

11 - Oil pick-up pipe

12 - Bolt M6 -tighten to 10 Nm (89 in-lb)

- On engines with integrated oil pump and oil scraper: Remove oil pump with scraper.
- On engines with separate oil pump and scraper:
 - ◆ First remove mounting bolts and withdraw oil pump intake pipe.
 - ◆ Remove oil pump mounting bolts. Remove oil pump assembly.

Note:

- ◆ Note any spacers between pump and engine block.
- ◆ Note positions of locating dowels.
- Remove cover from oil pump and check for wear or scoring. Spin oil pump shaft and check that gears turn smoothly. Replace pump if gears spin with difficulty or any wear is present.
- Installation is reverse of removal, noting the following:
 - ◆ Align sprocket splines to oil pump shaft splines before tightening sprocket nut.

Tightening torques	
Oil drain plug to oil	25 Nm (18 ft-lb)

Tightening torques

pan (M12)

Oil pan to engine block

M6, 8.8 grade 10 Nm (89 in-lb)

M6, 10.9 grade 12 Nm (106 in-lb)

M8, 8.8 grade 22 Nm (16 ft-lb)

Oil pump to engine block (M8) 22 Nm (16 ft-lb)

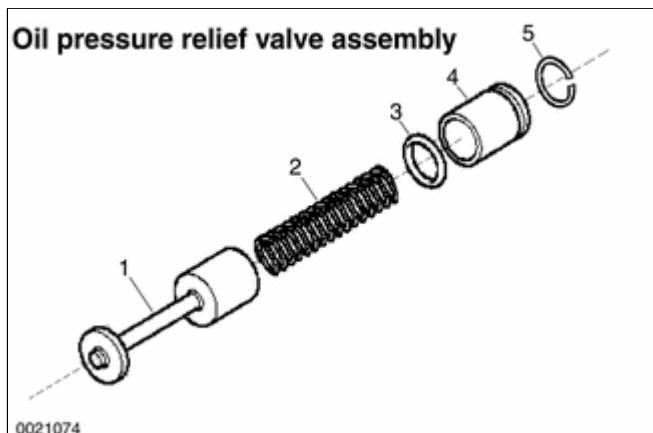
Oil pump sprocket to oil pump shaft

M10x1 left-hand thread 25 Nm (18 ft-lb)

Transmission bellhousing to oil pan

M8 Allen 24 Nm (17 ft-lb)

M8 Torx 21 Nm (15 ft-lb)

Oil pressure relief valve assembly

The oil pump pressure relief valve is held in the side of the oil pump with a circlip.

- 1 - Control plunger
- 2 - Spring
- 3 - Sealing O-ring
- 4 - Sleeve
- 5 - Circlip

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General

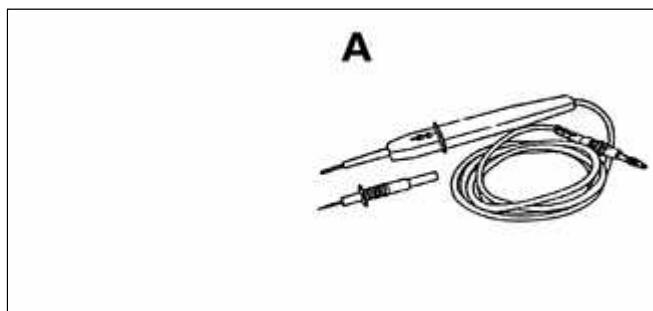
This repair group covers component replacement information for the ignition system.

When diagnosing engine management problems, including on-board diagnostics (OBD II) fault code analysis, also refer to these repair groups:

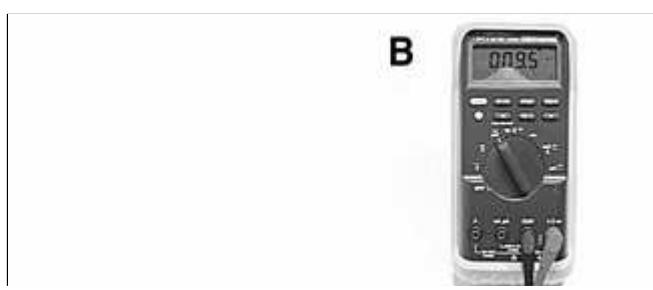
- ◆ ⇒ [100 Engine-General](#)
- ◆ ⇒ [130 Fuel Injection](#)
- ◆ Electrical Wiring Diagrams at the rear of this manual
- ◆ ⇒ [OBD On Board Diagnostics](#) at the rear of this manual

Special tools

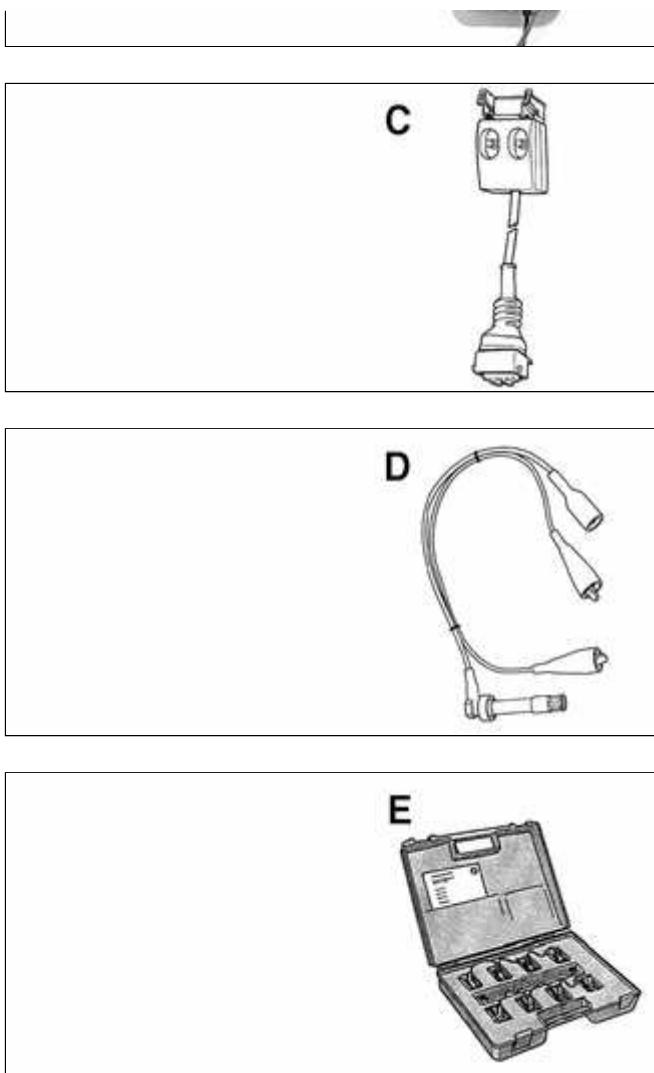
Owing to the coil-per-cylinder configuration, system diagnosis and testing requires special test equipment.



◀ LED test light Baum 1115 (Source: Baum Tools Unlimited)



◀ Automotive digital multimeter Fluke 87



◀ Primary voltage test harness BMW 12 7 020

◀ Secondary voltage test harness BMW 12 7 030

◀ Ignition coil test adapters BMW 12 7 040

Engine management

BMW E46 engines use an advanced engine management system known as Digital Motor Electronics (DME). DME incorporates on-board diagnostics, fuel injection, ignition and other engine control functions. DME variants are listed in ⇒ [Table a](#).

Second generation On-Board Diagnostics (OBD II) is incorporated into the engine management systems used on the cars covered by this manual. Using a BMW-specific electronic scan tool, it is possible to access Diagnostic Trouble Codes (DTCs) that pinpoint ignition and other engine management problems.

Additional information about DTCs and engine management system electronic system diagnosis is provided in ⇒ [OBD On Board Diagnostics](#) at the rear of this manual.

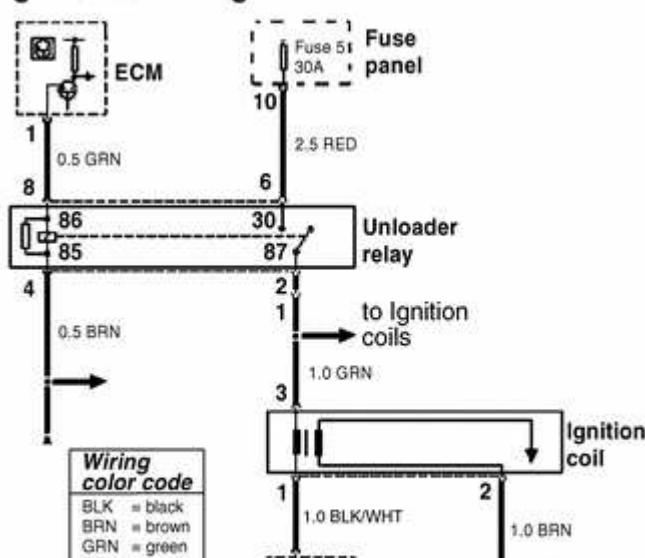
Table a. Engine management systems

Year: Engine	DME system
1999 - 2000: M52 TU B25 M52 TU B28	Siemens MS 42.0
2001: M54 B25 M54 B30	Siemens MS 43.0

Ignition system



Ignition coil wiring



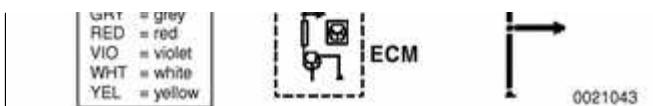
◀ All engines use a distributorless ignition system with individual ignition coils for each cylinder. There is no distributor cap or ignition rotor.

◀ Each coil can be controlled by the Engine Control Module (ECM) on a cylinder-by-cylinder basis.

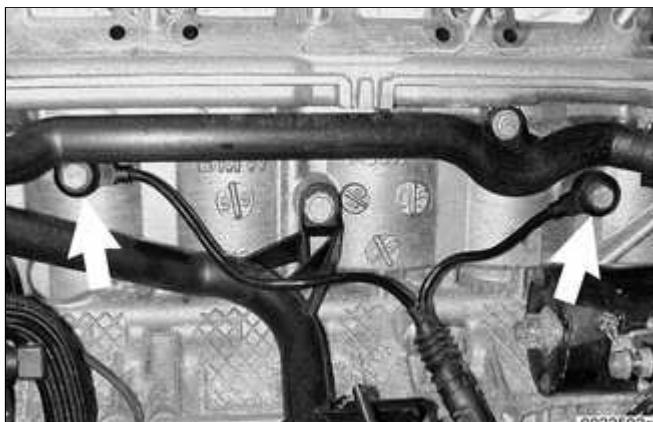
Note:

Schematic diagram of ignition coil circuit is for MS 42.0 engine management system. On MS 43.0 system, ignition coil terminal 3 receives power from Fuse 1 (30 amp). See Electrical Wiring Diagrams for specific wiring information.

WARNING!



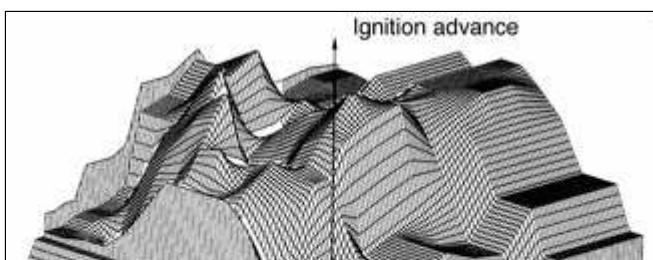
- ◆ ***Do not touch or disconnect any cables from the coils while the engine is running or being cranked by the starter.***
- ◆ ***The ignition system produces high voltages that can be fatal. Avoid contact with exposed terminals. Use extreme caution when working on a car with the ignition switched on or the engine running.***
- ◆ ***Connect and disconnect the DME system wiring and test equipment leads only when the ignition is OFF.***
- ◆ ***Before operating the starter without starting the engine (for example when making a compression test) always disable the ignition.***



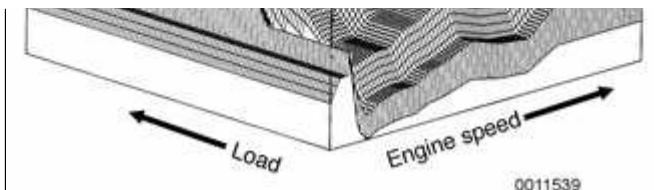
◀ Knock sensors (**arrows**) monitor the combustion chamber for engine-damaging knock. Two sensors monitor three cylinders each. If engine knock is detected, the ignition point is retarded by the ECM.

Note:

When knock is detected, ignition timing will be retarded at the selective cylinder(s) by 3° increments. If knock is no longer detected, the timing will be advanced in 1° increments.



◀ Ignition timing is electronically mapped and not adjustable. The ECM uses engine load, engine speed, coolant temperature, knock detection and intake air temperature as the basic inputs for timing control. A three



dimensional map similar to the one shown is digitally stored in the ECM.

The initial ignition point is determined by the crankshaft speed sensor during cranking. Once the engine is running, timing is continually adjusted based on operating conditions.

Basic troubleshooting principles

Poor driveability may have a variety of causes. The fault may lie with the ignition system, the fuel system, parts of the emission control system, or a combination of the three. Because of these interrelated functions and their effects on each other, it is often difficult to know where to begin looking for problems.

For this reason, effective troubleshooting should always begin with an interrogation of the On-Board Diagnostics (OBD II) system. The OBD II system detects engine management malfunctions. When faults are detected, the OBD II system stores a Diagnostic Trouble Code (DTC) in the Engine Control Module (ECM) along with other pertinent fault information. In addition, the Malfunction Indicator Light (MIL) will come on if an emissions related fault is detected. Additional OBD II information, including a DTC lookup table can be found in the back of this manual under ⇒ [OBD On Board Diagnostics](#).

Note:

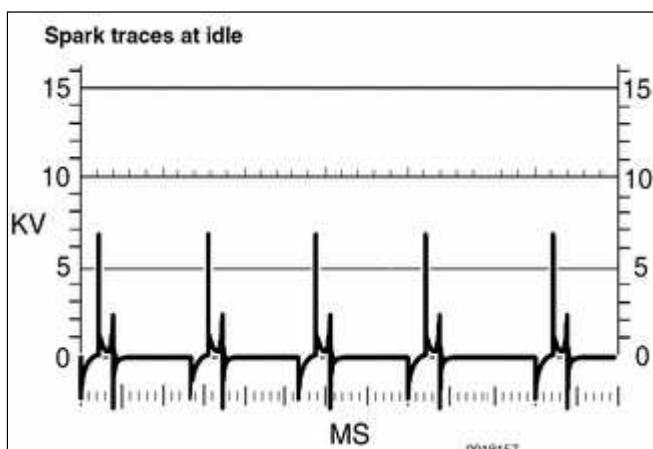
On model year 1999 and 2000 cars, the MIL is labeled Check Engine. On model year 2001 cars, the MIL is labeled Service Engine Soon.

An engine that starts and runs indicates that the ignition system is

fundamentally working-delivering voltage to the spark plugs. A hard-starting or poor-running engine, however, may indicate a problem with how well the spark is delivered. Faulty or worn ignition components, such as old spark plugs, or an individual coil problem may be the cause.

WARNING!

Inefficient combustion (rich air/fuel mixture) can cause elevated hydrocarbon exhaust emissions and catalytic converter damage. For this reason, if a severe misfire is detected, the fuel injector will be turned off to the specific cylinder and the MIL illuminated.

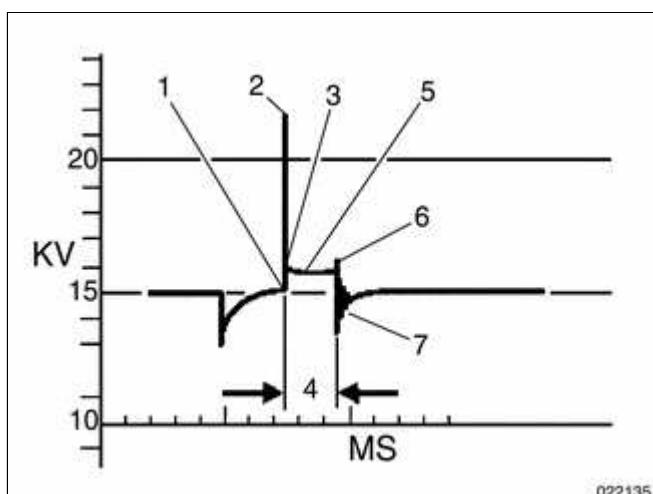


One way to diagnose a faulty coil on a car that is running is to use an oscilloscope to analyze spark quality. The illustrations show normal scope trace of spark at idle.

⇒ [Table b](#) lists common ignition coil voltage faults and related causes.

Note:

Note the length of sparking period and the up-down voltage attenuations. A short sparking period and/or an irregular/low voltage attenuation usually indicates a faulty coil.



A normal oscilloscope pattern for a six cylinder engine.

- 1 - Start of ignition voltage peak
- 2 - Level of ignition voltage
- 3 - Level of combustion voltage
- 4 - Period of combustion
- 5 - Combustion curve characteristics
- 6 - Start of decay process

7 - Termination oscillations

Note:

See ⇒ [Ignition coil assembly, testing and replacing as described later.](#)

Table b. Ignition trace diagnostics

Parameter	Ignition voltage low	Ignition voltage high
Spark plug electrode gap	too small	too big
Spark plug electrode condition	-	worn/burnt
Spark plug electrode temperature	too high	too low
Engine compression	too low	too high
Spark plug wire(s)	-	faulty
Fuel air mixture	-	too lean

Misfire detection

Engine misfire, the result of inefficient combustion in one or more cylinders, may be caused by a variety of malfunctions in various subsystems.

The OBD II system incorporated into the MS 42.0 and MS 43.0 engine management systems is designed to detect and warn of misfire faults during engine operation. Misfire fault codes are listed in ⇒ [Table c. Misfire fault codes](#). For a detailed list of fault codes see ⇒ [OBD On Board Diagnostics](#).

Once engine misfire has been detected and the fault codes downloaded from the ECM, it is necessary to follow a diagnostic path to correct the problem. The ignition subset of the diagnostic path is shown in ⇒ [Table d. Ignition system problems](#)

Table c. Misfire fault codes

P code	BMW fault code	Fault code	Possible cause(s)
P0301	238	Misfire cylinder 1	Ignition fault: Defective or incorrect spark plug(s) or connector(s); defective ignition coil(s) Mechanical fault: Crankshaft pulse wheel loose or damaged; damaged piston(s), valve(s) or camshaft(s); oil pressure low
P0302	239	Misfire cylinder 2	Catalyst fault: Excessive exhaust backpressure due to restricted catalyst
P0303	240	Misfire cylinder 3	Fuel supply fault: Contaminated fuel; fuel delivery fault (blocked filter, low fuel in tank, defective fuel pump); running loss system fault; leaking or blocked fuel injector(s); fuel pressure regulator fault; evaporative system fault
P0304	241	Misfire cylinder 4	ECM/sensor input fault: Implausible sensor signal; oxygen sensor(s) faulty; ECM faulty
P0305	242	Misfire cylinder 5	
P0306	243	Misfire cylinder 6	
P1396	244	Crankshaft sensor adaptation at limit	Misfire detection fault: Varying pulse wheel tolerances or loose pulse wheel

Table d. Ignition system problems

Component	Condition	Test	Repair
Spark plug	Incorrect spark plug Electrode gap too small Electrode(s) missing Oil or fuel fouled spark plug Ceramic insulation cracked	Inspect spark plugs.	Verify correct spark plugs. Replace plugs if defective. Check crankcase ventilation and oil level.

Component	Condition	Test	Repair
Secondary circuit	Wet coil Corroded coil connections	Secondary circuit	Check for water leak. Check resistance values (see ⇒ Table e).
Ignition coil	Primary or secondary circuit on or shorted Housing cracked, damaged	Primary and secondary circuits (see ⇒ Table e)	Replace coil as necessary.
Ignition coil harness connector	Power supply, primary control circuit or ground (shunt signal) circuits impaired	Primary ignition and terminal 4A feedback preset measurements	Look for open, loose connector, corrosion, crossed or damaged connector pins. Inspect ignition unloader relay. Replace coils as necessary.

Warnings and cautions

The engine management system contains sensitive electronic components. To protect the system and for general safety, the following warnings and cautions should be observed during ignition system troubleshooting, maintenance or repair work.

WARNING!

- ♦ ***Do not touch or disconnect any cables from the coils while the engine is running or being cranked by the starter.***
- ♦ ***The ignition system produces high voltages that can be fatal. Avoid contact with exposed terminals. Use extreme caution when working on a car with the ignition switched on or the engine running.***

- ♦ **Connect and disconnect the DME system wiring and test equipment leads only when the ignition is OFF.**
- ♦ **Before operating the starter without starting the engine (for example when making a compression test) always disable the ignition.**

CAUTION!

- ♦ **Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.**
- ♦ **Do not attempt to disable the ignition by removing the coils from the spark plugs.**
- ♦ **Connect or disconnect ignition system wires, multiple wire connectors, and ignition test equipment leads only while the ignition is off. Switch multimeter functions or measurement ranges only with the test probes disconnected.**
- ♦ **Do not disconnect the battery while the engine is running.**
- ♦ **A high impedance digital multimeter should be used for all voltage and resistance tests. An LED test light should be used in place of an incandescent-type test lamp.**
- ♦ **In general, make test connections**

***only as specified by BMW, as
described in this manual, or as
described by the instrument
manufacturer.***

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Ignition System Service

Ignition firing order



- Each ignition coil is mounted above the corresponding spark plug. Cylinder 1 is at the front of the engine.

Ignition firing order

M52 TU/M54 engine	1 - 5 - 3 - 6 - 2 - 4
----------------------	--------------------------

Disabling ignition system

The ignition system operates in a lethal voltage range and should therefore be disabled any time engine service or repair work is being done that requires the ignition to be switched on.

- The engine management system can be disabled by removing the DME main relay (arrow). The relay is located in the electronics box (E-box) in the left rear of the engine compartment.

CAUTION!

Relay locations may vary. Use care when identifying relays. The main relay has a large (4 mm 2) red wire at terminal 30 and a large (4 mm 2) red/white wire at terminal 87. See ⇒ [610 Electrical Component Locations](#).



Checking for spark

CAUTION!

If a spark test is done incorrectly, damage to the Engine Control Module

(ECM) or the ignition coils may result.

Note:

Spark plug replacement is covered in ⇒ 020 Maintenance.

Checking for spark is difficult on engines with distributorless ignition systems.

Try removing the spark plugs and inspecting for differences between them. A poor-firing plug may be wet with fuel and/or black and sooty, but not always. If a coil is not operating, the engine management system will electrically disable the fuel injector to that cylinder. The key is to look for differences between cylinders.

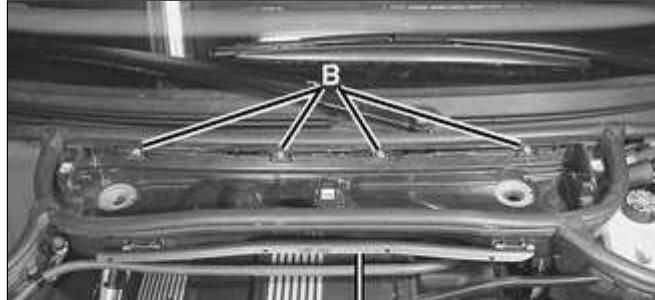
Ignition coil assembly, testing and replacing

CAUTION!

Use a digital multimeter for the following tests.

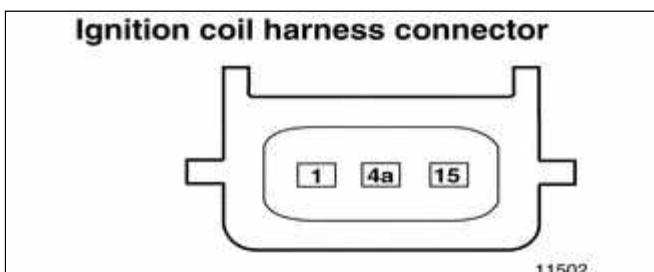


- ◀ Remove interior ventilation microfilter.



- ◀ Remove housing for microfilter for interior ventilation.

- ◆ Open wiring harness loom (**A**) and remove wires.



- ◆ Unfasten screws (**B**) and remove lower microfilter housing.
- Remove plastic engine cover from top of valve cover by prying off bolt covers and removing cover mounting bolts.

◀ Disconnect harness connector from coil. Connect multimeter between terminal **15** (+) in connector and ground.

- Turn ignition on and check for battery voltage.

- ◆ If battery voltage is not present, check wire between terminal **15** and ignition switch. See Electrical Wiring Diagrams.

CAUTION!

The wiring to terminal 15 (+) of the coil (via the ignition switch) is not fuse protected. Use care when testing this circuit.

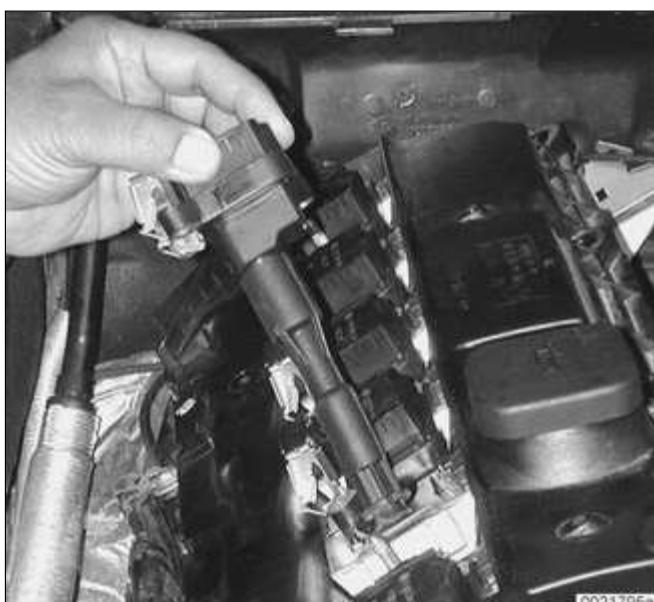
- Turn ignition off.

◀ Remove coil and inspect coil housing for hairline cracks or leaking casting material. A leaky ignition coil may indicate a faulty Engine Control Module (ECM). Check ECM before installing a new coil.

CAUTION!

Note location of coil ground straps before coil removal; reinstall in the same location.

- Use a multimeter to test:

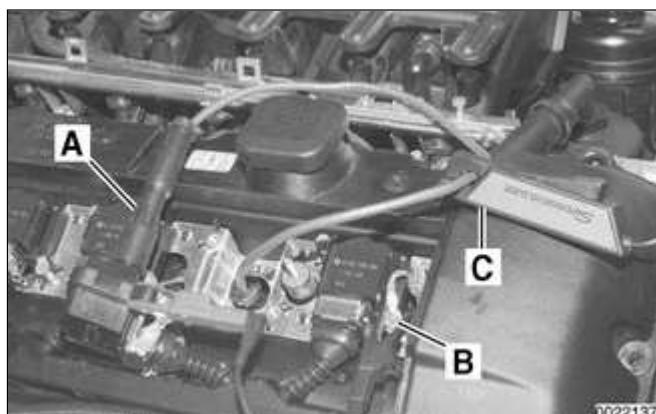


- ◆ Coil primary resistance at coil terminals
- ◆ Spark plug connector resistance
- ◆ Compare results to specification in
⇒ [Table e.](#)

Table e. Ignition coil resistance

Component	Terminals	Resistance
Coil primary	1 (-) and 15 (+)	approx. 0.8 Ω
Coil secondary		N.A.
Spark plug connector		
Bosch		1 k Ω 20%
Beru		1.8 k Ω 20%

- Replace ignition coil or spark plug connector if resistance readings do not meet specifications.



◀ Remove ignition coil to be tested.

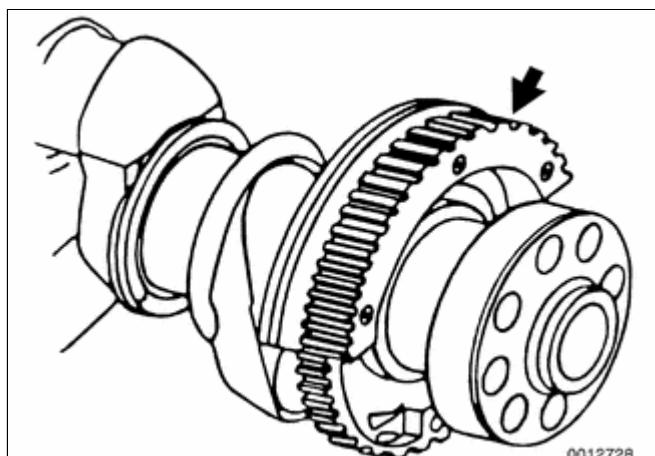
- ◆ Install BMW special tool 12 7 030 (A) on coil to be tested.
- ◆ Connect ground jumper between coil mounting point and engine ground point (B).
- ◆ Clip scope high pick-up lead (C) around ignition lead.
- ◆ Start engine.

- ◆ Compare scope pattern with diagrams in ⇒ [Basic troubleshooting principles](#).

Note:

When replacing ignition coils, ensure that the replacements are from the same manufacturer with the same part/code numbers. If individual coils with the correct specifications are not available, all coils should be replaced.

Crankshaft speed sensor, replacing



The crankshaft speed sensor is mounted in the left rear side of the cylinder block below the starter. The sensor reads a toothed pulse wheel (arrow) mounted to the end of the crankshaft.

If the Engine Control Module (ECM) does not receive a signal from the crankshaft speed sensor during cranking, the engine will not start.

If the OBD II system misfire detection protocol detects a catalyst damaging fault due to a malfunction in crankshaft speed sensor components, the Check Engine light (Malfunction Indicator Light or MIL) will be illuminated.

Note:

If the crankshaft speed sensor pulse wheel is damaged, the engine will have to be disassembled down to the crankshaft to replace the wheel.

- Make certain ignition has been turned off.

- Raise car and support in a safe manner.

WARNING!

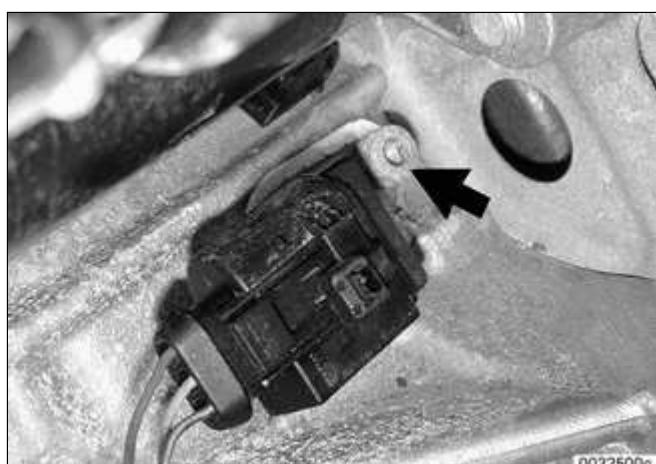
Make sure the car is stable and well supported at all times. Use a professional automotive lift or jack stands designed for the purpose. A floor jack is not adequate support.

- Remove under-engine splash guards.



Working just underneath starter:

- ◆ Cut off wire tie securing crankshaft speed sensor harness connector (arrow) to sensor.
- ◆ Disconnect harness connector.



Remove sensor mounting screw (arrow) and remove sensor from cylinder block.

- Installation is reverse of removal, noting the following:
 - ◆ Use a new O-ring when installing sensor.
 - ◆ Be sure wiring is rerouted in same orientation.
 - ◆ Secure sensor using new wire ties.
 - ◆ Use scan tool to read out and clear

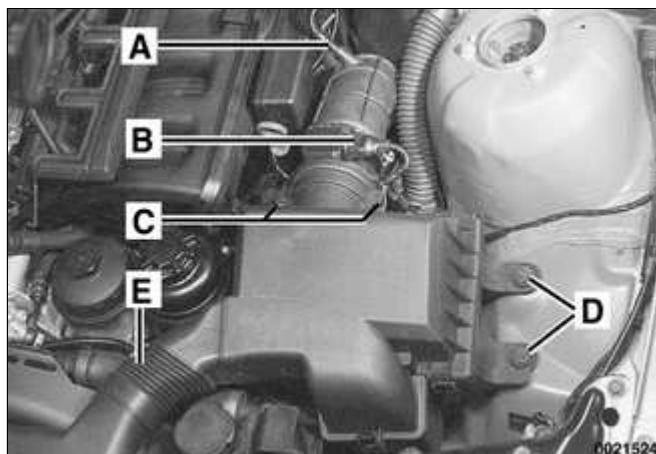
ECM fault memory.

Camshaft position sensors

The camshaft position sensors are used by the engine management system for VANOS control, sequential fuel injection and knock control.

Intake camshaft position sensor, replacing

- Make certain ignition has been turned off.
- Remove housing for the microfilter for interior ventilation as shown earlier.
- Remove plastic cover from above fuel injectors by prying off bolt covers and removing cover mounting bolts.



Remove complete air filter housing:

- ◆ Disconnect electrical harness connector on mass air flow sensor (B).
- ◆ Detach vacuum line at intake boot (A).
- ◆ Remove filter housing mounting screws (D).
- ◆ Loosen hose clamp at intake boot and detach air duct connections (C).

- ◆ Disconnect cold air duct tube (**E**).
- Disconnect harness connector from VANOS solenoid and unscrew solenoid from VANOS control unit. Be prepared with shop rags to catch oil released from VANOS unit.



◀ Remove camshaft sensor (**arrow**) from left front of cylinder head, next to top of oil filter housing.

- Disconnect camshaft sensor harness from under intake manifold. Prior to removal, attach a stiff piece of wire to the harness connector end to preserve proper routing of harness for reinstallation.
- Installation is reverse of removal.
- ◆ Use new O-rings when installing sensor and solenoid.
- ◆ Be sure wiring is rerouted in same orientation.
- ◆ Use scan tool to read out and clear ECM fault memory.

Tightening torques

Intake camshaft sensor to cylinder head	5 Nm (3.5 ft-lb)
VANOS solenoid to VANOS control unit	30 Nm (22 ft-lb)

Exhaust camshaft position

sensor, replacing

- Make certain ignition has been turned off.



Working at front of engine on exhaust (right) side, detach exhaust camshaft position sensor electrical harness connector (arrow).

- Remove camshaft sensor from right front of cylinder head.
- Installation is reverse of removal.
- ◆ Use a new O-ring when installing sensor.
- ◆ Be sure wiring is rerouted in same orientation.
- ◆ Use scan tool to read out and clear ECM fault memory.

Tightening torque

Exhaust camshaft sensor to cylinder head	5 Nm (3.5 ft-lb)
--	------------------

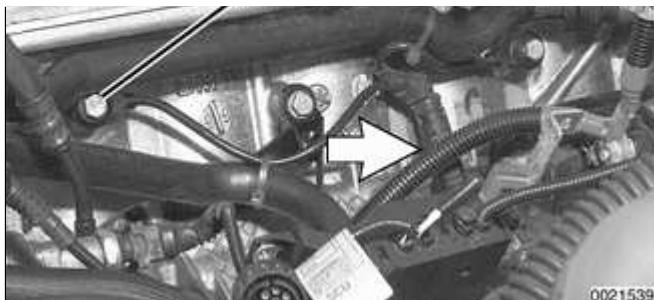
Knock sensors, replacing

The knock sensors are bolted to the left side of the cylinder block under the intake manifold.

- Remove intake manifold as described in ⇒ [113 Cylinder Head Removal and Installation](#).



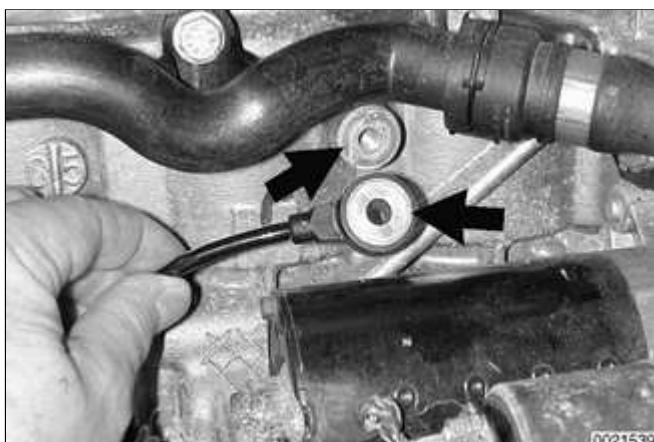
Disconnect knock sensor electrical harness connector (arrow) on left side of engine cylinder block.



- ◆ Remove knock sensor mounting bolts (**A**) on side of cylinder block. Remove sensors.

CAUTION!

Note the installed angle of the knock sensor on the block before removing it. Reinstall the sensor in the same position. Be sure to use a torque wrench when tightening the sensor mounting bolt.



- ◀ Clean knock sensor contact surface on engine block and sensor (**arrows**) before installing knock sensor.

Tightening torque

Knock sensor to cylinder block	20 Nm (15 ft. lbs.)
--------------------------------	---------------------

- Use scan tool to read out and clear ECM fault memory.

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General

This repair group covers service and repair for the Siemens engine management systems used on the E46 models covered by this manual. Additional engine management information may also be found in the following repair groups:

- ◆ ⇒ [100 Engine-General](#)
- ◆ ⇒ [120 Ignition System](#)
- ◆ ⇒ [160 Fuel Tank and Fuel Pump](#)
- ◆ Electrical Wiring Diagrams

Note:

Fuel pressure testing and fuel pump repair information is covered in ⇒ [160 Fuel Tank and Fuel Pump](#).

Table a. Engine management systems

Model Year: Engine code	DME system
1999 - 2000: M52 TU B25 M52 TU B28	Siemens MS 42.0
2001: M54 B25 M54 B30	Siemens MS 43.0

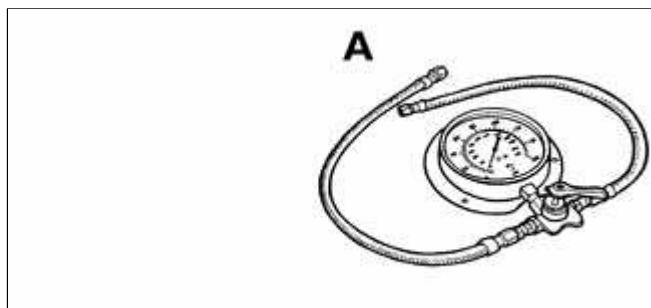
The Siemens systems are sophisticated self-diagnosing OBD II systems. These systems continuously monitor components and record and store valuable diagnostic information.

When faults arise, or if the MIL

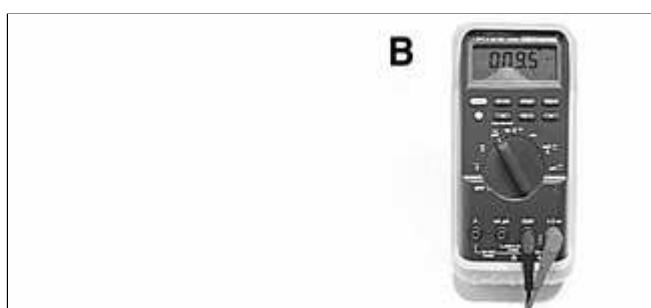
(malfunction indicator lamp) in the instrument cluster is illuminated, begin troubleshooting by hooking up a BMW-compatible scan tool. The rich diagnostic capabilities of these systems have the potential to save hours of diagnostic time, incorrect component replacement and possible damage to system components. See ⇒ [OBD On Board Diagnostics](#) at the back of this manual.

Tools and test equipment

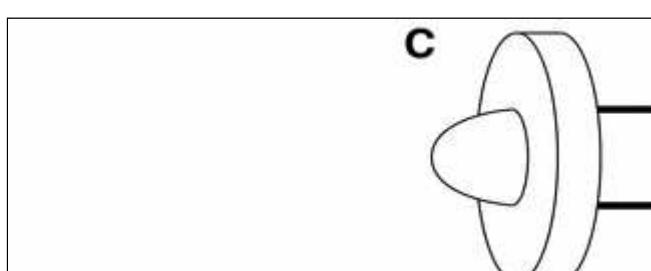
If the equipment required to do the job is unavailable, it is recommended that these repairs be left to an authorized BMW dealer or other qualified BMW repair facility.



- ◀ Fuel pressure gauge Baum 1318
(Source: Baum Tools Unlimited)



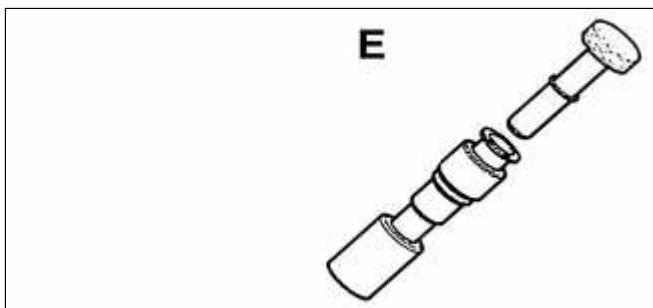
- ◀ Automotive digital multimeter Fluke 87



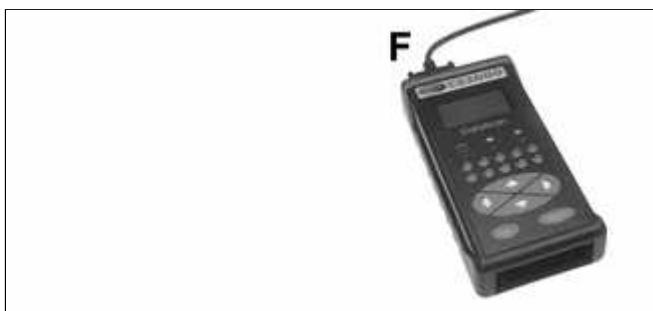
- ◀ Low current test light ("noid") Baum 1115a (Source: Baum Tools Unlimited)



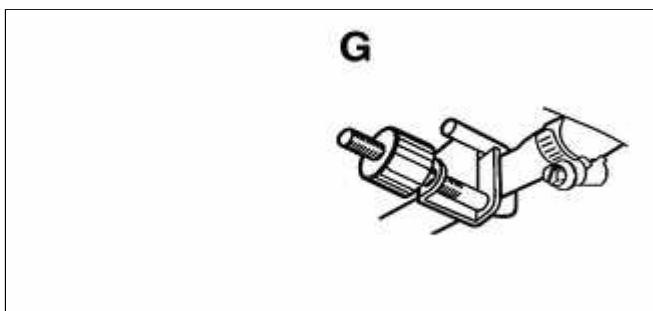
- ◀ Factory DTC scan tool BMW DIS/MoDiC



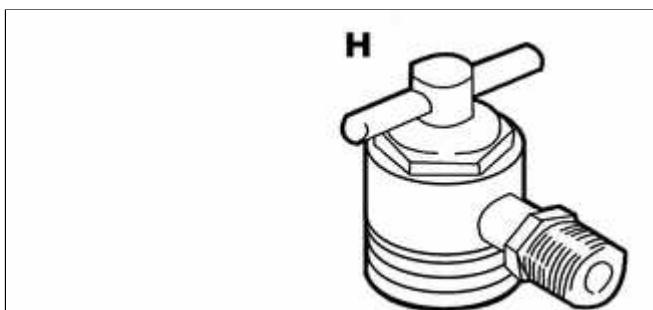
◀ Fuel line plugs BMW 13 5 281 / 13 5 282



◀ Aftermarket DTC scan tool Baum CS2000 (Source: Baum Tools Unlimited)



◀ Fuel line clamp BMW 13 3 010



◀ Fuel rail to pressure gauge fitting BMW 13 5 220

Note:

- ◆ *Professional diagnostic scan tools available at the time of this printing include the BMW factory tools (DISplus and MoDiC) and a small number of aftermarket BMW-specific tools. The 'CS2000' from Baum Tools Unlimited, the 'Retriever' from Assenmacher Specialty Tools, and the MT2500 from Snap-on are three examples*

of quality OBD scan tools.

- ◆ *In addition to the BMW professional line of scan tools, there are many inexpensive 'generic' OBD II scan tool software programs and handheld units available. Although these tools have limited capabilities as compared to the dedicated tools, they are powerful diagnostic tools. These tools read live data streams, freeze frame information for DTCs (diagnostic trouble codes) and impending DTCs, as well as a host of other valuable diagnostic data.*
- ◆ *For the DIY owner, simple aftermarket DTC readers are also available. These inexpensive BMW-only tools are capable of checking for DTCs as well as turning off the illuminated MIL, and resetting the service indicator lights.*
- ◆ *See ⇒ 020 Maintenance for specialty tool manufacturer contact information.*

Principle of operation

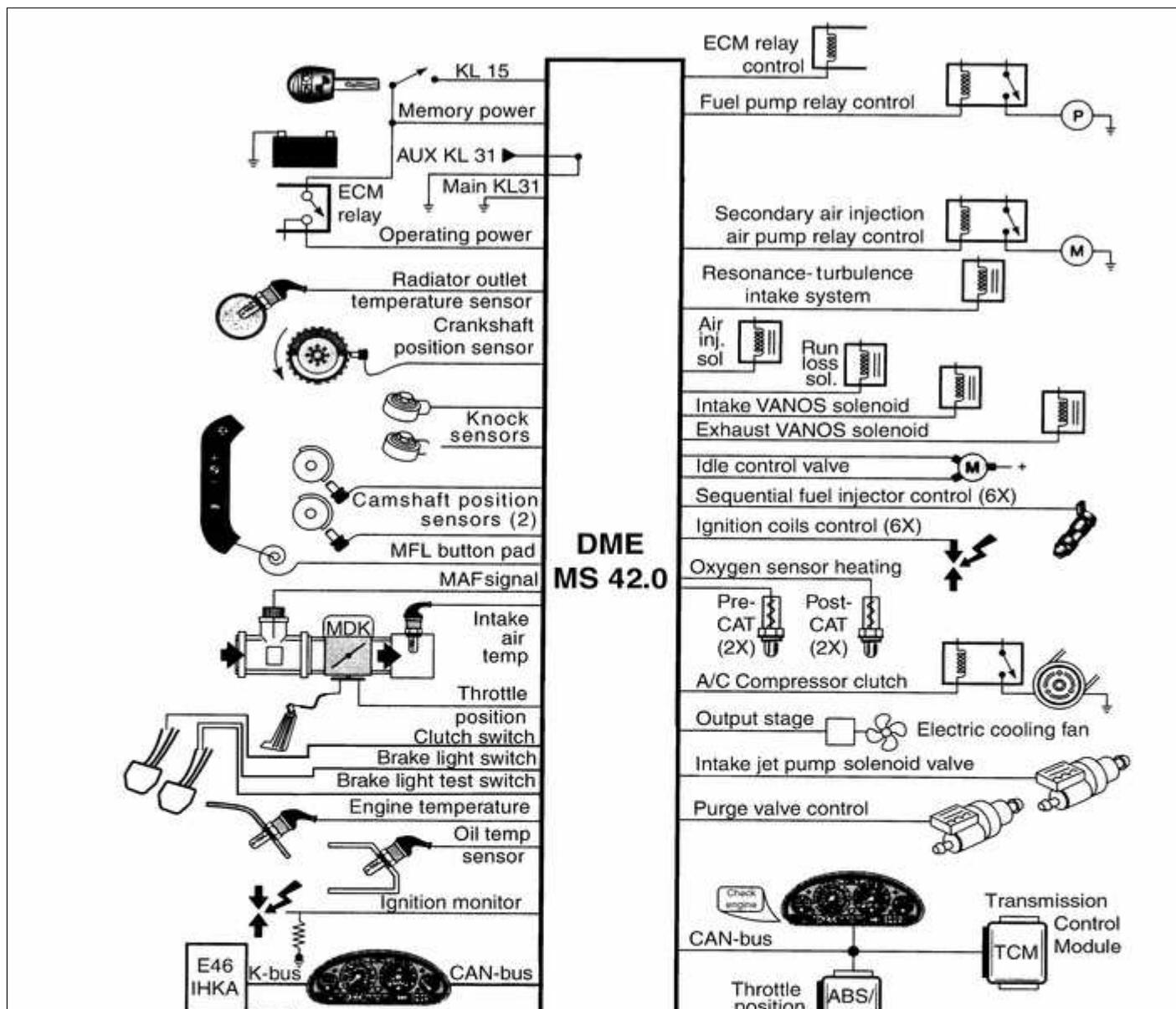
The DME fuel injection system is completely electronic in operation. Intake air, engine coolant temperature, crank and camshaft positions, engine speed and many other engine operating parameters are measured electronically and the information is supplied to the engine control module (ECM).

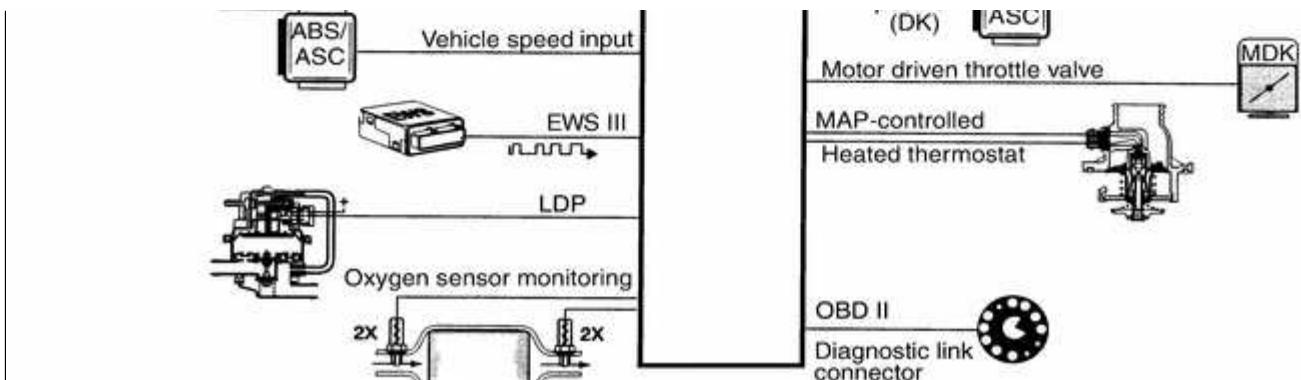
Based on input information, the ECM controls the ignition coils, fuel injectors,

motor driven throttle valve, double VANOS system, radiator cooling fan, electrically heated thermostat, as well as other outputs.

The illustration on the following page shows the MS 42.0 ECM inputs and outputs. The MS 43.0 system is similar in operation, with the main difference being the fully electronic 'drive-by-wire' throttle valve. Additional system operational information can be found in ⇒ [100 Engine-General](#).

DME MS 42.0





0021013

Warnings and cautions

For personal safety, as well as the protection of sensitive electronic components, adhere to the warnings and cautions on the following pages.

WARNING!

- ◆ ***Gasoline is highly flammable and its vapors are explosive. Do not smoke or work on a car near heaters or other fire hazards when diagnosing and repairing fuel system problems. Have a fire extinguisher available in case of an emergency.***
- ◆ ***When working on an open fuel system, wear suitable hand protection, as prolonged contact with fuel can cause illnesses and skin disorders.***
- ◆ ***The ignition system produces high voltages that can be fatal. Avoid contact with exposed terminals. Use extreme caution when working on a car with the ignition switched on or the engine***

running.

- ♦ *Do not touch or disconnect any cables from the coils while the engine is running or being cranked by the starter.*
- ♦ *Connect and disconnect the DME system wiring and test equipment leads only when the ignition is switched off.*
- ♦ *Renew fuel system hoses, clamps and O-rings any time they are removed.*
- ♦ *Before making any electrical tests that require the engine to be cranked using the starter, disable the ignition system as described in ⇒ 120 Ignition System.*

CAUTION!

- ♦ *Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.*
- ♦ *Do not connect any test equipment that delivers a 12-volt power supply to terminal 15 (+) of the ignition coil. The current flow may damage the ECM. In general, connect test equipment only as specified by BMW, or the equipment maker.*
- ♦ *Only use a digital multimeter for electrical tests.*
- ♦ *Only use an LED test light for*

quick tests.

- ♦ *Disconnecting the battery may erase fault code(s) stored in memory. Check for fault codes prior to disconnecting the battery cables.*
- ♦ *Wait at least 40 seconds after turning off the ignition before removing the engine control module (ECM) connector. If the connector is removed before this time, residual power in the system relay may damage the control module.*
- ♦ *Cleanliness is essential when working on an open fuel system. Thoroughly clean fuel line connections and surrounding areas before loosening. Avoid moving the car. Only install clean parts.*
- ♦ *Fuel system cleaners and other chemical additives other than those specifically recommended by BMW may damage the catalytic converter, the oxygen sensor or other fuel supply components.*

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Electrical Checks and Component Testing

Troubleshooting and fault diagnosis on OBD II cars is best performed using an electronic scan tool. However, it may be necessary to perform basic tests of the engine management main components, fuel system or wiring.

CAUTION!

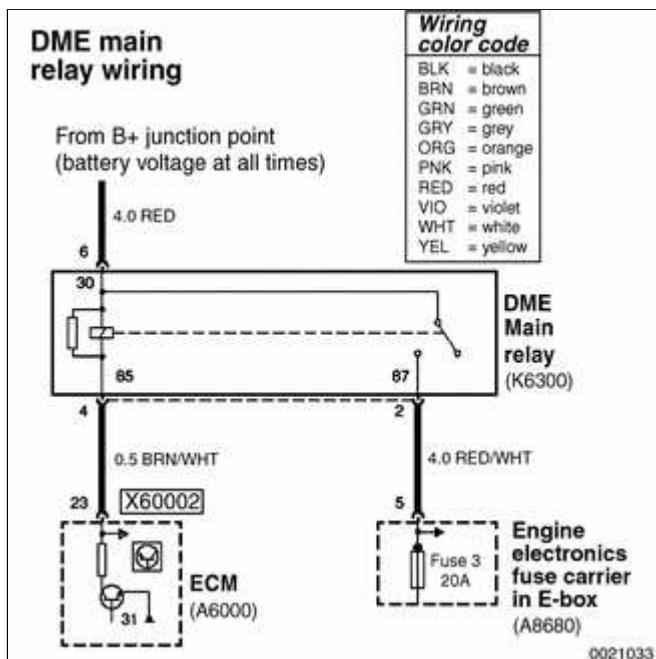
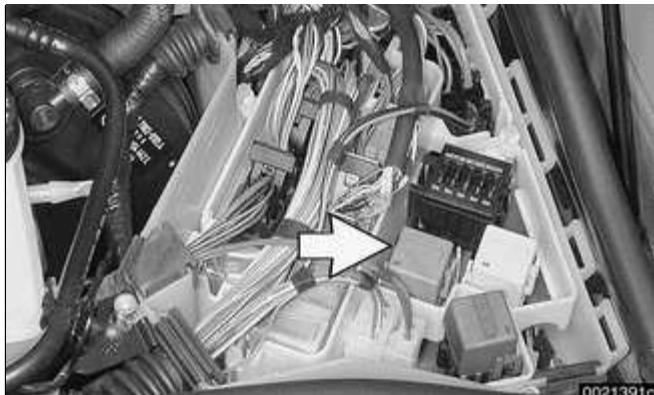
- ♦ *The tests in this section may set fault codes (DTCs) in the ECM and illuminate the MIL. After all testing tests is completed, access and clear DTC fault memory using a BMW compatible scan tool. See ⇒ OBD On Board Diagnostics at the back of this manual.*
- ♦ *Only use a digital multimeter for electrical tests.*
- ♦ *Relay positions can vary. Be sure to confirm relay position by identifying the wiring in the socket using the wiring diagrams found at the rear of this manual.*

DME main relay, testing

The DME main relay is energized via the engine control module (ECM) and supplies battery positive (B+) power to many of the engine management components and subsystems. If this relay is faulty, the engine will not start.



With ignition off, remove main relay (arrow) in electronics box (E-box) at



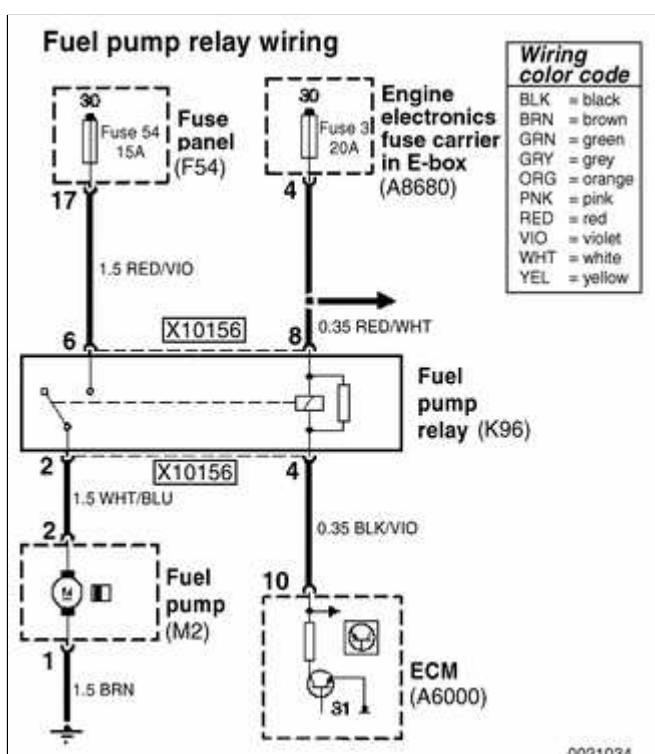
left rear of engine compartment.

- ◀ Check for voltage at terminal **6** of main relay socket (**30- red** wire).
- ◆ If battery voltage is present continue testing.
 - ◆ If battery voltage is not present, check large red wire in relay socket. See Electrical Wiring Diagrams.
 - Reinstall relay and turn ignition on. Gain access to underside of relay socket and check for ground at terminal **4** (**85- brown/white** wire).
 - ◆ If ground is present continue testing.
 - ◆ If ground is not present, signal from ECM (connector X60002, pin **23**) is missing. Check wire between ECM and relay.
 - With ignition on and relay installed, check for battery voltage at terminal **2** (**87- red/white** wire).
 - ◆ If battery voltage is present, relay has energized and is functioning correctly.

- ◆ If battery voltage is not present and all earlier tests are OK, relay is faulty and should be replaced.

Fuel pump relay, testing

The ECM energizes the fuel pump relay by providing the coil side of the relay with ground. During starting, the fuel pump runs as long as the ignition switch is in the start position and continues to run once the engine starts. If the relay is faulty the fuel pump will not run.



- ◀ Fuel pump relay (**arrow**) is located behind glove compartment. Remove glove compartment. See ⇒ [513 Interior Trim](#).

- Remove fuel pump relay from socket.

- ◀ With ignition in START position, check for battery voltage at relay connector (X10156) terminals **6** and **8** (**red/violet and red/white wires**).

CAUTION!

Ensure that manual transmission vehicles are not in gear, and automatic transmission vehicles are in Park or Neutral prior to operating ignition in START position.

- With ignition in START position, use digital multimeter to check for ground at terminal **4** (**black/violet wire**).

Note:

The ground at terminal 4 is switched by the ECM. The ECM harness must be connected to check the switched ground connection.

- If no faults are found up to this point, turn ignition key off. Using a fused (14 gauge) jumper wire, connect relay connector terminal **6** to terminal **2**. The fuel pump should run.
- ◆ If pump runs and all other tests are as specified, fuel pump relay is probably faulty.
- ◆ If pump does not run, test fuel pump operation as described in ⇒ [160 Fuel Tank and Fuel Pump.](#)

CAUTION!

The jumper wire should be 1.5 mm² (14 ga.) and include an in-line fuse holder with a 15 amp fuse. To avoid fuse/relay panel damage from repeated connecting and disconnecting, also include a toggle switch.

Fuel delivery and fuel pressure

Checking fuel delivery volume and fuel pressure is a fundamental part of troubleshooting and diagnosing the engine management system. Fuel pressure directly influences fuel delivery. Procedures for measuring the fuel pressure and fuel volume are given in ⇒ [160 Fuel Tank and Fuel Pump.](#)

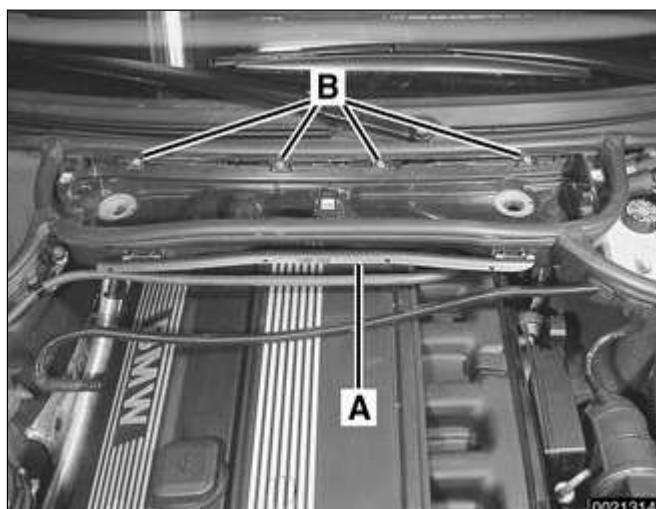
Relieving fuel pressure

The fuel system retains fuel pressure in the system when the engine is turned off. To prevent fuel from spraying on a hot engine, system fuel pressure should be relieved before disconnecting fuel lines. One method is to tightly wrap a shop towel around a fuel line fitting and loosen or disconnect the fitting.

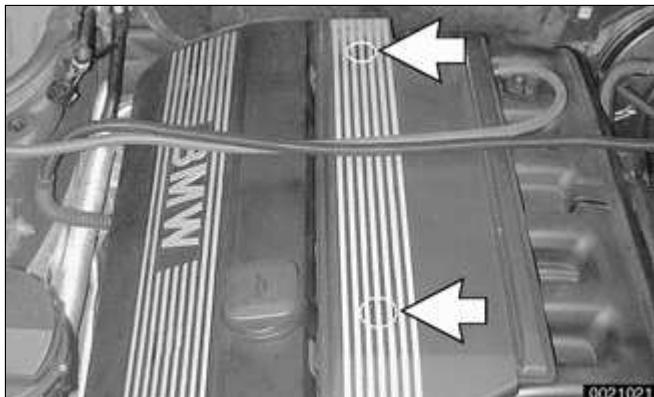
Cleanliness is essential when working with fuel circuit components. Thoroughly clean the unions before disconnecting fuel lines.

WARNING!

- ◆ *Gasoline is highly flammable and its vapors are explosive. Do not smoke or work on a car near heaters or other fire hazards when diagnosing and repairing fuel system problems. Have a fire extinguisher available in case of an emergency.*
- ◆ *When working on an open fuel system, wear suitable hand protection. Prolonged contact with fuel can cause illnesses and skin disorders.*



- ↖ Remove interior ventilation microfilter housing.
- ◆ Remove upper cover and microfilter.
 - ◆ Open wiring harness loom (**A**) and move wiring out of way.
 - ◆ Unfasten screws (**B**) and remove lower microfilter housing.



- ◀ Remove fuel rail cover by prying off nut covers (**arrows**) and removing nuts.



- ◀ Unscrew schræder valve cap (**arrow**) from fuel rail. Unscrew fuel tank cap to release pressure to vent tank.

- Using a brief burst of compressed air (maximum of 3 bar or 43.5 psi) blow fuel back through return line into fuel tank.

WARNING!

- ♦ **Fuel in fuel line is under pressure (approx. 3 - 5 bar or 45 -75 psi) and may be expelled under pressure. Do not smoke or work near heaters or other fire hazards. Keep a fire extinguisher handy. Before disconnecting fuel hoses, wrap a cloth around fuel hoses to absorb any leaking fuel. Catch and dispose of escaped fuel. Plug all open fuel lines.**
- ♦ **Always unscrew fuel tank cap to release pressure in the tank before working on the tank or lines.**

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Component Replacement

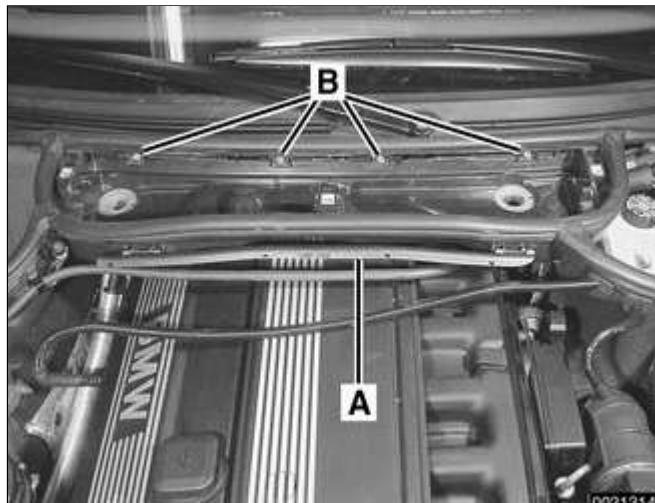
After diagnosing and replacing a faulty engine management component, be sure to use a BMW-compatible scan tool to check and clear the fault memory in the ECM. Diagnostic trouble codes are given in ⇒ OBD On Board Diagnostics at the back of this book.

Fuel rail and injectors, removing and installing

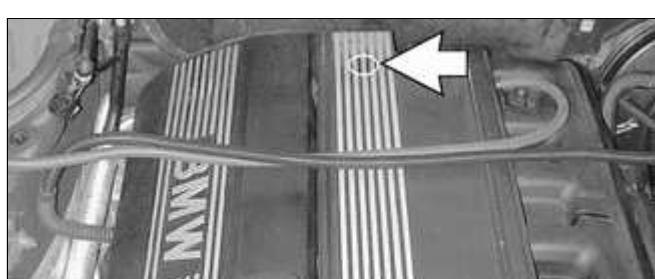
- Disconnect negative (-) battery cable.

CAUTION!

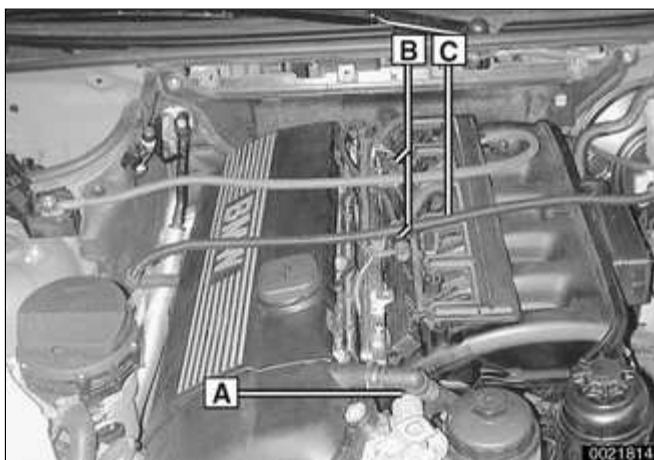
Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.



- ◀ Remove housing for microfilter for interior ventilation.
- ◆ Remove upper cover and microfilter.
 - ◆ Open wiring harness loom (A) and remove wires.
 - ◆ Unfasten screws (B) and remove lower microfilter housing.



- ◀ Remove fuel rail cover by prying off nut covers (**arrows**) and removing nuts.



Working above engine, disconnect electrical harness connectors:

- ◆ VANOS control unit harness connector (A)
- ◆ Connectors for oxygen sensors (B)
- ◆ Connector for intake air temperature sensor (C)

CAUTION!

Mark oxygen sensor harness connectors in order to avoid reversing them during installation. Incorrect reconnection can cause serious engine damage.



Disconnect fuel injector electrical connectors from injectors:

- ◆ Use small screwdriver to pry one corner of wire lock clip on fuel injector 1 connector.
- ◆ Repeat for all injectors.
- ◆ Lift off connector loom and set aside.



Unscrew schrader valve cap (arrow) from fuel rail. Unscrew fuel tank cap to release pressure to vent tank.

- Using a brief burst of compressed air (maximum of 3 bar or 43.5 psi) blow fuel back through return line into fuel tank.

**WARNING!**

- ◆ ***Do not smoke or work near heaters or other fire hazards. Keep a fire extinguisher handy. Before disconnecting fuel hoses, wrap a cloth around fuel hoses to absorb any leaking fuel. Catch and dispose of escaped fuel. Plug all open fuel lines.***
- ◆ ***Always unscrew the fuel tank cap to release pressure in the tank before working on the tank or lines.***
- Raise car and support in a safe manner.

CAUTION!

Make sure the car is stable and well supported at all times. Use a professional automotive lift or jack stands designed for the purpose. A floor jack is not adequate support.

- Remove protective engine splash guard.

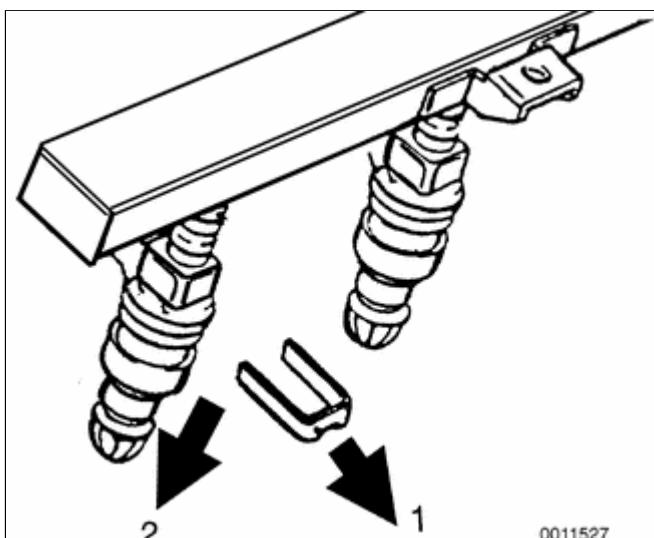
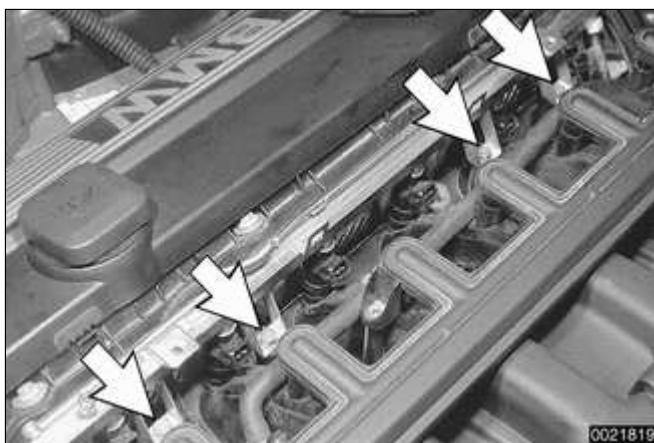
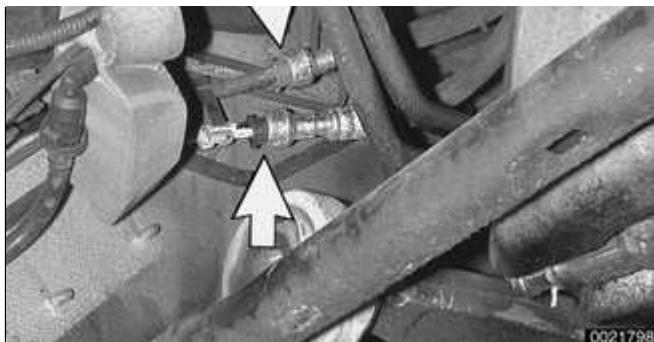
- ↖ Working beneath car (on left side under driver seat), remove fuel filter cover and clamp off fuel hose(s).

Note:

MS 42.0 vehicle shown. Fuel line arrangement on MS 43.0 vehicles varies from that shown. The MS 43.0 system uses a non-return fuel rail. Only a single fuel line leads to the engine compartment.

- ↖ Disconnect fuel hose(s) from fuel line(s) (**arrows**) using special fuel line





removal tool 16 1 050 or equivalent. Seal off fuel line(s) with BMW special tools 13 5 281/13 5 282.

CAUTION!

Fuel may be expelled under pressure. Do not smoke or work near heaters or other fire hazards. Keep a fire extinguisher handy. Before disconnecting fuel hoses, wrap a cloth around fuel hoses to absorb any leaking fuel. Plug all open fuel lines.

- ◀ Remove fuel rail mounting bolts (arrows).

- ◆ Carefully pry fuel rail off manifold.
- ◆ Separate fuel line support bracket at rear of intake manifold.
- ◆ Guide fuel line(s) out of rear of engine compartment while lifting fuel rail out.

- ◀ Remove individual injectors:

- ◆ Pry retaining clip from injector (1).
- ◆ Pull injector from rail (2).
- Installation is reverse of removal.
- ◆ Fit new O-rings when installing injectors. For ease of installation, lightly lubricate all fuel system O-rings with assembly lubricant.
- ◆ Check that injector electrical connections are correctly fitted and that injectors are fully seated prior to installing fuel rail mounting

bolts.

- ◆ Replace any wire ties removed during removal procedure.

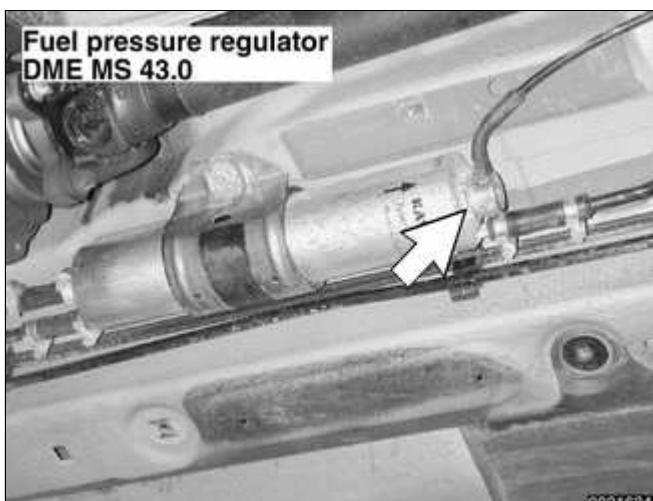
CAUTION!

Replace any flexible fuel lines which were pinched shut during testing.

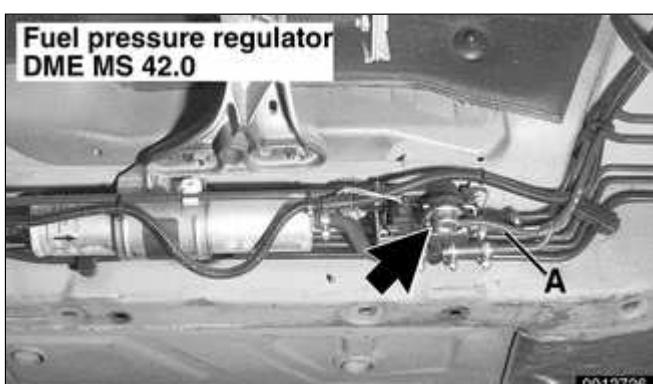
Fuel pressure regulator, replacing

E46 fuel pressure regulator location

DME MS 42.0	under left side of car, in 3/2-way valve
DME MS 43.0	under left side of car, in fuel filter



- ◀ On models with DME MS 43.0, the fuel pressure regulator (arrow) is an integral part of the fuel filter. Fuel filter replacement procedure is covered in ⇒ [020 Maintenance](#).



- ◀ DME MS 42.0: Working under car below driver's seat, remove protective cover from below fuel pressure regulator (arrow).

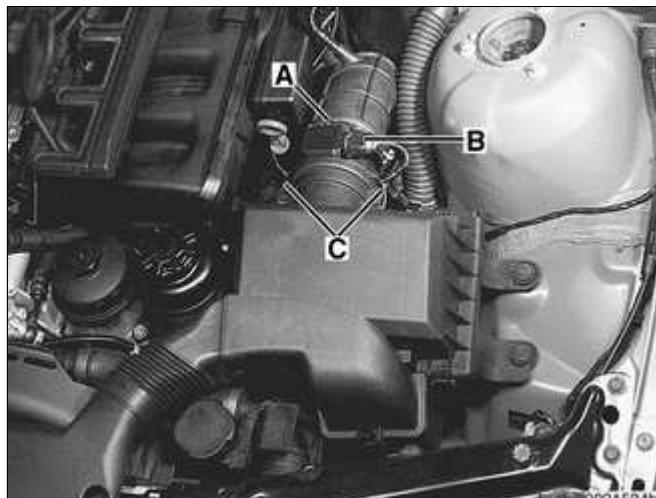
- Disconnect vacuum hose (A) from fuel pressure regulator.

- Remove locking spring clip retaining fuel pressure regulator.
- Wrap a shop rag around regulator, then remove regulator from 3/2 way valve by pulling straight down.
- Installation is reverse of removal. Replace sealing O-rings.

Mass air flow (MAF) sensor, removing and installing

CAUTION!

Be sure the ignition is OFF before replacing DME system components.



- ◀ Loosen hose clamp (A) and pull intake air duct from mass air flow (MAF) sensor.
- Disconnect electrical harness connector (B) and unclip fasteners (C).
 - Remove sensor. Inspect protective screen in sensor housing. Replace sensor if screen is damaged.
 - Inspect air intake ducting for damage and cracks. Replace rubber parts as necessary.
 - Installation is reverse of removal.
 - ◆ Replace sealing O-ring between sensor and air filter housing.

Note:

No adjustment to air flow sensor is possible.

Engine coolant temperature (ECT) sensor, replacing

The engine coolant temperature (ECT) sensor is located toward the rear of the cylinder head below intake runner no. 6. Intake manifold removal is required to access the ECT sensor.

CAUTION!

Be sure the ignition is OFF before replacing DME system components.

- Remove intake manifold as described in => [110 Engine Removal and Installation](#).

WARNING!

Due to risk of personal injury, be sure the engine is cold before beginning the removal procedure.



- Working at rear of cylinder head, disconnect harness connector (**arrow**) from ECT sensor.

- Remove sensor. Catch any coolant that leaks out with shop rags.
- Installation is reverse of removal.
- ◆ Use a new copper sealing washer when installing new sensor.
- ◆ Replace lost coolant.

Tightening torque

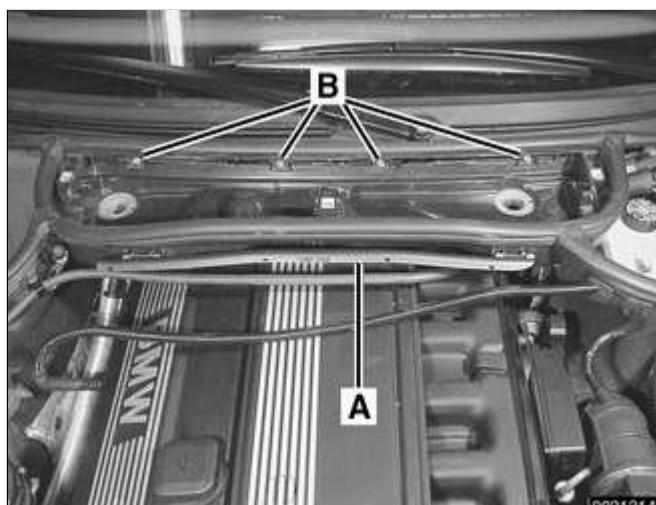
Tightening torque

ECT sensor to cylinder head

13 Nm (10 ft-lb)

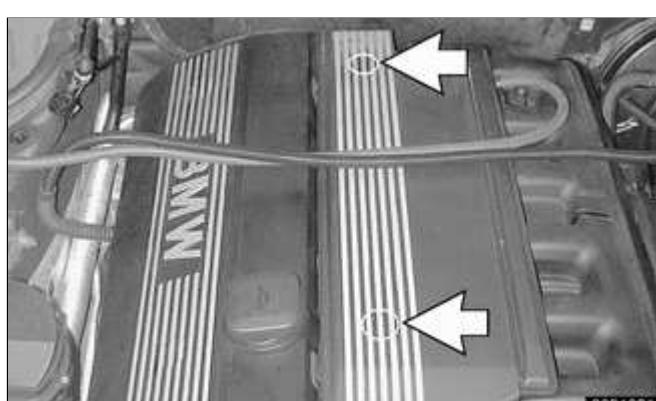
Intake air temperature (IAT) sensor, replacing

The intake air temperature (IAT) sensor is located at the top center of the intake manifold. The intake air temperature sensor functions to adapt or fine tune the fuel mixture and engine timing based on varying intake air temperatures.



- ◀ Remove housing for microfilter for interior ventilation.

- ◆ Remove upper cover and microfilter.
- ◆ Open wiring harness loom (**A**) and remove wires.
- ◆ Unfasten screws (**B**) and remove lower microfilter housing.



- ◀ Remove fuel rail cover by prying off plastic covers (**arrows**) and removing nuts.



- ◀ Remove electrical harness connector (**arrow**) from IAT sensor.

CAUTION!***Be sure the ignition is OFF.***



- Depress locking clip on side of temperature sensor and pull straight out of intake manifold.
- Installation is reverse of removal.
- ◆ Use a new sealing O-ring at base of sensor and lubricate with assembly lubricant for ease of installation.

Throttle assembly, removing and installing

Some throttle assembly faults will reset the engine control module (ECM) adaptation values. BMW's diagnostic tool (DIS or MoDiC) or aftermarket equivalent tool is necessary to reset ECM adaptations after throttle assembly replacement.

CAUTION!

After replacement of the throttle valve assembly, and/or on MS 43.0 systems the pedal position sensor, an adaption procedure must be performed using the factory scan tool or equivalent. The vehicle will not start unless this adaption procedure is carried out.

Disconnect battery negative (-) cable in luggage compartment.

CAUTION!

Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.



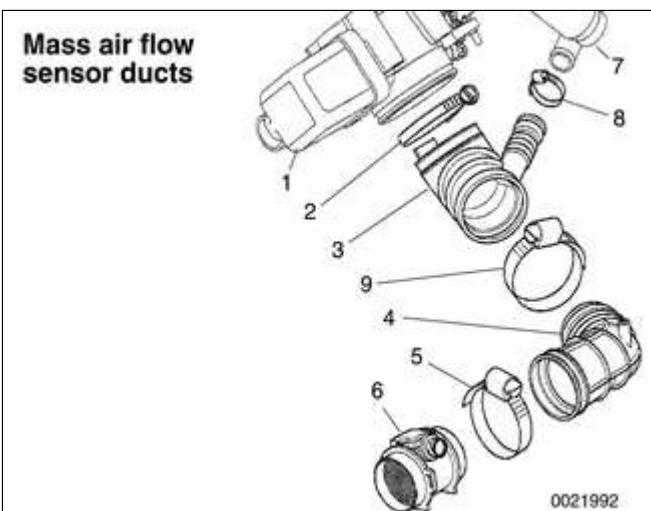
- ◀ Remove complete air filter housing:



- ◆ Disconnect vacuum line at intake boot (**A**).
- ◆ Disconnect electrical harness connector on mass air flow sensor (**B**).
- ◆ Release mass air flow sensor clips (**C**).
- ◆ Remove filter housing mounting screws (**D**).
- ◆ Disconnect air duct connections (**E**) and lift complete air filter housing out of engine compartment, pulling it forward away from mass air flow sensor.

Note:

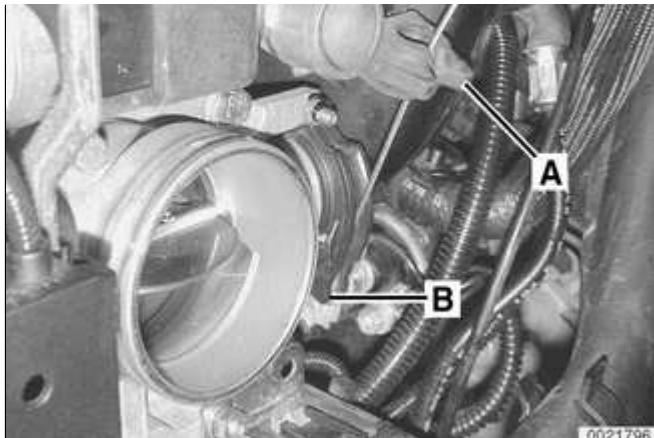
In this step, mass air flow sensor remains attached to rubber air duct.



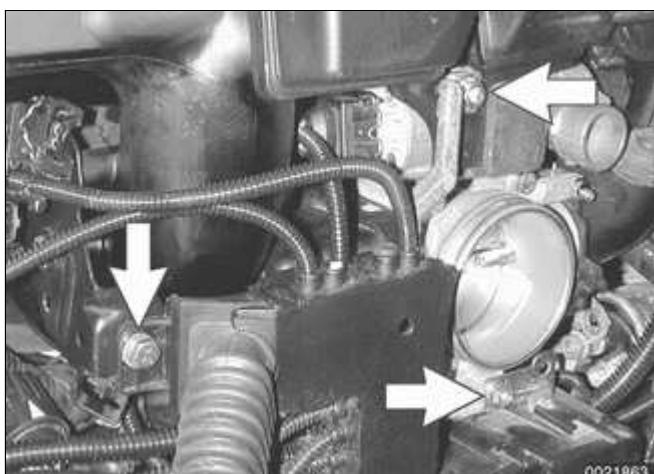
- ◀ Loosen clamps **2** and **8** and remove mass air flow sensor and air ducts.
- 1 - Throttle assembly
 - 2 - Hose clamp 77 - 84 mm
 - 3 - Y-duct
 - 4 - Air duct
 - 5 - Hose clamp 83 - 90 mm
 - 6 - Mass air flow sensor
 - 7 - Idle control valve
 - 8 - Hose clamp 28 - 33 mm
 - 9 - Hose clamp 77 - 84 mm

- ◀ On MS 42.0 vehicles: Pull throttle cable





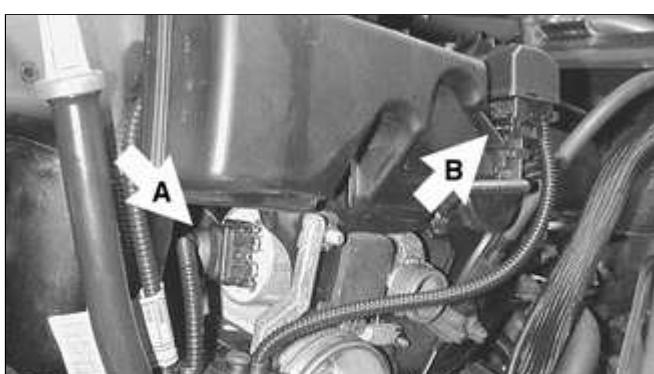
upwards out of rubber retainer (**A**) and unhook ball end of cable (**B**) from throttle actuator.



- ◀ Remove nuts and bolt (**arrows**) retaining wiring harness conduit to throttle body.

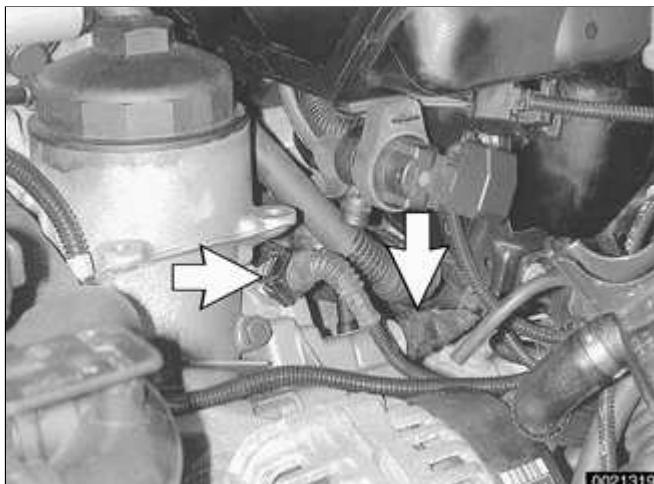


- ◀ Working at throttle housing: Turn harness plug (**arrow**) counterclockwise and remove.

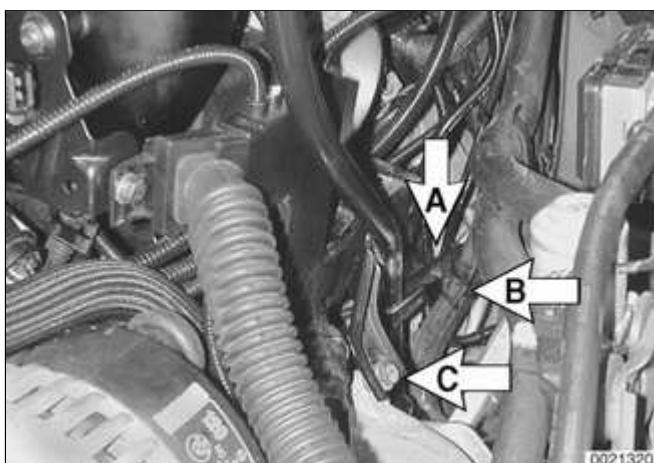


- ◀ Working at side of intake manifold, disconnect electrical harness connectors:

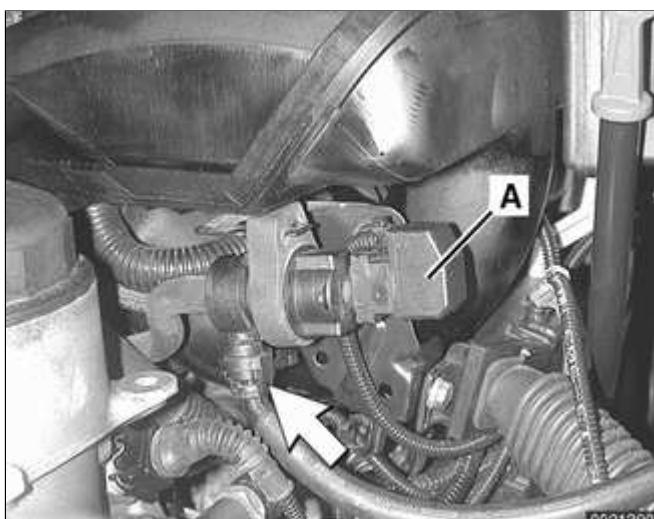
- ◆ Idle control valve (**A**)
- ◆ Intake manifold resonance valve (**B**)



- ◀ Disconnect electrical harness connectors (**arrows**) at oil pressure sender and oil temperature sender at base of oil filter housing.



- ◀ Remove dipstick guide tube:
- ◆ Disconnect wiring harness brackets from tube (**A**).
 - ◆ Unclip fuel lines from tube (**B**).
 - ◆ Remove lower guide tube mounting bolt (**C**). Pull out dipstick guide tube.

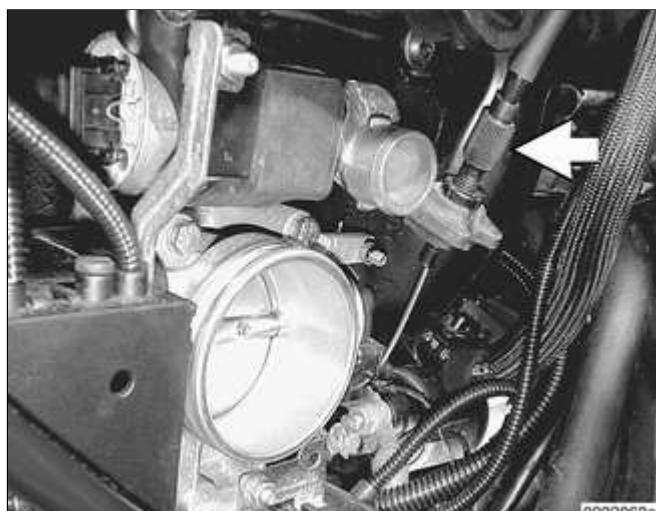


- ◀ If necessary, disconnect electrical harness connector at fuel tank venting valve (**A**). Disconnect hose at quick disconnect fitting (**arrow**).
- Remove throttle assembly mounting screws at all corners and pull assembly off manifold.
 - Installation is reverse of removal.
- ◆ Replace sealing ring between throttle assembly and intake manifold.

- ◆ Reattach throttle assembly harness connector with care. Arrow on fully tightened connector must line up with corresponding arrow on throttle assembly housing.
- ◆ On DME MS 42.0: Reattach throttle cable and adjust as described later.
- ◆ Use BMW scan tool to reset ECM adaptation values.

Throttle cable, adjusting (MS 42.0)

Models with DME MS 42.0 are equipped with a throttle cable. Cable adjustment should be adjusted any time it is disconnected or replaced. This procedure requires the factory scan tool or an equivalent to read and adjust throttle angle. It is recommended that procedure be done by an authorized BMW dealer service department.



Basic adjustment:

- ◆ Ensure that at idle (accelerator pedal in rest position) throttle cable has detectable play at throttle lever attaching point. Play must not exceed maximum allowable.
- ◆ Adjust by turning knurled adjustor (**arrow**) on end of throttle cable sheath at throttle housing.

Throttle cable clearance

Throttle cable clearance

Max. play at throttle plate lever	3 mm (0.125 in.)
--------------------------------------	------------------

- Full throttle adjustment (manual transmission):
 - ◆ With ignition key on press pedal fully to stop. Check throttle angle using scan tool. Adjust pedal stop if necessary.

Throttle angle specifications

Manual transmission:	
Full throttle	80° - 84°

- Full throttle adjustment (automatic transmission):
 - ◆ With ignition key on, press accelerator until pedal touches kickdown stop. Check throttle angle. Press accelerator pedal down beyond kickdown stop pressure point. Check throttle angle. Adjust kickdown stop if necessary, recheck.
 - ◆ Press accelerator down fully against stop. Check throttle angle.
 - ◆ Use scan tool diagnostic program or road test vehicle to confirm transmission downshifts when kickdown is actuated.

Throttle angle specifications

Automatic transmission:	
----------------------------	--

Throttle angle specifications

Kickdown stop contacted	76° - 80°
-------------------------	-----------

Kickdown pressure point range	84° - 88°
-------------------------------	-----------

Full-load downshift	100%
---------------------	------

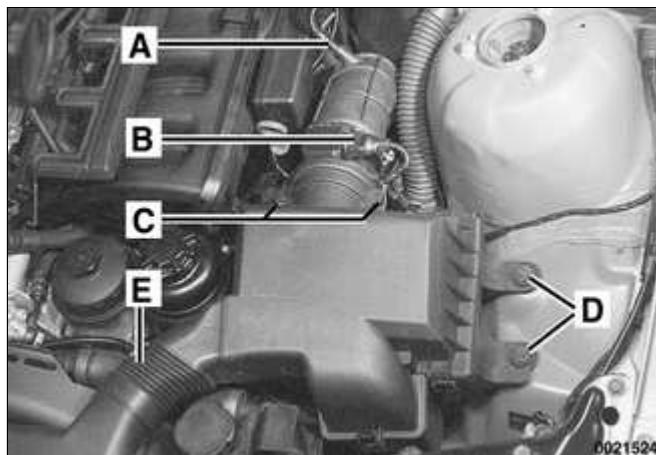
Idle speed control valve, replacing

The idle speed control valve is mounted under the intake manifold adjacent to the dipstick tube bracket. The valve can be removed with the manifold in place, although the job is easier if the manifold is first removed. Intake manifold removal is described in ⇒ [113 Cylinder Head Removal and Installation.](#)

- Disconnect battery negative (-) cable in trunk.

CAUTION!

Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.



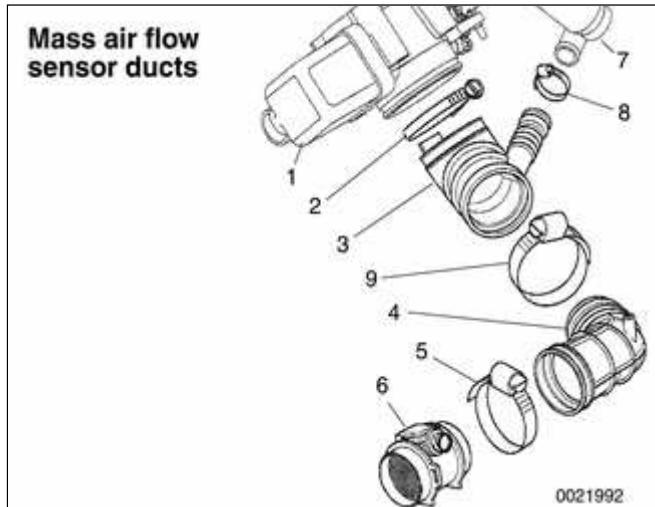
- ◀ Remove complete air filter housing:

- ◆ Disconnect vacuum line at intake boot (A).
- ◆ Disconnect electrical harness connector on mass air flow sensor (B).
- ◆ Release mass air flow sensor clips (C).

- ◆ Remove filter housing mounting screws (**D**).
- ◆ Disconnect air duct connections (**E**) and lift complete air filter housing out of engine compartment, pulling it forward away from mass air flow sensor.

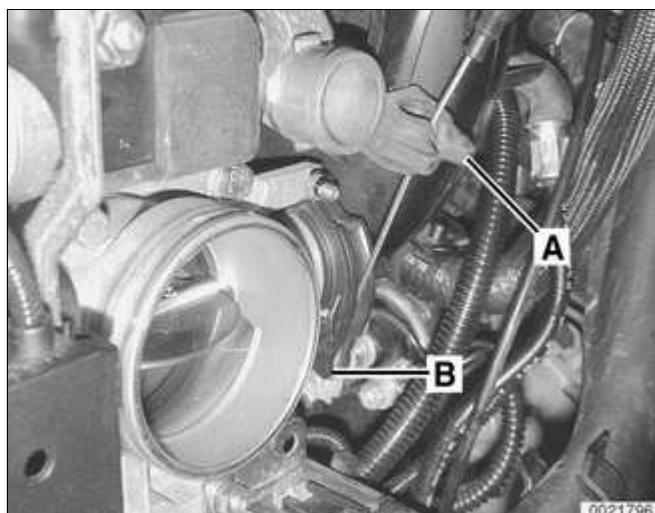
Note:

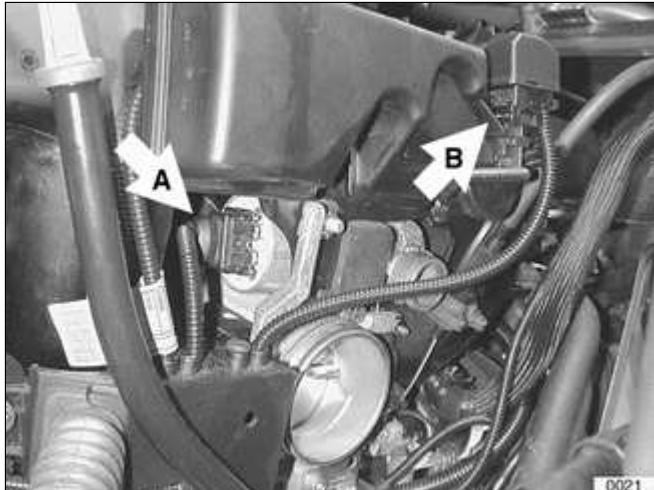
In this step, mass air flow sensor remains attached to intake duct.



- ◀ Loosen clamps **2** and **8** and remove mass air flow sensor and air ducts.
 - 1 - Throttle assembly
 - 2 - Hose clamp 77 - 84 mm
 - 3 - Y-duct
 - 4 - Air duct
 - 5 - Hose clamp 83 - 90 mm
 - 6 - Mass air flow sensor
 - 7 - Idle control valve
 - 8 - Hose clamp 28 - 33 mm
 - 9 - Hose clamp 77 - 84 mm

- ◀ DME MS 42.0: Pull throttle cable upwards out of rubber retainer (**A**) but leave attached to throttle actuator (**B**).





Working at side of intake manifold, disconnect electrical harness connectors:

- ◆ Idle control valve (**A**)
- ◆ Intake manifold resonance valve (**B**)
 - Disconnect bypass hose from idle control valve.
- Remove idle control valve:
 - ◆ Remove idle control valve bracket mounting fasteners.
 - ◆ Slide control valve with bracket out from between intake manifold and throttle assembly.
 - ◆ Pull control valve from rubber retainer.
- Installation is reverse of removal.
 - ◆ Use new gaskets and O-ring seals when installing. Use assembly lubricant to facilitate reassembly.
 - ◆ Install idle control valve rubber seal in intake manifold first, then insert control valve.
 - ◆ Similarly, install mass air flow sensor into intake duct, then install to throttle assembly.

Engine control module (ECM), removing and installing

Note:

Replacement ECMS must be coded with application information (i.e. engine code, transmission type, etc.) prior to installation. Consult an authorized BMW dealer before replacing the ECM. Alternatively, coded ECMS may be available at an additional cost.

- Disconnect negative (-) battery cable. Wait at least three minutes.

CAUTION!

Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.

- Remove E-box cover at left rear of engine compartment. Cover is retained with four captive screws.



- ◀ ECM (**arrow**) is located in right rear of E-box, as identified with five electrical harness connectors.



- ◀ Disconnect ECM harness connectors by releasing lock on each plug and pivoting lever. Pull all five connector up and off ECM.

- Remove ECM from retaining brackets and pull from its holder.



- Installation is reverse of removal.

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ECM Pin Assignments

ECM pin assignments are given in ⇒ [Table b. ECM pin assignment-DME MS 42.0 and MS 43.0](#). This information may be helpful when diagnosing faults to or from the ECM. If all inputs and wiring are OK but operational problems still exist, the ECM itself may be faulty.

Generally, absence of voltage or continuity means there is a wiring or connector problem. Test results with incorrect values do not necessarily mean that a component is faulty. Check for loose, broken or corroded connections and wiring before replacing components. If the results are still incorrect, check the component itself.

For engine management system electrical schematics, see Electrical Wiring Diagrams.

CAUTION!

- ♦ *Always wait at least three minutes after turning off the ignition before removing the connector from the engine control module (ECM). If the connector is removed before this time, residual power in the system relay may damage the ECM.*

- ♦ *Always connect or disconnect the control module connector and meter probes with the ignition off.*

When making checks at the ECM itself, a breakout box should be used to allow tests to be made with the connector attached to the ECM. This also prevents damage to the small terminals

in the connector. As an alternative, the harness connector housing can be separated so that electrical checks can be made from the back of the connector.

Table b. ECM pin assignment-DME MS 42.0 and MS 43.0

Connector X60001 9-pin black			
Pin	Signal	Component/function	Notes
1	Output	Terminal 15	Unloader relay terminal 15
2		not used	
3		not used	
4	Ground	Ground	Ground point
5	Ground	Ground	Ground connector
6	Ground	Ground	Ground connector
7	Input	Terminal 30 (Fuse 80 amp)	B+ Terminal
8	Input	Voltage supply (Fuse 2)	Fuse carrier, engine electronics
9	Input	Voltage supply	Fuse carrier, engine electronics

Connector X60002 24-pin black			
Pin	Signal	Component/function	Notes
1	Input	Heater, precatalyst oxygen sensor 1	Heated oxygen sensor 1 in front of catalytic converter
2		not used	
3	Input/output	CAN bus signal, low	Transmission control module
4	Input/output	CAN bus signal, high	Transmission control module
5		not used	
6	Input/output	Transmit diagnosis line (TXD) data link signal	Transmission control module
7	Input	Heater, post-catalyst oxygen sensor 1	Heated oxygen sensor 1 behind catalytic converter
8		not used	

Connector X60002 24-pin black			
Pin	Signal	Component/function	Notes
9		not used	
10		not used	
11		not used	
12	Input	Signal, 3/2-way valve, running losses (MS 42.0)	3/2 way valve, running losses (MS 42.0)
13	Input	Heater, precatalyst oxygen sensor 2	Heated oxygen sensor 2 in front of catalytic converter
14	Input	Signal, precatalyst oxygen sensor 1	Heated oxygen sensor 1 in front of catalytic converter
15	Input	Signal, precatalyst oxygen sensor 2	Heated oxygen sensor 2 in front of catalytic converter
16	Input	Signal, post-catalyst oxygen sensor 1	Heated oxygen sensor 1 behind catalytic converter
17		not used	
18	Input	Signal, post-catalyst oxygen sensor 2	Heated oxygen sensor 2 behind catalytic converter
19	Input	Heater, post catalyst oxygen sensor 2	Heated oxygen sensor 2 behind catalytic converter
20	Ground	Ground, precatalyst oxygen sensor 1	Heated oxygen sensor 1 in front of catalytic converter
21	Ground	Ground, precatalyst oxygen sensor 2	Heated oxygen sensor 2 in front of catalytic converter
22	Ground	Ground, post-catalyst oxygen sensor 1	Heated oxygen sensor 1 behind catalytic converter
23	Input	DME main relay signal activation	DME main relay
24	Ground	Ground, post-catalyst oxygen sensor 2	Heated oxygen sensor 2 behind catalytic converter

Connector X60003 52-pin black			
Pin	Signal	Component/function	Notes
1	Input	Signal, mass air flow	Hot film mass air flow sensor

Connector X60003 52-pin black			
Pin	Signal	Component/function	Notes
		sensor	
2	Input	Signal, exhaust camshaft sensor 1	Camshaft position sensor II
3	Input	Signal, suction jet pump valve (2.8 L, 3.0 L)	Suction jet pump valve
4	Output	Throttle valve supply (MS 42.0)	Throttle valve (MS 42.0)
5	Input	Signal, intake camshaft position sensor	Camshaft position sensor I
6		not used	
7	Output	Throttle valve supply	Throttle valve
8	Input	Signal, crankshaft position sensor	Crankshaft position sensor
9	Input	Signal, pedal position sensor 2 (MS 42.0)	Throttle valve (MS 42.0)
10	Input	Signal, throttle position potentiometer 2	Throttle valve
11		not used	
12	Input	Feedback signal, engine start	Starter
13	Input	Signal, battery charge indicator lamp	Generator (Alternator)
14	Ground	Ground, throttle position sensor (MS 42.0)	Throttle valve (MS 42.0)
15	Ground	Ground, exhaust camshaft sensor 1	Camshaft position sensor II
16	Input	Signal, pedal position sensor 1 (MS 42.0)	Throttle valve (MS 42.0)
17	Ground	Ground, mass air flow sensor	Hot film mass air flow sensor
18	Ground	Ground, intake camshaft sensor 1	Camshaft position sensor I