MSCR01

DIESEL ENGINE CONTROL SYSTEM CR / EDC 15

https://autoedu.lt/

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CONTENT

1. SAFETY REQUIREMENTS

General safety requirements

Attention:

Before using the training board, take a look at the user manual.

Training equipment may only be used for the training purposes specified in the instructions.

The staff conducting the training (lecturer, teacher, instructor and others) must be familiar with the instructions for the training equipment, know the methods and principles of use, settings, control of the equipment, be able to switch off (stop) the training equipment in an emergency.

The training staff (lecturer, teacher, instructor and others) acquaint those working and learning with the training equipment with the work safety requirements.

It is forbidden to work with educational equipment for children, unqualified staff.

It is forbidden to work with training equipment for persons under the influence of alcohol or other psychotropic substances.

It is forbidden for people who do not have the appropriate qualifications to open the electrical input boxes, connect or change anything there.

It is prohibited to improve, modify or otherwise change the design of training equipment without the written consent of the manufacturer.

The connection of the power supplies of the training equipment is performed according to the instructions provided in the section "Power supplies".

Do not ignore the information on possible dangers provided by the warning signs on the training equipment. Beware of the hazards indicated on the warning signs.

The training equipment must be switched off completely during cleaning work.

It is forbidden to wash the training equipment with running water or any chemical cleaning agents.

It is forbidden to clean the electronic components of the training equipment with damp cloths.

The equipment must be completely switched off during maintenance and repair work on the training equipment.

If the training equipment consists of several parts, the parts are first connected to each other and only then the power supply is connected.

It is forbidden to disconnect the power cords of the electrical elements of the training equipment. Careless or repeated disconnection of these wires will result in damage to the connectors and loss of contact. The desired electrical measurements can be performed at specially designed and installed banana-type connectors in the training equipment. Banana type connectors are resistant to multiple joints.

Before working with training equipment, check that:

- Equipment is not mechanically damaged, broken;
- All protective shields are assembled;
- All heated, rotating parts (e.g., heating plugs, pulleys, gears, etc.) are covered;
- All components (e.g., wires, jumpers, fuses, handles, etc.) are available;
- Sufficient technical fluids (e.g., brake fluid, oil, coolant, etc.);
- Liquids do not leak through the joints;
- The equipment components are free of foreign bodies;
- Undamaged power cords;
- Neat power supplies (battery or stand power supply);
- Power supplies are properly connected (e.g., battery terminals are screwed on, polarity is not mixed, proper power supply is used according to local electrical installation standards);
- The training equipment is properly constructed and locked (e.g., the equipment is placed on a sufficiently solid base, the transport wheels are locked);
- During operation, the equipment will not pose any danger to those working with it and the surrounding staff;
- There are other factors not specified in the instructions that may endanger the health of personnel working with the equipment and others.

Observe during work with the equipment:

- The noise emitted by the equipment is characteristic of such a work process (no extraneous sounds);
- No leakage of liquids from the equipment;
- Odour of glowing, burning objects;
- Power supplies are working properly;
- There are no factors or processes other than those specified in the instructions that could endanger the health of personnel working with the equipment or other persons.

2. GENERAL INFORMATION

2.1. Purpose of training equipment

Teaching equipment for educational activities. It is a visual tool for explaining and demonstrating the structure and operation of various automotive parts, assemblies, structures, systems. The equipment is used as a teaching and learning tool for monitoring and analysis of various car systems work processes. It is possible to perform various measurements of the system installed in the training equipment, parameters of ongoing processes, to perform fault simulations, to diagnose. A variety of laboratory tasks can be performed using the training equipment. The equipment is designed and manufactured in order to provide learners with the clearest and most convenient information about the structure of the unit, the composition of the system and the principle of operation.

The training equipment is intended for demonstration, training and learning of the design, construction, principle of operation, settings and adjustments of the Common Rail diesel fuel injection system. With this stand it is possible to change the engine operating parameters, monitor fuel injection. The bench can simulate the change of the following parameters: air mass, air pressure, coolant temperature, crankshaft speed, accelerator pedal position. When the parameters change, the values of the signals entering the motor control unit change. When evaluating the change of the incoming signals, the engine control unit changes the signals supplied to the actuators accordingly: the amount of fuel injected changes, the cooling fan is switched on, and so on.

2.2. Training equipment parameters

Length	1360 mm (I part) and 800 mm (II part);
Width	510 mm (I part) and 500 mm (II part);
Height	1820 mm (I part) and 1500 mm (II part);
Weight	142 kg (both parts);
Power supply	230 V 50 Hz household electricity network

2.3. Transport and storage conditions

Training equipment is installed in a dedicated box. Do not overturn or lay the equipment during transport. During transport, the equipment must be protected from falling, tipping, shocks, humidity, temperature, vibration.

Training equipment with its own chassis must be equipped with locked transport wheels during training and storage (including transport). The wheels can only be unlocked when the training equipment is relocated.

Export or import procedures must take into account the legislation in force between the countries. Import export procedures and various taxes apply to various technical fluids, oils, batteries, tires and more.

Training equipment must be stored in a room with a minimum ambient temperature of at least +10 ° C. Relative humidity not more than 60 %.

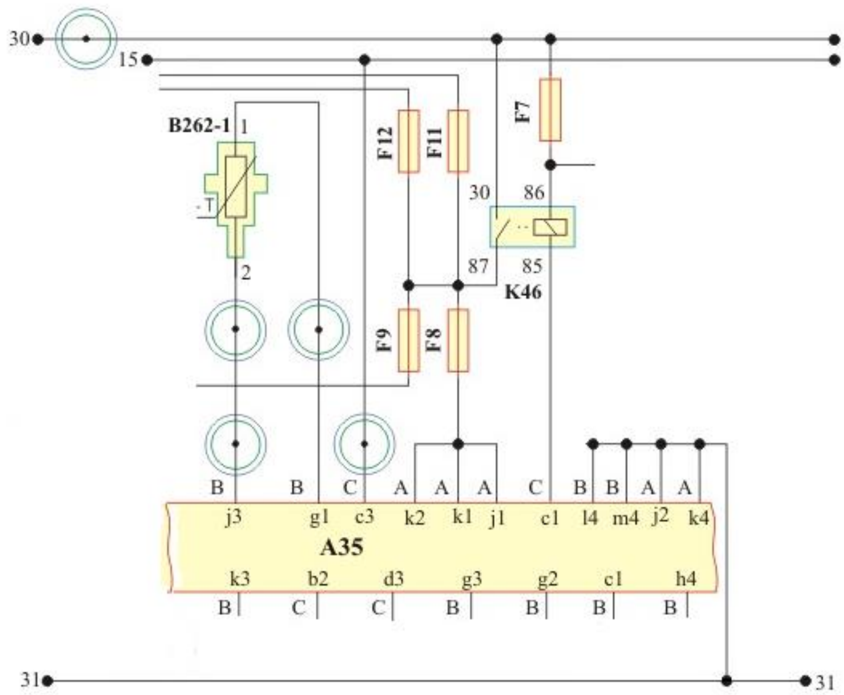
Training equipment must not be exposed to direct sunlight. Equipment must be covered by protective equipment if it is stored in a place exposed to direct sunlight.

Unused training equipment is kept completely switched off. The training stands are switched off with the control key and by disconnecting the power supply.

The stand must be run at least once a month and work for at least 20 minutes. It is not recommended to leave the stands unused for more than 2 months. period. If it is necessary to leave the stands unused for more than two months, they must be properly prepared and preserved.

2.4. Symbols and markings

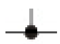
Automotive symbols for marking wiring diagrams and components are used in the training equipment. The figure below shows an example of component marking in a wiring diagram.



Example of wiring diagram and component marking.

Marking of wiring diagrams:

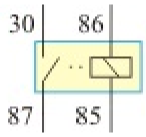
Black line connecting wires;

 the wires are connected to each other;

30 a numbered wire is an electrical circuit having a constant voltage of +12 V from a battery;

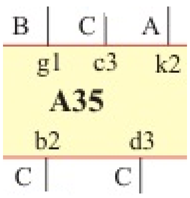
15 the numbered wire is an electrical circuit in which a +12 V DC voltage is turned on by the ignition key;

31 is the electrical circuit connected to the car body and the negative terminal of the battery (ground ⏚);

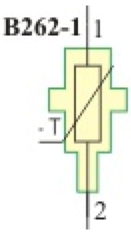


4-pin relay. Numbers 86 and 85 denote the contact numbers on the relay through which the relay electromagnet connecting contacts 30 and 87 is controlled. Numbers 30 and 87 denote contact numbers through which a current of 30 A (or greater) may be transmitted;

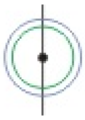
Fuse. Fuse marking symbol. In the circuit it is an F7 fuse.



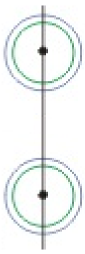
A35 vehicle system (unit) control unit (computer) (e.g., engine control unit, airbag control unit, brake ABS control unit or other). The letters A, B, C denote the connection used to connect the electrical wiring to the control computer. The symbols g1, c3, k2, b2, d3 denote the contact of the control unit connector.



B262-1 Temperature Sensor 1. Numbers 1, 2 temperature sensors contact numbers.



A 4 (2) mm banana was installed in the training equipment and connected to that cable. connector (socket) for connecting measuring equipment or a jumper.



Two banana connectors (sockets) are mounted on the cable for connecting the jumper. A jumper removed from the connectors breaks the circuit of this wire. Electric current cannot flow. The wiring diagram of the stand does not show this disconnection of the cord, because in real cars banana connectors are not installed. These connections are installed in the electrical circuit of the training equipment, enabling measurements to be made and faults to be simulated.

Jumper. Connector with 2 banana type 4 (2) mm contacts (plugs) at the bottom and one banana type 4 (2) mm contact (socket) at the top. All three contacts inside the jumper are connected to each other.

Attention:

It is recommended to connect measuring wires with 4 (2) mm banana type contacts (plugs) to the training equipment when performing various measurements of electrical parameters.

2.5. Preparation and use of equipment

The training equipment is maintained as conventional mechanical, hydraulic, pneumatic, electrical machines and systems. Training equipment requires minimal maintenance and service.

All components of the training equipment must be controlled and ensured.

Damaged, broken parts, blown fuses, damaged connecting cables and other parts are replaced with new ones.

In the case of training equipment with internal combustion engines, gearboxes and air-conditioning systems, maintenance and service shall be carried out in accordance with the vehicle used in the training equipment.

Only technical fluids of the appropriate quality and technical specification (engine, transmission oil, coolant, brake fluid, etc.), quality filters and other spare and component parts must be used for maintenance and service work on the training equipment.

When preparing training equipment for work, it must be properly constructed and secured. Equipment with its own stand or chassis is built on a level and solid floor. The equipment transport wheels are locked by locking the brakes.

The technical condition of the equipment, attachment of protective shields, complete set and other things are checked. For more information on safe work requirements, see the section "Occupational safety → Before working with the training equipment, check that:".

The position of the emergency stop switch is checked. If the training equipment has been stopped in an emergency, the emergency stop switch will remain depressed and the equipment will not start. When the emergency stop switch is unlocked, it pops out when its upper part is turned clockwise (the upper part moves to the right).

Emergency stop switch

If the emergency stop switch needs to be used, it is pressed with your finger or palm. There is no need to turn anything.

The training equipment is activated by main on-off button and ignition key.

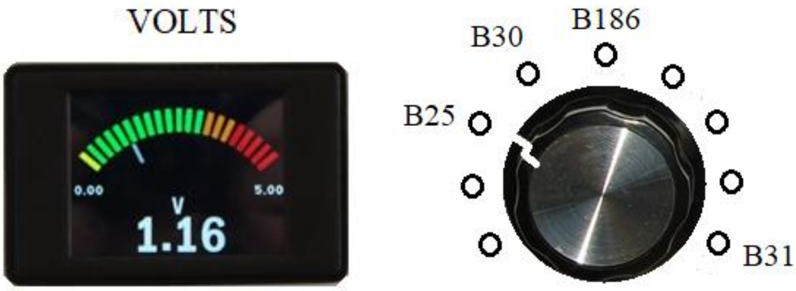
Main on-off button and ignition key

The training equipment is equipped with a light indication, in which a yellow LED (PWR) indicates that the equipment is connected to the power supply, a red LED (ON) - the ignition is on, a green LED (RUN) - the equipment is started and running.

Equipment with ignition key, operated in the same way as a normal car. In the middle position, the training equipment is switched off. In the first locked position, turning the key to the right turns on the ignition. Turning the key further to the right (position without locking) activates the starter. The key rotation to the left from central position has got fixed position which does not have perform any function

Training equipment is made for the study and demonstration of parts, assemblies, systems, engine structure, construction, operation. The systems installed in the training equipment are fully operational. In equipment where it is not possible to have real vehicle operating parameters (e.g., air mass, coolant temperature etc.), these parameters are simulated. Means of regulation and setting are provided to simulate real operating parameters.

The training equipment is equipped with voltmeters for monitoring and measuring sensor signals. Multiple sensor signals are displayed on one screen. The setting wheel selects the signal of the desired sensor to be displayed.



TFT voltmeter and setting wheel

When the setting wheel is selected on B25 position (air temperature), then on the TFT voltmeter will be displayed the voltage signal of this sensor. When the setting wheel is selected on B186 (fuel pressure sensor), then will be displayed the fuel pressure value.

By learning diagnostics, car control computer system scanners (computer diagnostics), it is possible to activate the execution components. This item can be activated depends on the available diagnostic and training equipment.

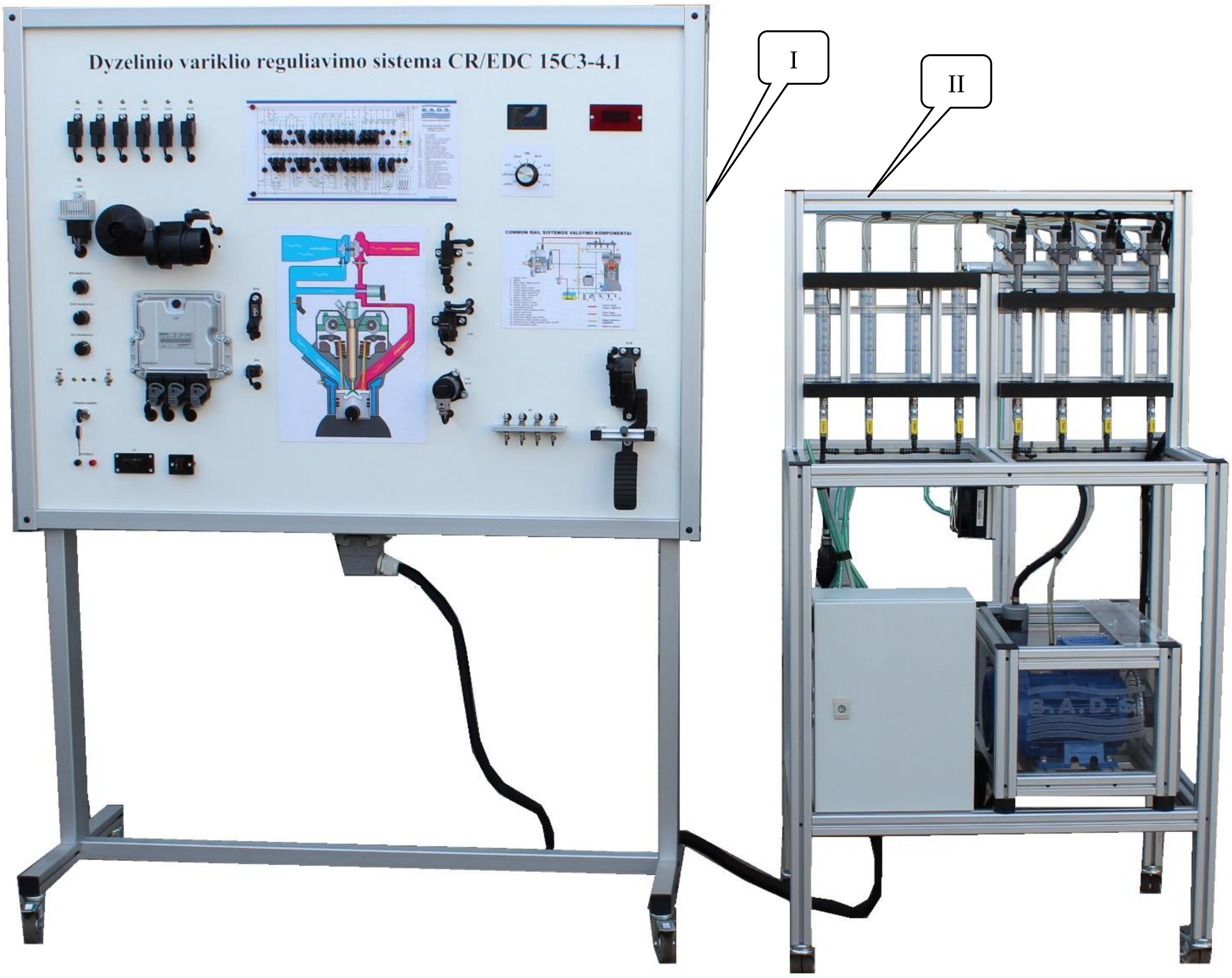
With the help of system scanners, written fault codes / messages can be found in the car's control computer memory. These codes / messages are stored in the memory when the sensor, the actuator, the wire is broken, the contacts are lost, the jumper is removed from the circuit. All fault codes can be deleted from the car's control computer memory using system scanners. Fault codes are stored in the memory, for example: when the jumper is disconnected when the training equipment is switched on, the signals of the speed sensors do not match, due to voltage fluctuations and other real or simulated malfunctions. As in cars, errors can only be cleared from the control computer's memory when the fault has been physically rectified (e.g., jumper inserted, cable connected, faulty sensor replaced, etc.).

3. TRAINING EQUIPMENT

3.1. General overview of training equipment

A general view and structure of the training equipment is given in the illustrations below.

Training - demonstration stand for Common Rail fuel supply system internal combustion engine and EDC 15 engine control unit operation demonstration and training. At this time, it is possible to change the engine operating parameters, monitor fuel injection. Changes in the following parameters can be simulated: air mass, air pressure, coolant temperature, crankshaft speed, accelerator pedal depression. When the parameters change, the signals entering the motor control unit change. When evaluating the change of the incoming signals, the engine control unit changes the signals supplied to the actuator accordingly: the amount of fuel changes, the cooling fan is switched on, and so on.



The first and the second parts of the stand.

The stand includes two parts. In the first part of the stand, most sensors and actuators, engine control unit, diagnostic connector, electrical diagram and accelerator pedal are mounted. In the second part of the stand, power supply of the stand, electric motor, fuel pump, injectors, measuring cylinders and some sensors are mounted. Both parts of the stand are mobile as they are fitted on the wheels.

Both parts are interconnected by the cable. This cable has got a connector, which is plugged to the bottom part of the first stand. The second part of the cable is connected to the second part of the stand and cannot be disconnected.

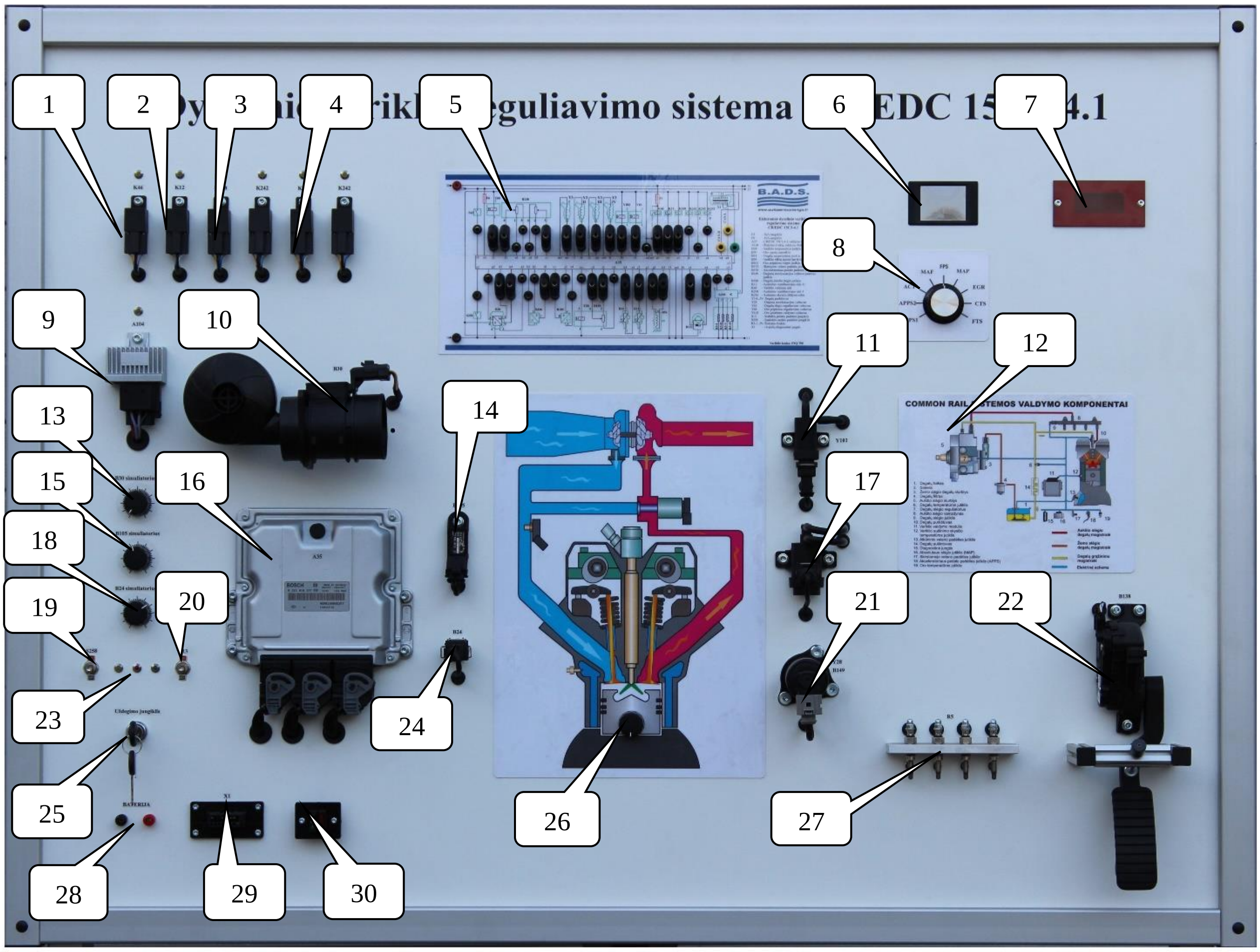
The connector of the electric part of the stand

The cable connector that interconnects both parts of the stand is suitable to connect only one position. It is impossible to connect the parts incorrectly because of the special design of the connector. When it is connected, it is blocked by bending the right and the left fixers. Before disconnecting the connector, first of all it is necessary to unblock the fixers.

The main power cable is connected to the network of ~ 220 V only after both parts of the stand are electrically interconnected. Disconnection is carried out in reverse order: the cable is pulled out of the network of ~ 220 V and the cable that connects both parts of the stand is disconnected. The main power cable is installed in the second part of the stand.

Important

The stand is made on the basis of the Renault Laguna II car. Using computer diagnostics and identifying the vehicle, the following information is indicated: mark – Renault, model – Laguna II, year of production – 03/2001 – 12/2005, engine capacity – 1,9 litre DCI, engine power – 88 kW, engine code – F9Q 750. The engine code can be found on the electrical diagram of the stand. The engine idle speed is 750 – 850 min-1.

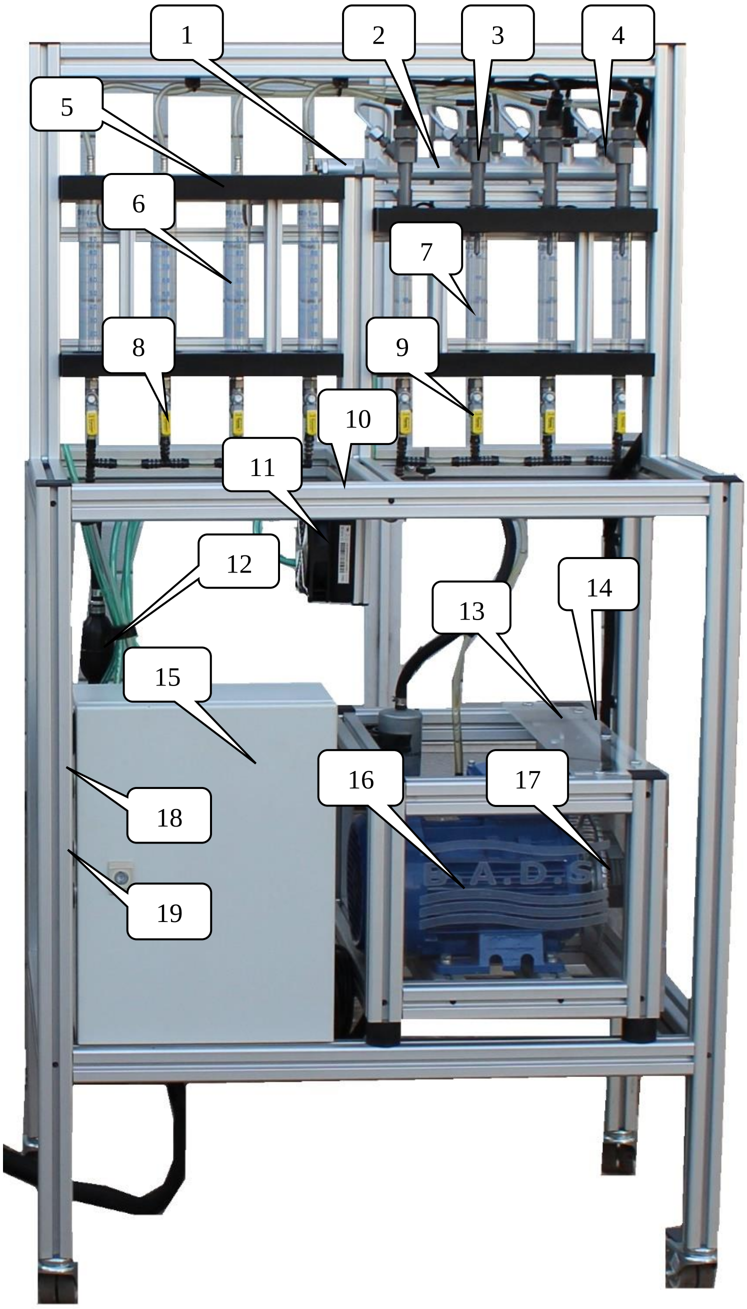


The first part of the stand

Indication values of the figure:

1 Main engine control relay (K46)
2 Coolant blower motor relay I (K12)
3 Coolant blower motor relay II (K208)
4 Engine coolant heater three relays (K242)
5 Electrical diagram with fault simulation connections
6 TFT voltmeter
7 Tachometer
8 Setting dial of the 6th parameter that you desire to follow on the TFT voltmeter
9 Glow plug control unit (A104)
10 Mass-Air flow sensor simulator (B30), intake air temperature sensor (B25) and fan
11 Intake air control valve (Y102)
12 Diagram of the Common rail fuel injection system
13 Mass-Air flow sensor simulator (B30)
14 Turbocharger boost pressure sender (B105)
15 Turbocharger boost pressure sensor simulator (B105)
16 CR/EDC 15 Electronic control unit (A35)
17 Turbocharger wastegate control valve (Y68)
18 Engine coolant temperature sensor simulator (B24)
19 Clutch pedal position switch (S258)
20 Brake pedal position switch (S13)
21 Exhaust gas recirculation valve (Y28) and exhaust gas recirculation potentiometer (B149)
22 Accelerator pedal position sensors (B138)

23 LED indicators: yellow – stand is turned on, red – the ignition is switched on, green – the stand is operating (fuel pump is working)
24 Engine coolant temperature sensor (B24)
25 Ignition switch with a key
26 Manual adjuster of the engine crankshaft speed
27 Glow plugs (R5-I…IV)
28 Battery terminals
29 Diagnostic connector (X1)
30 Fuses 10A and 30A (F6 and F3)



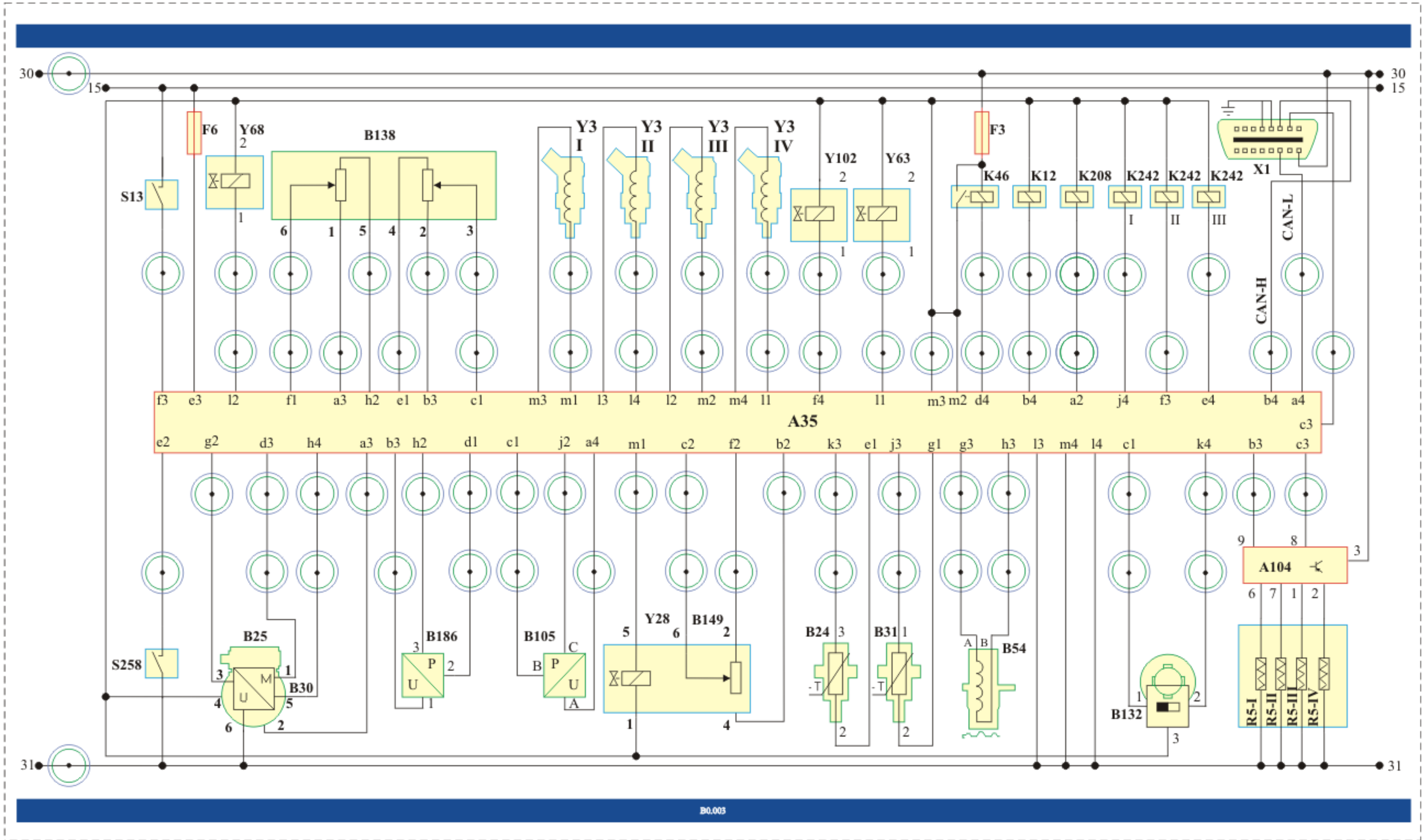
The second part of the stand

Indication values of the figure:
1 Fuel pressure relief valve
2 Fuel rail

3 Fuel injector (Y3-I...IV)
4 Fuel rail pressure sensor (B186)
5 Drain pipes for the overflow measurement cylinders
6 Measurement cylinder for fuel back leak
7 Measurement cylinder for injected fuel
8 Tap for fuel back leak
9 Tap for injected fuel
10 Fuel temperature sensor (B31)
11 Fuel cooler
12 Manual rubber fuel pump
13 Fuel metering valve (Y63) (fitted on the fuel pump)
14 Camshaft position sensor (B132) (fitted on the fuel pump drive)
15 Electric box
16 Electric motor
17 Engine speed sensor (B54)
18 Emergency stop button
19 Main switch ON /OFF

3.2. Electric diagram

The wiring diagram contains all the elements: sensors, actuator components, data transmission lines, diagnostic connection. According to this diagram it is possible to see the connection circuits of the elements, the connection contact numbers, the component numbers, the mounting locations of the jumpers.



Electrical diagram of the training board

3.3. Legend

F3 – 30 A Fuse
F6 – 10 A Fuse
A35 – CR/EDC 15 Electronic control unit
A104 – Glow plug control unit
B24 – Engine coolant temperature sensor
B25 – Intake air temperature sensor
B30 – Mass-Air flow sensor
B31 – Fuel temperature sensor
B54 – Engine speed sensor
B105 – Turbocharger boost pressure sensor
B132 – Camshaft position sensor
B138 – Accelerator pedal position sensor
B149 – Exhaust gas recirculation potentiometer
B186 – Fuel rail pressure sensor
K12 – Coolant blower motor relay - II
K46 – Main relay
K208 – Coolant blower motor relay - I
K242 – Engine coolant heater relay
Y3-I...IV – Fuel injectors
Y28 – Exhaust gas recirculation valve
Y63 – Fuel metering valve
Y68 – Turbocharger wastegate control valve
Y102 – Intake air control valve
S13 – Brake pedal position switch
S258 – Clutch pedal position switch
R5-I...IV – Glow plugs
X1 – 16 – pin diagnostic connector

4. COMPONENTS

Educational training board operates by simulating some real engine parameters. Engine speed, air mass, turbine pressure, coolant temperature is simulated determining these indicators manually. The real engine operating parameters are determined on the training board using the data of descriptive components.

Electronic control unit (A35)

Electronic (engine) control unit processes information obtained from a number of sensors and according to a written factory program sends signals to various actuators.

Signals that control unit receives from sensors (general case):

- Accelerator pedal position
- Needle lift
- Fuel temperature
- Coolant temperature
- Supplied air temperature
- Throttle air valve position
- Engine load - air mass or intake air pressure
- Speed
- Crankshaft position
- Crankshaft revolutions
- Atmospheric pressure
- Protection against theft (immobilizer)

After processing information received from sensors, engine control unit sends signals to these control or information elements:

- Fuel injectors
- Fuel pump relay
- Injection start point magnetic valve
- Fuel amount control
- Fuel pressure control
- Idle control
- Exhaust-gas recirculation valve
- Supplied air pressure control
- Intake air flow switchover for the magnetic valve
- Glow plug control relay
- Glow plug pilot light operation
- In case of the engine failure, it informs by a symbol in the dashboard
- Turning on the emergency mode and simulating signal parameters of a faulty sensor so that the car would be able to reach the repair workshop

Engine control unit controls these engine settings:

1. The crankshaft idling speed control.
2. The crankshaft speed equivalent control. Fuel supply to each cylinder is adjusted so that the crankshaft speeds up to 1500 min-1 would be equal.
3. Active speed equivalent control. It is done when the external load is changing and connecting the clutch.
4. Maximum speed control. Engine control unit reduces fuel supply to cylinders, when the crankshaft speed reaches the maximum value.

5. Fuel amount correction during engine start. The amount of fuel supplied to cylinders is controlled so that emission of harmful particles in the exhaust-gas would be as small as possible.
6. Observation of the signal settings. Engine control unit checks signal values from sensors and actuators.

Engine control unit is switched on by turning the key in the ignition switch. Engine control recognizes the signal of actuated ignition and switches the ground in the main engine relay control circuit. After switching on the ground, relay magnetic coil is activated and links up the contacts. When the contacts link up, the engine control unit and all the other engine control units requiring on-board voltage are powered. Having turned off the ignition with the ignition key, the engine control unit remains turned on for some time in order to finish the functions performed smoothly and gradually to turn off the control unit. The control unit can be powered with a maximum voltage of 16V. When the ignition is turned on with a voltage of 11,5 – 12,5 V, the engine is idling with a voltage of 12 – 15 V. Dimensions of these values depend on the condition of the rail, engine speed, generator operation and other activated electricity consumers.

Turbocharger boost pressure sensor (B105)

The pressure sensor measures the absolute pressure in the intake manifold between the compressor and the engine (0 – 250 kPa or 0 – 2,5 bar) in the reference vacuum chamber. Using reference chamber in the vacuum sensor, it is possible to determine the air mass precisely and adjust boost pressure.

Micromechanical pressure sensor includes silicon chip, where a thin membrane is etched. Tenzoresistors are placed on the membrane in a diffuse way and their electric resistance changes when they are pulled mechanically. Under pressure the membrane is bent to a certain size. Because of stretching or compression, the electric resistance of tenzoresistors changes. When resistance changes, electric voltage changes as well. This voltage change is an information signal for control module about the pressure size. Signal voltage can be 0 – 5 V. Power supply voltage necessary for sensor's work is 4,5 – 5,2 V. Performing computer diagnostics, pressure sensor must show pressure of 90 – 110 kPa, when the engine has reached its operating temperature and is idling.

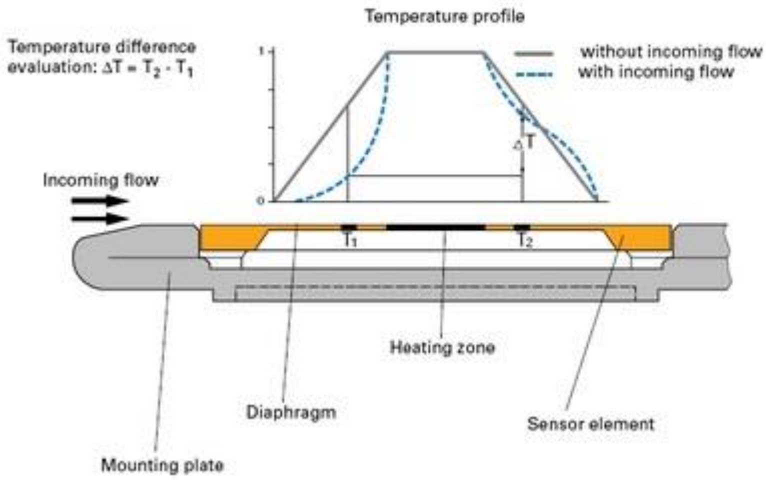
Turbine supercharging pressure in this stand is simulated by changing the position of the potentiometer „B105 Simulator ". When the engine has reached operating temperature and is idling, the signal value is 1,6 – 2,1 V. Having pressed the accelerator pedal to the floor, the signal value is 2,7 – 3,3 V. With increasing pressure in the intake manifold, the signal voltage increases.

Mass-Air flow sensor (B30)

Hot film air mass meter has no mechanical moving parts and can accurately measure the part of the air mass flow, which actually flows through the air filter and the measuring tube. Thus, for each operation mode such amount of fuel is burned that exhaust emission rates would coincide with intended limit values. The accuracy of the hot- film air mass meter is very high. This meter senses pulsations and reverse flows, which are caused by the opening and closing of the exhaust valves.

Inlet air temperature changes do not affect the measurement accuracy. Heating element which is located in the center of the meter measuring element heats the micromechanical diaphragm of the sensor and maintains its constant temperature. As the air flow runs, the diaphragm is being cooled. Temperature difference formed between individual diaphragm sites is the measure of the air mass flow. If the air flow does not run, the temperature on both sides of the diaphragm is the same.

Evaluation electronics installed in the sensor converts resistance difference into an analog voltage signal of 0 – 5 V adjusted to the engine control unit. Using recorded sensor characteristics, the measured voltage is converted into air mass flow rate (kg/h). Characteristic is made so that the engine control unit could recognize the errors of the air flow sensor.



Measuring principle of the Mass-Air flow sensor

The measuring range of the air mass meter is 0 – 300 g/s. As the engine runs and reaches its operating temperature, the air flow is 10 – 13 g/s. Having increased the engine crankshaft speed up to 2500 min-1, the air flow becomes equal 23 – 26 g/s. The air flow through the air-mass sensor is simulated with the help of the fan fitted in front of the measurer. The air flow of this fan can be changed by rotating a switch of the potentiometer „B30 Simulator “.

Sensor heating elements are powered with voltage of 12V by switching on the main power relay K46. Evaluation electronics converts resistance difference in the measurement points into an analog voltage signal adjusted to the engine control unit. The signal can be from 0 to 5 V. It is measured between the contact 5 and the ground (31 contact). The signal is sent from the sensor to the engine control unit connector h4. When the car ignition is switched on, this signal value is 0,5 – 0,65 V; warm engine is idling, the signal value is 1,8 – 2,2 V; the engine crankshaft speed reaches 3000 min-1, the voltage is 3,5 – 3,8 V. (Simulation of the airflow running into the engine is performed by changing the settings of the potentiometer „B30 Simulator “on the training board. In the real engine the airflow depends on the speed of the crankshaft. After removing the connector from the circuit connecting the sensor 5 and the contacts of the engine control unit h4, air mass will not be shown during computer diagnostics. Having inserted the connector back, air mass will appear at once despite of the fault registered in the engine control unit. In order to remove the error of the air mass meter, the adjuster of the potentiometer „B30 Simulator “must be fully turned to the left.)

Sensor characteristics recorded into the engine control unit recalculates the measured voltage into the mass flow rate (kg/h or g/s). The characteristic is formed so that the engine control unit could detect the faults or malfunctions.

Intake air temperature sensor (B25)

Air temperature sensor (measuring range -40 +200 ºC) registers the temperature of the intake air. If you know the air temperature and pressure it possible to calculate the intake air mass. Furthermore, the loops of the exhaust recirculation and inflation pressure control can be adjusted to the air temperature.

Temperature sensor is a semiconductor measurement resistor whose resistance changes depending on the temperature. Temperature sensors are usually with a negative (Negative Temperature Coefficient – NTC) and positive (Positive Temperature Coefficient – PTC) temperature coefficient. With increasing ambient temperature NTC sensor resistance decreases and PTC sensor resistance increases. NTC sensors are used more often.

Temperature sensors are powered with the voltage of 5V. Voltage measured beside the sensor depends on resistance, which varies depending on the ambient temperature. This voltage measured beside the sensor is scanned through the analog digital converter and is a temperature measurement beside the sensor. Characteristics is recorded into the engine control module, which assigns the appropriate temperature to each resistor or to the outlet voltage value.

When checking the air temperature sensor, it is necessary to check its power supply, resistance and voltage at different temperatures. When checking the power supply, the sensor is not disconnected from the electrical circuit. Between contacts g2 (+) and a3 (-) there has to be a voltage of 4,5 – 5,2 V. Resistance is measured between contacts 1 and 2. The measurement can be carried out directly at the sensor contacts or on the terminals of the sensor contacts. This can be done only if the connector is removed from the electrical circuit diagram. Between sensors contacts 1 and 2 it is possible to measure the voltage signal depending on temperature.

Air temperature, °C	Resistance, kΩ	Signal value, V
0	6,3 – 6,5	3,9 – 4,3
20	2,2 – 2,8	3,0 – 3,5
40	1,0 – 1,7	2,2 – 2,4
60	0,4 – 0,8	1,3 – 1,9
80	0,2 – 0,4	0,8 – 1,0

Turbocharger wastegate control valve (Y68)

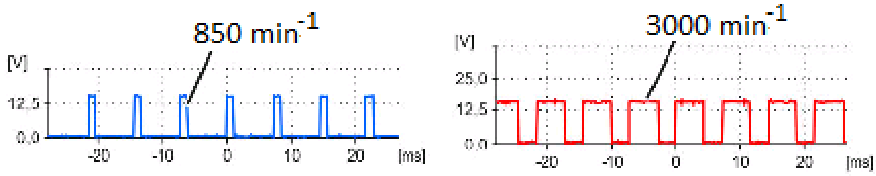
Boost pressure can be regulated in several ways. One of them is a turbocharger with a passageway, another way is a turbocharger with a variable turbine geometry (VTG). In both cases pressure control mechanisms are actuated by the vacuum unit using a pneumatic unit or a pneumatic actuator mechanism. Operation of the turbine with a passageway goes as follows: at high engine crankshaft speed or at high load part of the exhaust gas is transmitted through a transmission valve into in the exhaust tract overtaking the turbine. This reduces the gas flow going through the turbine and its pressure as well. Also, excessive speed of the turbocharger is avoided. At low engine speed or at low load the passageway is closed up and therefore, the turbine is rotated by the whole gas flow.

Boost pressure of the VTG is operated differently. Here the adjusting blades change the cross-sectional width of the channel, where the exhaust gas flows into the turbine. Thus, the turbine operating pressure is adjusted to the required boost pressure. Operation of both turbines is performed with the help of the vacuum unit by moving the pressure relief valve or by turning the adjusting blades.

Boost pressure control operates the passageway. This controller is an electrically operated valve connected to a vacuum pump. In a starting position (current does not flow) it transmits the ambient air into the pneumatic chamber. The spring installed in the chamber opens the passageway and the adjusting blades are in such position where the cross-sectional width is the largest. In case of the failure of any element, the turbines do not develop the maximum effect and thus they are protected from damage. When the engine control unit supplies the current to the boost pressure control, it connects the pneumatic chamber with a vacuum pump. Thus, the diaphragm is pulled back overcoming the spring force. The passageway is closed and the speed of the turbocharger increases.

When checking the power supply, pressure controller is disconnected. Measured power between the controller connection cable contact 1 and the ground (31 contact) is of 11,5 – 13,5 V. Power voltage may be measured in the electric diagram which is on the training board (controller must be disconnected). The opening of the electromagnetic valve is controlled by the pulse width modulation signal (PWM Control). The position of the boost pressure regulator valve and therefore the size of the vacuum in the vacuum chamber that operates the bypass valve depends on the aggregate ratio. Control signal characteristics can be measured by the oscilloscope. Measurements are performed using the measuring points made in the electric diagram of the training board. It is extremely important that there were no fault codes in the engine control unit.

Resistance of the electromagnetic valve 15,5 – 17,5 Ω.



Air supply valve control signal

Intake air control valve (Y102)

Intake control air control valve (air throttle valve) is used to close the intake air channel when stopping the engine. This reduces the engine vibration and it stops faster. The valve can also be used when the engine is running in the zone of low and maximum load. The valve is controlled with the help of the vacuum unit through the solenoid valve. When the current does not flow through the solenoid valve, the valve is closed.

Intake control air control valve is supplied with the on-board voltage of the engine control relay K46. When checking the power supply the solenoid valve is disconnected. Measured voltage between the solenoid connection cable contact and the ground (31 contact) is of 11,5 – 13,5 V. Resistance of the solenoid valve coil is measured between 1 and 3 contacts. Resistance of a well-functioning coil is of 41 – 48 Ω.

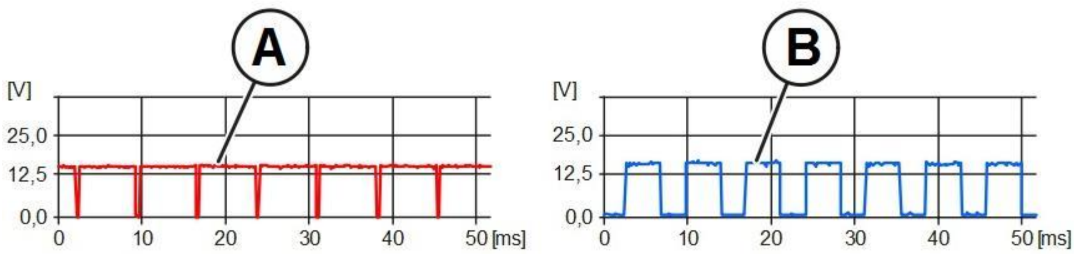
It is possible to activate the air intake valve control on the training board only by using computer diagnostic equipment. In order to activate the valve control chose the “Activation of the actuators “function. Having activated the valve, the light-emitting diode (LED) which is near the valve lights up. Possibility to perform the “Activation of the actuators “function determines the available diagnostic equipment.

Exhaust gas recirculation valve (Y28)

Exhaust gas recirculation valve includes engine control unit, exhaust gas recirculation magnetic valve and exhaust gas recirculation valve position sensor. The purpose of the exhaust gas recirculation system is to reduce the formation of nitrogen oxides (NOx) in the exhaust gases. This can be done by returning part of exhaust gases into the combustion chamber in order to reduce combustion temperature. Exhaust gases are returned through the valve connecting the exhaust gases and the air intake canals.

Exhaust gas recirculation magnetic valve is supplied with on-board voltage by switching the main engine control relay. When checking the valve power supply, the valve is disconnected from the circuit. There must be a voltage of 11,5 – 13,5 V between the wire contact m1 and the ground (31 contact).

For checking the nature of the signal, you need to use an oscilloscope between the contact m1 and the ground (31 contact). The nature of the signal, when warm engine is idling, is shown in figure A. The nature of the signal after pressing the accelerator pedal to the end and waiting at least for 2 seconds is shown in figure B.



Valve control signal

As the exhaust gas recirculation valve on the training board can actually be forced to operate only working with computer diagnostics and using the „Activation of actuators “function, the change of the solenoid valve signal can be seen only at the time when activation of actuators is performed using computer diagnostics.

Magnetic valve resistance is 7,5 – 8,5 Ω.

Exhaust gas recirculation potentiometer (B149)

Maximal values of the exhaust gas recirculation potentiometer voltage are 0 – 5 V.

Exhaust gas recirculation potentiometer voltage is checked by disconnecting the sensor from the circuit. Voltage between contacts f2 „+ “and b2 „- “must be of 4,5 – 5,2 V.

When checking the signal value, sensor is connected to the circuit. Between contact c2 (6) and the ground (31 contact) when the engine is idling the signal value must be 1 – 1,5 V.

Exhaust gas recirculation potentiometer signal changes when moving the valve may be observed using computer diagnostic „Actuator activation “function. When exhaust gas recirculation valve is closed, exhaust gas recirculation potentiometer signal is 0,93 V. When it is activated, the signal is 3,96 V.

Engine speed sensor (B54)

Engine crankshaft speed sensors are used to measure crankshaft speed frequency and to register shaft position (piston position).

Engine speed is calculated from speed sensor signal time interval. The sensor is measured before ferromagnetic pulse wheel. They are separated by the air gap. There is a ferromagnetic core in the sensor, which is surrounded by a winding. Pole rod is connected to the permanent magnet. The magnetic field is diffusing within the pole rod to the pulse wheel. The size of the magnetic field that crosses the coil depends on what is located opposite the sensor. It may be a pulse wheel gap or a tooth. The tooth concentrates the magnet flow and strengthens magnetic field that crosses the coil. The gap weakens the magnetic field. These magnetic field changes in the coil induce sinusoidal output voltage proportional to the rate change i.e., speed frequency. Variable voltage amplitude increases as increases the speed frequency. The number of pulls wheel teeth depends on the situation. In the engine control system, the number of teeth is 60 – 2 = 58. Two teeth are taken out and a big gap forms a reference mark to record a particular position of the crankshaft. It is a synchronization signal for the engine control unit.

Evaluation circuit mounted in the engine control unit transforms this sinusoidal voltage with different amplitude into square voltage with constant amplitude. This signal is evaluated by the control unit microcontroller.

Engine speed sensor checked by measuring the AC voltage between the contacts g3 (A) and h3 (B). When the engine is idling, alternating voltage changes within 20 – 22 V. When the engine crankshaft speed reaches 3000 min-1, the voltage is ~ 37 V. The signal nature of the engine speed sensor is checked by connecting oscilloscope. Speed sensor resistance is 600 – 750 Ω.

Camshaft position sensor (B132)

Camshaft position speed sensor works on the principle of Hall effect. The segment is formed on the camshaft and it is fixed by Hall sensor. Ferromagnetic rotor rotates together with the camshaft. Hall integrated circuit sits between the rotor and the permanent magnet which creates a magnetic field perpendicular to the Hall element. Through the sensitive sensor element where the current flows, ferromagnetic rotor teeth go through, which changes the magnetic field strength perpendicular to the Hall element. Voltage, connected along the element, forces electrons to move. They are more directed perpendicular to the current direction. Thus, the Hall voltage signal appears (Hall voltage) which is in millivolt range. Integrated evaluation electronics fitted in the Hall integrated circuit processes the signal and helps spread square signal waves.

When you turn on the ignition of the engine, the sensor detects the position of the camshaft and allows the engine to be started. The shaft is combined so that it coincides with the first cylinder power stroke and this is fixed by the sensor. According to the signals of the camshaft position sensor and the crankshaft speed sensor, the engine control unit calculates when the power stroke occurs in other three cylinders. Camshaft position sensor is supplied by the on-board voltage. The power supply on the sensor must be of 11,5 – 12,5 V between contacts 3 (+) and 1 (-). The measurement of the voltage coming out of the sensor is performed between contact 2 and the ground (contact 31). The voltage of the outgoing signal is 11,5 – 12,5 V. The nature of the signal is checked using an oscilloscope.

Accelerator pedal position sensor (B138)

Accelerator pedal includes two potentiometers mounted on the same axle. The engine control unit, evaluating the voltage on both potentiometers, can determine the position of the pedal. Due to the change of the pedal position the resistance value changes as well. The voltage which is evaluated by the engine control unit changes too. The engine control unit defines the position of the accelerator pedal by these two voltages. Comparing these two voltage values, the engine control unit can check whether the sensors of the accelerator pedal position work properly.

Each accelerator pedal sensor has got power, ground and signal cables. In one of these two sensors additional resistance is added in order to distinguish signals. In case of the failure of at least one sensor voltage values change and by this the engine control unit detects the fault. The engine torque is reduced. After pressing the brake pedal, engine crankshaft speed is reduced to the minimum. Under unfavourable conditions and in case of the failure of both potentiometers, the engine control unit will not be able to recognize this. In this case, the engine speed is increased and does not react to the pedal press.

Accelerator pedal position sensor can be checked using computer diagnostics. Sensor measurement field is defined by 0 – 100 %. When the engine is switched off and the pedal is not pressed, the shown value is 0 – 5 %. Having pressed the pedal to the floor the value is 95 – 100 %. When measuring the voltage (maximum value is 0 – 5 V), the voltage value coming out of the sensor is 0,5 – 0,9 V, when the pedal is not pressed. Having pressed the pedal to the floor the voltage value is 4 – 4,5 V. When pressing the pedal, the voltage and the pressing size percentage value must increase without jumps or breakups.

When checking the accelerator pedal position sensor in detail, individual parameters are measured: power supply voltage, signal voltage, resistance. Power supply voltage of the first potentiometer (4,5 – 5,2 V) is checked after disconnecting the sensor from the circuit between e1 „+ “and b3 „- “wire contacts. Power supply voltage of the second potentiometer is checked between h2 „+ “and a3 „- “wire contacts. Check may be done not only measuring wire contacts indirectly but also on the training board contacts. Outcoming signal is checked between 3 „+ “jumper and b3 „- “contacts of the first potentiometer and between the 6 „+ “ jumper and a3 „- “contacts of the second potentiometer. When the pedal is not pressed, voltage drop on the first potentiometer is 0,5 – 0,8 V and when the pedal is pressed to the floor, it is 3,2 – 4 V. Signal voltage values of the second sensor are 0,2 – 0,4 V and 1,6 – 2 V.

Resistance of the first disconnected potentiometer measuring between 2 and 4 contacts is 0,7 – 1,7 kΩ. Resistance of the second potentiometer between 1 and 5 contacts is 1,5 – 2,7 kΩ. Measuring between these two contacts resistance value remains constant despite of the accelerator pedal press.

Clutch pedal position switch (S258)

Clutch pedal position switch provides information about the use of the clutch pedal. This information is used to control the fuel supply (having switched off the speed maintenance system) and driving speed. In case of the failure of the pedal switch the engine control unit switches the emergency mode. When performing computer diagnostics, pedal switch values can be seen: “Active”, “Inactive” or “Component unprogrammed”. Usually after pressing the clutch pedal, value “Active’’ is shown. Computer diagnostic equipment of different manufacturers can give information on the status of the clutch pedal switch differently.

Clutch pedal switch supply voltage is checked by disconnecting the switch from the circuit. Between the wire contact e2 „+ “and the ground (31 contact) voltage must be 11,5 – 13,5 V.

Clutch pedal switch resistance between contacts 1 and 2 is 0 – 1 Ω when the clutch pedal is not pressed. When the clutch pedal is pressed, resistance is > 1MΩ.

Brake pedal position switch (S13)

Brake pedal position switch informs the engine control unit about the pressing of this pedal and performs the second function - activates the brake lights. This is a dual switch, whose one contact is normally closed (for the engine control unit signal) and normally open (for switching on the lights). Only one part of the switch is used for the information of the engine control unit.

When checking the brake pedal with computer diagnostics, possible signal values are the following: “Switched on”, “Switched off” and “No value”. Signal value “Switched on” is shown when the brake pedal is pressed.

When measuring the brake pedal switch power supply voltage between f3 „+ “and the ground (31 contact) contacts, power voltage is in the range of 11,5 – 13,5 V. When the pedal is not pressed, the voltage is in the range of 11,5 – 13,5 V. After switching the pedal its value between 0 – 0,4 V.

Engine coolant temperature sensor (B24)

The coolant temperature sensor is mounted so that heat-sensitive sensor tip would have a direct contact with the coolant. Sensor resistance changes depending on the coolant temperature.

The resistance of negative temperature coefficient sensor decreases as the coolant temperature increases. As resistance decreases, voltage signal that reaches the engine control unit increases. The signal size is proportional to the coolant temperature. Engine control unit compares saved in the memory curve of the sensor voltage dependence on temperature and by the voltage value calculates the current coolant temperature. Signal received from the coolant temperature sensor is used for the fuel correction, injection start point correction, exhaust gas recirculation adjustment, glow plug control and for additional engine heating adjustment. In case of the failure of the coolant temperature sensor, at the same time the engine control unit carries out the engine control as if the engine was cold. The coolant temperature sensor work limits are 10–120 ºC.

The temperature sensor power supply voltage between k3 and the ground (31 contact) contacts must be 4,5 – 5,2 V. Temperature sensor signal voltage (actually the value of this voltage is changed with the help of the potentiometer „B24 Simulator “) is measured between the contact 3 and the ground.

Resistance measurement is performed between contact 3 and the ground (31 contact). After removing the connector from the circuit, the engine control unit understands this as a system failure. The engine switches into the emergency mode.

Engine coolant temperature, °C	Resistance, kΩ	Signal voltage, V
0	5,3 – 6,5	3,9 – 4,3
20	2,2 – 2,8	3,0 – 3,5
40	1,0 – 1,7	2,2 – 2,4
60	0,4 – 0,8	1,3 – 1,9
80	0,2 – 0,4	0,8 1,0

Fuse (F3)

Car fuse 30 A is mounted to protect a circuit which supplies engine control relay, engine control unit, 1 and 2 cooling fan relays, coolant heating relays, fuel pressure control valve, air intake control valve, air boost control valve, mass-air flow sensor, exhaust gas recirculation valve and camshaft position sensor. If the fuse melts, it is not repaired but replaced by a new one. During the fuse test we determine whether the circuit is not broken.

Fuse (F6)

Car fuse 10 A is mounted from the ignition switch to the circuit in the engine control unit. If the fuse melts, it is not repaired but replaced by a new one. During the fuse test we determine whether the circuit is not broken.

TFT voltmeter

It is an information screen used for controlling and observing measuring parameters.

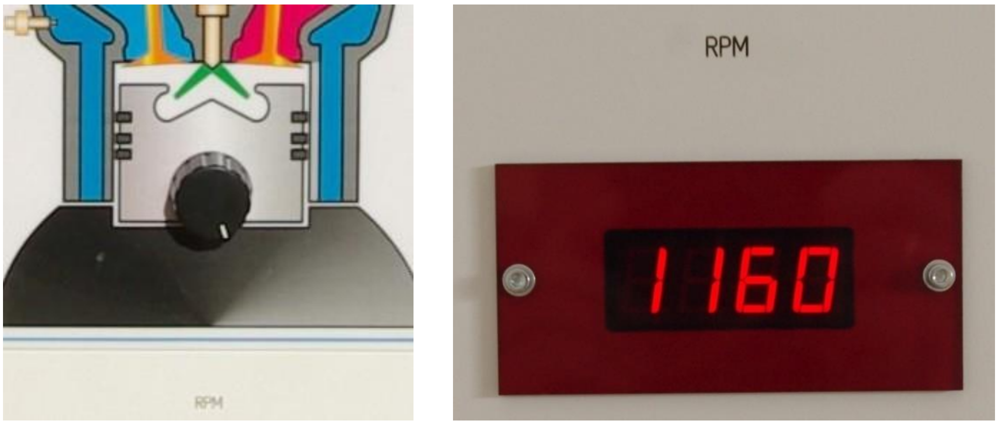
TFT voltmeter and dial of the measuring parameters

B24 – Engine coolant temperature sensor;
B25 – Intake air temperature sensor;
B30 – Mass-Air flow sensor;
B31 – Fuel temperature sensor;
B105 – Turbocharger boost pressure sensor;
B138-I – First accelerator pedal position sensor;
B138-II – Second accelerator pedal position sensor;
B149 – Exhaust gas recirculation potentiometer;
B186 – Fuel rail pressure sensor;

As you turn the dial to the appropriate mark you can choose the parameter you want to follow. You need to watch according to the parameter specification what value of the followed parameter coincides with the displayed voltage. For example, B24 - coolant temperature sensor voltage of 3,9 ... 4,3 coincides with V 20 ° C temperature. Voltage of 2,2 ... 2,4 V coincides with 40 ºC, 1,3 ... 1,9 V – 60 ºC, 0,8 ... 1,0 V – 80 ºC. Other sensors signal values can be found in the sensor descriptions.

RPM screen

Engine crankshaft speed is min^{-1}. Engine speed is controlled with the help of the knob.



Engine speed control adjuster and speed indicator

Glow plugs (R5-I...IV)

Glow plugs heat the air entering into the engine cylinders and make it easier the cold engine start.

Preheating process consists of 5 phases. During the initial warm-up time pencil-type glow plugs are heated up to operating temperature. Then, in standby mode the heating system maintains the required glow plug temperature for a definite period. During the engine start, the start-up heating mode is turned on. Having released the starter, warm-up after start-up phase begins. Glow plugs can be turned on for a short time after the engine cools (engine braking) or to maintain regeneration of the solid particle filter.

The traditional heating system consists of 11 V rated voltage pencil-type glow plug, relay glow control unit, heating function software module integrated in the engine control unit.

Glow plug consists of a hot-gas and corrosion resistant heater tube tightly pressed into a metal shell. Inside the tube there is a coil (spiral) surrounded by magnesium oxide insulation powder. The coil is made up of two resistors connected in series. The heating coil is located in the tip of the heater tube, and in front of the regulation coil. The coils are connected with the terminal through the central electrode. Wires on the terminal are attached by the terminal-nut or they are fixed by pressing them up. The central electrode and the metal shell are separated by the insulating nonconducting material. A fastening thread is prepared on the metal shell for glow plug attachment in the engine.

Glow plugs are tested by measuring resistance, power supply voltage and current. Between the central plug contact and the body (ground) the resistance is from 0,5 to 0,7 Ω. When the glow plug control unit operates, the power supply voltage between the glow plug power cable 6 „+ "and the ground (31 contact) is from 11,5 to 13,5 V. After connecting the plugs and when the glow control unit operates, the current of 20 A may flow in the circuit. It is impossible to check the strength of the flowing current.

The LED mounted above the glow plug control relay shows only the operation of the relay. It is not a symbol equivalent of the heating spiral on the dashboard.

Fuel metering valve (Y63)

Fuel metering valve is mounted on the high-pressure fuel pump. The purpose of this metering valve is to control the amount of the fuel supplied depending on the need. Also, by pressing only the required amount of fuel (not the maximum possible), the fuel heating reduces and less energy is used for the fuel pump rotation. Metering valve is mounted on the high-pressure pump fuel suction side. Fuel metering valve is controlled by the engine control unit which uses a signal with a different duty cycle. How much the valve is closed depends on the duty cycle. The valve is open without a power supply voltage metering valve. What fuel control method is used depends on the pump design.

When checking the power supply the metering valve is disconnected from the circuit. Between the wire contact 1 and the ground (31 contact) also after switching on the ignition, the voltage is 11,5 – 13,5 V. When testing the metering valve control signal, oscilloscope is required. Oscilloscope is connected to the contact 1 and the ground (31 contact).

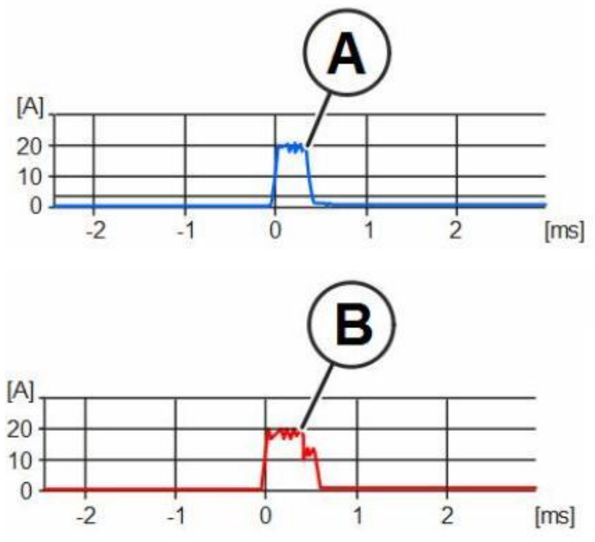
Metering valve resistance is 3,3 – 5,3 Ω.

Fuel injectors (Y3-I...IV)

The fuel pressure in the battery reaches the chamber situated near the valve control plunger and the nozzle needle. The fuel pressure in the valve control chamber and the spring do not let the nozzle needle open. The start of the fuel supply is controlled with the help of the solenoid coil. When the current flows through the solenoid coil, the valve opens and the fuel flows into the return passage from the valve control chamber through the outlet restrictor. As a sufficient amount of fuel cannot flow through the inlet restrictor, pressure decreases in the valve control chamber. Increased pressure in the nozzle needle chamber lifts the needle opening the nozzle. Fuel injection lasts as long as the current flows through the solenoid coil.

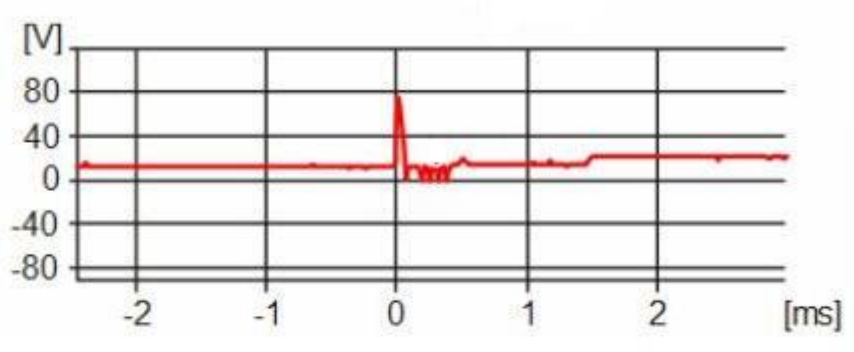
Maximum amount of fuel, injected by the fuel injector is 50 mg/cycle. When the warm engine is idling, injected fuel amount is 6 – 12 mg/cycle. Having pressed the accelerator pedal to the maximum for a short time, the amount of injected fuel is 14 – 23 mg / cycle. Current intensity may be 25 A for injector control.

When the warm engine is idling, injector control signal is like the one shown in figure below A. When the accelerator pedal is pressed, injector control signal is like the one shown in figure below B.



Injector control signal current

Injector control voltage signal may reach up to 80 V. It is measured using the oscilloscope after connecting to the injector control line contacts m1, l4, m2, l1 and the ground (31 contact).



Injector control signal voltage

When testing the injector throughput (returning the amount of fuel), the engine must be at operating temperature. (Coolant knob B24 is set to simulate the operating temperature of the coolant to 90 ºC).

After turning off the taps of the fuel release measuring cylinders, wait until the measuring cylinders are filled so much that the liquid could be seen at the selected interval. This will be the starting point of measurement.

Injector resistance 0,2 – 0,4 Ω.

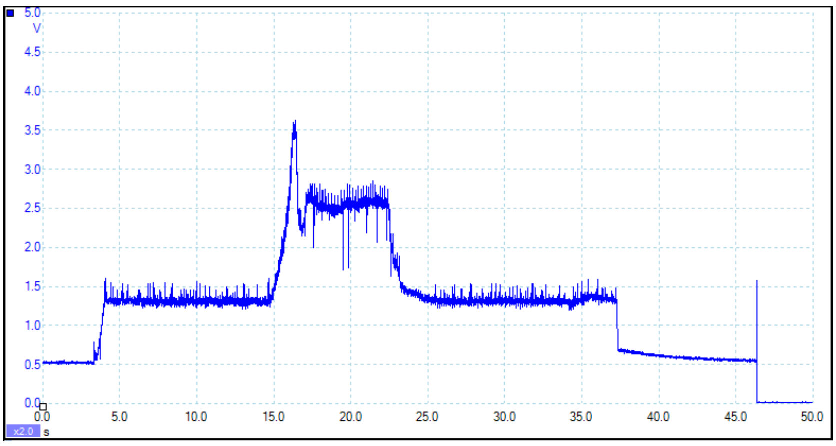
Fuel rail pressure sensor (B186)

Fuel rail pressure sensor is used for measuring fuel pressure in the fuel rail. The sensor is designed so that due to the pressure change, a metal membrane changes its geometric shape and it is recorded by the sensor mounted on it. Sensor signal is processed by an evaluation circuit and it transmits information into the engine control unit. Sensor signal is of 0 ... 70 mV size and the evaluation circuit strengthen the signal up to 0,5 ... 4,5 V.

The fuel pressure in the fuel battery may vary in the range between 0 ... 200000 kPa. This is the maximum range. When the warm engine is idling, fuel pressure may be between the values of 35000 ... 55000 kPa. At maximum engine load fuel pressure may be between the values of 110000 ... 135000 kPa. The pressure sensor provides information about live made pressure in the fuel rail.

Testing of the sensor supply voltage is performed after disconnecting the sensor from the circuit. Between the contacts b3 „- "and contacts h2 „+ "the voltage value must be 4,5 – 5,2 V. The value of the signal is measured between contact 2 „+ "and the ground (31contact).

When the warm engine is idling, the voltage value is 0,9 ... 1,3 V. When the accelerator pedal is pressed to the floor, the voltage value is 1,9 ... 2,4 V. As the pressure increases, the voltage increases as well.



Variation curve of the fuel pressure sensor voltage

You can see the variation curve of the fuel pressure sensor voltage in figure above. Here you can see that ignition is turned on up to 4 s, the engine has been started and is idling for 4 – 15 s, engine crankshaft speed is increased for 15 – 25 s, idle speed is on for 25 – 37 s, pressure drop in the fuel rail for 37 – 47 s after switching the engine off. From the 47 s engine control unit shuts down and sensor supply voltage is cut off.

Hand priming fuel pump

After having done the repair or maintenance work with the fuel supply system, the manual fuel pump can be used for eliminating the air out of the system.

Main relay (K46)

The main relay supplies various actuators and the engine control unit. Having switched off the engine and turned off the ignition, with the help of this relay power voltage is supplied to the engine control unit and to some other components. The engine control unit can complete the programme execution, test the components and turn off. Actuation of the relay **can** be controlled through the engine control unit contact e3. Voltage is provided into this contact through fuse F6 after switching on the ignition. The ground is actuated in the contact d4 of the engine control unit and the current begins to flow through the relay indraft coil. After the current starts flowing through the attracting coil**,** the contacts are connected. In this way the engine control unit and other components are supplied through the control unit contacts m2 and m3. After switching off the ignition with the ignition key, the relay remains actuated for some time in order the engine control unit could finish all the ongoing programmes.

Coolant blower motor relay I (K208) Coolant blower motor relay II (K12)

Engine coolant is chilled by blowing the coolant radiator with the air. If the car is in motion and there is enough air flow for the engine cooling, cooling system fans are not activated. If the car's driving speed is very low and there is not enough air flow to chill the coolant, fans are switched on. Fans are switched on with the help of relays. The system is controlled by two relays, which give an opportunity to have two different kinds of fan rotation speed. The first relay (K208) turns the fan on when the coolant temperature is higher than 95 ºC. The second relay (K12) increases the fan speed or turns on the second fan when the coolant temperature is higher than 102 ºC. The fans are switched off when the coolant temperature becomes 3 degrees lower than the activation temperature. If the fan is switched on in a car, then cooling system fan starts rotating at maximum speed.

Relay operation on the training board (actuation of different speeds of the cooling fan) may be simulated by turning the coolant simulation knob „B24 Simulator “to the right. As soon as the coolant temperature is above 95 ºC, the first relay K208 turns on (light-emitting diodes situated above the relay signal about its operation), and when the temperature is above 102 ºC, the second relay K12 will turn on. Cooling fan speed (relay actuation) also can be controlled manually using computer diagnostic (if diagnostic equipment and programme maintains such functions).

Engine coolant heater relay (K242)

At small engine load and low ambient temperature, the engine reaches the operating coolant temperature over a sufficiently long period of time. To speed up the engine warm-up to the operating temperature additional electric coolant glow plugs are installed in the cooling system. These plugs are controlled with the help of relays K242. Relay control signals can be checked through contacts j4, f3 and e4. Relay activation is carried out using the diagnostic equipment maintaining the activation functions. Light-emitting diodes situated above the relays signal about their operation.

Glow plug control unit (A104)

Glow plug control relay operation is tested by measuring the voltage between the positive power cable and negative terminal (ground) of the plug. The power supply voltage must coincide with the on-board voltage. If the ambient temperature is > 0 °C, the engine control unit may not actuate the relay. In this case the coolant temperature sensor should be disconnected. The measurement should be made from the start.

Mass-Air flow sensor B30 Turbocharger boost pressure sensor B105 Engine coolant temperature sensor B24

Adjusters (potentiometers) are used for the air fan control and for the simulation of the air boost pressure and coolant temperature.

Diagnostic Connector (X1) CAN H and CAN L connections

OBD (On-board diagnostics) II standard diagnostic connection is used for searching engine operating parameters, faults and observation. According to the OBD II connection reports SAE-J1962, SAE-J2012, SAE-J1850, the connection has got 7 operational contacts, 1 on-board voltage after switching on the ignition. These contacts are used for: 4 and 5 - vehicle weight, 6 - CAN H connection, 7 – K Line, 14 – CAN L connection, 16 - positive battery terminals. Duplication of this connection is also made on the electric diagram CAN H and CAN L connections. Power supply is tested when the ignition is switched off and also when it is switched on.

Between connections CAN H and the ground (31 contact), CAN L and the ground when the ignition is switched off, voltage must be – 0,4 V and when the ignition is switched on, voltage must be 2,3 – 2,7 V. Resistance between CAN H and CAN L contacts when the ignition is switched off is 120 Ω. In the line of CAN signal the measurement is carried out with the help of two passage oscilloscope, which is connected to L and H line and the ground (31 contact).

Fuel temperature sensor (B31)

Fuel temperature sensor measures fuel temperature and sends information to the engine control unit. Possible limits of measurement are from -50 – to 190 ºC. Design and operation principle is analogous to other temperature sensors.

Fuel temperature sensor is supplied with voltage of 4,5 – 5,2 V. Power supply is tested after removing the connector from the circuit between the contacts j3 “+” and the ground (contact 31).

Sensor resistance is measured between the contacts 1 and the ground when the sensor is disconnected from the system. Resistance value depends on the temperature.

Sensor signal voltage is measured between the connector 1and the ground (contact 31) contacts. Voltage value depends on the fuel temperature.

Fuel temperature, °C	Resistance, kΩ	Signal value, V
0	5,3 – 6,5	3,9 – 4,3
20	2,2 – 2,8	3,0 – 3,5
40	1,0 – 1,7	2,2 – 2,4
60	0,4 – 0,8	1,3 – 1,9
80	0,2 – 0,4	0,8 1,0

5. COMMON RAIL SYSTEM STRUCTURE AND OPERATION

„Common Rail "(CR) is a rail diesel fuel injection system. The main advantage of this system is that there is a big choose of injection pressure and injection moment. This is achieved by separating the creation of a pressure (high pressure pump) and fuel injection (injectors). Fuel distribution pipe (rail) serves as pressure rail. Common Rail system flexibly adapts fuel injection process for the engine. This is achieved by:

- High (up to 2400 bar) fuel injection pressure;
- Pressure (200 – 2400 bar) adjusted to working mode;
- Variable fuel supply starting point;
- Opportunity to perform some auxiliary and additional injections.

Common Rail system consists of the following major groups:

- Low-pressure fuel supply part (fuel tank, tubes, filters, low pressure fuel pump);
- High-pressure fuel supply part (high pressure fuel pump, fuel rail, tubes, injectors);
- Electronic control system (EDC) with sensors, control unit and actuators.

High-speed valve (electromagnetic or piezoelectric) installed in the injectors of the Common Rail system opens and closes the injector. In this way, the injection process can be operated separately for each cylinder. As the injectors are connected to the common fuel rail that is why it is called „Common Rail ". CR system can set the pressure of the system to working mode.

Operating principle

In the CR fuel injection system, the creation of the fuel pressure is separated from the injection. Despite of the engine speed and the amount of the injected fuel, injected fuel pressure is created here. The electronic control system (EDC) operates individual components, the moment of injector opening and duration. Fuel pressure creation and injection are separated by the rail. Compressed and ready for injection fuel is stored in the rail. High pressure pump continuously supplies fuel and creates the desired injection pressure. Due to the steady fuel supply high-pressure pump can be by far smaller. Torque fluctuation peaks that are necessary for the pump are smaller than traditional injection systems and this strongly reduces the load of the drive pump. High pressure pumps are radial plunger pumps. Sectional pumps can be used for trucks.

Several different regulation methods are used for the fuel pressure regulation. In the car rail system, the desired pressure is regulated by the pressure control valve located on the high-pressure side. Fuel not required for injection flows back to the low-pressure loop via the pressure control valve. By this regulation, pressure in the rail can be adjusted very quickly when the operating mode is changing. Such pressure regulation was used in the first Common Rail systems. The pressure control valve is attached to the rail, in some cases, to the high-pressure pump.

Another pressure control method is possible on the suction side. Metering valve flanged on the high-pressure pump makes sure that the pump delivers exactly the right quantity of fuel to the rail in order to maintain the pressure required by the system. In a fault situation, pressure relief valve prevents rail pressure to exceed to the maximum. Fuel delivery control on the suction side reduces the quantity of fuel under high pressure and lowers the power input of the pump. This reduces the general fuel consumption. The temperature of the fuel flowing to the fuel tank is reduced in contrast to the control method on the high-pressure side.

Using system with two actuators on the suction side and on the high-pressure side, advantages of both regulatory approaches are integrated.

Fuel injection goes directly into the engine combustion chambers. Fuel for injectors is supplied from the rail via short high-pressure tubing. Engine control unit operates the valve integrated into the injector, which opens and closes the nozzle.

The amount of injected fuel depends on the duration of the open position of the injector and the system pressure. When the pressure is constant, it is proportionate to the duration of activated position of the control valve and does not depend on the engine speed.

Applying auxiliary or multiple injection in the Common Rail system, it is possible to reduce the emission of harmful substances into the environment and reduce engine noise during its operation. Switching a very fast control valve many times, it is possible to achieve multiple injection (up to five injections per work cycle).

The nozzle needle closes hydraulically and in this way the end of a sudden injection is guaranteed.

Control system

Engine control unit measures the position of the accelerator pedal and the parameters of live engine and vehicle operating mode with the help of the sensors. These modes include:

- Crankshaft speed and rotation angle;
- Pressure in the fuel rail;
- Supplied air boost pressure;
- Intake air temperature, coolant and fuel;
- Intake air mass;
- Driving speed;
- Other settings (brake and clutch pedal pressing and etc.)

The control unit evaluates the input signals and calculates the signals of the control valve or the measuring valve, injectors, exhaust gas recirculation valve, turbocharger control valve synchronously for the combustion process. The necessary small injector actuation terms can be achieved with the help of the optimized high pressure control valves and special control. Angle - time system uses crankshaft and camshaft sensor signals and adjusts the injection moment to the engine status. Electronic control system enables to dose the amount of injected fuel precisely. Moreover, EDC allows to use other functions, which improve driving performance and comfort.

The basic functions control the required diesel fuel injection at the right moment and at fixed pressure. This ensures a smooth engine operation and economy. In order to compensate injection system and engine limits, correction functions are applied. Correction functions are: injector delivery compensation, zero delivery calibration, fuel-balancing control, fuel-quantity mean-value adaptation. Additional control and regulation functions reduce the emission of harmful substances and fuel consumption. Additional functions are: control of exhaust gas recirculation, boost pressure control, cruise control, electronic protection.

6. WORKING WITH TRAINING EQUIPMENT

Before working with the training stand, connect the two parts of the stand together. This requires connecting the power cord to the first part of the stand. The cable must be connected properly, the connector lock must be locked.

The stand is designed and manufactured to reproduce the work of a real engine as much as possible. The values of the individual elements (B30 Simulator, B105 Simulator, B24 Simulator, RPM) are set manually using dedicated potentiometers. Depressing the accelerator pedal is also done manually. If a fixed position of the accelerator pedal is required for various measurements simulating certain engine operating conditions, it shall be determined by means of a propeller. If the motor's operating values do not correspond to reality, the stand may operate incorrectly, or a fault or error message may be recorded in the memory of the motor control unit.

Depressing the accelerator pedal does not increase the engine crankshaft speed. Depressing the pedal only simulates a higher load, and if other conditions allow, the amount of fuel injected will increase. The speed of the crankshaft is changed with the help of a potentiometer, the speed is displayed on the RPM screen.

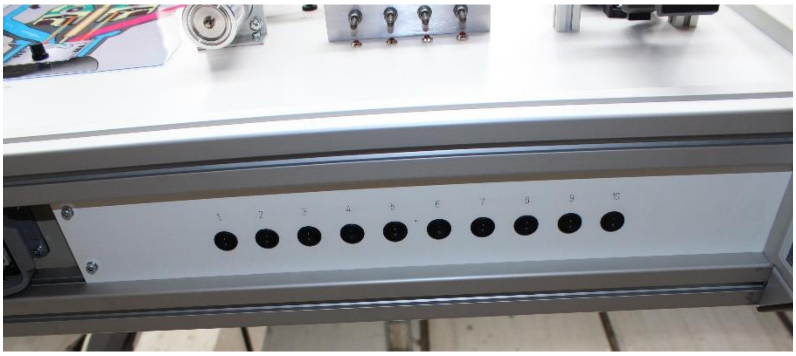
In the contacts of the electrical circuit, it is possible to measure the voltages, signal forms, frequencies, currents of the elements connected there. When the jumper is removed from the electrical circuit, an open circuit is simulated. This responds to the operation of the stand components. A fault is detected in the motor control unit. Suitable medium for diagnostic studies.

The values of the sensor signals can be measured with a multimeter directly at the contacts in the wiring diagram. The display of the sensor signal voltage you want to see is displayed on the TFT voltmeter screen. Which sensor voltage will be displayed is determined by the rotary switch below the display?

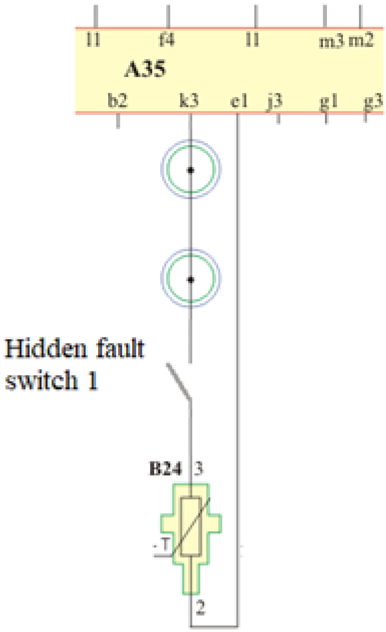
Using system scanners (computer diagnostics), it is possible to see the actual engine operating parameters, perform diagnostics, scan and clear fault errors, and perform activation functions of various elements by connecting to the OBD II connector. Diagnostic capabilities will depend on the system scanner model and software version used.

7. HIDEN FAULT SIMULATION

There are 12 hidden faults installed on the training stand. They are activated by a switch. The switches are mounted on the bottom of the first part of the stand.


Hidden faults switches

Switching off the switch interrupts the electrical circuit. This causes an error in the system. Switches are installed between the component and the electrical circuit breaker. Look on the picture below. Electronic control unit A35 contact k3, hidden fault switch, electrical circuit breaker, component B24.



Location of the hidden fault switch

Switching off the switch interrupts the electrical circuits of the following components:

If no errors need to be simulated, all switches must be turned on.

In the powertrain management system

FAULT 1
B24
ACTUAL FAULT

Open circuit between engine control unit A35 pin k3 and engine coolant temperature sensor B24 pin 3

DTC DESCRIPTION

DF001 Water Temperature Sensor Circuit, Open Circuit or Short Circuit To +12 V

FAULT 2

B31

ACTUAL FAULT

Open circuit between engine control unit A35 pin j3 and fuel temperature sensor B31 pin 1

DTC DESCRIPTION

DF098 Fuel Temperature Sensor Circuit, Open Circuit or Short Circuit To +12 V

FAULT 3

B30

ACTUAL FAULT

Open circuit between engine control unit A35 pin h4 and Mass – air flow sensor B30 pin 5

DTC DESCRIPTION

DF056 Air flow Sensor Circuit, Open Circuit or Short Circuit to Earth

FAULT 4

B186

ACTUAL FAULT

Open circuit between engine control unit A35 pin d1 and fuel rail pressure sensor B186 pin 2

DTC DESCRIPTION

DF192 Fuel Pressure Sensor Circuit, Open Circuit or Short Circuit To +12 V

FAULT 5

B138

ACTUAL FAULT

Open circuit between engine control unit A35 pin f1 and Accelerator pedal position sensor B138 pin 6

DTC DESCRIPTION

DF198 Track 2 Pedal Sensor Circuit, Open Circuit or Short Circuit to Earth

FAULT 6

B138

ACTUAL FAULT

Open circuit between engine control unit A35 pin c1 and Accelerator pedal position sensor B138 pin 3

DTC DESCRIPTION

DF196 Track 1 Pedal Sensor Circuit, Open Circuit or Short Circuit to Earth

FAULT 7

Y102
ACTUAL FAULT
Open circuit between engine control unit A35 pin f4 and Intake air control valve Y102 pin 1
DTC DESCRIPTION
DF226 Inlet Flap Circuit, Open Circuit or Short Circuit to Earth

FAULT 8
B54
ACTUAL FAULT
Open circuit between engine control unit A35 pin g3 and Engine speed sensor B54 pin A
DTC DESCRIPTION
DF195 Coherence Between Camshaft Sensor/Engine Speed, No Engine Speed Signal or Speed Signal Interference

FAULT 9
B132
ACTUAL FAULT
Open circuit between engine control unit A35 pin k4 and Camshaft position sensor B132 pin 2
DTC DESCRIPTION
DF195 Coherence Between Camshaft Sensor/Engine Speed, No Camshaft Signal or Problem on The Timing (Belt Tension or Timing Setting)

FAULT 10
B149
ACTUAL FAULT
Open circuit between engine control unit A35 pin c2 and Exhaust gas recirculation potentiometer B149 pin 6
DTC DESCRIPTION

FAULT 11
K208
ACTUAL FAULT
Open circuit between engine control unit A35 pin a2 and Coolant blower motor relay – I
DTC DESCRIPTION
DF176 Fan Unit Slow Speed Circuit, Open Circuit or Short Circuit to Earth

FAULT 12
B25
ACTUAL FAULT
Open circuit between engine control unit A35 pin d3 and Intake air temperature sensor pin1
DTC DESCRIPTION
DF002 Air Temperature Sensor Circuit, Oper Circuit or Short Circuit to + 12 V

8. WARRANTY CONDITIONS

Our products meet modern technical standards. We guarantee that our product is perfectly constructed and manufactured. They operate reliably if used correctly and in accordance with the provided maintenance rules.

Educational training board is used for educational purposes and can be used only with the components and operating fluids that are fitted on the board.

The guarantee of ____ months is provided for the educational training board. The guarantee begins to run from the sale date of the stand.

In order to warrant the setting of the appropriate date of sale, we ask the buyer to save the relevant contract documents: purchase check, invoice, transfer-acceptance act, warranty card with a product name filled correctly and clearly, number, date of sale, store stamp, signature and the signature of the seller.

The warranty is not applied:

- if the user did not comply with the usage, transportation and storage conditions, used not appropriate operating fluids and aggressive cleaning agents;
- if the stand was damaged by the third parties, force majeure (fire, catastrophe etc.) or another side effect;
- for mechanical breakings and other breaches;
- for warn out parts of the stand, fuses and if non-original spare parts are used;
- when the stand is regulated, improved or remade by unauthorized persons who cannot carry out this work;
- for naturally worn parts such as collars, straps and filters;
- in case of the fluid spill;
- when using the incomplete kit;
- if extraneous objects or some water gets into the product;
- when operating incorrectly or plugging into a messy electric network.

Warranty conditions do not cover the costs related with dismantlement of the product and transportation to the authorized warranty service enterprise. Also, it does not cover consultation, actuation and adjustment work costs. If the elements necessary for repairing the board have to be ordered from the supplier, the repair work may be prolonged.

Warranty repair is done at technical service stations authorized by the manufacturer. During the warranty period defective product components are repaired or replaced free of charge. Technical service station has the right to make a decision about the repair or replacement of the components. The elements that are being changed become the property of the service station.

After completion of the warranty repairs, the guarantee is not extended but remains valid until the time limit provided. The manufacturer reserves the right to change the appearance, design and structure of the product. Service center has the right to suspend the guarantee if the stand was used for other purposes.

Warranty maintenance coupon

Name	________________
Product number	
Date of sale	
Training equipment owner	________________
Trading partner / representative	________________

Description of work performed

Data	Description of the fault and its elimination process	Technician / Signature

NOTES

Shell V-Oil 1412

Special dilution oil for V-Oil 1404

Shell V-Oil 1412 is a spezial dilution oil for viscosity adjustment of Shell V-Oil 1404.

Application

Shell V-Oil 1412 is developed for the viscosity adjustment of Shell V-Oil 1404.

Properties

Shell V-Oil 1412 contains the same performance additives as Shell V-OIL 1404. This means there is no dilution effect in terms of additives while using this product.

Typical Physical Characteristics

Shell V-Oil 1412			
Density at 15°C	kg/m³	DIN 51757	818
Flashpoint COC	°C	DIN ISO 2592	92
Pourpoint	°C	DIN ISO 3016	-27
Kinematic viscosity		DIN 51562	
at 40°C	mm²/s		1,85
at 20°C	mm²/s		2,8
Boiling range		DIN 51751	
Initial boiling point	°C		220
Final boiling point	°C		360
Oxidation	Residue mg/100ml	ASTM D 2274	0,4

These charcteristics are typical of current production. Whilst future production will conform to Shell`s specification, variations in these characteristics may occur.

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