Tips & Technology
For Bosch Partners

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Diesel injection

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Diagnosis of injectors in a common rail system

The requirements for fuel injection systems on diesel engines are becoming increasingly challenging. Higher pressures, faster switching times and flexible adaptation of injection to the operating state of the engine make the diesel engine economical, clean and powerful. Consequently, diesel engines have also gained a foothold in the premium class of automobiles. One of these highly developed fuel injection systems is the *Common Rail (CR)* accumulator injection system. The major advantage of the common rail system is the great variety of possibilities available for configuring the injection pressure and injection times. This is achieved by decoupling pressure generation (high-pressure pump) and injection (injectors). The rail serves as the pressure accumulator.

The injectors, which permit short intervals between injections, are the central component of the common rail system (CRS).

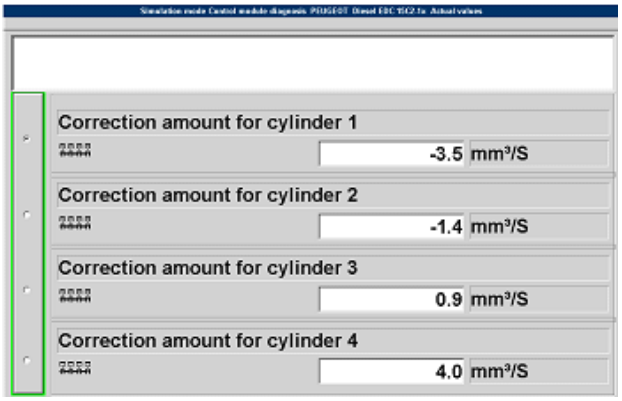
Diagnosis of injectors

1. Injection quantity comparison test

The injection quantity comparison test can be used to check for correct operation of the injectors as well as the condition of the injectors. This is a software-based injector test.

With the smooth-running control activated, the specific correction quantities for the individual cylinders are entered.

The smooth-running control equalizes the power differences between the individual cylinders (e.g. compression, injector throughput). The objective is to achieve the most "smoothly running engine" possible through adjustment. The correction quantities for the individual cylinders can be changed by +5.00 mm3/H to -5.00 mm3/H.



Quantity added (up to +5.00 mm3/H):

- Compression too low in this cylinder (power loss)
- Injector dirty (e.g. nozzle needle "sticks", nozzle orifices are "clogged")

Quantity removed (up to -5.00 mm3/H):

- Compression increase too high in this cylinder (e.g. deposits on the piston, incorrect exhaust valve clearance)
- Injector leaking (e.g. injector leaks, drips after injecting, nozzle washed out, solenoid valve detective)

2. Idle speed comparison

The idle speed comparison test can be used to check for proper operation of the injectors as well as the correct condition of the injectors. This is a software-based injector test. With the smooth-running control deactivated, the specific idle speeds of the individual cylinders are entered.

The smooth-running control now no longer equalizes the power differences between the individual cylinders (e.g. compression, injector throughput). The objective is to achieve the most "smoothly running engine" possible through adjustment. The correct speed differences for the individual cylinders can always be obtained from the currently valid ESI[tronic]-SIS manual.

Example:

Idle speed comparison	
Cylinder 1:	820 rpm
Cylinder 2:	790 rpm
Cylinder 3:	810 rpm
Cylinder 4:	780 rpm

Low speed:

- The cylinder is receiving a smaller amount of fuel
- Compression too low in this cylinder (e.g. piston rings, wrong valve clearance)
- Injector leaking (e.g. injector leaks internally, nozzle needle "sticks", nozzle orifices are "clogged")

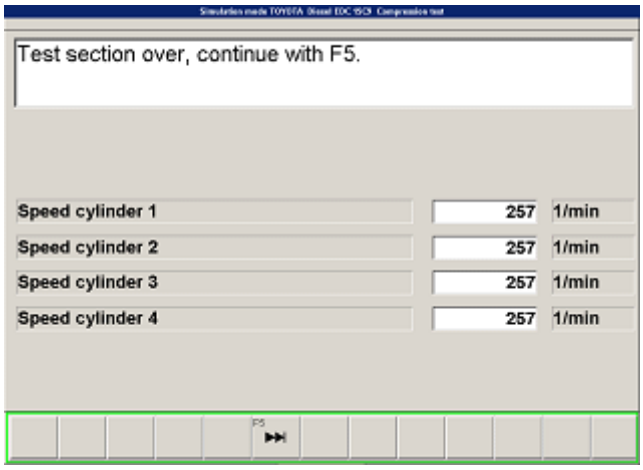
Higher speed:

- The cylinder is receiving a larger amount of fuel.
- Increased compression in this cylinder (Increased power)
- Injector leaking (e.g. injector leaks, drips after injecting, nozzle washed out)

3. Compression test

The compression test can be used to check the cylinders for correct operation as well as their condition. This is a software-based engine compression test. With injection deactivated, the specific engine speeds for the individual cylinders are entered.

During the compression test, the engine is prevented from starting by the software. Uniform compression pressure is of major importance for optimal, smooth running of the engine. The correct speed differences for the individual cylinders can always be obtained from the currently valid ESI[tronic]-SIS manual.



The cylinder has a higher speed:

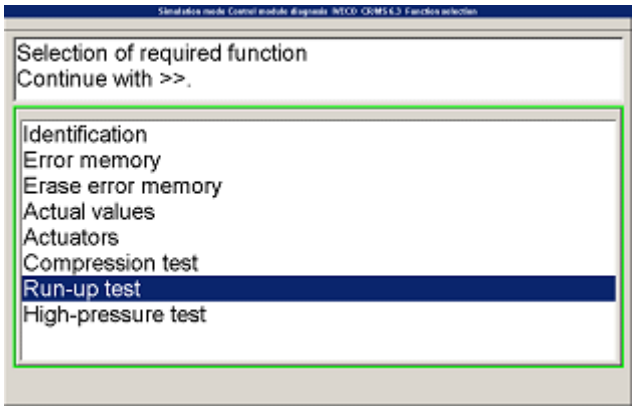
- Compression too low in this cylinder (e.g. defective cylinder head gasket, piston rings, valves, ...)
- Leak at injector
- Leak at the glow plug

The cylinder has a lower speed:

- Increased friction in this cylinder (e.g. sticking piston, connecting rod damage, inadequate lubrication, ...)

4. Run-up test

The run-up test can be used to check individual cylinders for correct operation. With this function, the time needed to achieve a certain speed is measured with a specified rail pressure, injection quantity, charge-pressure actuator and exhaust gas recirculation from the remaining cylinders by intentionally deactivating cylinders.



Prerequisites for conducting the test:

- No error entries stored in the engine control module
- Engine has reached operating temperature
- No loads are connected (e.g. air conditioner, ...)
- Vehicle with particulate filter, particulate filter regeneration not initiated

During the test, the injection quantity is constant and the number of injections is defined precisely.

First measurement:

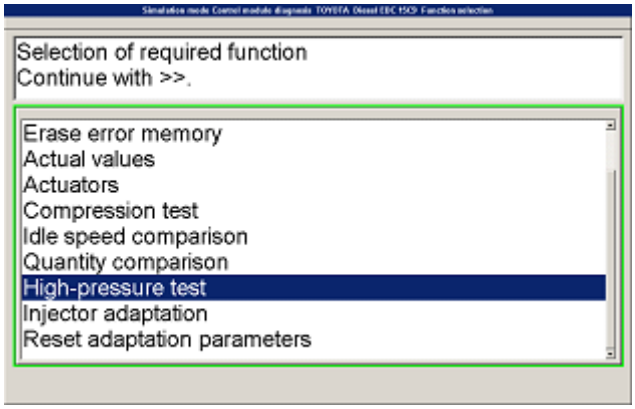
Engine accelerates from the lower to the higher speed range. During this acceleration, all injectors are active.

Second measurement:

Engine acceleration is repeated. Injector on 1st cylinder is deactivated; as a result, the final speed is lower and the time measured longer than the 1st measurement. If there is no reduction in the final speed or lengthening of the time measured, the injector or flow limiter is defective. Measurement 2 is repeated for all cylinders, enabling a cylinder that is not working properly to be selected.

5. High-pressure test 1

The high-pressure test 1 can be used to check the high-pressure pump for correct delivery rate and pressure build-up as well as the high-pressure fuel system for internal and external leaks. With this function, the maximum system pressure is built up through targeted actuation of the metering unit and pressure regulating valve at a manually set engine speed of about 3500 rpm.



Prerequisites:

- Metering unit and pressure regulating valve are actuated
- Maximum system pressure is set/built up
- Increase engine speed manually to about 3500 rpm

Evaluation:

If it is possible to build up the maximum system pressure, it can be concluded that the high-pressure pump is operating correctly. If no leakage is detected (internal or external) during the test, it can be concluded that the high-pressure fuel system is tight. If the maximum system pressure is not built up, the source of the problem may be the fuel supply, a faulty metering unit or an internal/external leak.

6. High-pressure test 2

The high-pressure test 2 can be used to check the high-pressure pump for correct delivery rate and pressure build-up as well as the high-pressure fuel system for internal and external leaks. With this function, the time needed by the high-pressure pump to build up the maximum system pressure in the high-pressure fuel circuit is measured at 4 different engine speeds through targeted actuation of the metering unit and pressure regulating valve.

Prerequisites for conducting the test:

- No error entries stored in the engine control module
- Engine has reached operating temperature
- No loads are connected (e.g. air conditioner, ...)
- Vehicle with particulate filter, particulate filter regeneration not initiated

High-pressure test 2 is divided into 3 steps, with the performance of the high-pressure pump, the adjustment curve of the pressure regulating valve and operation of the element switch-off valve (CP 1) being checked in 5 different speed ranges. In 4 speed ranges, it is possible to evaluate the performance of the high-pressure pump by increasing the rail pressure to its

maximum value and then the adjustment curve of the pressure regulating valve by subsequently lowering the rail pressure again in steps. In the 5th speed range, operation of the element switch-off valve is checked.

Test procedure for high-pressure test 2:

- Approach speed
- Increase pressure setpoint and measure time for pressure buildup
- Reduce pressure setpoint and measure time for pressure reduction
- Repeat the process five times at four different speeds
- At the last speed, the test is repeated with injection shut off while the pressure decreases

Special aspects of high-pressure test 2:

- Control is by means of the engine control module
- Evaluation takes place in the engine control module
- Assessment is performed in the diagnostic tester
- Specification of test parameters by either the control module or diagnostic tester

Diagnosable errors:

Pressure build-up too slow, but pressure reduction OK:

- Poor pump efficiency
- Pump delivering from only one or two pistons
- Flow through metering unit too low
- Pre-supply pump delivering too little fuel or too little pressure

Pressure reduction too slow:

- Metering unit (ZME) leaking
- Pressure in return too high
- Suction valve NOK

Pressure reduction too fast:

- Severe leakage at injectors or pressure regulating valve (return quantity)
- External leakage in high-pressure circuit
- Leakage through high-pressure pump

Tools for repairing common rail systems

Return flow measuring unit

Used to diagnose individual injectors

Item number 0 986 612 950

Various tools for CR injection systems

Impact extractor	Item number 0 986 612 727
Injector release tool	Item number 0 986 611 481
Sealing tool	Item number 0 986 612 734
Brushing unit	Item number 0 986 612 729

Diesel set 1

Used to test the low-pressure fuel circuit of in-line pumps and up to the latest common rail systems

Included with delivery:

- A test pressure line for return pressure measurements on Bosch piezo injectors
- Two test hoses with connection couplings
- 10 Y-connection combinations with the original manufacturer couplings
- Miscellaneous drain valves
- Dual banjo bolts
- Hollow threaded studs and banjo bolts with insert nipple
- One pressure gauge for a measuring range from -100 to 500 kPa
- One pressure gauge for a measuring range from 0 to 1600 kPa
- Various test pressure lines and Y-hoses for additional commercial vehicle applications available as accessories

Item number 0 986 613 100

Diesel set 2

Used to remove air from the system

Content:

- Double-acting high-capacity hand pump
- Suction line
- Fuel return line
- Set with adapters for connecting to various bleeding points

Item number 0 986 610 234

Diesel set 3

Used to test the rail pressure sensor

Content:

- Digital pressure display with charger
- Pressure pickup module with rail pressure sensor
- Connecting lines
- Additional container
- Threaded rings and various cones

Item number 0 986 613 200

More information on this subject is available in the training course "Diagnosis of Bosch Common Rail Systems for Automobiles" (Course No. 1987726292).

You can find this course and additional information on our training courses at www.automotive-campus.com.