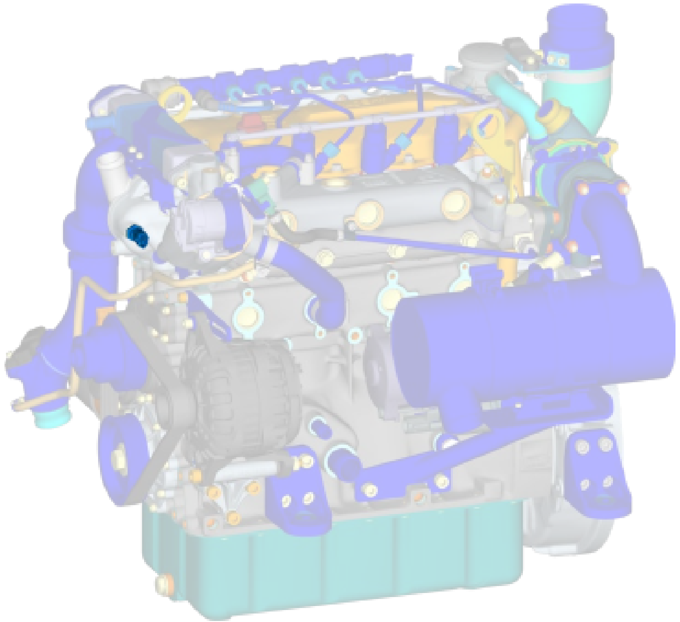


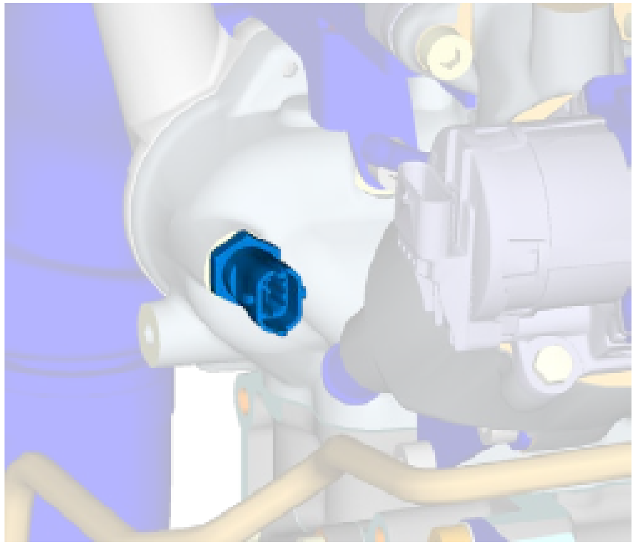
With the help of the TPO function (True-Power-On), the sensor can immediately recognize if there is a tooth or a gap in front of the sensor when the operating voltage is applied. This is a component of the quick start function. If the sensor fails: Function due to cable breakage or defective sensor, the control unit switches the motor into the emergency program.

Note:
3-sprocket wheels can be used from EDC17. It has an emergency stop function and a quick start function (synchronization after 90 ° Camshaft). The advantage of the 3-tooth encoder wheel lies in the fact that it can be designed smaller than a Z + 1 encoder wheel.

General:

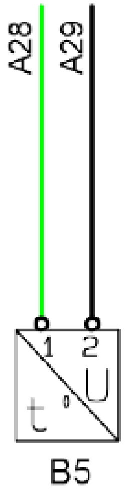
The Temperature Sensor is a sensor that converts a Temperature into an Electrical Variable. This Temperature Sensor is a NTC (Negative Temperature Coefficient Thermistor), i.e. it reduces its resistance with increasing temperature, or conducts the electric current better at high temperatures than at low temperatures.

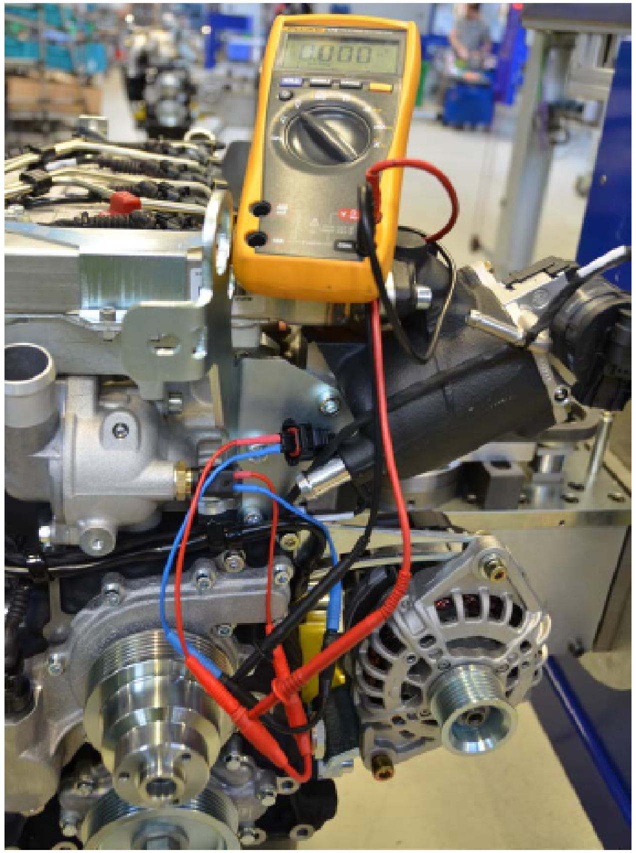




Dynamic Check of the Coolant Temperature Sensor

Step	Decsription
1	Full Adaptation of the Sensor
2	Measure Voltage between Pin 1 (Signal Input) and Pin 2 (GND)
3	If this Voltage value is between 0.5V and 4.5V → Sensor OK (For example Room Temperature 20-25 ° C → voltage value approx. 3V)



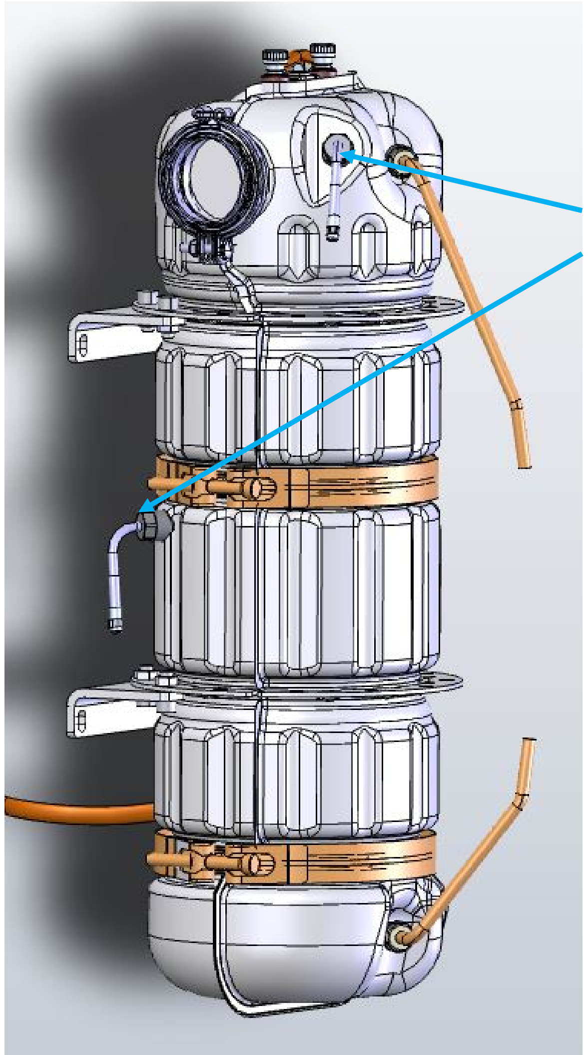


Static Check the Coolant Temperature Sensor

Set	Description
1	Measure Resistor between Pin 1 (Signal Input) and Pin 2 (GND)
2	Compare measured Value with figures provided in the Temperature Table (refer Table below for Static Verification of Temperature Sensor). (eg. Room Temperature = 20 - 25°C → Value is approx. 2200 Ω) → Sensor OK

Temperatur Temperature **T**		Widerstand Resistance **R** in Ω	
°C	**°F**	Min.	Max.
-40	-40	40481	50124
-30	-22	23575	28640
-20	-4	14093	16824
-10	14	8640	10149
0	32	5465	6324
10	50	3541	4042
20	68	2351	2648
25	77	1940	2173
40	104	1118	1231
50	122	798	869
60	140	573	618
70	158	421	450
80	176	313	332
90	194	237	249
100	212	183	190
110	230	141	148
120	248	110	116
130	266	87	92
140	284	69	74

Overview DPF

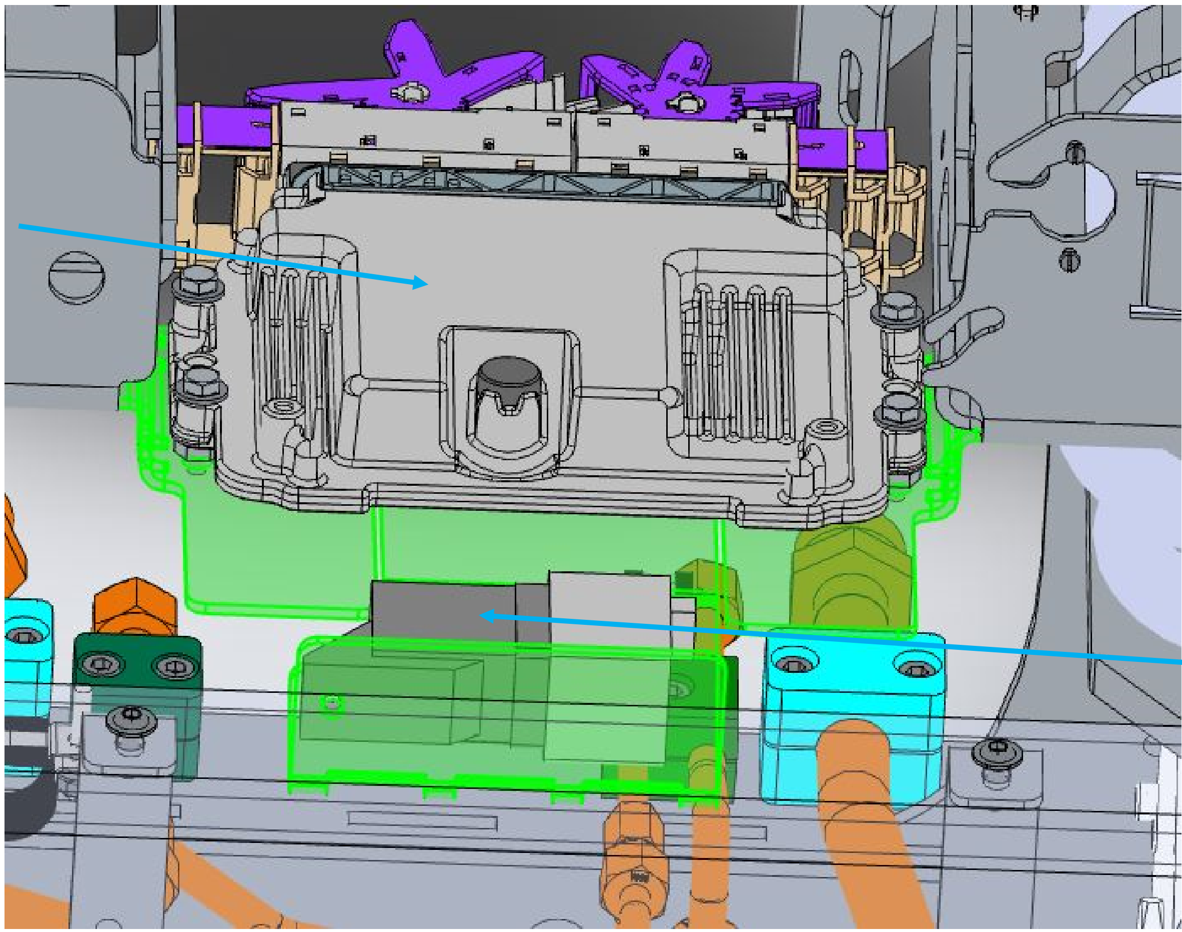


Temperature sensor T1 before DOC B36
Temperature sensor T2 after DOC B37

Differential pressure sensore DPF B35

Overview control unit

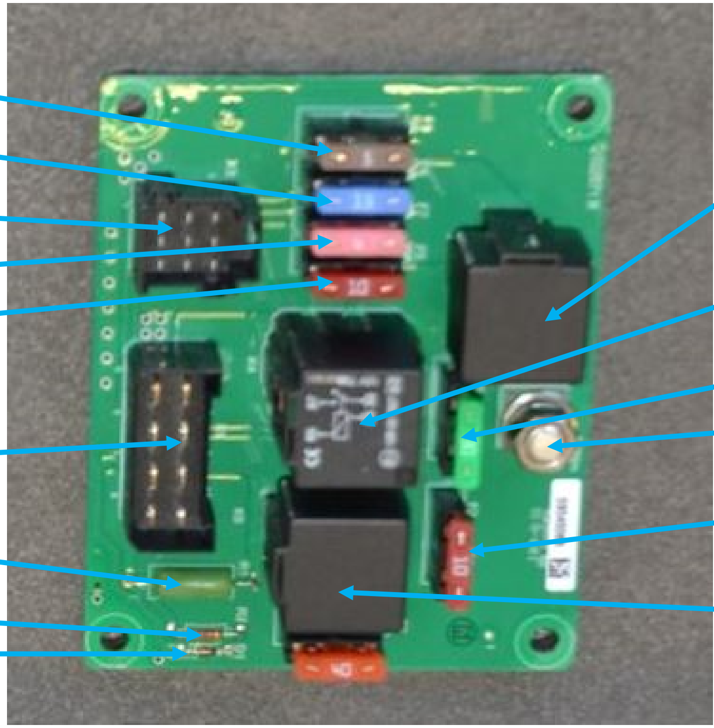
Engine control unit A01



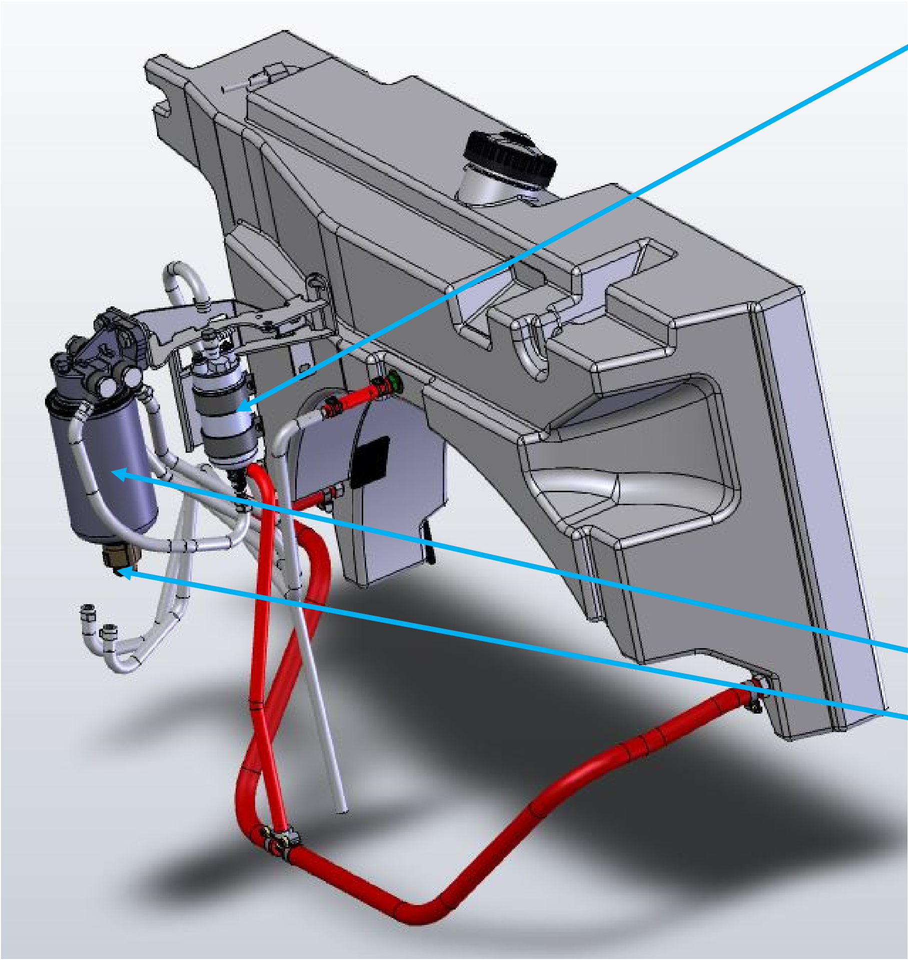
Glow time
control unit
A09/K3

Hako Group

overview E-Box

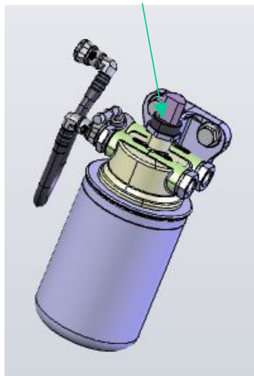


Low pressure fuel system



Fuel pump M10

Fuel pressure -
And temperatur sensor B3



Fuel filter

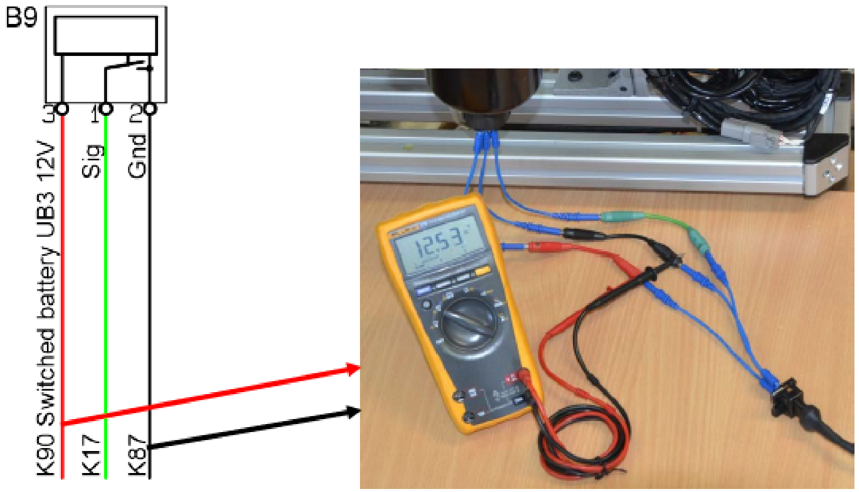
Prefilter and water seperator

Water in fuel sensor B33

Water in Fuel Sensor (conductivity measurement):
This method is also known as conductive measurement. When reaching a certain level of electrical current between two electrodes by the liquid. This changes the resistance between two measuring electrodes by the presence or absence of the medium.

1. Checking the Power Supply

Step	Description
1	Full adaption of the Sensor
2	Switch the Ignition ON
3	Supply Voltage between Pin 2 (GND) and Pin 3 (B+) = Battery Voltage
4	If Voltage Value is correct → Proceed to Item **2** and Item **3** in Order



If Voltage is OK → Check the Signal Voltage, see Item 3

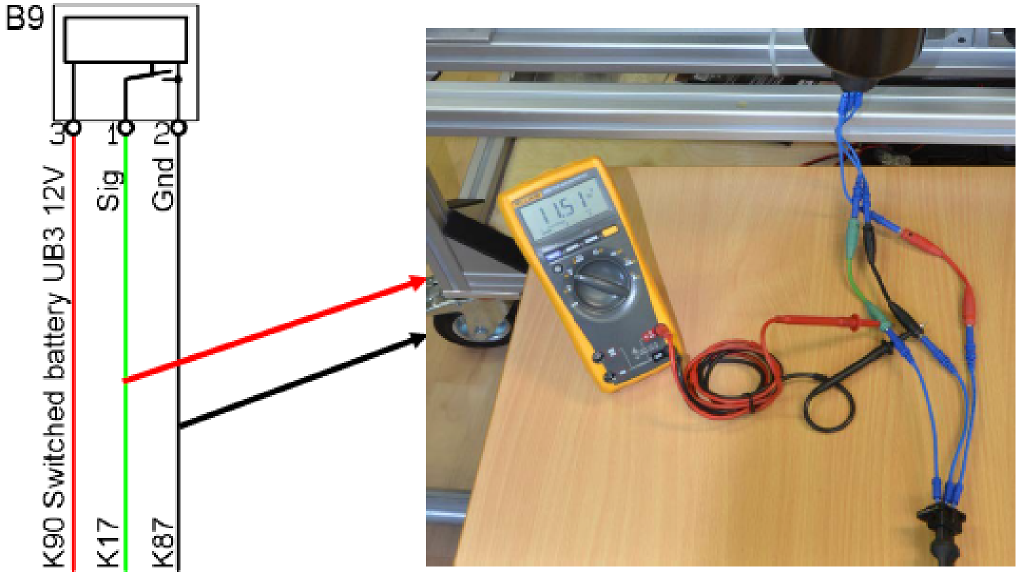
2. No Voltage Value is Displayed → Check Item 2 and Item 3

Step	Check the Cable 3
1	Ignition ON
2	Measure Voltage on Cable 3 with B- GND) = Battery Voltage
3	Battery OK → Battery Cable (B+) Defective

Step	Check the Line 2
1	Ignition ON
2	Measure Voltage on Wire 2 with B- GND) = Battery Voltage
3	Battery OK → Battery Cable (B+) Defective

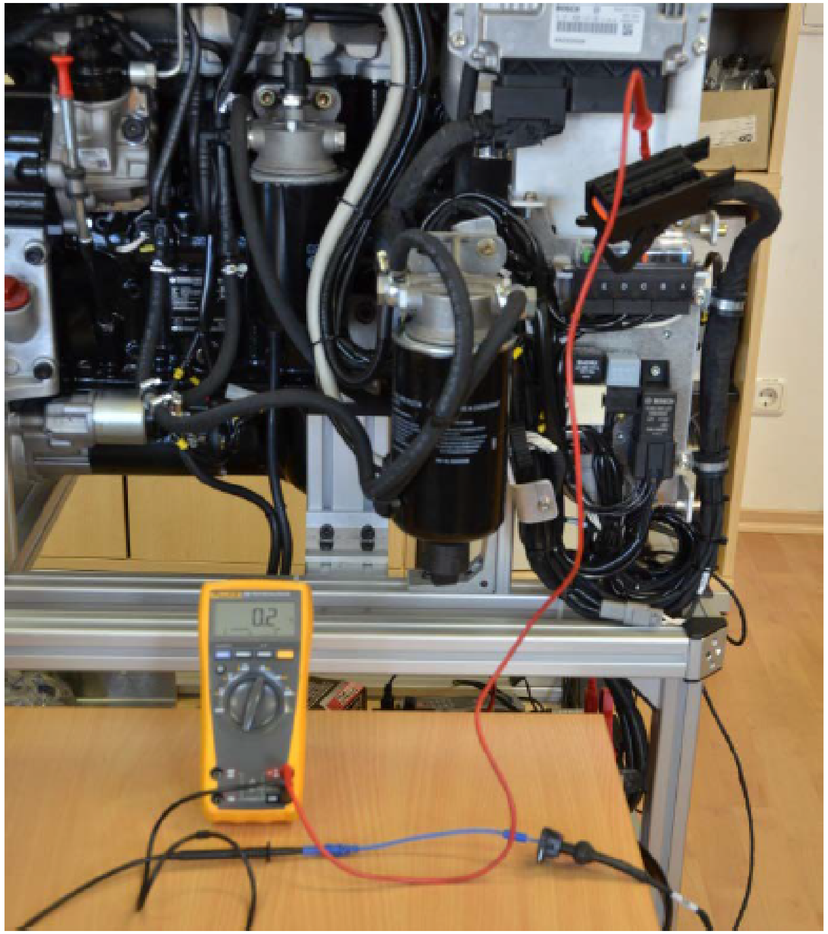
3. Check the Signal Voltage

Step	Description
1	Ignition ON
2	Initiation of a Self Test (wait 5 seconds)
3	Voltage measurement between Pin 2 (GND) and Pin 1 (Signal); U >11V
4	If the Reading shows 0V the Sensor is Defective

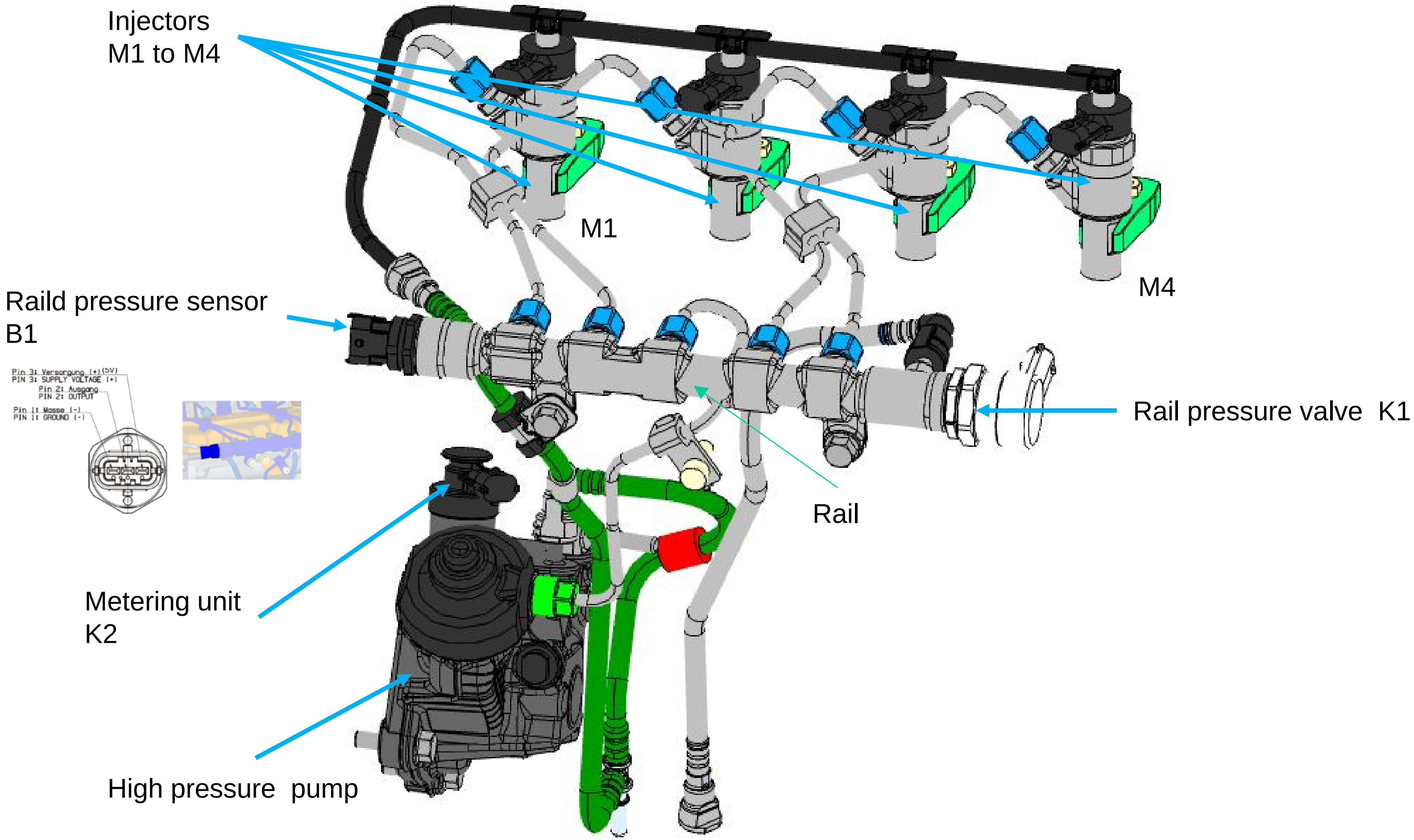


4. **Check the Cable between the Control Connector and the respective Sensor Cable, refer to Wiring Diagram 054 604 xx.**

ATTENTION!
All continuity tests between the device plug and the sensor cable must only be carried out using a suitable tool.

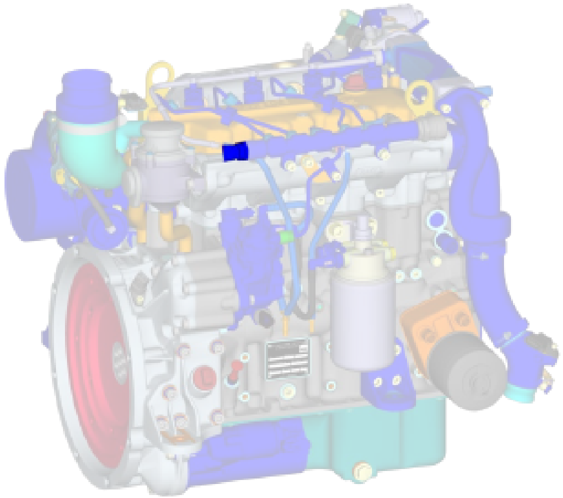


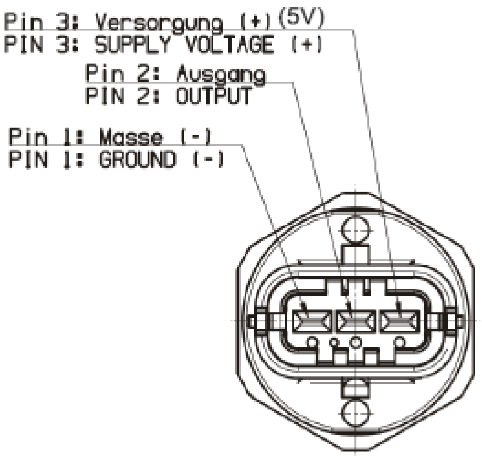
High pressure fuel system

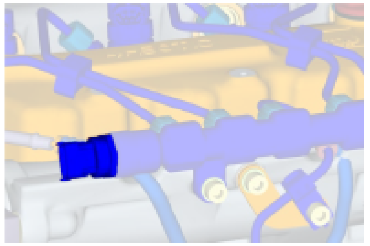


Rail Pressure Sensor (strain Gauge):

A thin film resistor bridge is applied to a metal membrane. Strain gauges (strain gauges) are measuring devices for the detection of stretching and compressive deformations. They change their electrical resistance even with small deformations and are used as strain sensors. The bridge is detuned when pressurized and provides a signal proportional to the pressure. This is scaled and amplified by an electronic evaluation circuit.

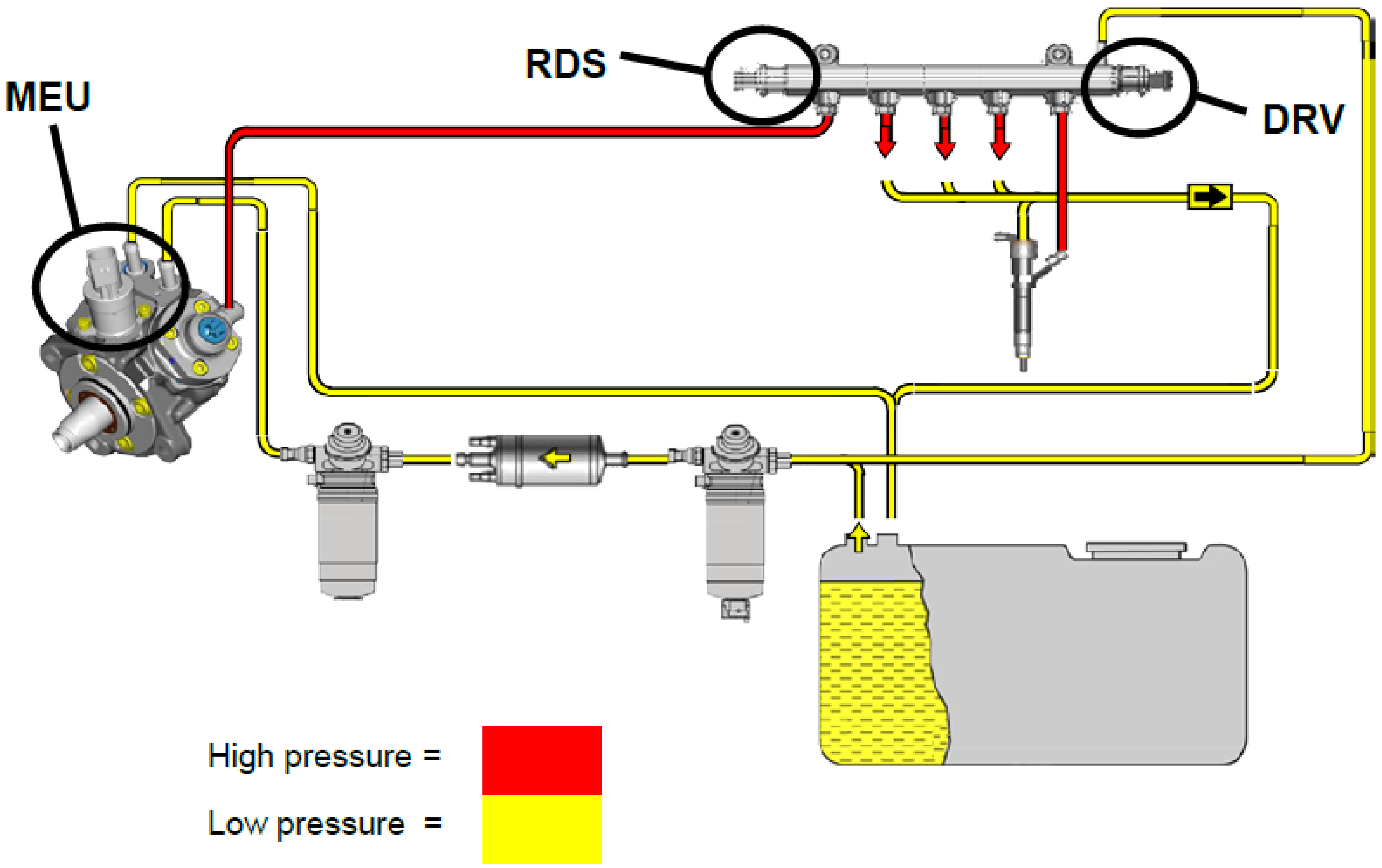






Druck Pressure P			Signalausgangsspannung Signal Output Voltage U_{out}
Bar	kPa	psi	V
0	0	0	0,5
100	10	1450	0,7
200	20	2900	0,9
300	30	4351	1,1
400	40	5801	1,3
500	50	7252	1,5
600	60	8702	1,7
700	70	10153	1,9
800	80	11603	2,1
900	90	13053	2,3
1000	100	14503	2,5
1100	110	15954	2,7
1200	120	17405	2,9
1300	130	18855	3,1
1400	140	20503	3,3
1500	150	21756	3,5
1600	160	23206	3,7
1700	170	24656	3,9
1800	180	26106	4,1
1900	190	27557	4,3
2000	200	29008	4,5

High pressure system



Description (see next page)

High pressure system

1. Start

- The control of the rail pressure takes place via the DRV, thereby the MEU is switched to full fuel supply (currentless resp. duty factor 0).

- There is a warming of the fuel in the fuel system (lines, filter, but without tank contents), due to the by-passing fuel in the rail via the DRV.

- The rail pressure is controlled via the DRV until the start is finished.

2. End of start

- After the start there is the „rail pressure control“ via the DRV at full fuel supply of the high pressure pump (MEU), up to the fuel temperature of approx. 30°C.

- Here, the present value of the rail pressure (by the RDS) is compared with the set point of the performance map and adjusted by the DRV to a minimum deviation.

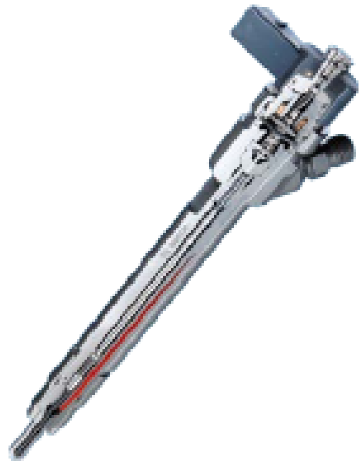
3. Engine is running

- After reaching the fuel temperature of >30°C (measured at the filter by FLPS1), the DRV will be closed and the rail pressure control takes place via the MEU.
- From this moment on the heating resp. warming of the fuel is stopped. The parameter of the desired rail pressure (set point) occurs via various performance maps in the control unit and is controlled by the metering unit (MEU) from this time on.
- If the fuel temperature drops below 20°C during operation, the DRV is reopened and the fuel in the pre-filter is heated.

High pressure system

The injector control is via the "Injector Output“ connections. This output is divided as "High Side“ and "Low Side". These actuators have no permanent mass or B+ connection. They are switched individually and on both sides by the Control Unit. In the Control Unit software, switching cycles are stored for several injections. Because the solenoid valve in the actuator must react quickly (microseconds), the Current Supply is higher during the switch-on process.

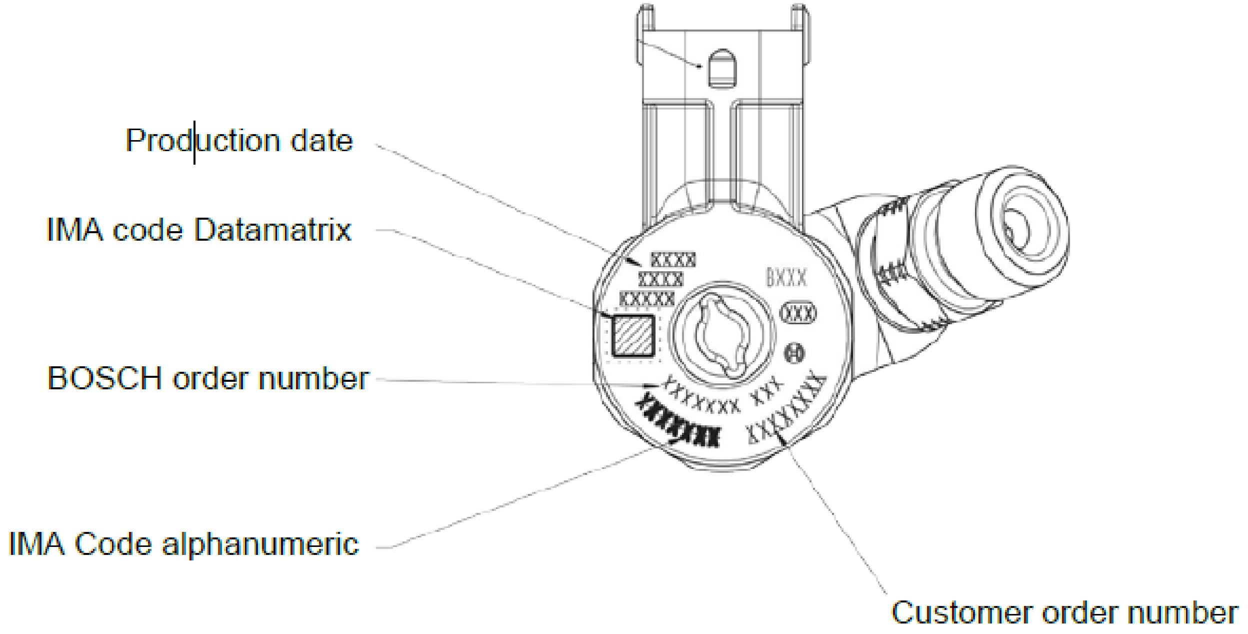
The Function Test of the injector can be measured over a Resistance Value of 0.3-0.5 Ohm at 20 °C. A 100% statement cannot be made in this area.



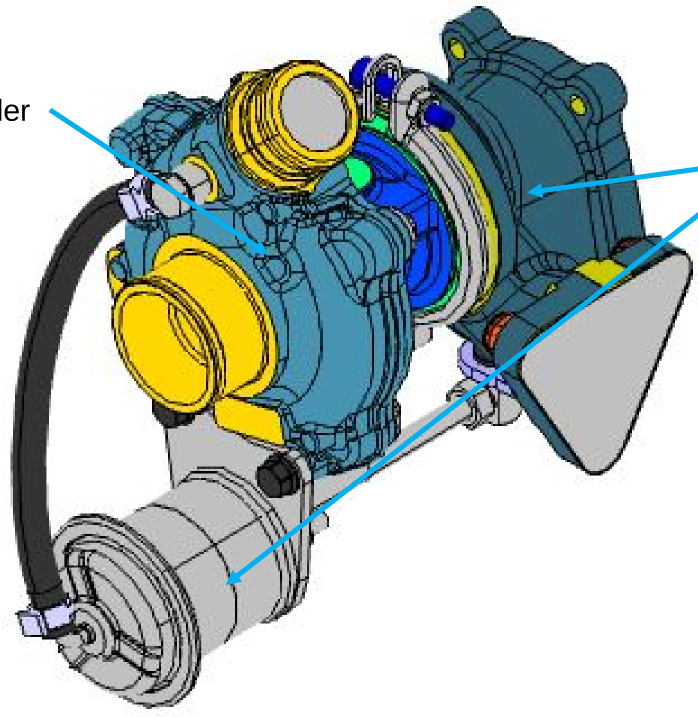
Note on Injection:
In the Injection strategy of the 3 / 4H50TIC, the Maximum number of Injections per work stroke is limited to 2. Depending on the Load and the Speed, this is varied between either main and main injection, only main injection or main and secondary injection. The pilot injection mainly serves to reduce the noise in the lower speed and load spectrum, while the post-injection in the upper speed and power range serves to reduce the particle emissions.

HD Kraftstoffsystem

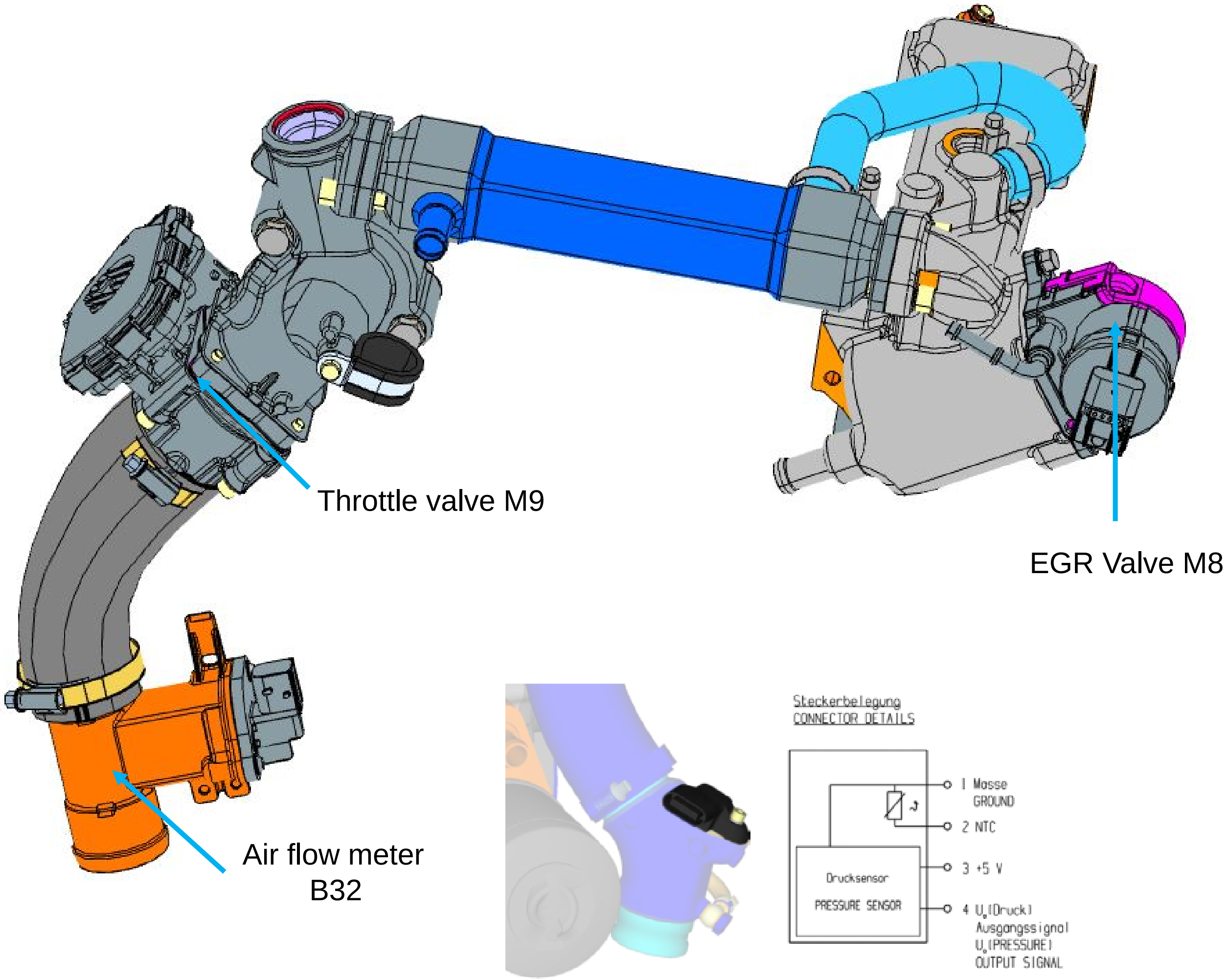
IMA-Code:
The IMA code (injector quantity matching code = alpha-numerical code) has the task to individually correct the injection quantity for each injector of a CR system in the characteristic area. The difference to the injection quantity actual value is raised or reduced by means of the EDC adjustment values in order to reach the set point value. This is corrected by the activation time (opening time) of the injector. In total, the 5 EDC trim values are determined at idling, partial load, full load, 1st preinjection and 2nd pre- injection. Due to the multiplicity of possible combinations, a class formation for
the injectors is excluded.



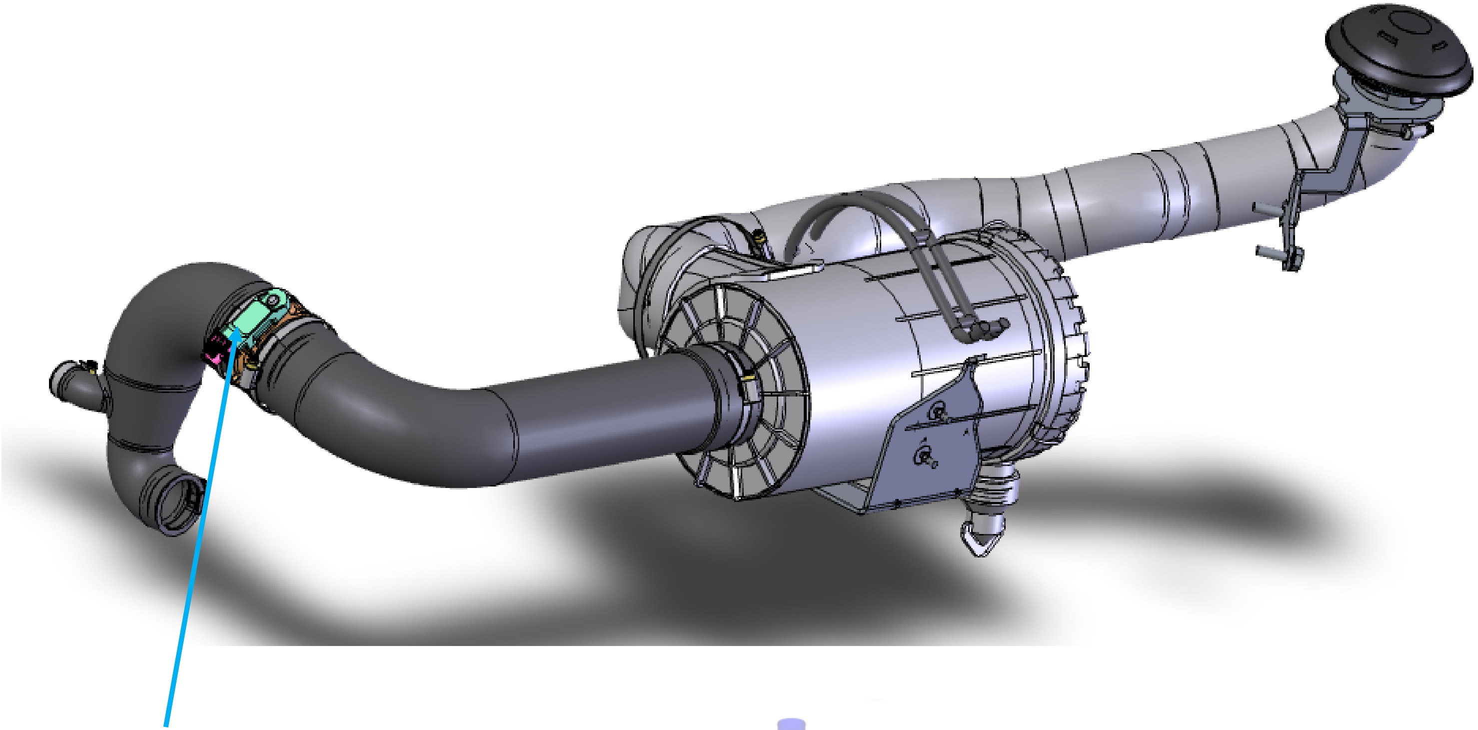
Turbo charger



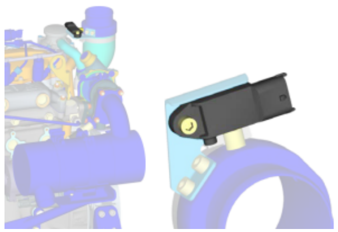
Fresh air system



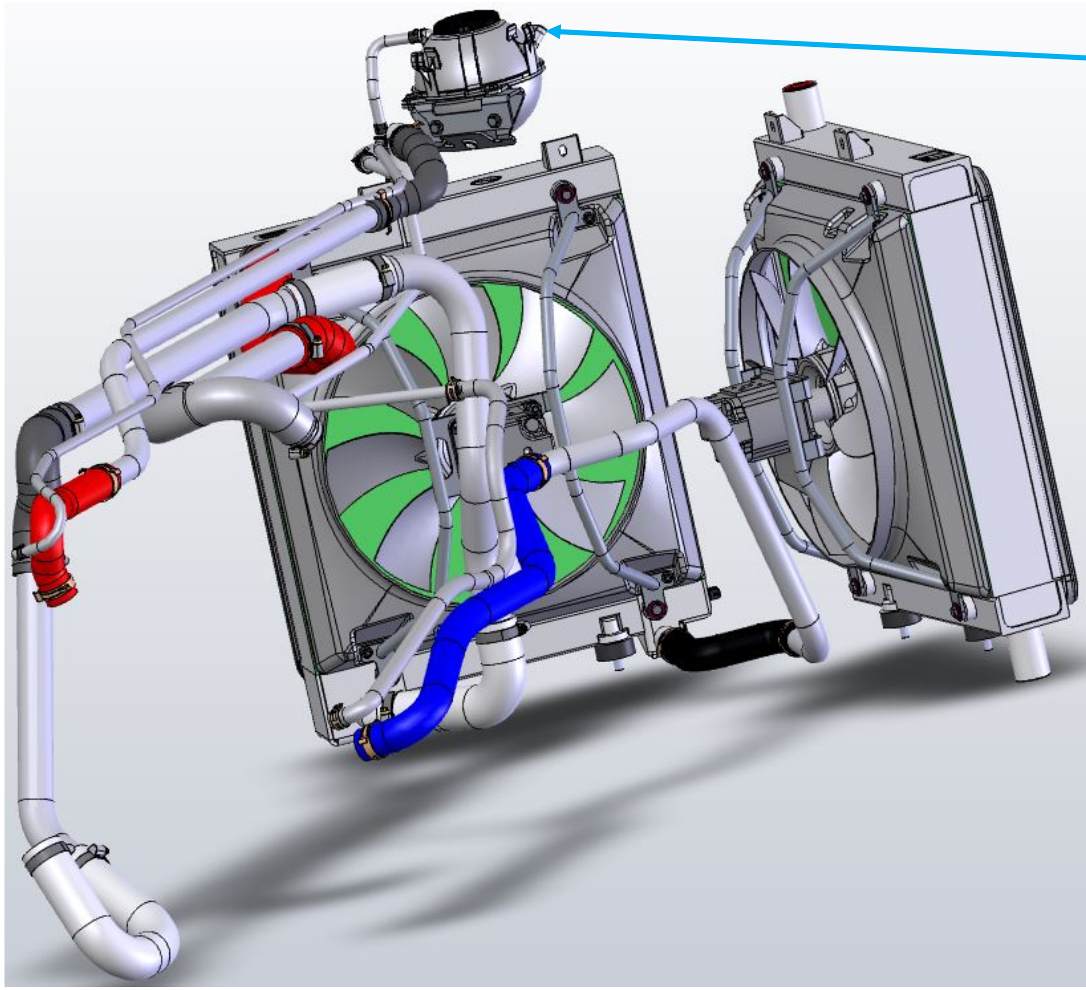
Intake air



Differential pressure sensor intake air B31
(Filter contamination)

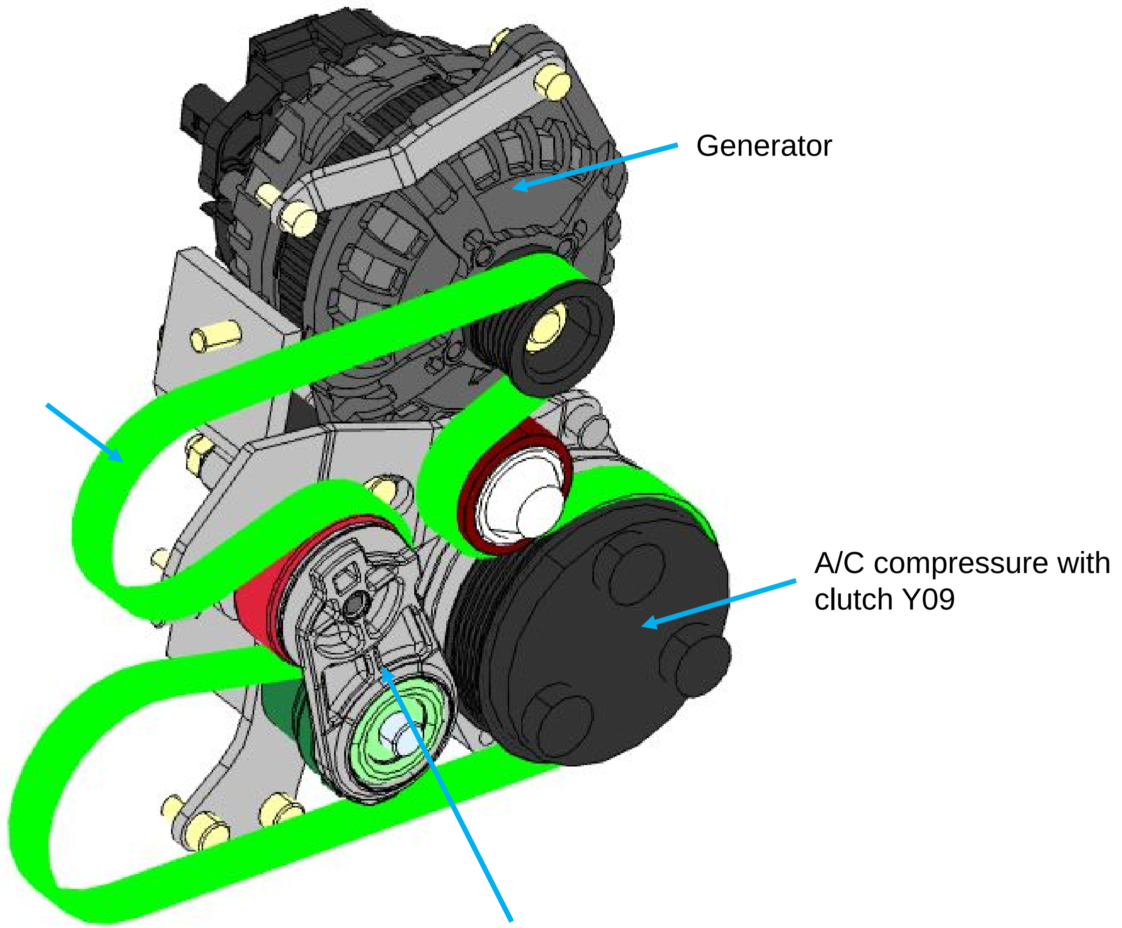


Cooling system

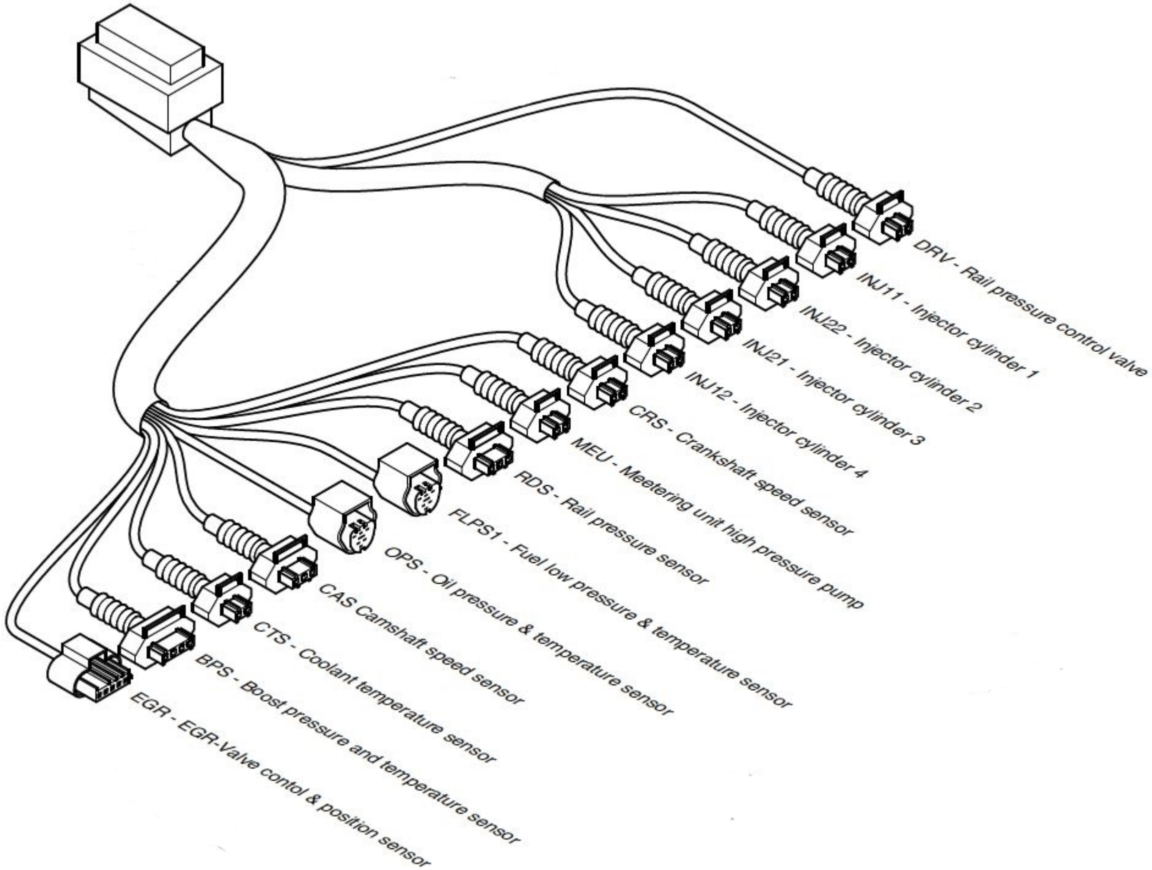


Level sensor coolant
B34

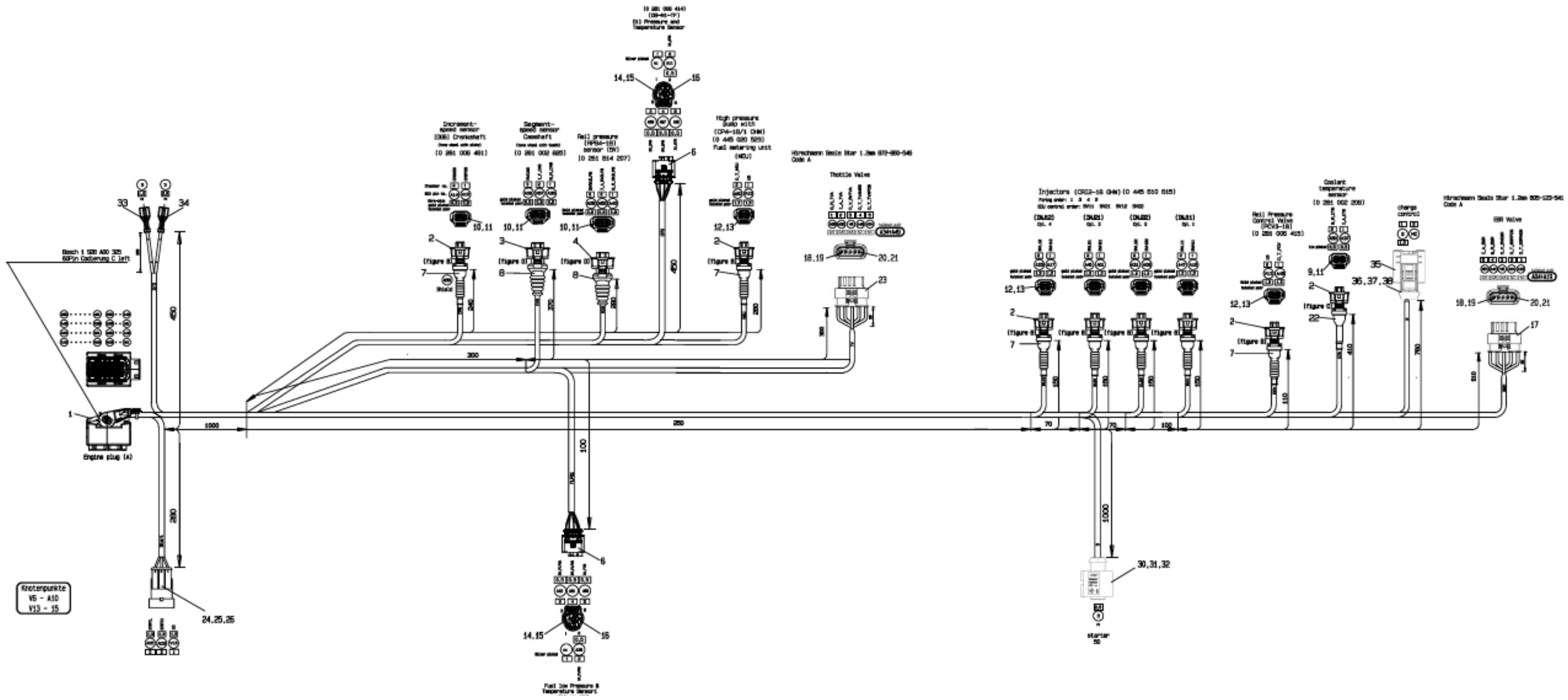
Generator and A/C



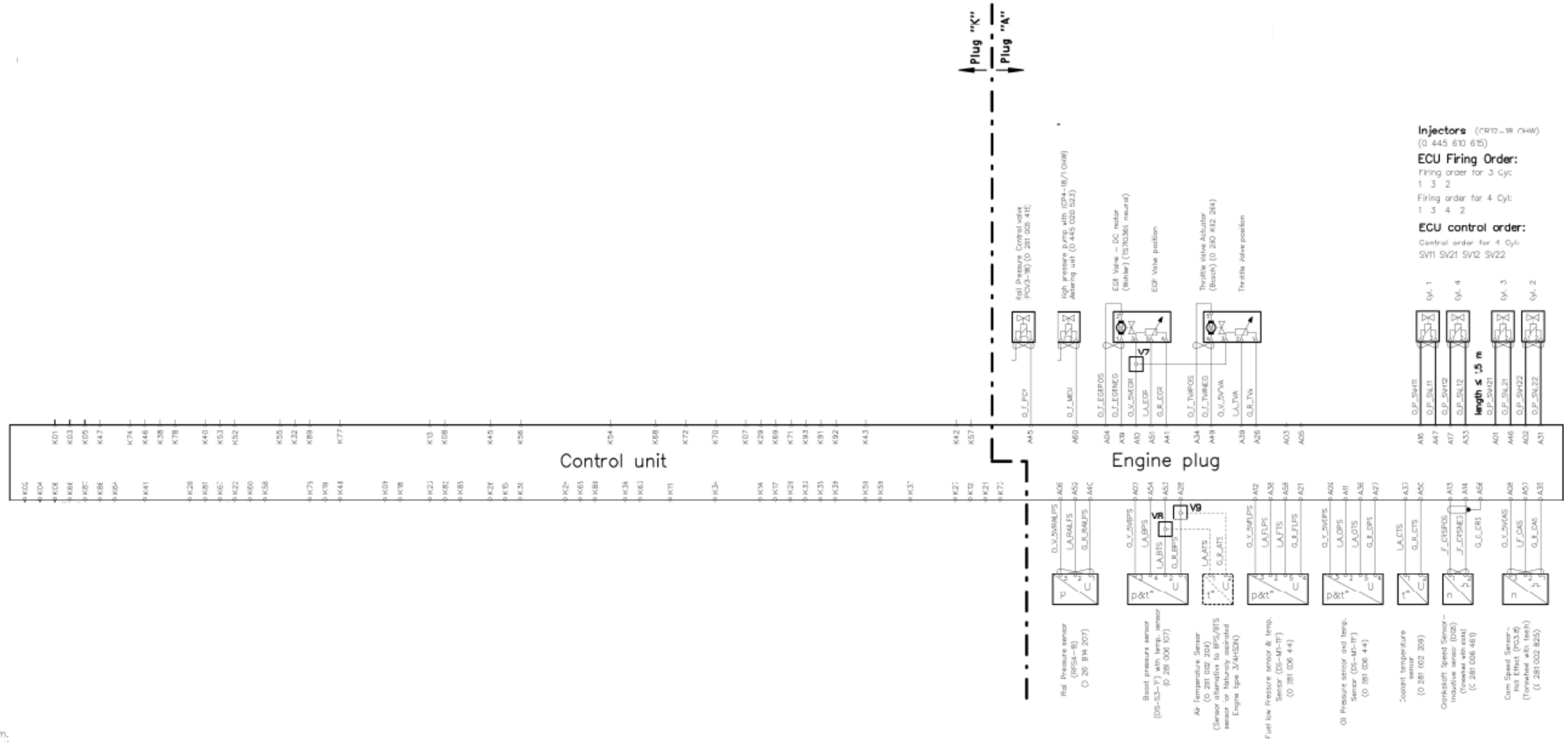
Engine harness



Engine harness

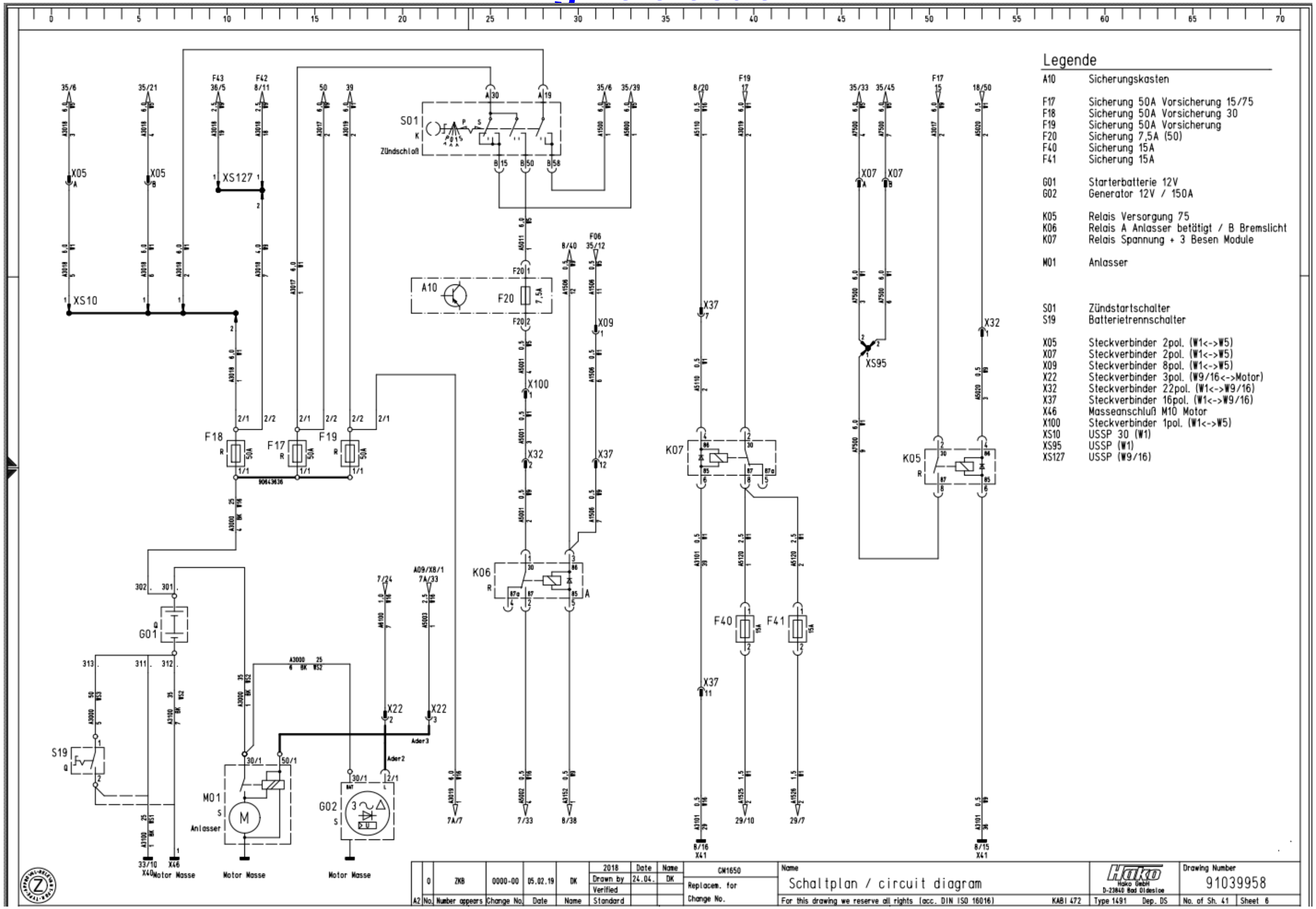


Engine harness

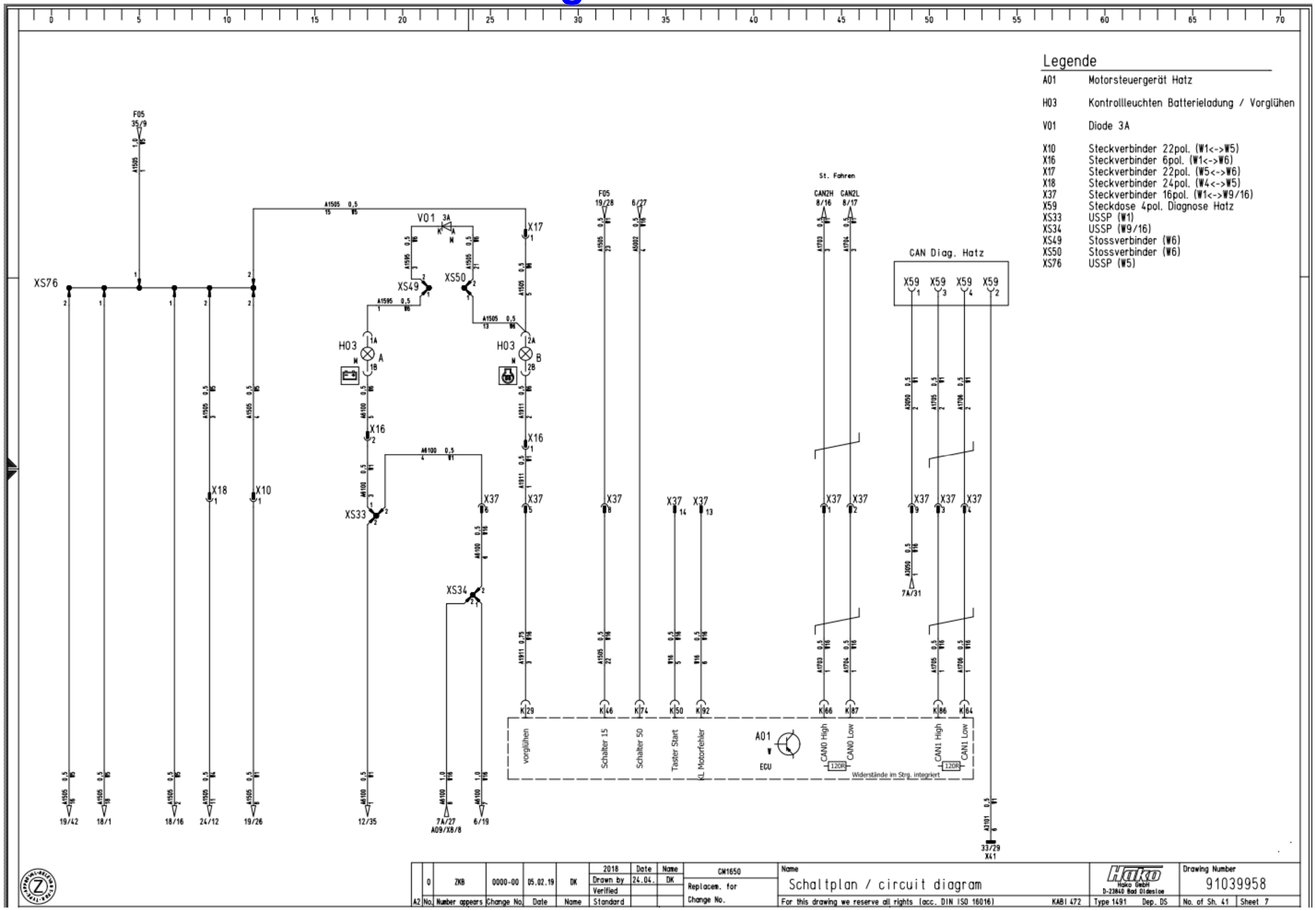


Hako Group

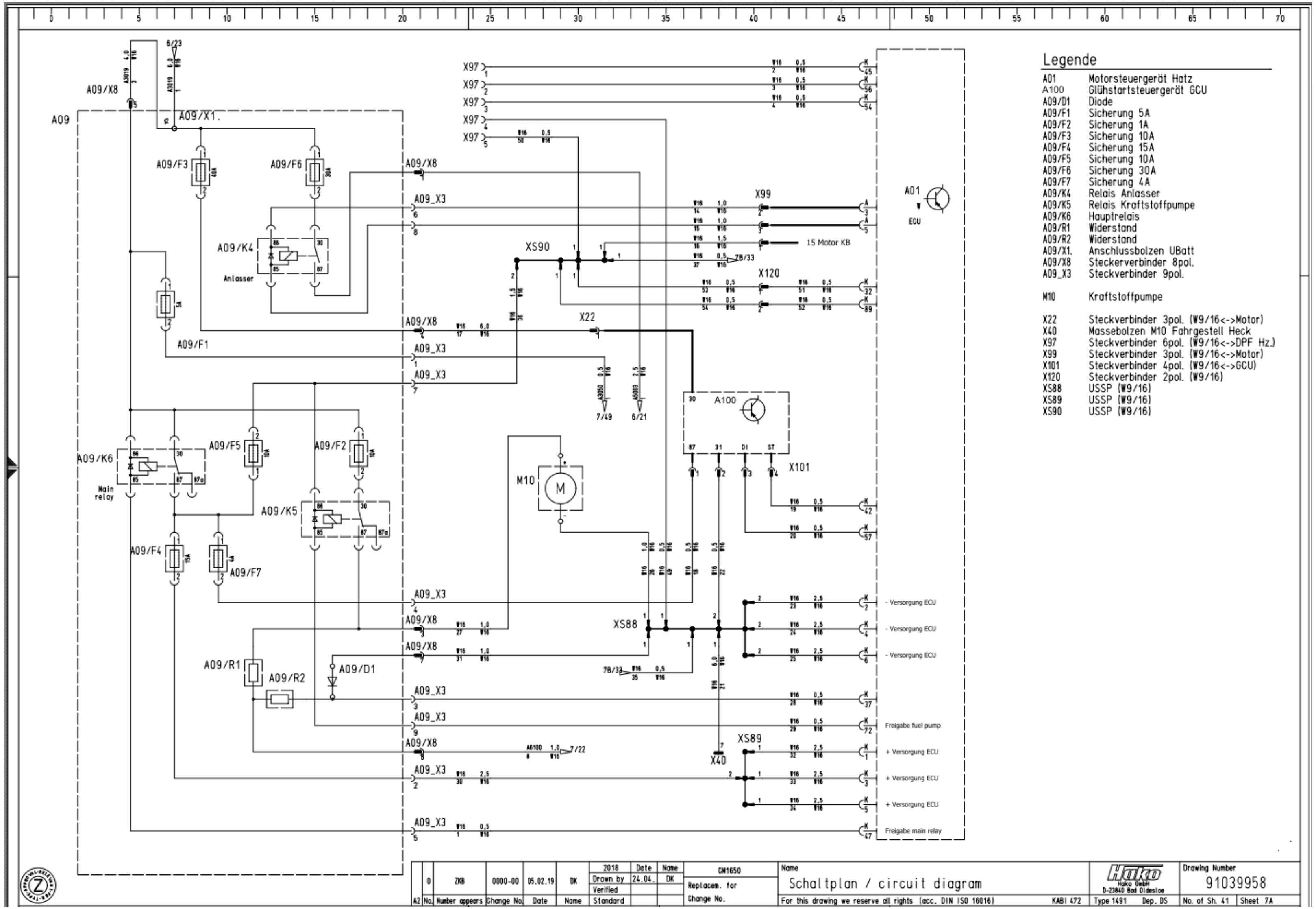
Engine electic



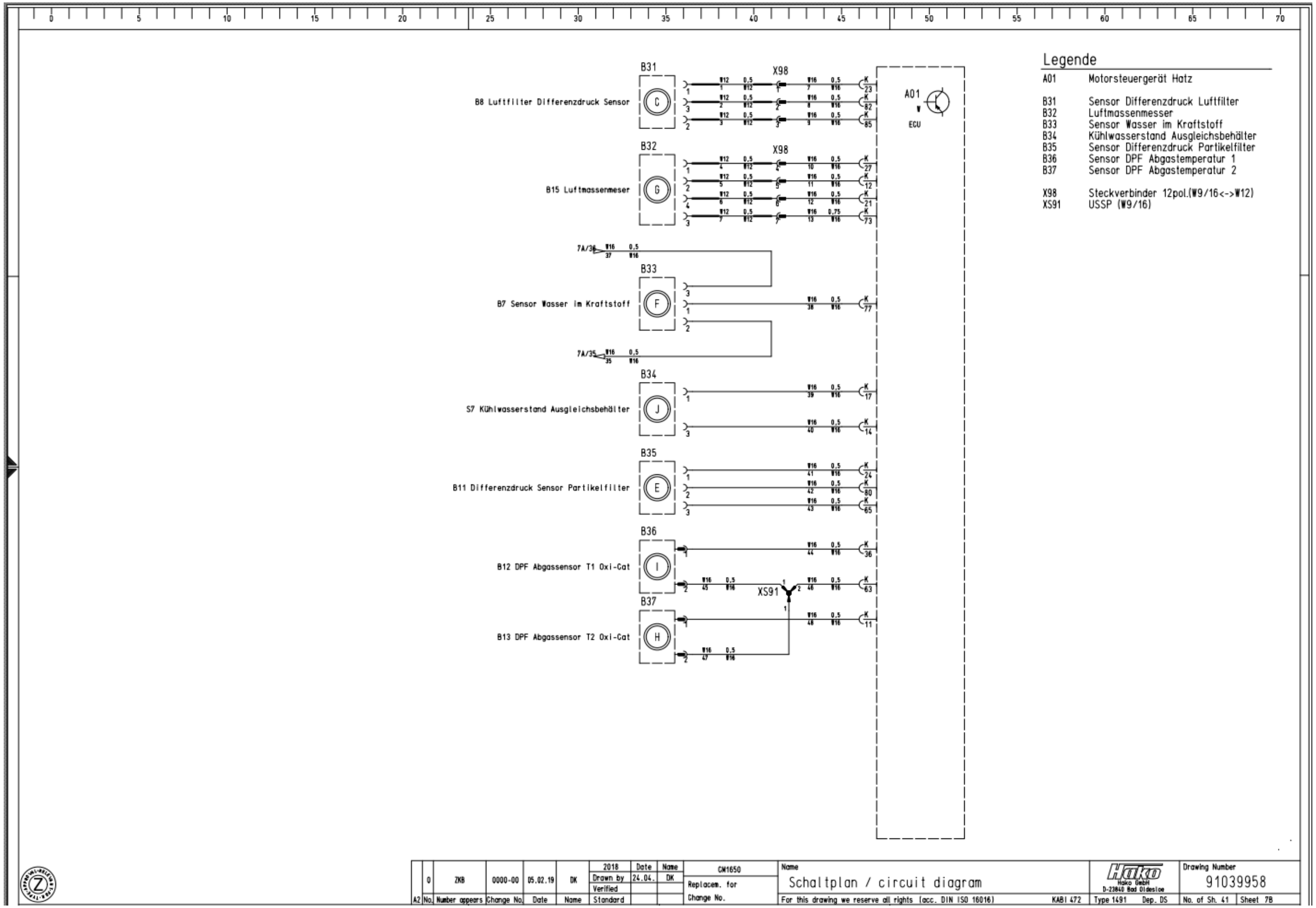
Engine electic



Engine electic



Engine electic



Basics of recondition systems

Passive regeneration:

Reduction of soot which happens as natural **chemical** reaction in a temperature range of 250-450°C. Not actively controlled by engine controller.

Active regeneration:

Reduction of soot which happens as **thermal** reaction in a temperature range of >550°C. In this temperature range you can only get through active engine management.

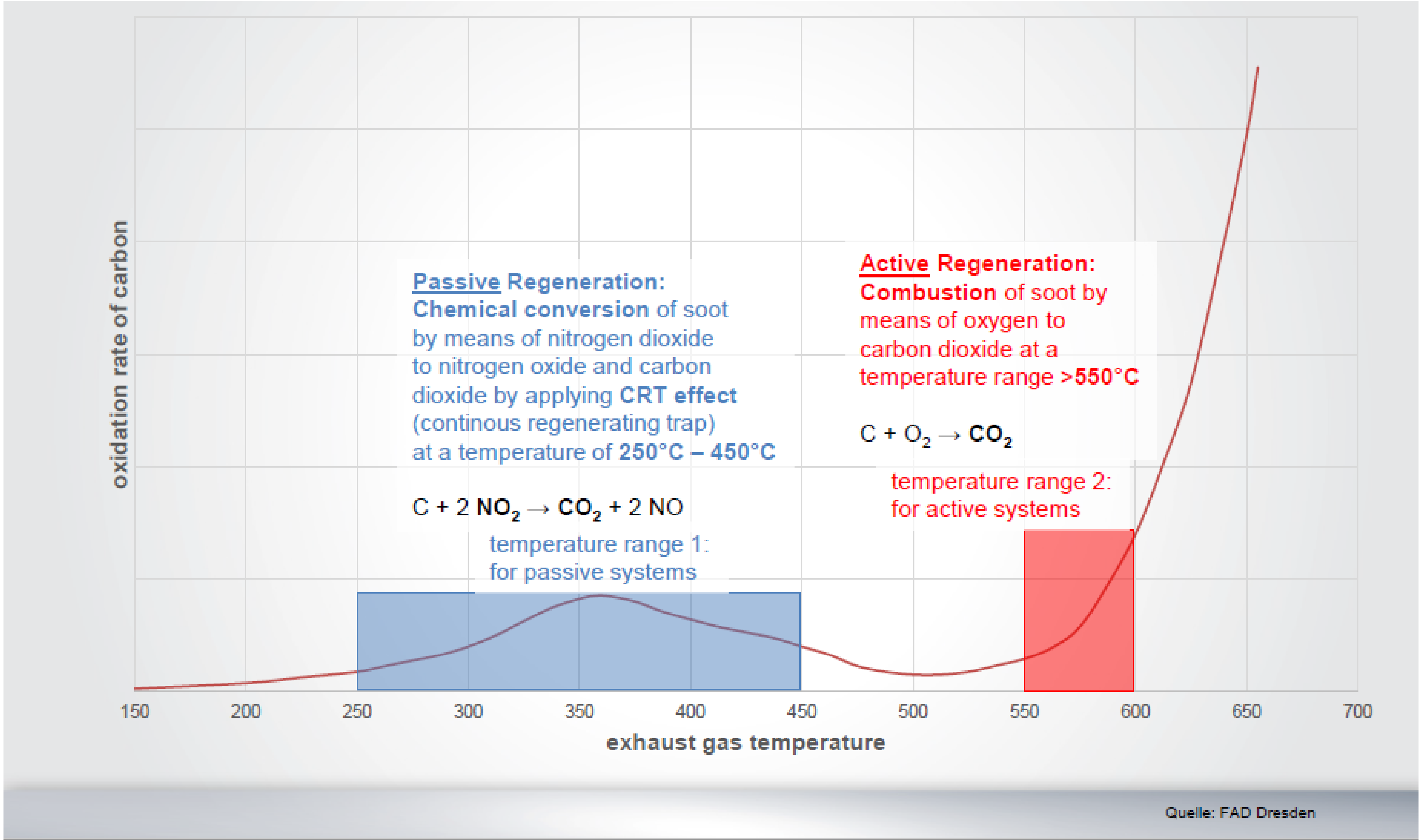
Dynamic regneration:

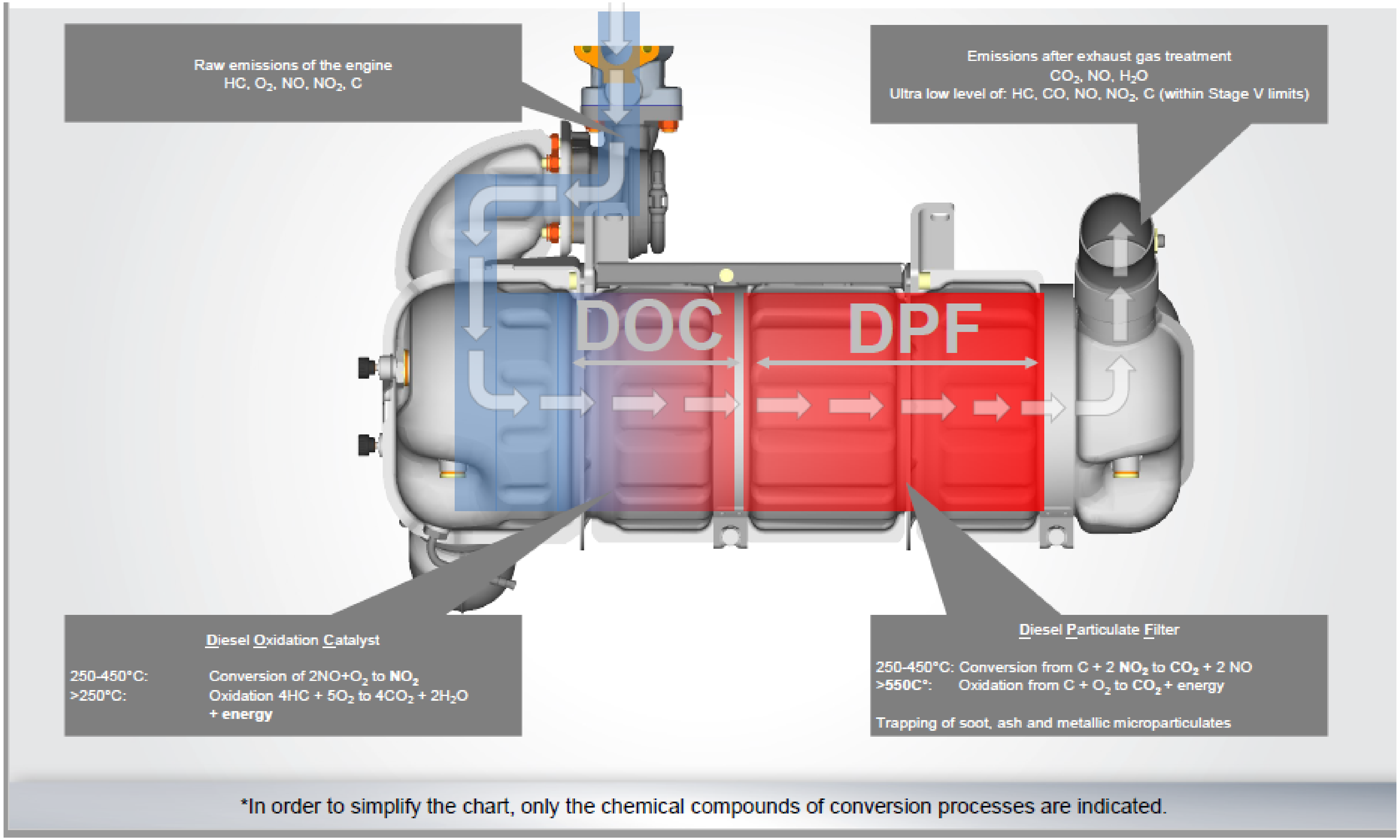
Active regeneration (see above) while standard machine operation.
No power loss, no downtime

Standby regeneration:

Active regeneration while machine downtime. Engine is running in a fully automatic cycle with a pre-set high-idle speed.

250-450°C: Conversion from C + 2 NO_2 to CO_2 + 2 NO
>550C°: Oxidation from C + O_2 to CO_2 + energy




Raw emissions of the engine
HC, O_2, NO, NO_2, C
Emissions after exhaust gas treatment
CO_2, NO, H_2O
Ultra low level of: HC, CO, NO, NO_2, C (within Stage V limits)
DOC
DPF
Diesel Oxidation Catalyst
250-450°C: Conversion of $2NO+O_2$ to NO_2
>250°C: Oxidation $4HC + 5O_2$ to $4CO_2 + 2H_2O$ + energy
Diesel Particulate Filter
250-450°C: Conversion from $C + 2 NO_2$ to $CO_2 + 2 NO$
>550C°: Oxidation from $C + O_2$ to CO_2 + energy
Trapping of soot, ash and metallic microparticulates
*In order to simplify the chart, only the chemical compounds of conversion processes are indicated.

	Level 0 	- Regeneration not necessary
90% **18,9g 25,2g** **7,7 g/l**		- Start Standby regeneration possible from **90% 18,9g 25,2g 7,7 g/l to 136% 29g 38g 11,5 g/l**
100% **21g 28g** **8,5 g/l** **60h**	Level 1 	- Regeneration necessary during running engine operation - Activation either via automatic release conditions or request switches by the operator - Inhibit switch must be disabled
124% **26g 35g** **10,5 g/l** **78h**	Level 2 	- Last chance standby regeneration by operator - Need Standby regeneration during vehicle standstill at low load - Activation via request switch by the operator - Inhibit switch deactivated - Neutral gear activ - Hand brake activ
Activation at 136% **29g 38g 11,5 g/l** **Healing at** **26g 35g 10,5 g/l**	Error path 	- "Emergency running" or "stop engine" via error path DFC_PFltSotMsMax activated due to possible damage to the particulate filter - Regeneration request only possible via diagnostic tool

Preconditioning for regeneration

- Temperature before DOC **< 280°C** beginning with preconditioning for regeneration.
  - Preconditioning actions:
    - Regeneration active on (from ECU SPN3700=1)
    - EGR closed
    - Injection strategy uses later injection timing
    - Air throttle valve control
  - If temp. before DOC doesn‘t exceed 280°C within 25 minutes (dynamic) or 15 minutes (standby), break for 120 minutes to avoid massive oil dilution

- Temperature before DOC **>280°C** starting regeneration process
  - Regeneration active on (from ECU SPN3700=1)
  - no preconditioning actions needed, directly go to next step of regeneration

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Regeneration activities

After preconditioning is done (temp. before DOC exceeded 280°C) the actual soot reduction process starts:

- Regeneration actions:
  - Regeneration active on (from ECU SPN3700=1)
  - EGR closed
  - Injection strategy uses later injection timing
  - Air throttle valve control

  (the four items above: Same actions than preconditioning)
  - Fuel injection near lower pistion position. This fuel doesn‘t burn in cylinder but is only transported to DOC and is reacting with the coating there for heating up DOC/DPF to 550-650°C.
  - Cylinder shut-off (2-cylinder mode, standby only)
  - speed increase to preset regeneration speed (standby only)
  - High temperature message on (from ECU SPN3698=x1x)
- At these temperatures the soot within the DPF gets burned till process counter reaches 100%
- When process counter reaches 100%:
  - EGR control active again
  - Injection strategy back to standard
  - Air throttle fully open again
  - High temperature message off (from ECU SPN3698=x0x)
  - Regeneration needed off (from ECU SPN3701=0)
  - Regeneration active off (from ECU SPN3700=0)

Disturbances during regeneration

I. **Engine stop**
- 5 minutes break after engine restart!

II. **Pressing inhibit switch on**
- No regeneration till inhibit switch is pressed off

III. **After inhibit switch off and 5 minutes break :**
- Temperature before DOC **>280°C** continuing with regeneration
- Temperature before DOC **< 280°C** beginning with preconditioning for regeneration

IV. **Permanent load drop so that necessary temperatures can not be hold:**
- 120min. break before dynamic regen starts trying, standby regen. immediatelly possible

V. **Standby Regeneration:**
Exceeding of 60Nm Torque limit / parking brake OFF / neutral gear OFF
- 5 minutes break for dynamic regeneration, Standby regeneration immediatelly possible

VI. **Engine starts derating**
- Need of regeneration ignored and soot level of 124% reached. Service regeneration is needed!