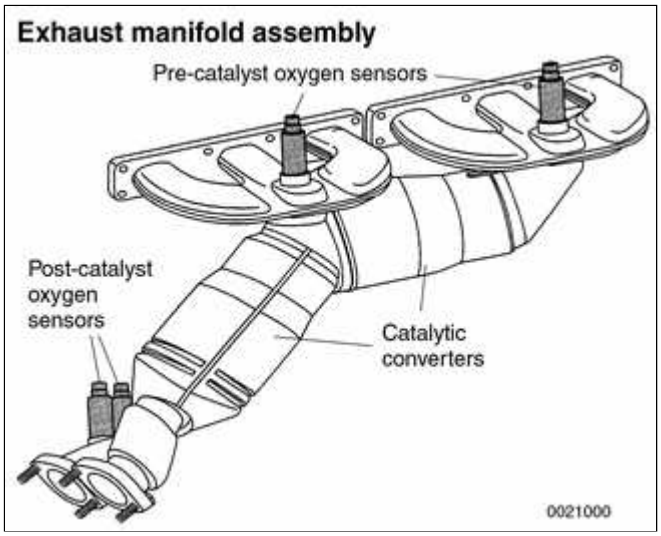
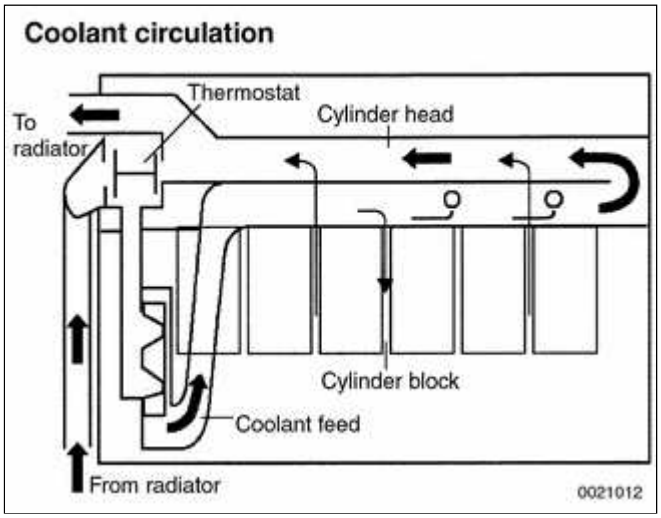


Each exhaust manifold assembly incorporates a catalytic converter. The converters are mounted close to the engine for faster heat up. Pre- and post-catalyst oxygen sensors are a mounted in each exhaust manifold.

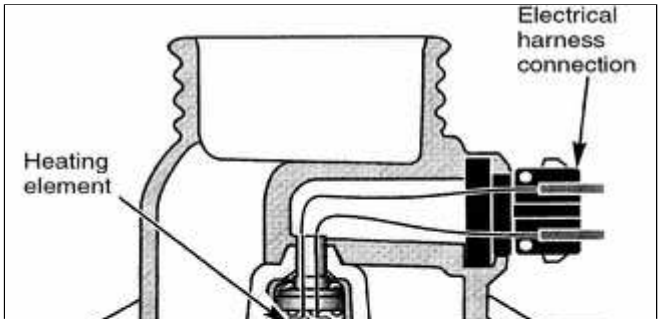
Cooling system



The cooling system circulation is designed so that coolant flows directly from the coolant pump to the cylinder head. The coolant is fed from the coolant pump through a cast coolant feed passage to the rear of the cylinder head. From there it flows forward to the thermostat housing, radiator and heater valve.

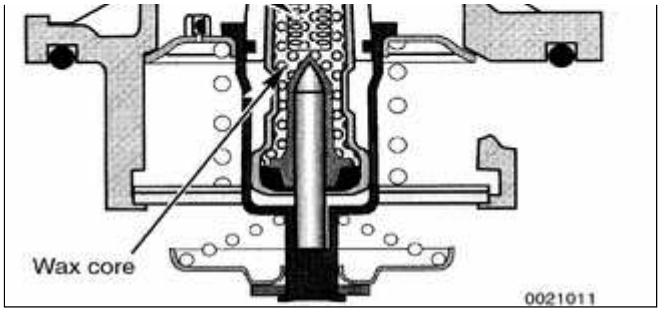
The coolant passages in the cylinder block are only connected to the coolant supply through the holes in the head gasket. A reduced volume of the coolant flows through the cylinder block.

All models are equipped with a DME-controlled electric cooling fan. On some models, a supplemental cooling fan is used. See ⇒ 170 Radiator and Cooling System for specific configuration and application information.



An electrically heated thermostat controls the flow of coolant through the radiator based on coolant and outside temperature, engine load, and driving speed, rather than just coolant temperature.

The DME-controlled heated thermostat



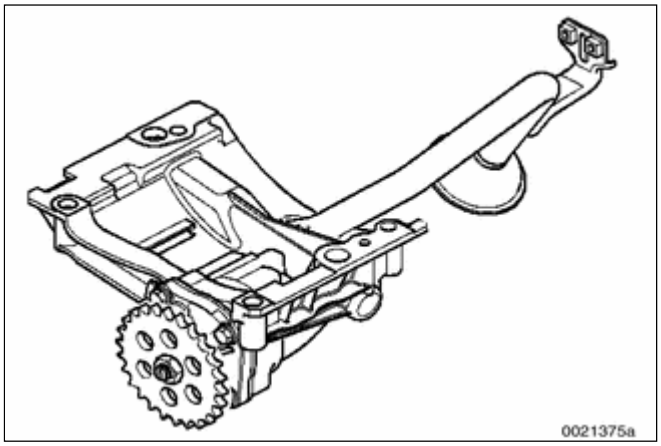
allows the engine to be operated at higher controlled temperatures during low and part throttle. This optimizes operating temperatures in both cylinder head and block, reduces friction and thereby fuel consumption.

The cooling system is designed to:

- Reduce operating temperatures of cylinder head. The result of lower temperatures is increased torque due to improved volumetric efficiency.
- Increase operating temperature of cylinder block.

Lubrication system

The lubrication system is pressurized whenever the engine is running. The oil pump draws oil through a pickup in the bottom of the oil pan, then forces it through a replaceable oil filter and into the engine oil passages.



The chain-driven oil pump is bolted to the bottom of the cylinder block inside the oil pan. A pressure relief valve limits the maximum system pressure. A bypass valve prevents the oil filter from bursting and insures engine lubrication should the filter become plugged. See ⇒ 119 Lubrication System for additional information.

Resonance/turbulence intake system

The intake manifold, made of molded plastic, is configured as two sets of three runners. This design enhances low end

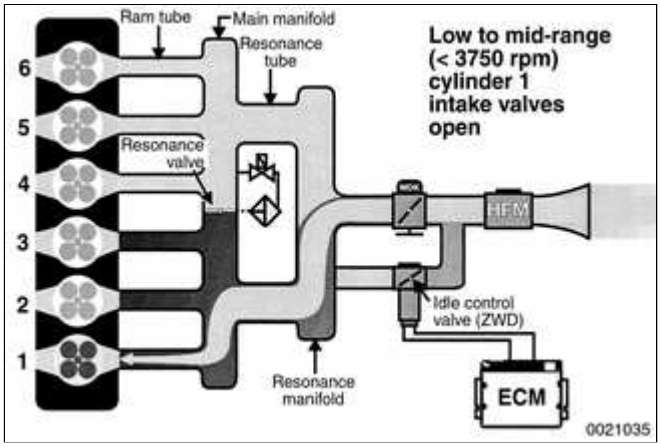
torque by changing the intake air flow configuration for varying engine speeds. This helps achieve optimum torque throughout the entire RPM range.

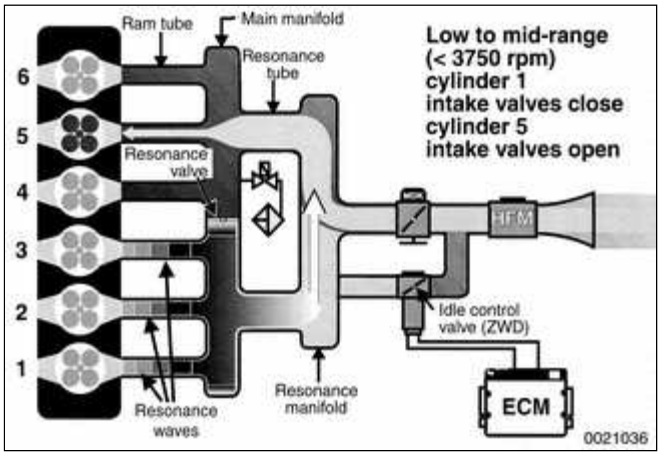
During engine operation, a closed resonance valve gives the intake air charge the dynamic effect of long intake runners at low to mid-range RPM (up to 3750 rpm). This helps increase torque.

During mid-range to high rpm operation (above 4100 rpm), the solenoid is de-energized and the resonance valve is sprung open. This allows intake air to be drawn through both resonance tubes, providing the air volume necessary for additional power at the upper rpm range.

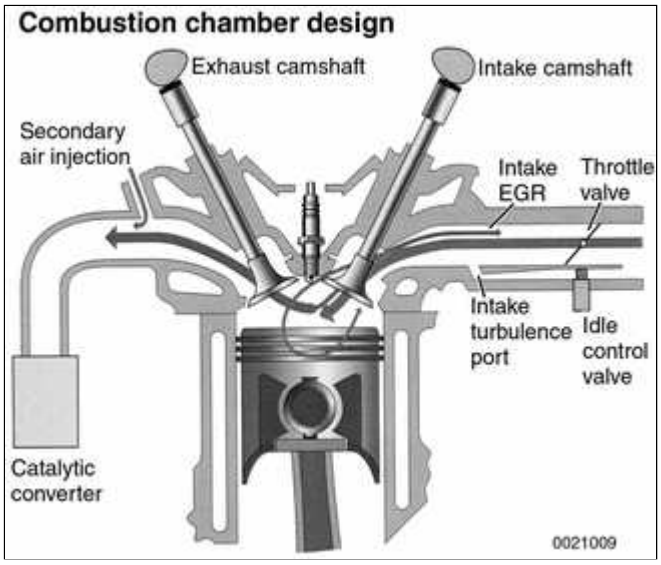
Note:

The rpm for resonance valve activation may vary slightly depending on temperature.





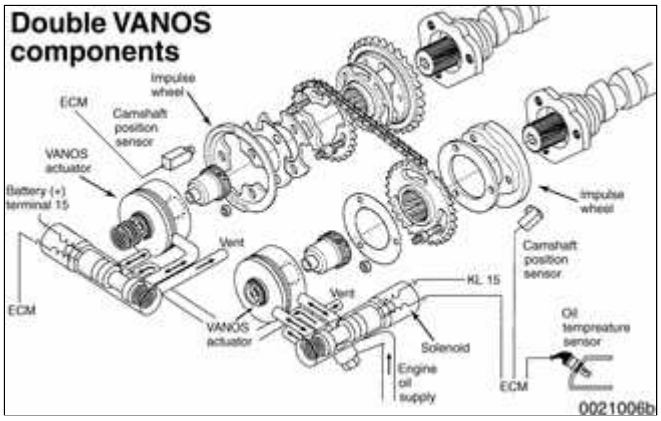
In addition, when the valve is closed, a dynamic effect is produced. For example, as intake air is flowing into cylinder 1, the intake valves will close. This blocks the onrushing air. The cylinder 1 air flow will stop and expand backward (resonance back pulse) to fill cylinder 5. The resonance wave along with the intake velocity enhances cylinder filling.



The intake manifold includes intake turbulence ports. The 5.5 mm (0.217 in.) turbulence ports channel idle and low speed air directly from the idle speed control valved to one intake valve of each cylinder.

Routing intake air to one intake valve per cylinder causes the air charge to swirl in the cylinder. Together with the high flow rate of intake air across the small (5.5 mm) port, intake fluctuations are reduced for more stable combustion.

VANOS (Variable Camshaft Timing)



A double VANOS system is used on both the M52 TU and the M54 engines. VANOS is fully variable and operates independently on both intake and exhaust sides.

When the VANOS solenoid is actuated, engine oil pressure is applied to the front side of the gear cup piston. This forces the gear cup into the camshaft helical gears to change camshaft timing.

In addition to offering increased power, the double VANOS system offers the following advantages:

- Increased torque at lower and medium RPM ranges
- More efficient combustion and improved idle quality
- Internal EGR in part-load range for lower NOx emissions.
- Quicker warm-up cycle for catalytic

converter and faster reduction in emissions.

- Overall improved fuel economy.

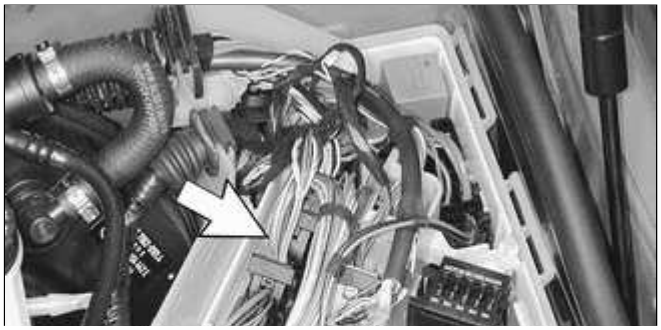
See ⇒ 117 Camshaft Timing Chains for VANOS system testing and repair information.

Engine management system

The Siemens engine management systems used in E46 cars combine fuel injection, ignition and other functions under the control of the engine control module (ECM) They are compliant with second generation on-board diagnostics (OBD II) standards. See ⇒ OBD On Board Diagnostics at the back of this manual for additional information.

Table b. 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

Engine control module (ECM)



The engine control module (ECM) is mounted in the electronics box (E-box) next to the brake master cylinder.

- The ECM is flash-programmable and features 5 electrical harness connectors with a total of 134 pins.

- Connector 1: Voltages and grounds
- Connector 2: Ancillary signals (oxygen sensors, CAN, etc.)
- Connector 3: Engine signals
- Connector 4: Vehicle signals
- Connector 5: Ignition signals

Note:

The flash EEPROM (chip) is specifically `programmed' to the vehicle. It has the capability to be programmed up to 13 times.

ECM inputs:

- Hot film mass air flow (MAF) sensor monitors intake air with no moving parts.
- Pre- and post-catalytic converter oxygen sensors monitor engine emissions and catalyst efficiency.
- MS 42.0: Static Hall-effect sensors are used to detect camshaft position as soon as the ignition is turned ON, before the engine is started.
- Dynamic Hall-effect crankshaft position sensor is mounted at the flywheel end of the engine block and is integral to misfire detection.
- Engine coolant temperature sensor

(ECT) in cylinder head supplies coolant temperature information to the ECM.

ECM outputs:

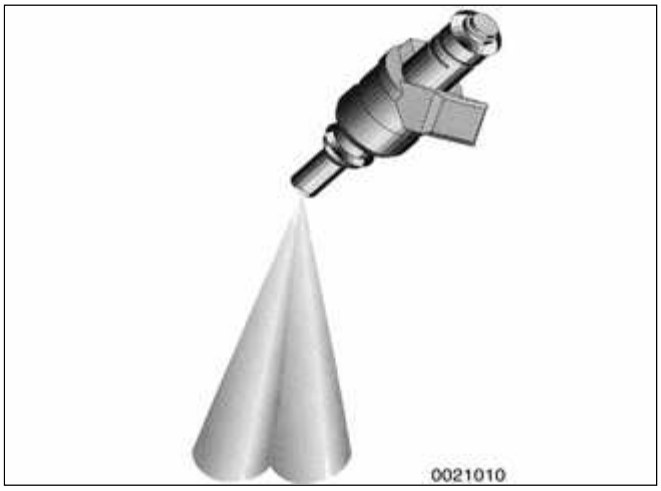
- Fuel injector opening duration.
- Intake and exhaust valve timing via the VANOS system.
- The radiator cooling fan and the heated coolant thermostat.
- Motor-driven throttle valve: MDK in MS 42.0 or EDK in MS 43.0.
- Idle speed control valve (MS 42.0)
- Resonance valve in the intake manifold.

ECM outputs (cont.):

- MS 42.0: Fuel pressure via 3/2 way valve monitors running losses (evaporative losses during engine operation).
- Secondary air injection (if applicable) to reduce HC and CO.
- Multiple spark ignition system.
- Maximum vehicle speed and cruise control.
- Brake booster vacuum pump.

- Fuel purge valve and fuel tank leakage diagnosis pump (LDP or DM-TL).

Fuel metering: The ECM meters pressurized fuel by changing the opening time (pulse width) of the fuel injectors. The exact amount of fuel injected is determined by the amount of time the injectors are open. To ensure that injector pulse width is the only factor that determines fuel metering, fuel pump pressure is maintained by a pressure regulator. The injectors are mounted to a common fuel rail.



The ECM monitors engine operating conditions to determine injector opening duration. Each injector can be individually controlled for cylinder selective fuel trim. The fuel-injectors inject fuel at an angle in a dual cone spray pattern.

Air intake: Air entering the engine passes through a pleated paper air filter in the air cleaner. Intake air mass is then measured by a mass air flow (MAF) sensor. A reference current is used to heat a thin film in the sensor when the engine is running. The current needed to hold the temperature of the film constant is the basis of the electronically converted voltage measurement corresponding to the mass of the intake air.

Idle speed control: Idle speed is electronically controlled via the idle speed control valve by bypassing varying amounts of air around the closed throttle valve. Idle speed is not adjustable. The ECM determines idle speed by controlling a dual-winding rotary idle control valve. The basic functions and parameters of idle speed control are as follows:

- Control of cold air intake volume. For example, at air temperatures below 0°C (32°F), electronic throttle control (MDK/EDK) is also opened during idle.
- Smooth idle speeds regardless of load and inputs
- Lower rpm range
- Smooth transition from acceleration to deceleration

Idle speed stabilization is active during the following conditions:

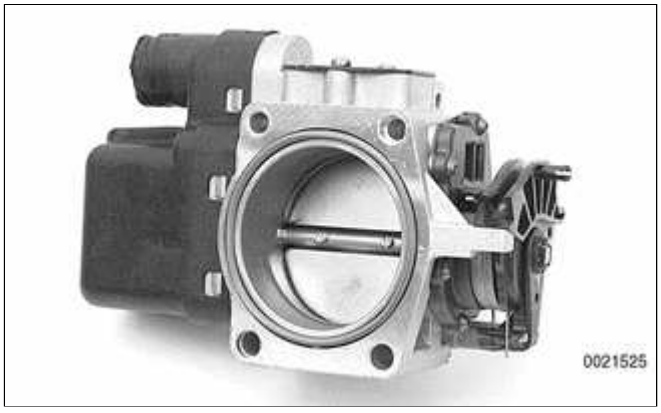
- Engine warm up
- A/C activation
- Drive gear selected (auto. transmission)
- During passenger compartment heating
- During different cooling fan speeds

If the ECM detects a fault in the idle control valve, it will increase or decrease air flow, depending on the nature of the fault:

- If the fault causes decreased air flow (idle control valve closed), the electronic throttle control (MDK or EDK) will compensate to maintain idle. The EML lamp will illuminate to inform the driver of a fault.

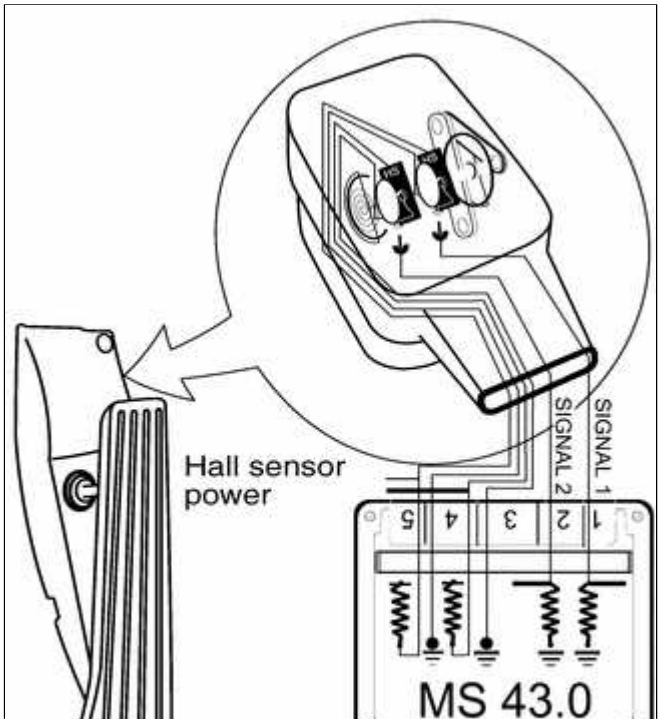
- If the fault causes increased air flow (actuator failed open), VANOS and knock control are deactivated. This reduces engine performance noticeably.

Throttle control: The throttle valve plate is electronically operated for precise throttle operation, OBD II compliant for fault monitoring, and ASC/DSC and cruise control. This integrated electronic throttle reduces additional control modules, wiring and sensors. Adjusting electronic throttles is not permitted and the throttle assembly must be replaced as a unit if found to be faulty.



➢ The throttle assembly for the MS 42.0 system is referred to as the MDK (Motor Driven Throttle Valve). The MDK is identified as follows:

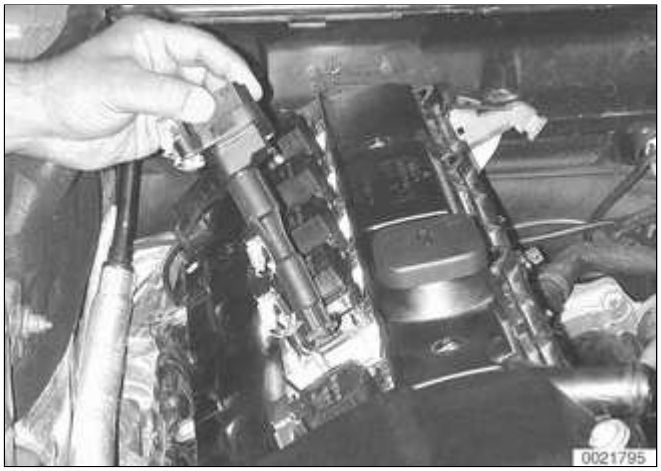
- A throttle cable is used to actuate the accelerator pedal position potentiometers and also serves as a backup to open the throttle plate (full control) when the MDK system is in the failsafe mode.



➢ The throttle assembly for the MS 43.0 system is referred to as the EDK (Electronic Throttle Valve). The EDK is identified as follows:

- The accelerator position potentiometers (PWG) are located in the accelerator pedal assembly.

- The EDK is fully electronic. The accelerator pedal is not mechanically linked to the EDK.



- Ignition function: a distributorless ignition system with individual ignition coils for each cylinder is employed. The coils are mounted over the spark plugs and connect to the plugs via a short lead.

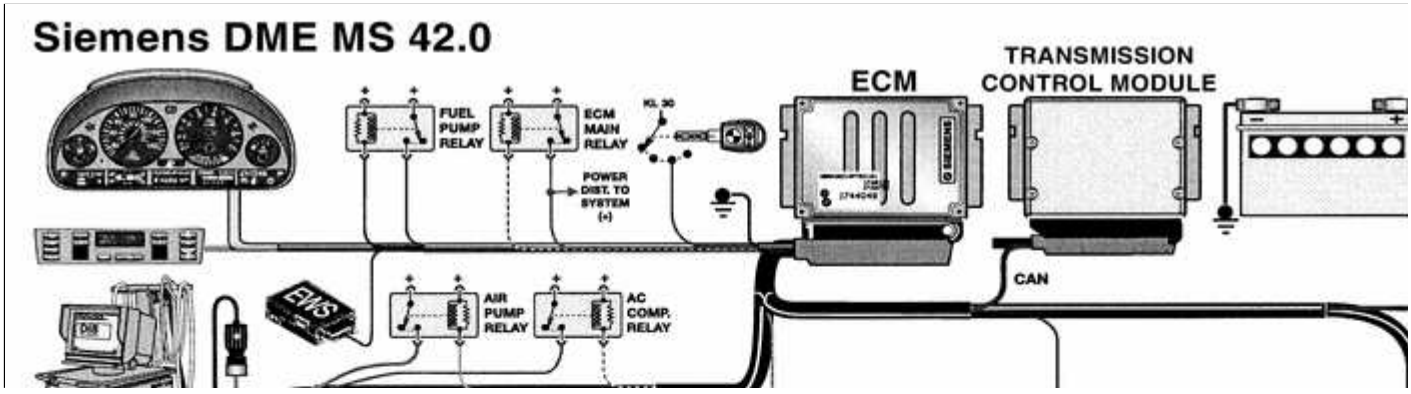
  The Siemens systems use multiple spark ignition to reduce emissions and extend spark plug life.

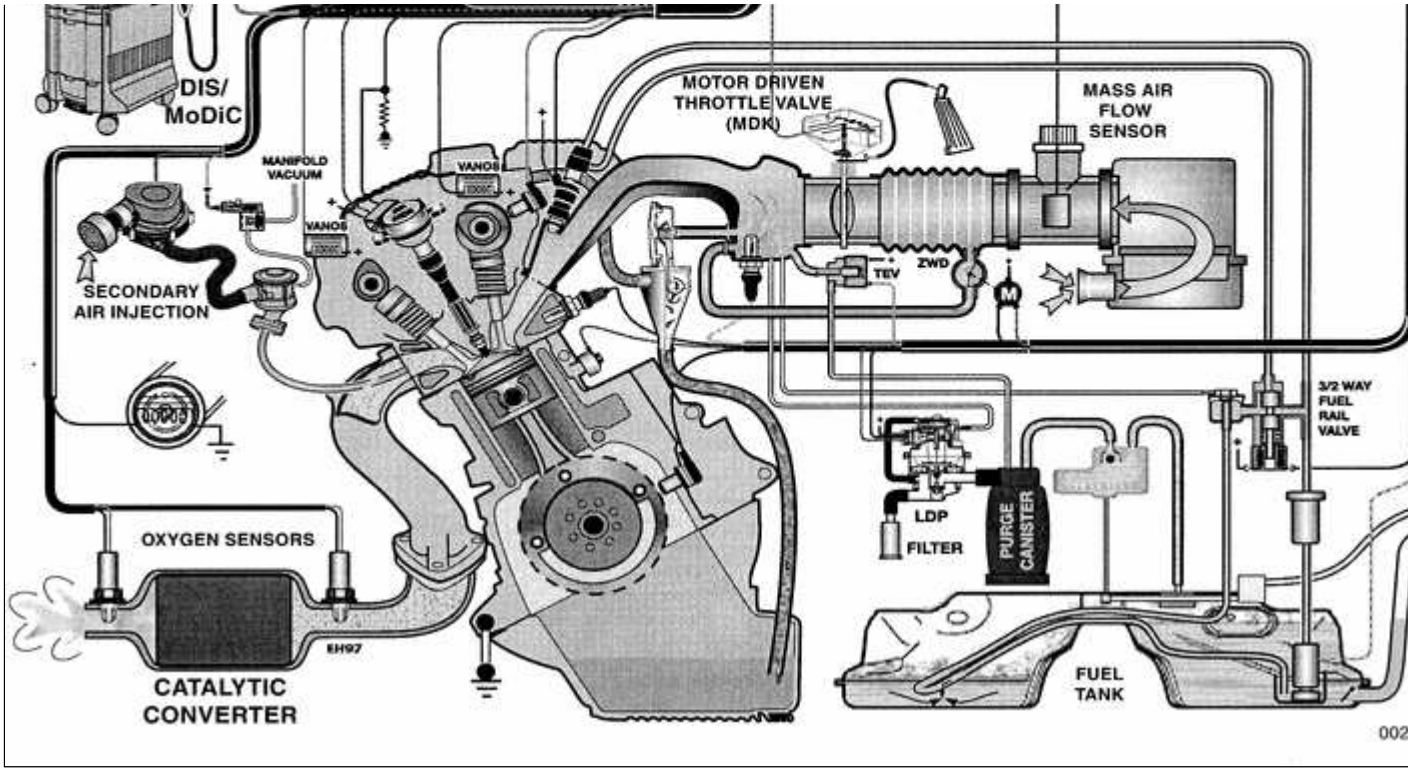
  Knock control. Knock (detonation) sensors monitor and control potentially damaging ignition knock through the ECM. The knock sensors function like microphones and are able to convert mechanical vibration (knock) into electrical signals. The ECM is programmed to react to frequencies that are characteristic of engine knock and adapt the ignition timing point accordingly. See ⇒ 120 Ignition System for further details.

  Note:

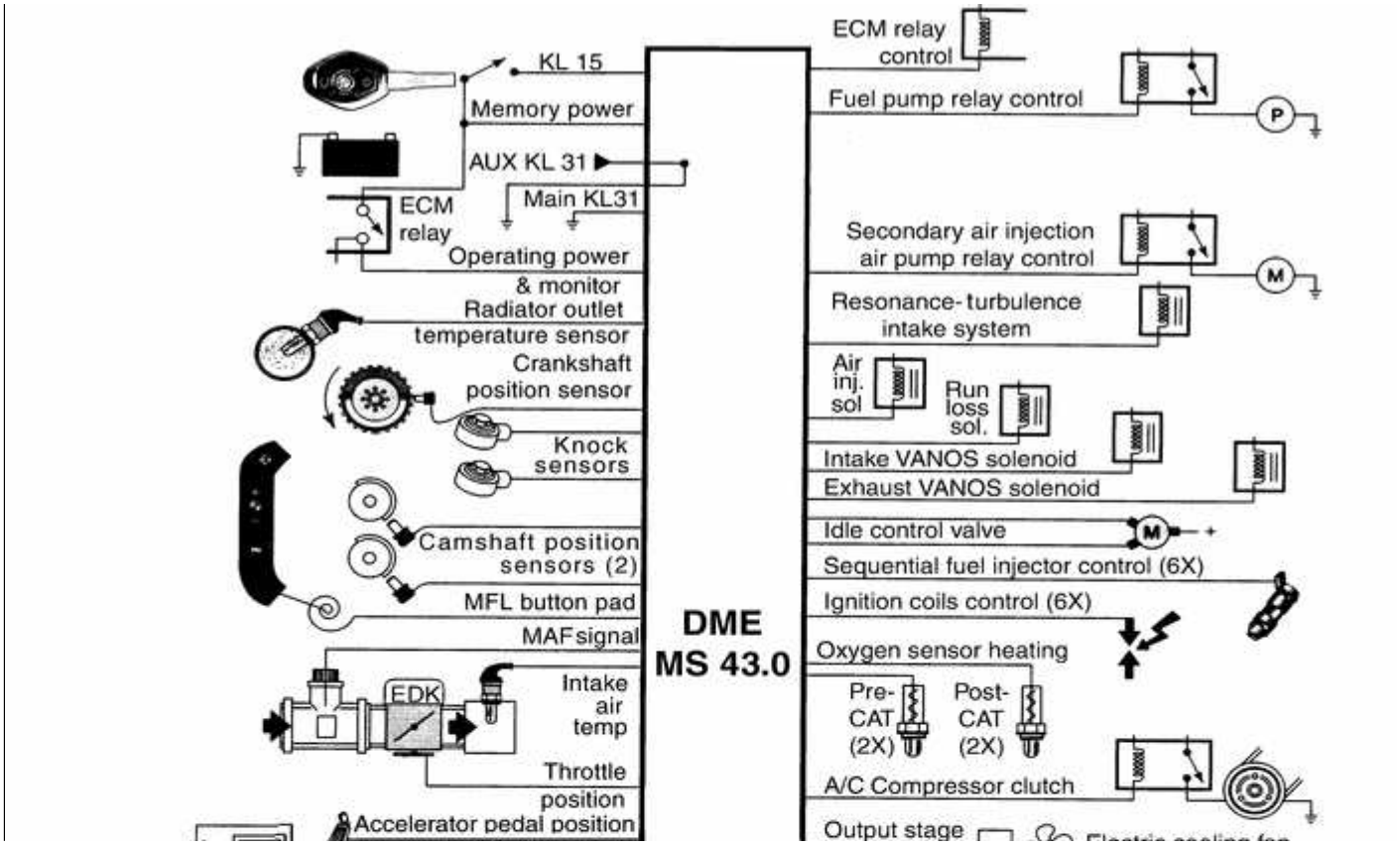
  M52 TU and M54 engines are designed to operate best with fuel octane of at least 91 anti-knock index (AKI). The adaptive engine management system, however, will allow use of fuel rated 87 AKI.

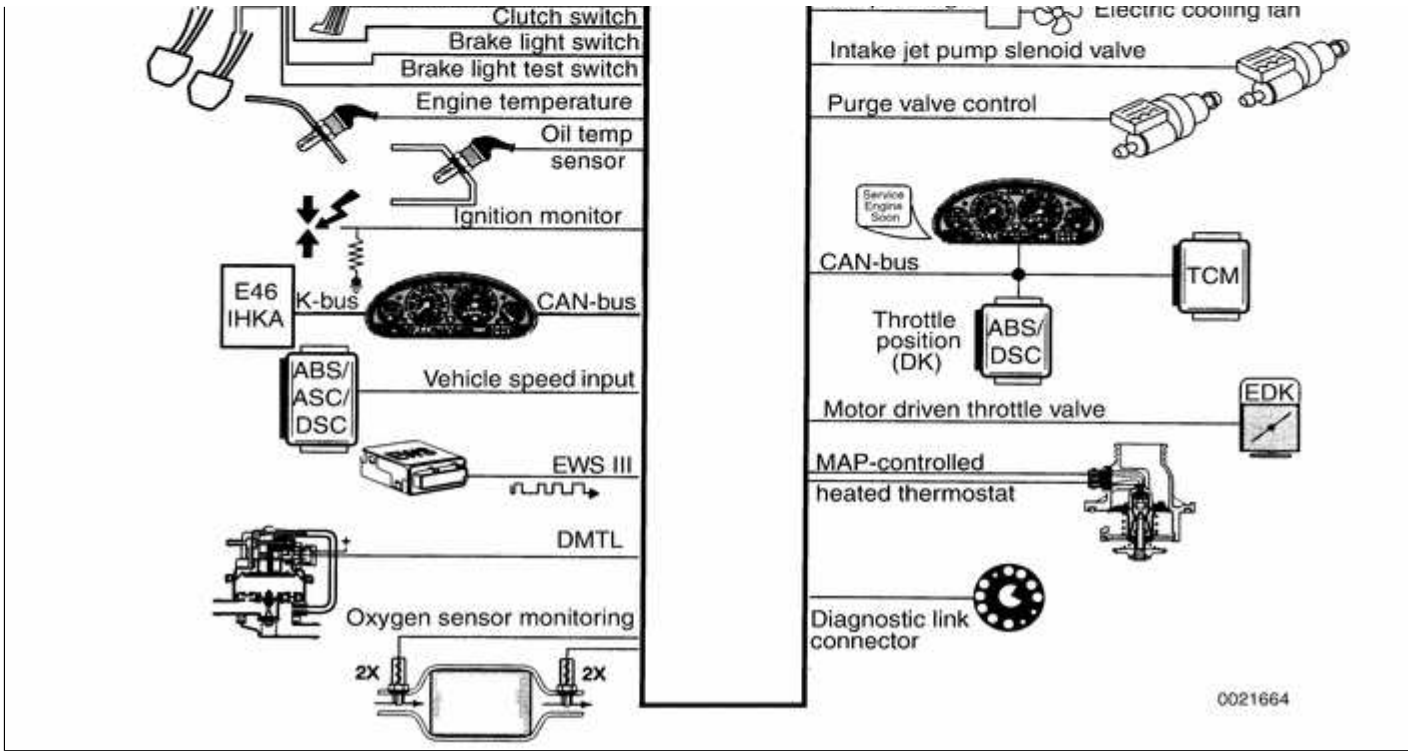
Siemens DME MS 42.0





Siemens DME MS 43.0





Driveability Troubleshooting

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

If the `Check Engine' or `Service Engine Soon' light [also known as the malfunction indicator lamp (MIL)] is illuminated, the first diagnostic test should be to hook up a BMW-compatible scan tool and check the fault memory.

The powerful 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.

Two of the most common causes of driveability problems are system voltage levels and poor grounds.

System voltage

The DME system requires that the system (battery) voltage be maintained within a narrow range. Voltage levels outside the operating range can cause havoc. When troubleshooting an illuminated MIL, make sure the battery is fully charged and capable of delivering all its power to the electrical system.

To make a quick check of the battery charge, measure the voltage across the battery terminals with all cables attached and the ignition off. A fully charged battery will measure 12.6 volts or slightly more, compared to 12.15

volts for a battery with a 25% charge.

Even a fully charged battery cannot deliver power unless it is properly connected to the electrical system. Check the battery terminals for corrosion or loose cable connections. If the battery does not maintain the proper voltage, the charging system may be at fault. See ⇒ 121 Battery, Alternator, Starter.

If a battery cable connection has no visible faults, but is still suspect, measure the voltage drop across the connection. A large drop indicates excessive resistance, indicating that the connection is corroded, dirty, or damaged. Clean or repair the connection and retest.

Note:

For instructions on conducting a voltage drop test and other general electrical troubleshooting information, see ⇒ 600 Electrical System–General.

The DME system operates at low voltage and current levels, making it sensitive to small increases in resistance. The electrical system is routinely subjected to corrosion, vibration and wear, so faults or corrosion in the wiring harness and connectors are not uncommon.

Visually inspect all wiring, connectors, switches and fuses in the system. Loose or damaged connectors can cause intermittent problems, especially the small terminals in the ECM connectors. Disconnect the wiring harness connectors to check for corrosion, and use electrical cleaning spray to remove contaminants.

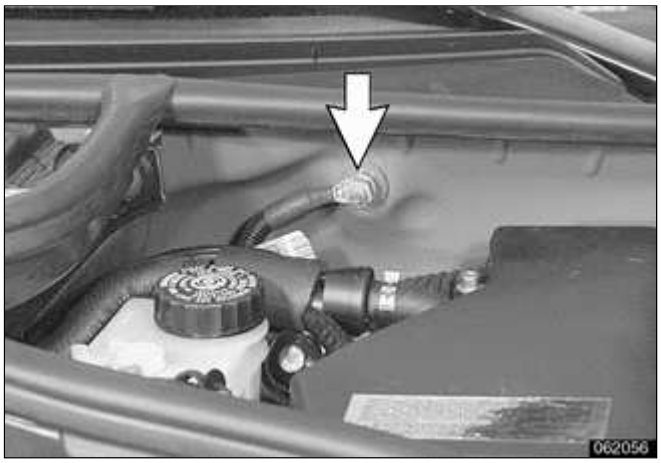
Main grounds

Good grounds are critical to proper DME operation. If a ground connection has no visible faults but is still suspect, measure the voltage drop across the connection. A large voltage drop indicates high resistance, indicating that the connection is corroded, dirty or damaged. Clean or repair the connection and retest.

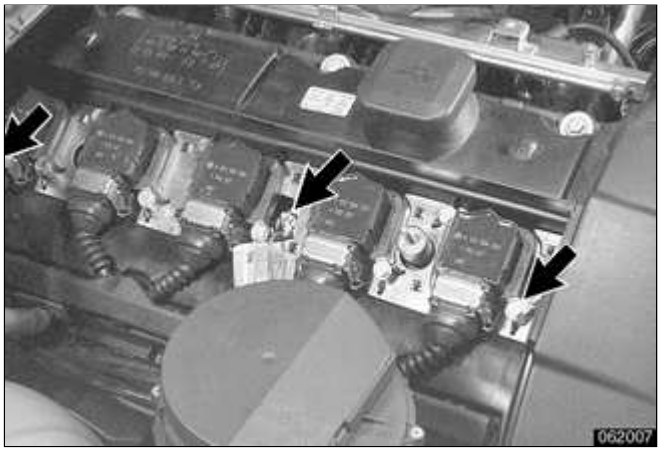
Note:

For instructions on conducting a voltage drop test and other general electrical troubleshooting information, see ⇒ 600 Electrical System–General.

Below is a listing of the main grounds for the fuel and ignition circuits of the DME system.

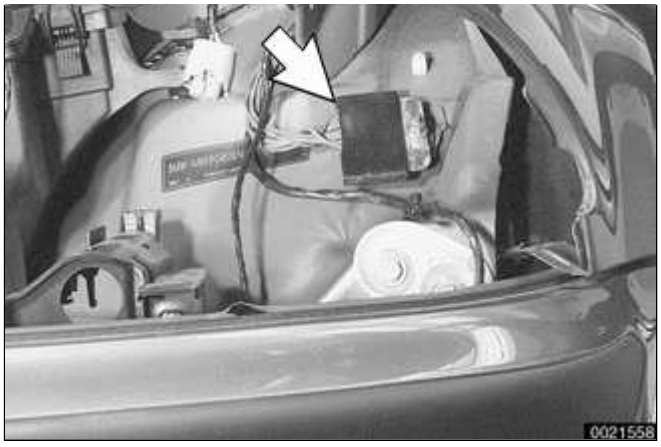


- Main ground (**arrow**) for engine management system in left rear of engine compartment on bulkhead behind E-box.

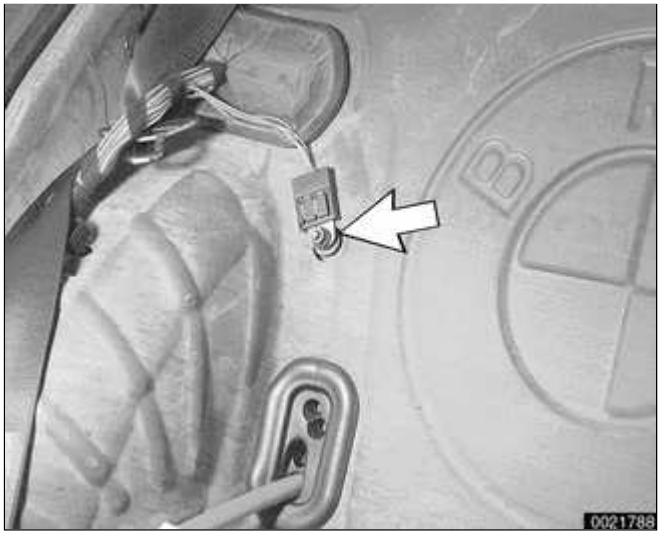


- Main grounds for ignition coils (**arrows**).

- Main chassis ground harness connection (**arrow**) in left front of



engine compartment, behind left headlight assembly (headlight assembly shown removed).



- Main fuel pump ground (**arrow**) behind right rear seat back rest.

Engine Removal and Installation

Be sure to cover all painted surfaces before beginning the removal procedure. As an aid to installation, label all components, wires and hoses before removing them. Do not reuse gaskets, O-rings or seals during reassembly.

WARNING!

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

- Remove engine hood or place hood in service position. See ⇒ 410 Fenders, Engine Hood.

Note:

It is not necessary to remove the engine hood, but it is helpful and will make engine removal and installation easier.

Intake manifold, removing and installing

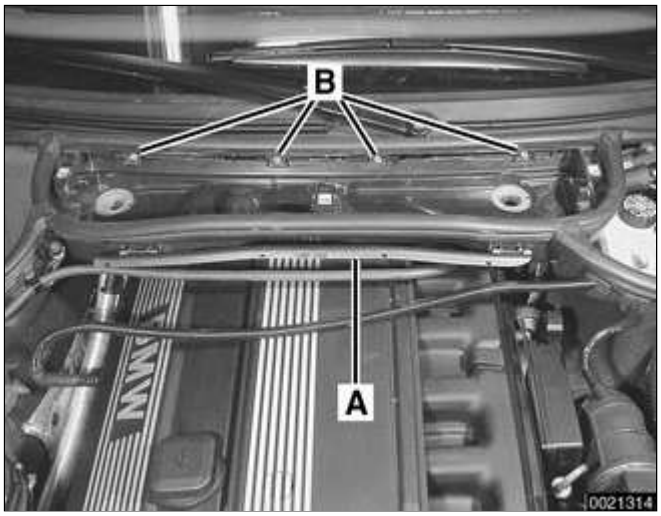
Note:

The intake manifold must be removed to facilitate engine assembly removal.

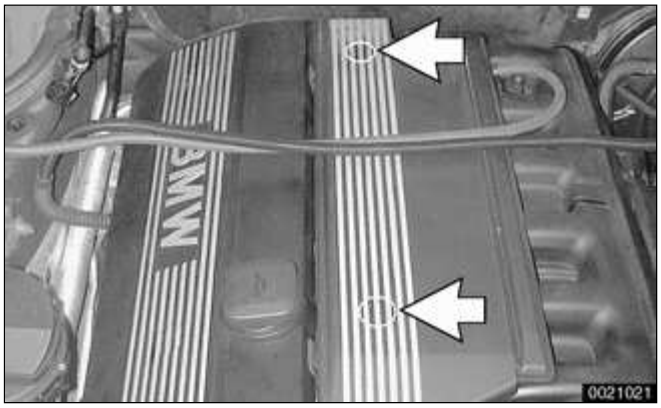
- Disconnect negative (-) battery cable in luggage compartment.

CAUTION!

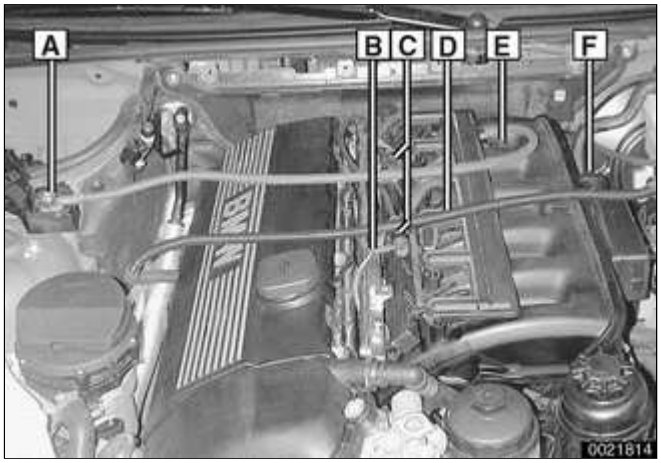
Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.



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



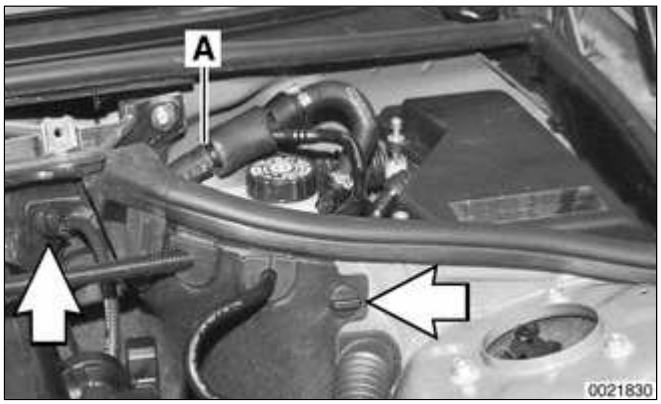
- Remove intake manifold cover:
  - Remove plastic trim covers (**arrows**).
  - Remove cover hold down bolts and lift off cover.



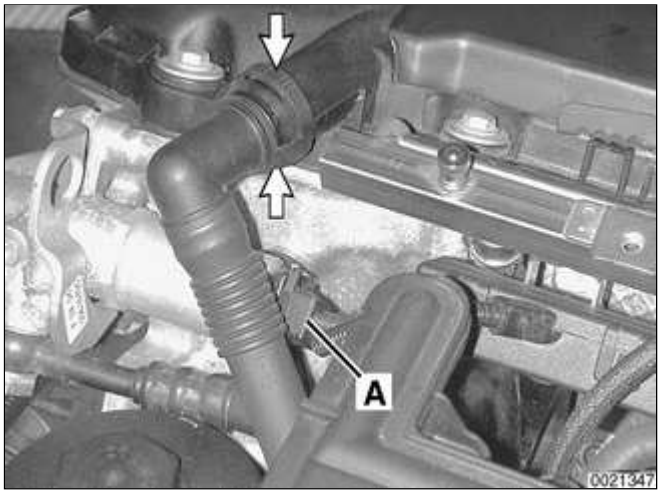
- Working above engine, detach the following:
  - **A** Positive engine lead at B+ terminal
  - **B** Manifold vacuum line
  - **C** Oxygen sensor connectors
  - **D** Electrical harness connector for intake air temperature sensor
  - **E** Positive lead hold-down bracket
  - **F** Resonance valve electrical connector

CAUTION!

If oxygen sensor harness connectors are separated, be sure to mark them so that they can be reassembled as before.



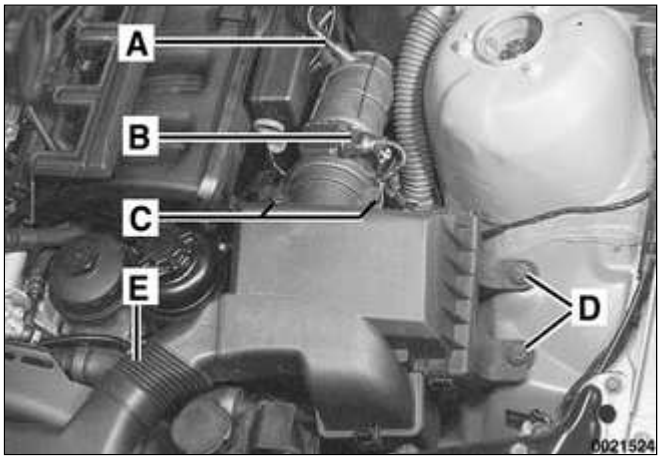
- Working at left rear of engine compartment:
  - Peel rubber edge seal off top of panel.
  - Twist plastic panel retainers (**arrows**) 90° and pull out to remove.
  - Disengage panel from hoses and wiring harnesses and remove from engine compartment.
  - Separate brake booster vacuum hose at one way valve (**A**). Plug hose ends.



- Detach engine vent hose from cylinder head cover by squeezing sides of spring clip (**arrows**). Detach VANOS solenoid electrical harness connector (**A**).

- Detach 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 lay aside.

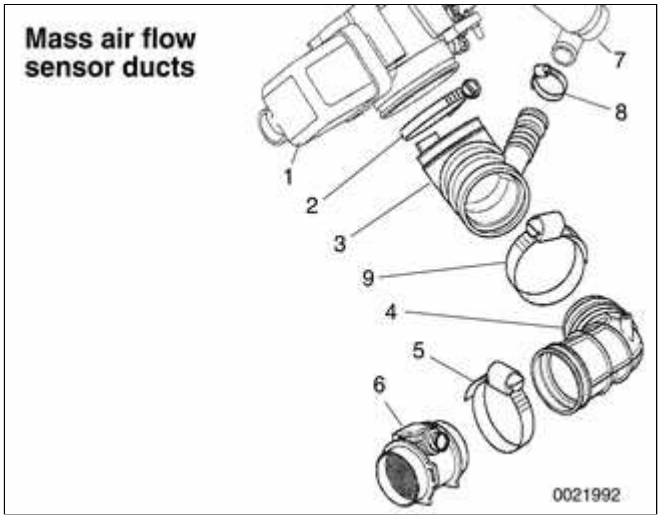


➢ Remove complete air filter housing:

- Detach 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**).
- Detach air duct connection (**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

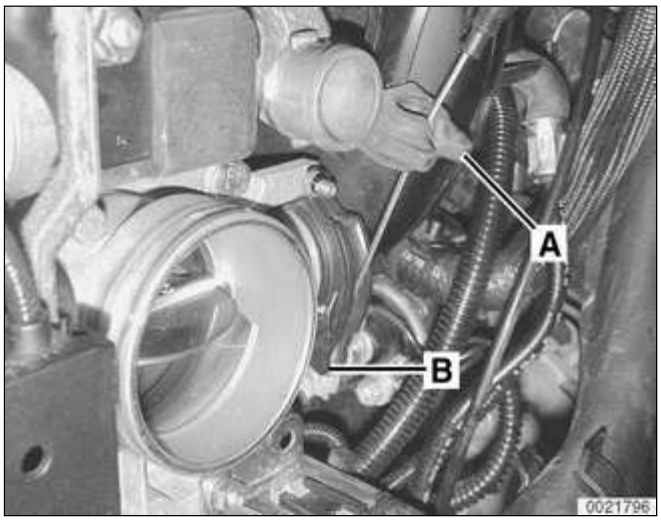
5 - Hose clamp 83 - 90 mm

6 - Mass air flow sensor

7 - Idle control valve

8 - Hose clamp 28 - 33 mm

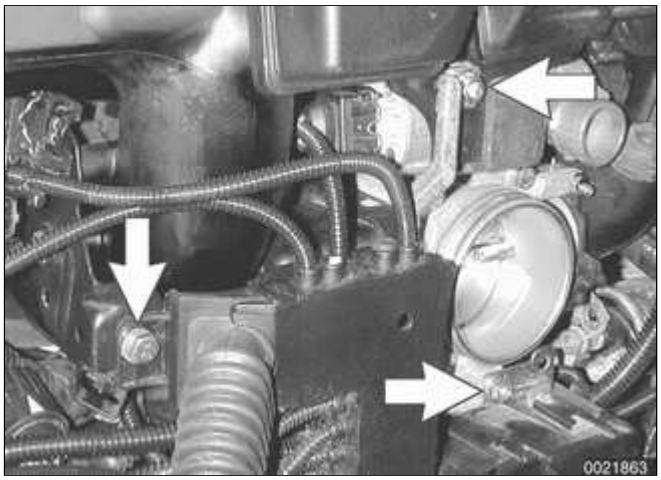
9 - Hose clamp 77 - 84 mm



- Where applicable: Pull throttle cable upwards out of rubber retainer (**A**) and unhook ball end of cable (**B**) from throttle actuator.

Note:

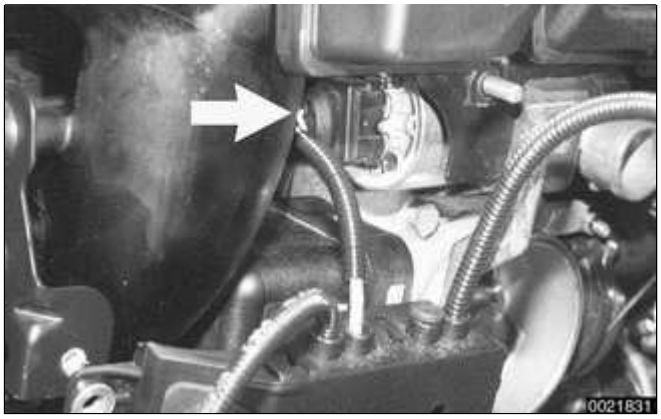
Models equipped with M54 engines do not use a throttle cable mounted to throttle housing.

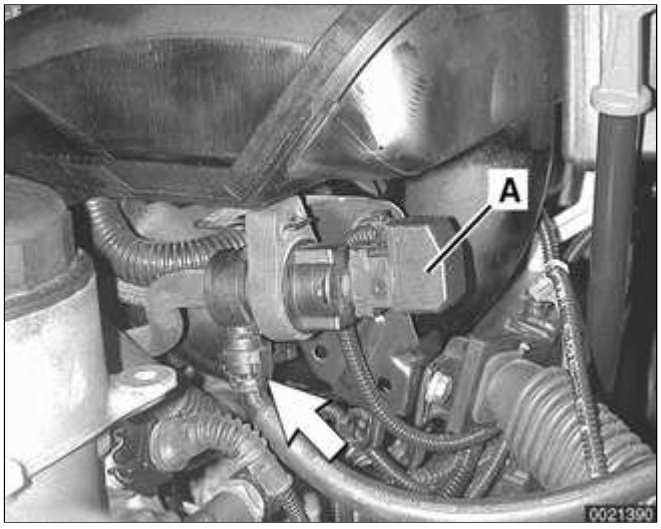


- Remove nuts and bolt (**arrows**) retaining wiring harness conduit to throttle body.

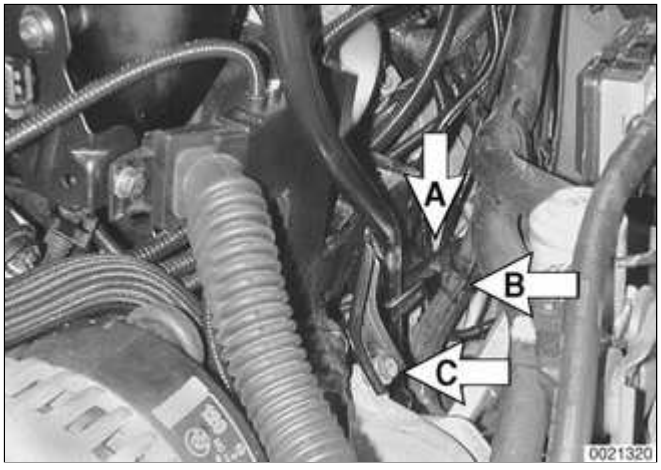
- Working at throttle housing: Turn harness plug (**arrow**) counterclockwise and remove.

- Disconnect electrical harness connector at idle speed control valve (**arrow**).





- Detach electrical harness connector at fuel tank venting valve (**A**). Disconnect hose at quick disconnect fitting (**arrow**).



- Remove dipstick guide tube:
  - Detach wiring harness brackets from tube (**A**).
  - Detach fuel lines from tube (**B**).
  - Remove lower guide tube mounting bolt (**C**). Pull out dip stick guide tube.

- Remove schræder valve cap (**arrow**) from air connection on fuel rail. Using a tire chuck, blow fuel back through feed line using a brief burst of compressed air (maximum of 3 bar or 43.5 psi).

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 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.

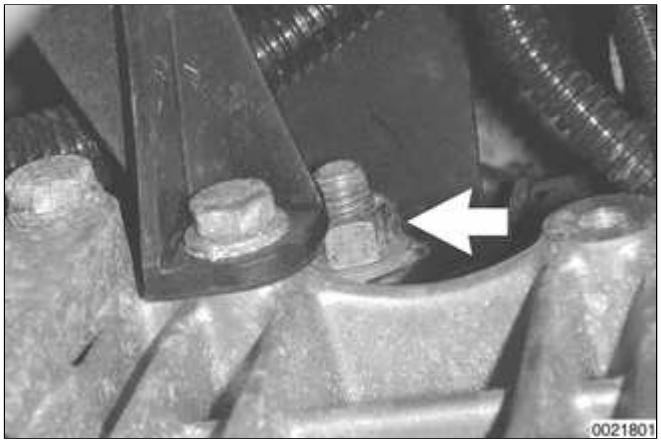
➢ Working beneath car (on left side under driver seat), remove fuel filter cover and clamp fuel hose(s).

➢ Detach 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

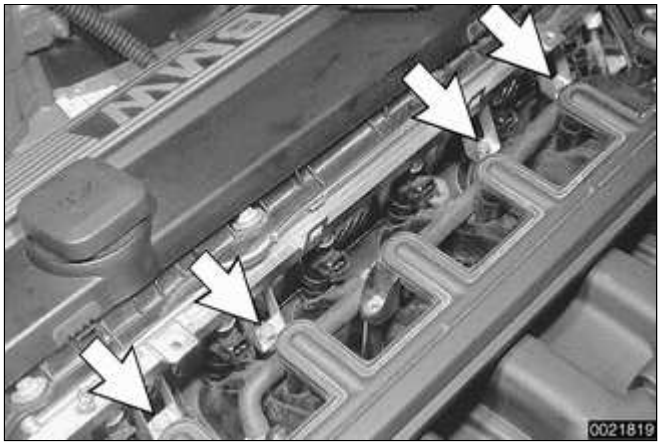
tools 13 5 281/13 5 282.

CAUTION!

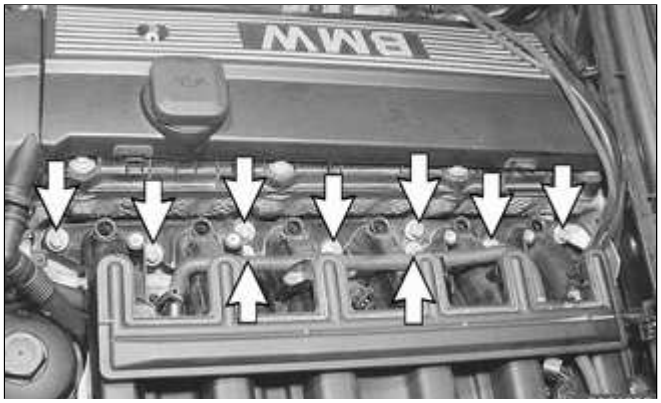
Fuel may be expelled under pressure. Do not smoke or work near heaters or other fire hazards. Keep a fire extinguisher handy. Before disconnecting fuel hoses, wrap a cloth around fuel hoses to absorb any leaking fuel. Plug all open fuel lines.



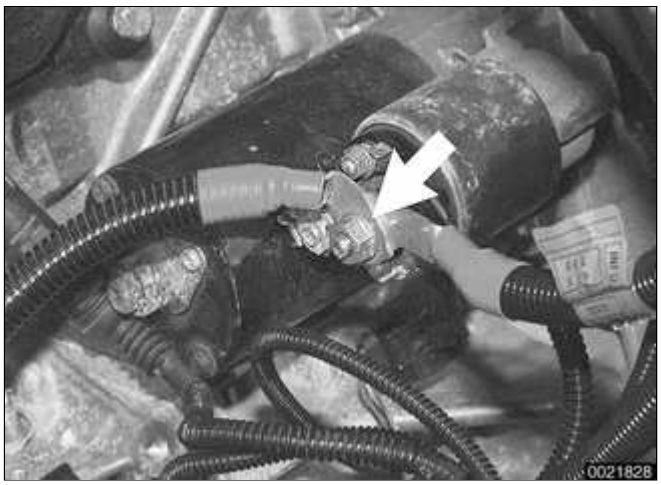
- Working underneath car, remove lower intake manifold support mounting bolt (**arrow**), located adjacent to left engine mount.



- Remove fuel rail mounting bolts (**arrows**).
  - Carefully pry fuel rail off manifold.
  - Separate fuel line support bracket at rear of intake manifold.
  - Thread fuel line(s) out of rear of engine compartment while lifting fuel rail out.



- Remove manifold mounting nuts (**arrows**).



➢ Lift up manifold just enough to detach positive cables from starter motor terminal 50 (**arrow**).

- Remove intake manifold from cylinder head while carefully checking for electrical connections or hoses.

CAUTION!

Stuff clean rags into open intake ports to prevent any parts from falling into the engine intake.

- Intake manifold Installation is reverse of removal.

♦ Use new fuel injector seals.

♦ Carefully check intake manifold gasket and replace if necessary.

♦ Inspect O-ring seal between mass air flow sensor and air filter housing. To facilitate reassembly, coat seal with acid-free grease. nothing

CAUTION!

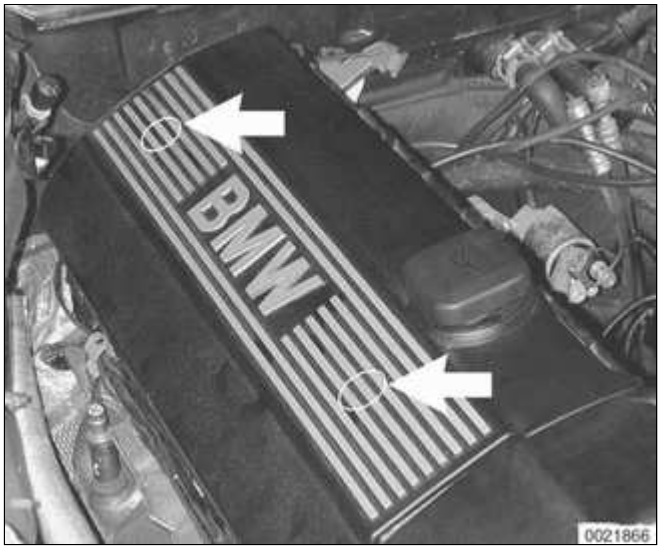
When reattaching throttle assembly harness connector, connector is fully tightened when arrows on connector and plug line up.

Tightening torques	
Intake manifold to cylinder head	
M7	15 Nm (11 ft-lb)
M8	22 Nm (16 ft-lb)

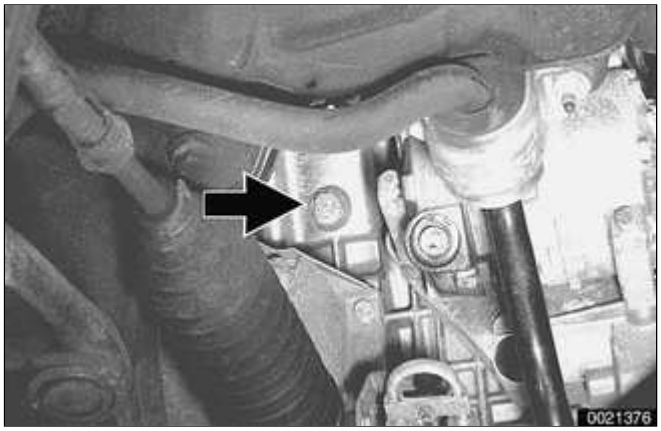
Engine assembly, removing and installing

Note:

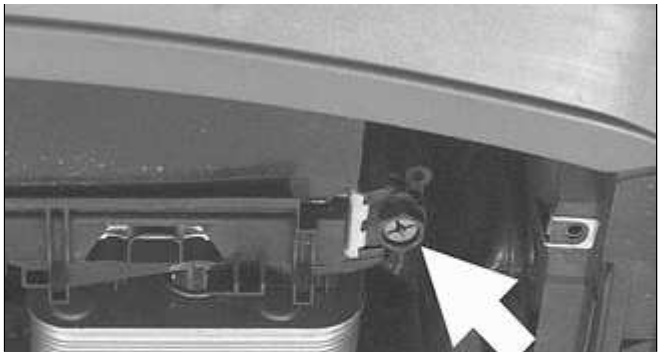
The intake manifold must be removed as described earlier to facilitate engine assembly removal.



- Remove cylinder head top cover:
  - Remove plastic trim covers (**arrows**).
  - Remove cover hold down bolts and lift off cover.



- Drain engine coolant and remove coolant hoses.
  - Remove expansion tank cap on radiator.
  - Place a 3-gallon pail beneath engine to capture coolant.
  - Remove coolant drain plug located on exhaust side of cylinder 2 of engine block (**arrow**).



- Drain radiator into a 3-gallon pail by removing plastic drain plug completely (**arrow**).

WARNING!

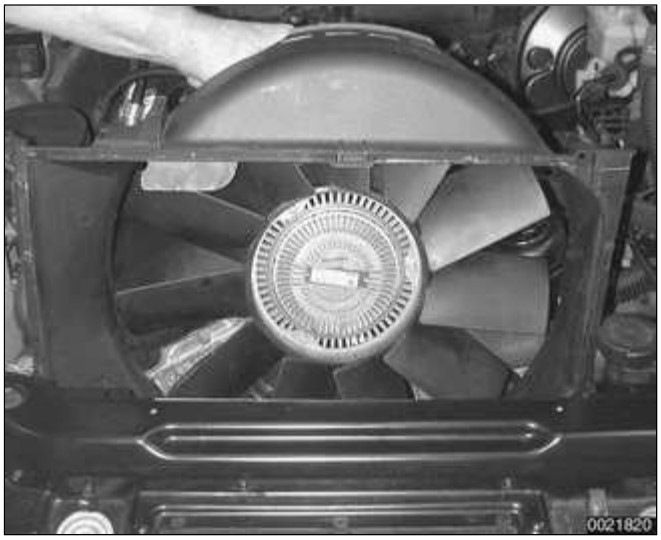
Use extreme caution when draining and disposing of engine coolant. Coolant is poisonous and lethal to

humans and pets. Pets are attracted to coolant because of its sweet smell and taste. Consult a veterinarian immediately if coolant is ingested by an animal.

Note:

Catch and dispose of drained coolant according to local, state, and federal laws.

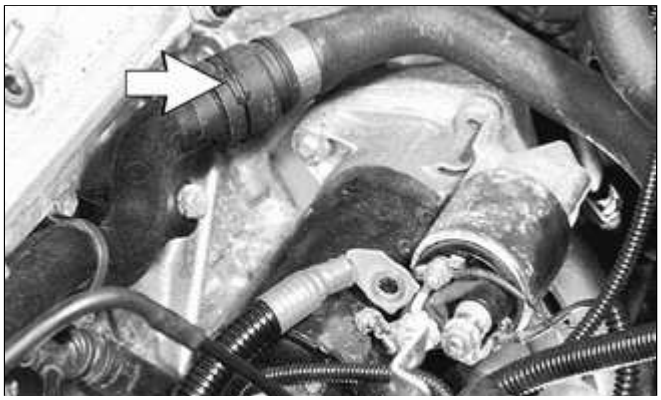
- Remove hoses from thermostat housing by releasing locks (**arrows**).



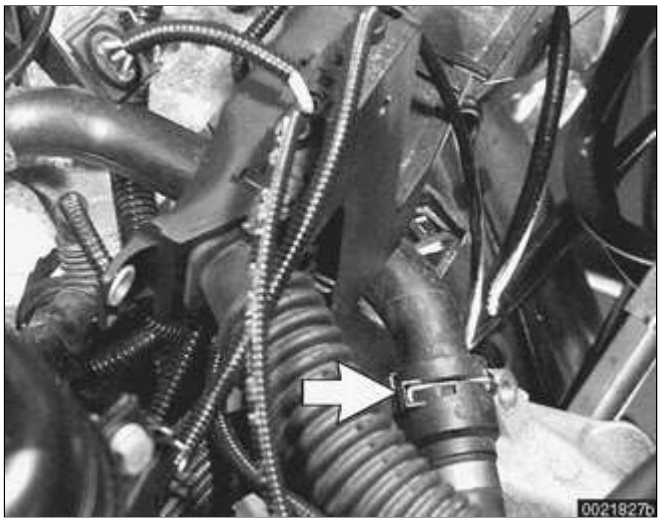
- On vehicles equipped with automatic transmissions: Remove radiator cooling fan and radiator as described in ⇒ 170 Radiator and Cooling System.

CAUTION!

32 mm radiator fan mounting nut has left hand threads.

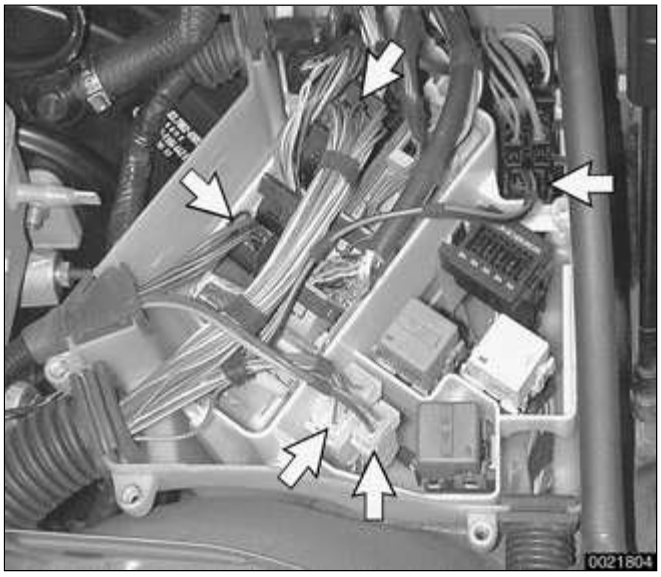


- Detach coolant hose at rear left side of engine above starter by releasing lock (**arrow**).



- Detach coolant hose at front left side of engine by engine mount by releasing lock (**arrow**).

  - Unbolt power steering fluid reservoir and pull aside without detaching hoses. Tie to fender with cord or stiff wire.



- Working at E-box at left rear of engine compartment:

  - Detach engine electrical harness connectors (**arrows**).

  - Lift off harness looms and lay over engine.

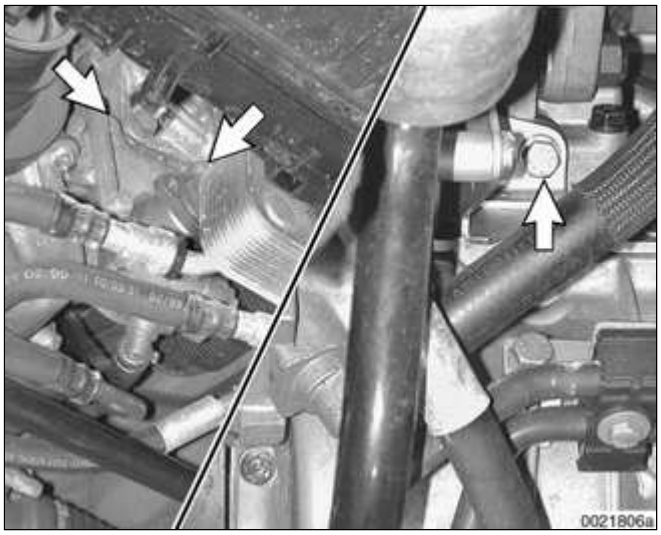
  - Remove poly-ribbed drive belts. Mark belt direction of rotation if belts will be reused. See ⇒ 020 Maintenance.

  - All wheel drive models: Remove front axle differential and output shaft bearing pedestal. See ⇒ 311 Front Axle Final Drive.

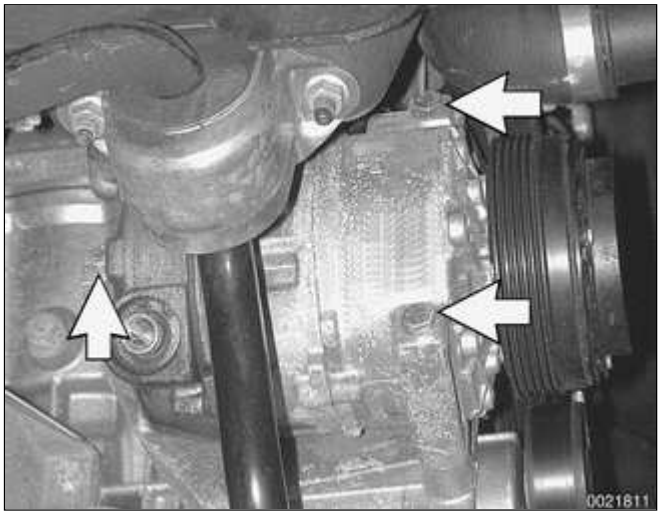
  - Remove transmission from car. See ⇒ 230 Manual Transmission or ⇒ 240 Automatic Transmission.

Note:

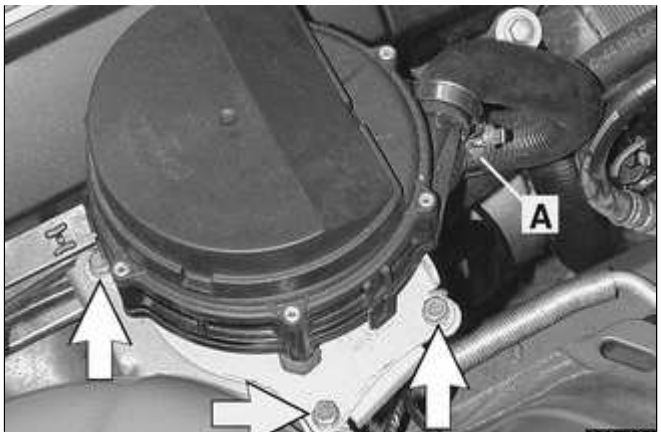
Detach automatic transmission cooler lines from radiator, remove brackets holding lines to side of engine, and store lines in a clean environment.



- Remove power steering pump:
  - Remove steering pump pulley.
  - Remove front and rear pump mounting bolts (**arrows**).
  - Hang pump from body using stiff wire.



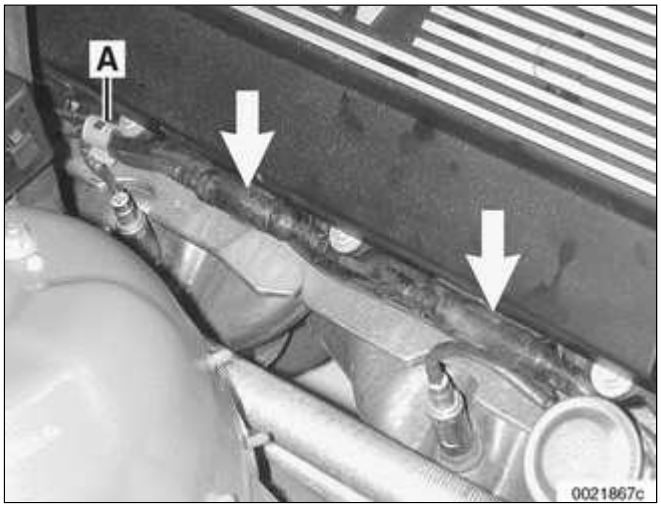
- Remove A/C compressor mounting bolts (**arrows**) and A/C compressor from its mounting bracket without disconnecting, distorting, or deforming any refrigerant lines. Hang from body using stiff wire.
  - Remove windshield and headlight washer reservoir:
  - Remove bolt on top of reservoir.
  - Lift tank and disconnect electrical connections to pump and to washer fluid level sensor.
  - Disconnect hoses to windshield washer and headlight washer. Tilt reservoir to prevent fluid from leaking out.



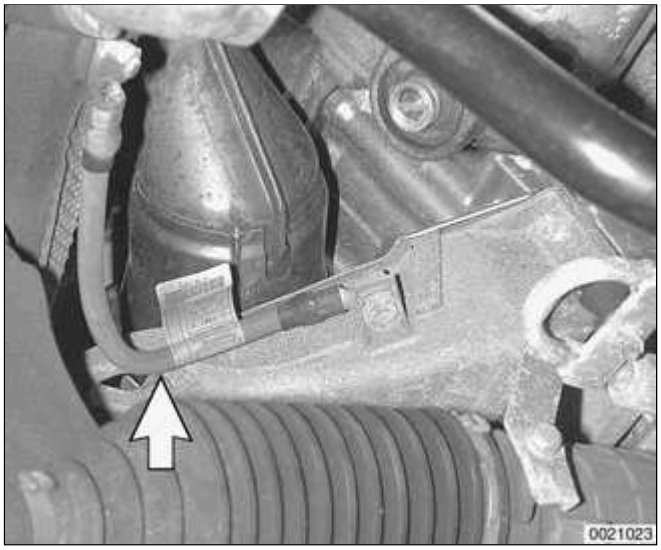
- Remove secondary air pump:
  - Remove hose at one-way valve (**A**).
  - Remove bolts at support bracket on strut tower **(arrows**).
  - Disconnect electrical harness from

bottom of secondary air pump.

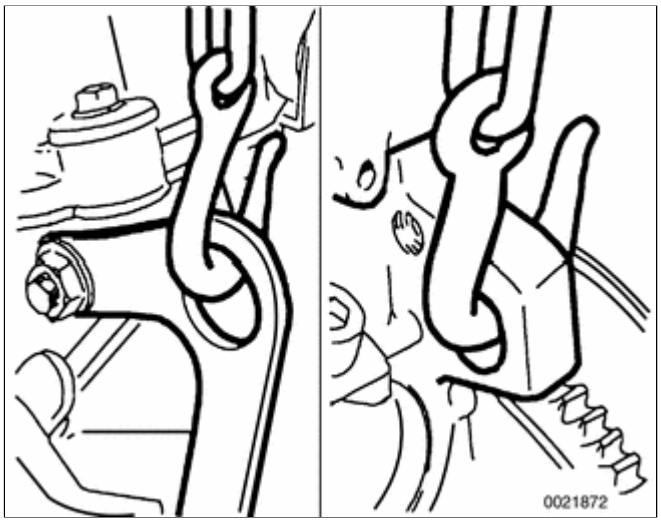
- Remove bracket from strut tower.



- Separate oxygen sensor electrical harness connectors (**arrows**) and mounting clip (**A**) on right side of engine.

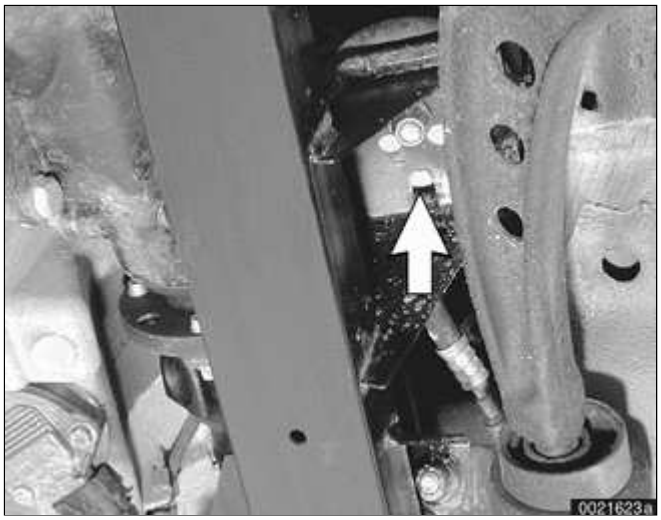


- Remove chassis ground strap (**arrow**) at right engine mounting pedestal.



- Install an engine lifting device (BMW 11 0 000 or equivalent) to the front and rear engine supports and raise engine until its weight is supported. Detach left and right engine mounts.

  - Carefully raise engine out of car, checking for any wiring, fuel lines, or mechanical parts that might become snagged as engine is removed.



- When reinstalling, make sure locating pin on left engine mount (**arrow**) seats correctly in slot of subframe boss.

- Installation is reverse of removal, noting the following:

- Replace all gaskets, O-rings and seals.

- Change engine oil and filter and check all other fluid levels. See ⇒ 020 Maintenance.

- Refill and bleed cooling system. See ⇒ 170 Radiator and Cooling System.

- Use new fuel injector seals.

- Carefully check intake manifold gasket and replace if necessary.

- Inspect O-ring seal between mass air flow sensor and air filter housing. To facilitate reassembly, coat seal with acid-free grease.

CAUTION!

When reattaching throttle assembly harness connector, connector is fully tightened when arrows on connector and plug line up.

- Check that engine drive belts properly engage pulley grooves.

- Install exhaust manifolds using new gaskets and self-locking nuts. Use copper paste on threads. See ⇒ 180 Exhaust System.

Tightening torques	
Coolant drain plug to cylinder block	25 Nm (18 ft-lb)
Engine mount to subframe	
M10	45 Nm (33 ft-lb)
Exhaust manifold to cylinder head	
M6	10 Nm (8 ft-lb)
M7 or M8	20 Nm (15 ft-lb)
Intake manifold to cylinder head	
M7	15 Nm (11 ft-lb)
M8	22 Nm (16 ft-lb)
Radiator cooling fan to coolant pump	40 Nm (30 ft-lb)
Radiator drain screw to radiator	2.5 Nm (22 in-lb)

General

This group covers E46 cylinder head removal and installation as well as cylinder head/valve diagnosis procedures.

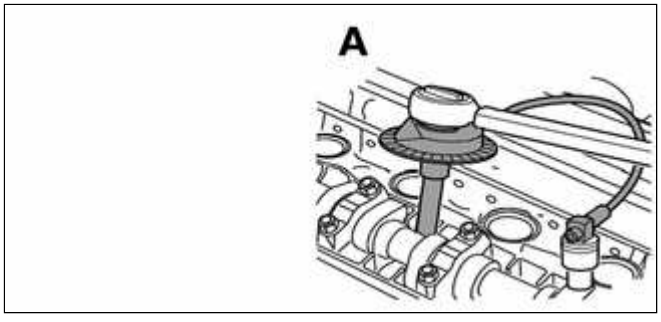
The information given in this repair group assumes that the engine is installed in the engine bay. In order to remove the cylinder head from the engine block, the VANOS control unit and the camshafts must be removed from the cylinder head. For cylinder head and valvetrain reconditioning information, see ⇒ 116 Cylinder Head and Valvetrain.

Note:

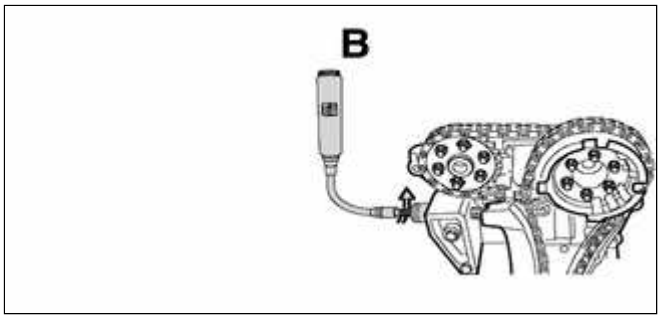
If a head gasket problem is suspected, a compression test or leak-down test will usually detect the fault. See ⇒ Diagnostic Testing later in this group.

Special tools

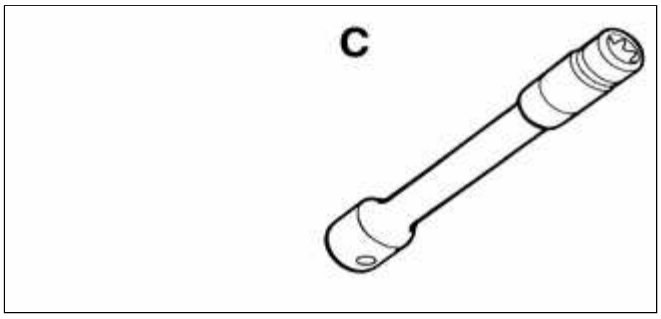
Special BMW service tools are required to properly remove and install the cylinder head on engines covered by this manual. The special tools are used to time the valvetrain to the crankshaft, to remove the VANOS control unit, the camshafts and the Torx (E12) head bolts. Read the entire procedure through before beginning the job.



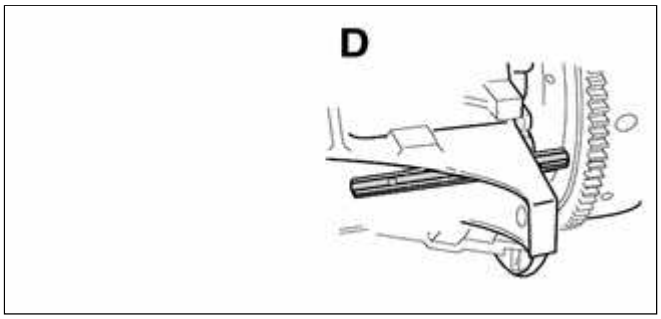
- Rotary angle dial gauge BMW special tool 00 9 120



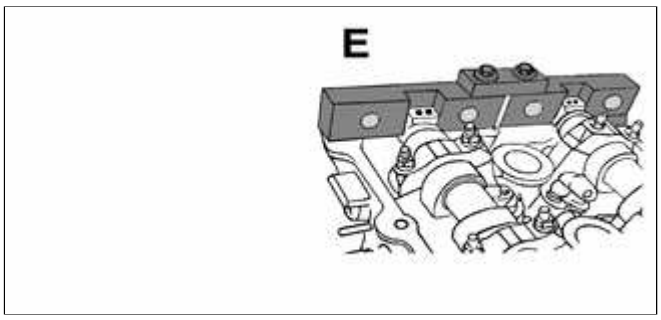
- Torque wrench w/ flex extension BMW special tool 00 9 250



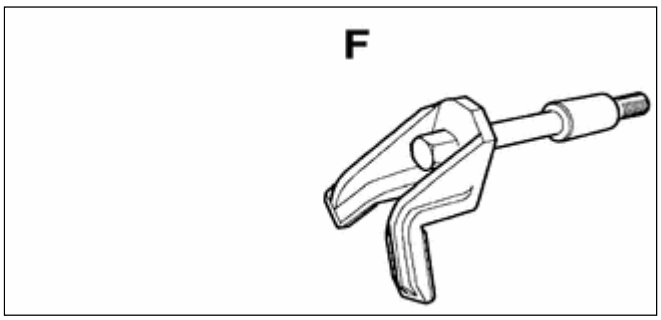
- E-12 Torx socket BMW special tool 11 2 250



- Crankshaft locking tool BMW special tool 11 2 300

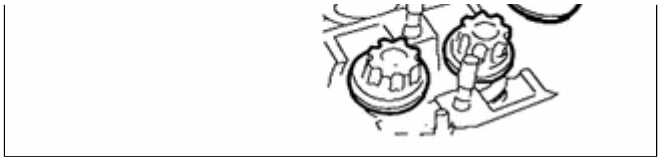


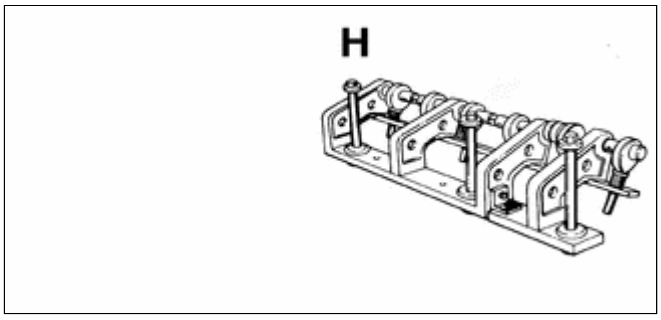
- Camshaft locking tool BMW special tool 11 3 240



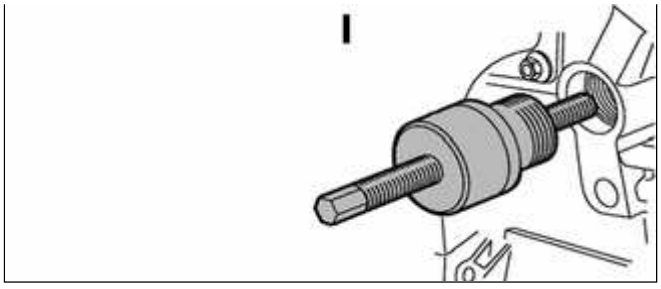
- Camshaft locking tool bracket BMW special tool 11 3 244

- Lifter retaining suction cup BMW special tool 11 3 250

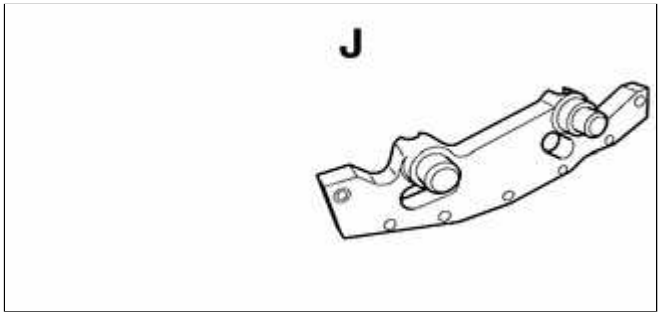




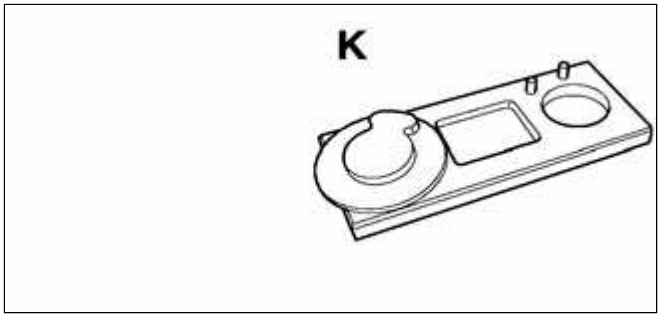
- Camshaft bearing cap removal tool BMW special tool 11 3 260 /11 3 270



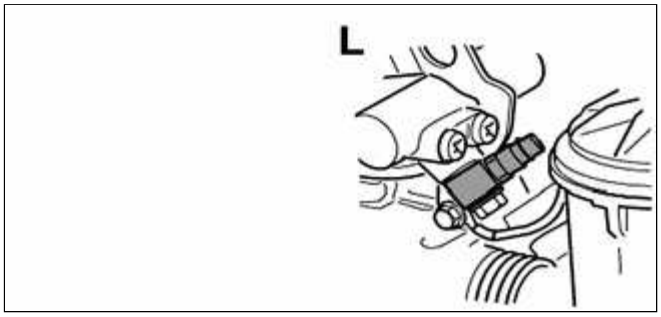
- Timing chain tensioner tool BMW special tool 11 4 220



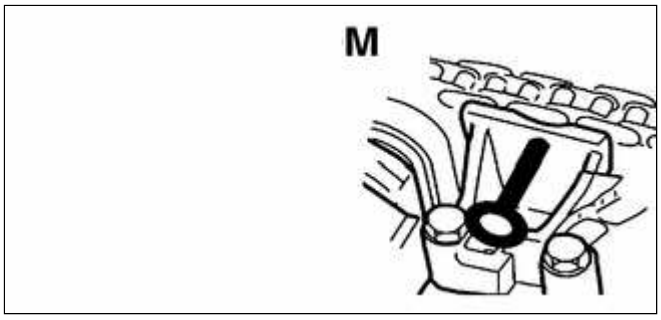
- VANOS adjustment plate BMW special tool 11 6 150



- Secondary sprocket setup tool BMW special tool 11 6 180



- Air line adapter BMW special tool 11 3 450



➢ Secondary chain tensioner lock pin
BMW special tool 11 3 292

Cylinder Head Removal

WARNING!

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

Cylinder head removal and installation is a complicated repair procedure. VANOS control unit, timing chain, and camshaft removal and installation all require special tools. Read the entire procedure before beginning the repair.

CAUTION!

Cover all painted surfaces before beginning the removal procedure. As an aid to installation, label all components, wires, and hoses before removing them. Do not reuse gaskets, O-rings or seals during reassembly.

To assist the technician in this repair, the procedure has been organized into discrete jobs. Please be advised that these individual jobs must be accomplished in the order in which they appear.

⇒ Intake manifold, removing

⇒ Cylinder head cover, removing

⇒ VANOS control unit, removing

⇒ Camshafts and valvetrain, removing

⇒ Cylinder head assembly, removing

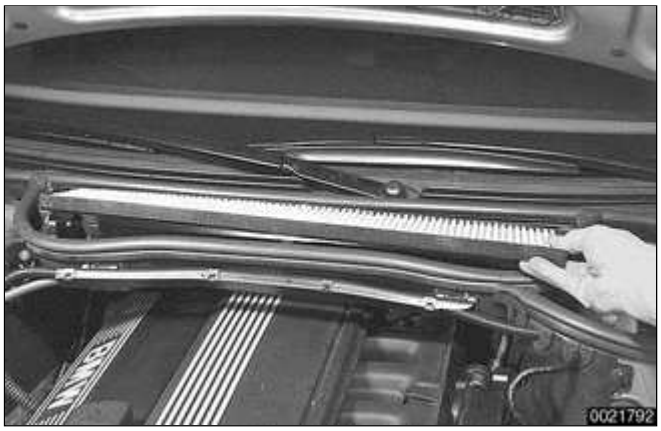
Intake manifold, removing

- Disconnect negative (-) battery cable in trunk.

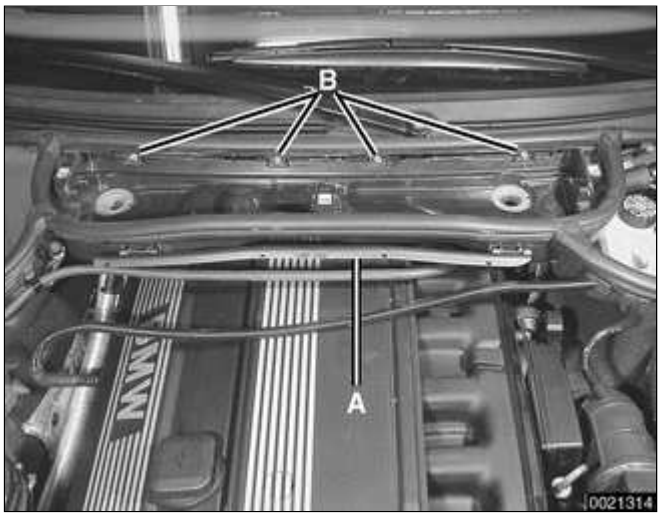
CAUTION!

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

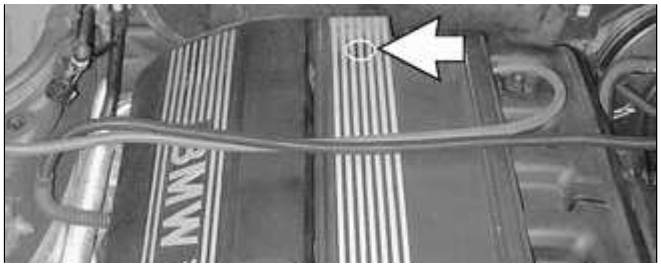
- ***Disconnecting the battery may erase fault code(s) stored in control module memory. Check for fault codes using special BMW diagnostic equipment.***



- Remove microfilter for interior ventilation.

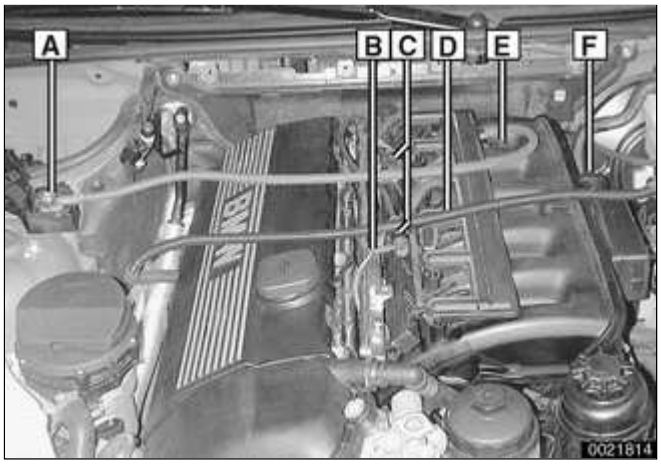


- Remove housing for interior ventilation microfilter.
  - Open wiring harness loom cover (**A**) and remove wires.
  - Unfasten screws (**B**) and remove lower microfilter housing.

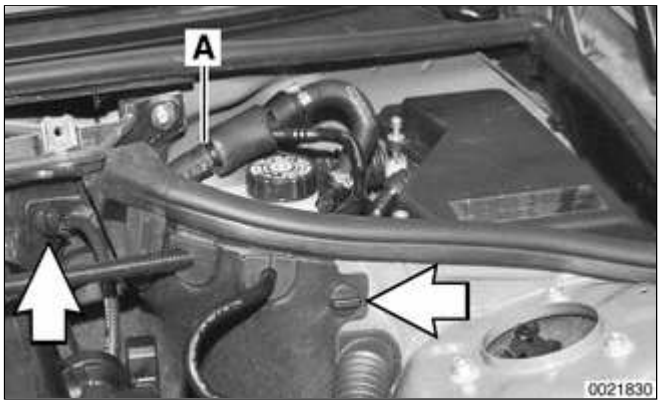


- Remove intake manifold cover:
  - Remove plastic trim covers (**arrows**).

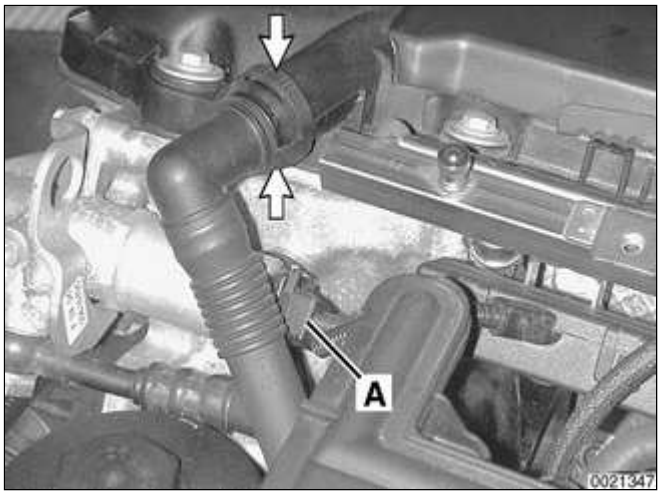
- Remove cover hold down bolts from intake cover and lift off cover.



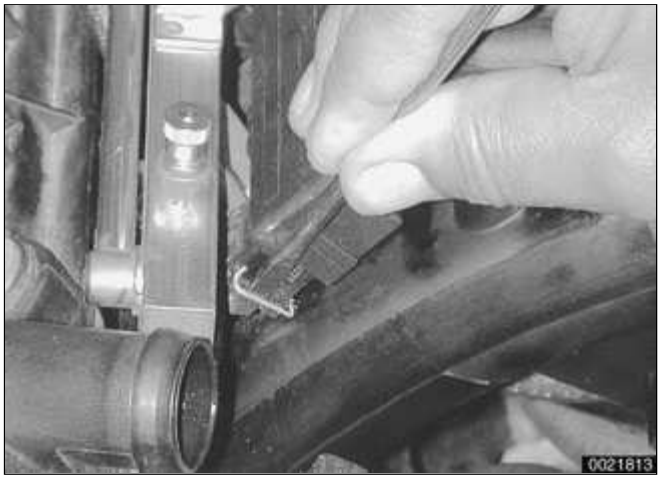
- Working above engine, disconnect the following:
  - **A** Positive engine lead at B+ terminal
  - **B** Manifold vacuum line
  - **C** Oxygen sensor connectors (label connectors before disconnecting)
  - **D** Electrical harness connector for intake air temperature sensor
  - **E** Positive lead hold-down bracket
  - **F** Intake manifold resonance valve electrical connector



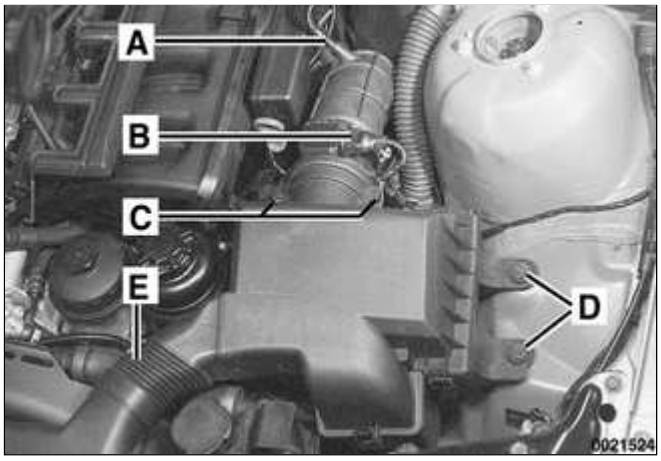
- Working at left rear of engine compartment:
  - Peel rubber edge seal off top of panel.
  - Separate brake booster vacuum hose at intake jet pump (**A**). Plug hose ends.
  - Twist plastic panel retainers (**arrows**) 90° and pull out to remove.
  - Disengage panel from hoses and wiring harnesses and remove from engine compartment.



- Disconnect engine vent hose from cylinder head cover by squeezing sides of spring clip (**arrows**). Disconnect VANOS solenoid electrical harness connector (**A**).



- 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 lay aside.

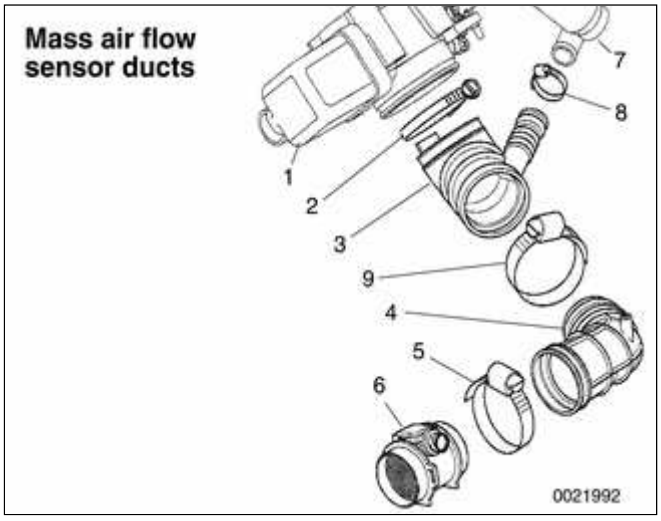


- Remove complete air filter housing:
  - Disconnect vacuum line at intake boot (**A**).
  - Disconnect electrical harness connector on mass air flow sensor (**B**).
  - Release mass air flow sensor clips (**C**).
  - Remove filter housing mounting screws (**D**).
  - Disconnect air duct connection (**E**) 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 duct.

1 - Throttle assembly

2 - Hose clamp 77 - 84 mm

3 - Y-duct

4 - Air duct

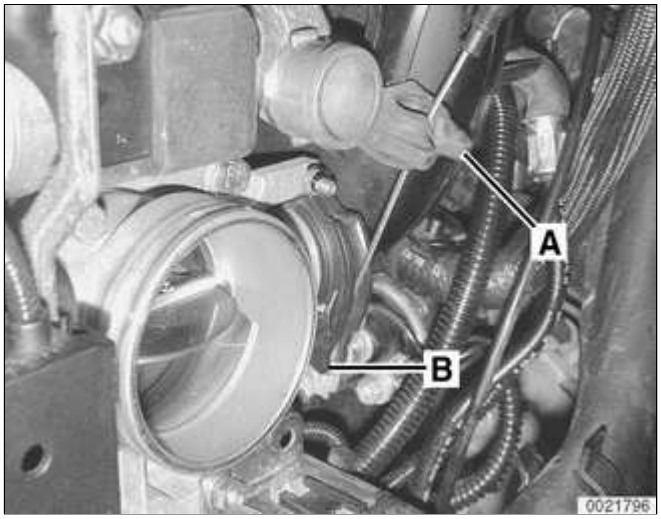
5 - Hose clamp 83 - 90 mm

6 - Mass air flow sensor

7 - Idle control valve

8 - Hose clamp 28 - 33 mm

9 - Hose clamp 77 - 84 mm

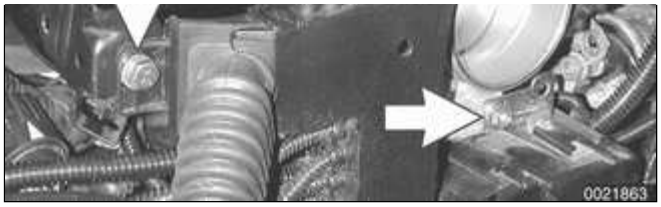


- Where applicable: Pull throttle cable upwards out of rubber retainer (**A**) and unhook ball end of cable (**B**) from throttle actuator.

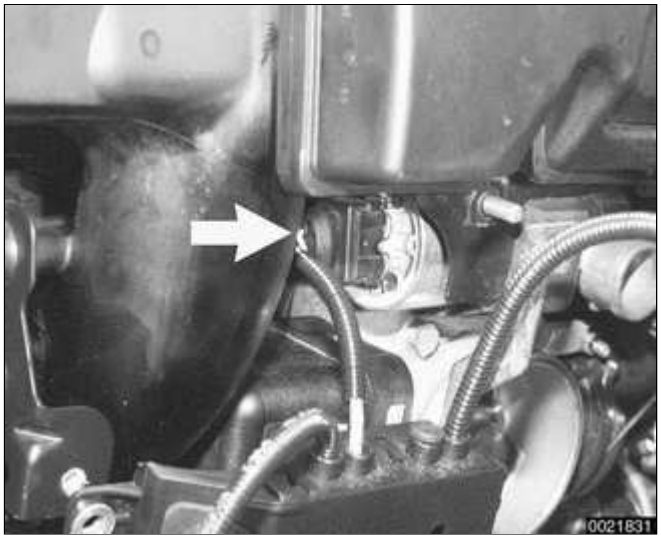
Note:

Models with M54 engines do not use a throttle cable.

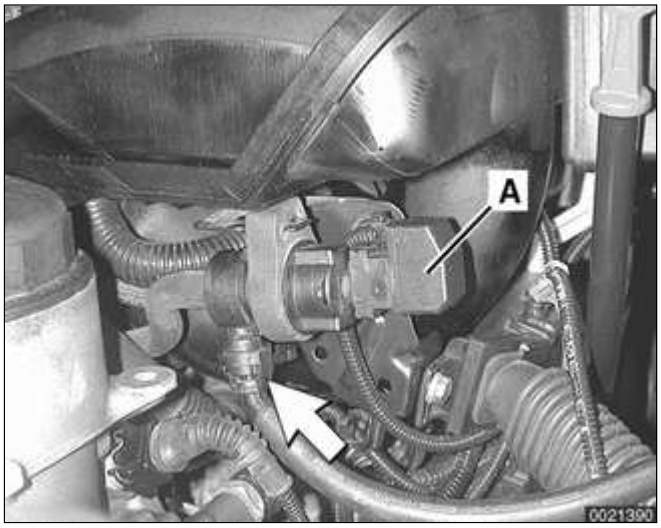
- Remove nuts and bolt (**arrows**) retaining wiring harness conduit to throttle body.



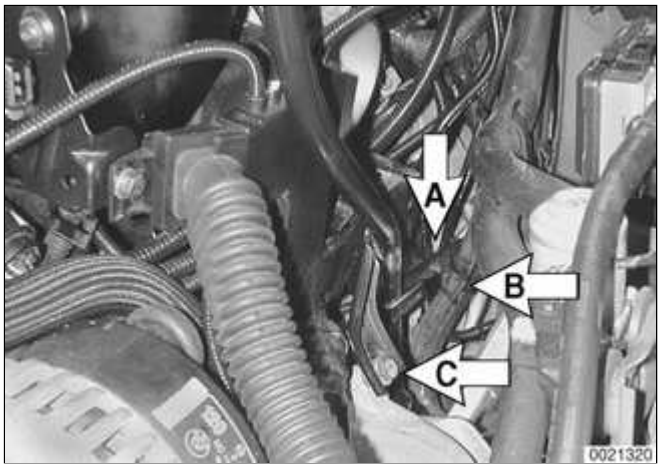
- Working at throttle housing:
  - Turn harness plug (**arrow**) counterclockwise and remove.



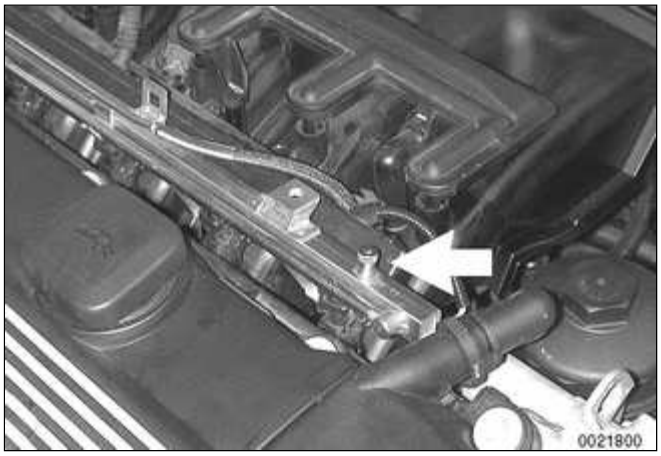
- Disconnect electrical harness connector at idle speed control valve (**arrow**) directly above throttle housing.



- Working under front corner of intake manifold, disconnect electrical harness connector at fuel tank venting valve (**A**). Disconnect vent hose at quick disconnect fitting (**arrow**).



- Remove dipstick guide tube:
  - Disconnect wiring harness brackets from tube (**A**).
  - Disconnect fuel lines from retaining clips (**B**).
  - Remove lower dip stick guide tube mounting bolt (**C**). Pull out guide tube.



- Remove schræder valve cap (**arrow**). Using a tire chuck, blow fuel back through feed line using a brief burst of compressed air (maximum of 3 bar or 43.5 psi).

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.***

- Raise car and support in a safe manner.

WARNING!

Make sure the car is stable and well supported at all times. Use a

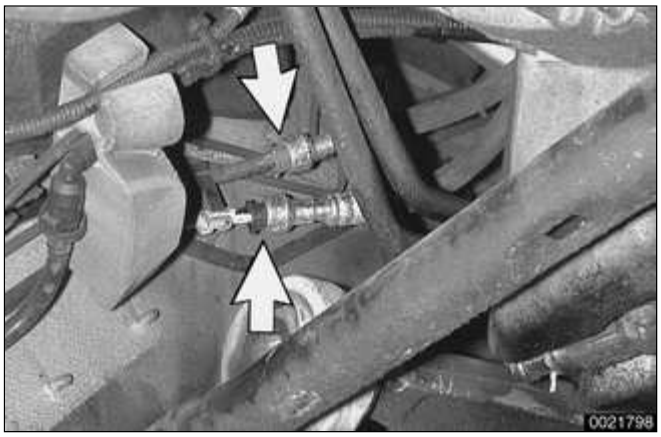
professional automotive lift or jack stands designed for the purpose. A floor jack is not adequate support.

- Remove protective engine splash guard from beneath engine compartment.

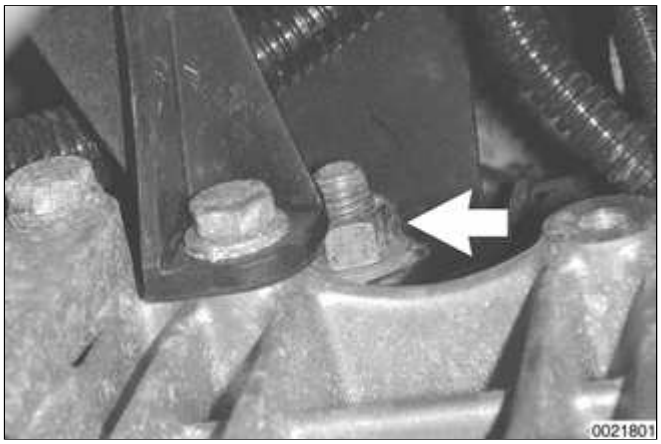
➢ Working beneath car (on left side under driver seat), remove fuel filter cover and clamp off fuel hose(s) (**arrows**).

Note:

M54 engines equipped with a non-return fuel rail use only a single supply line.



➢ Disconnect fuel hose(s) from fuel line(s) (**arrows**) using special fuel line removal tool 16 1 050 or equivalent. Plug open fuel line(s) with BMW special tools 13 5 281/13 5 282.

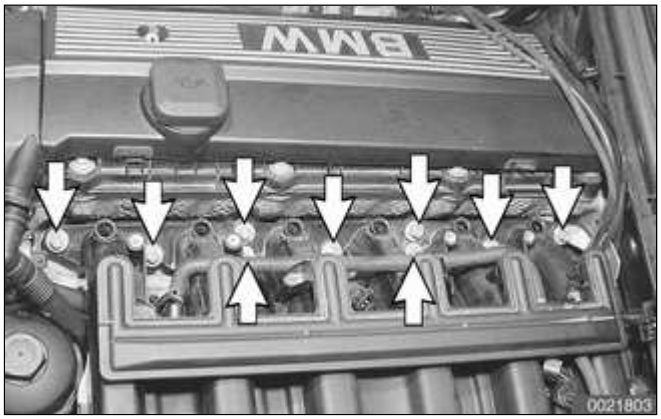


➢ Working underneath car, remove lower intake manifold support mounting bolt (**arrow**), located adjacent to left (driver's side) engine mount.

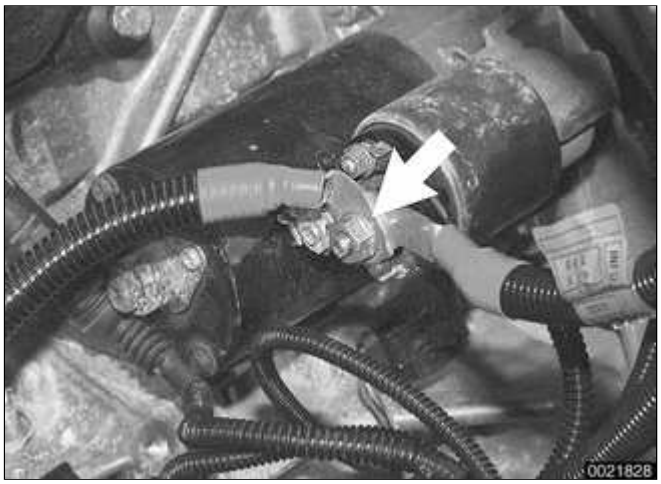
➢ Remove fuel rail mounting bolts (**arrows**).

- Carefully pry fuel rail off manifold.

- Separate fuel line support bracket at rear of intake manifold.
- Thread fuel line(s) out of rear of engine compartment while lifting fuel rail out.



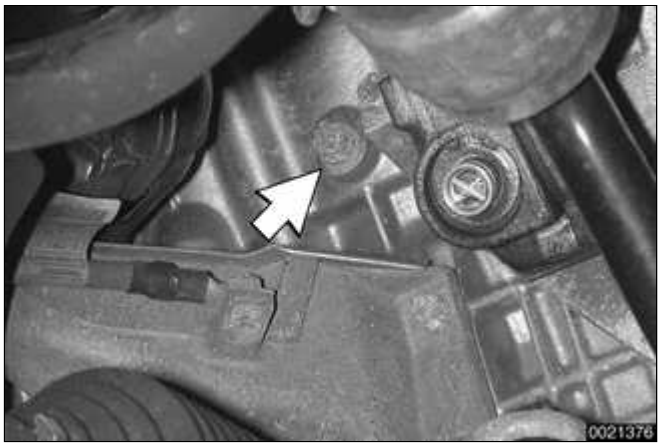
- Remove intake manifold mounting nuts (**arrows**).



- Lift up manifold enough to disconnect positive cables from starter motor terminal (**arrow**).
- Remove intake manifold from cylinder head while carefully checking for any remaining electrical connections or hoses.

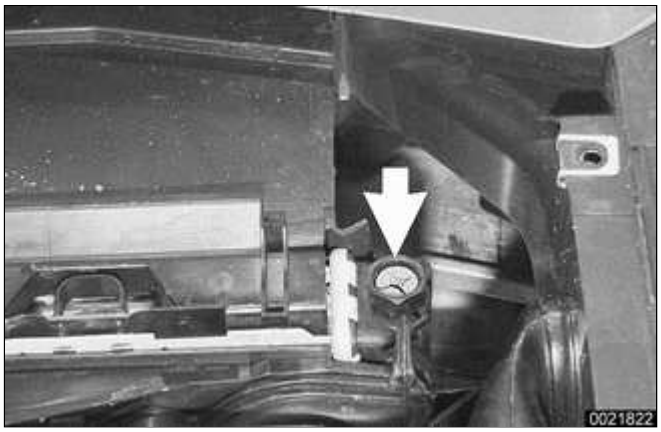
CAUTION!

Stuff clean lint free rags into open intake ports to prevent any foreign matter from falling into the ports.



- Drain engine coolant from engine block:
  - Remove expansion tank cap on radiator.
  - Place 3-gallon pail beneath engine to capture coolant.
  - Remove coolant drain plug located on exhaust side of cylinder

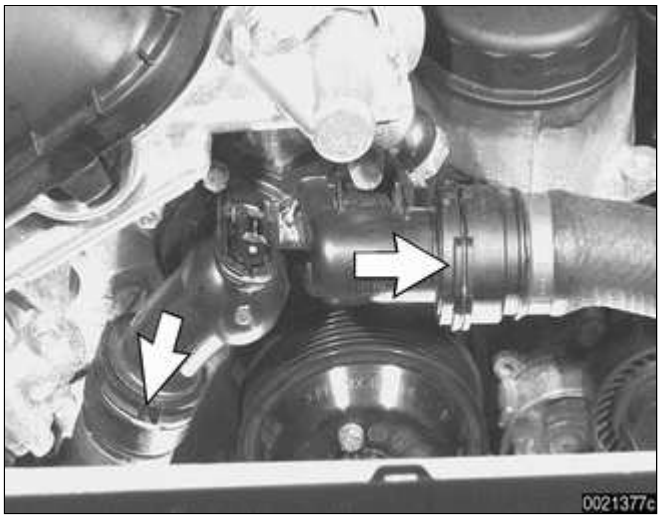
2 of engine block (**arrow**).



- Drain radiator into a 3-gallon pail by removing plastic drain plug at lower left end of radiator (**arrow**).

WARNING!

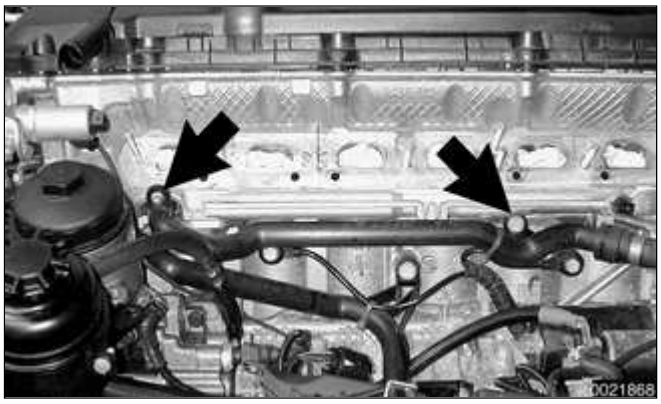
Use caution when draining and disposing of engine coolant. Coolant is poisonous and lethal to humans and pets. Pets are attracted to coolant because of its sweet smell and taste. Consult a veterinarian if coolant is ingested by an animal. Dispose of drained coolant according to local, state, and federal laws.



- Remove hoses from thermostat housing by releasing locks (**arrows**).
  - Disconnect electrical harness at thermostat housing.
  - Remove radiator cooling fan and shroud as described in ⇒ 170 Radiator and Cooling System

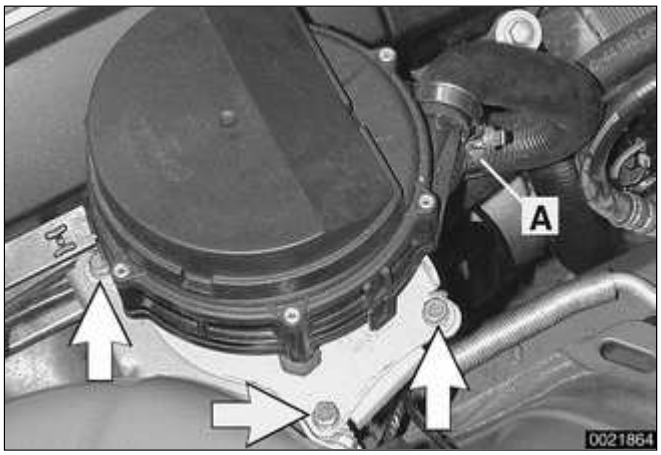
CAUTION!

On cars with viscous clutch cooling fan, radiator fan mounting nut (32 mm) has left-hand threads.



- Remove fasteners (**arrows**) from heater bypass tube and set tube to side leaving heater hose connected.
  - Unbolt power steering fluid reservoir and pull aside without disconnecting hoses. Tie to fender with cord or stiff wire.
  - Remove windshield and headlight washer reservoir:

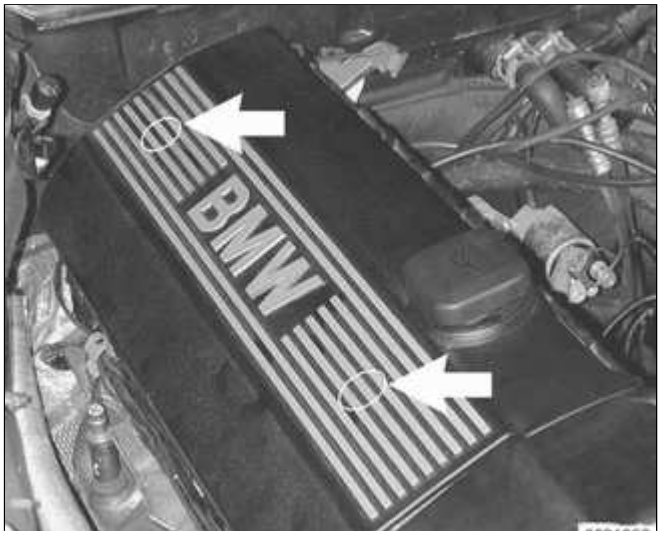
- Remove bolt on top of reservoir.
- Lift tank and disconnect electrical connections to pump and to washer fluid level sensor.
- Disconnect hoses to windshield washer and headlight washer. Tilt reservoir to prevent fluid from leaking out.



➢ Remove secondary air pump:

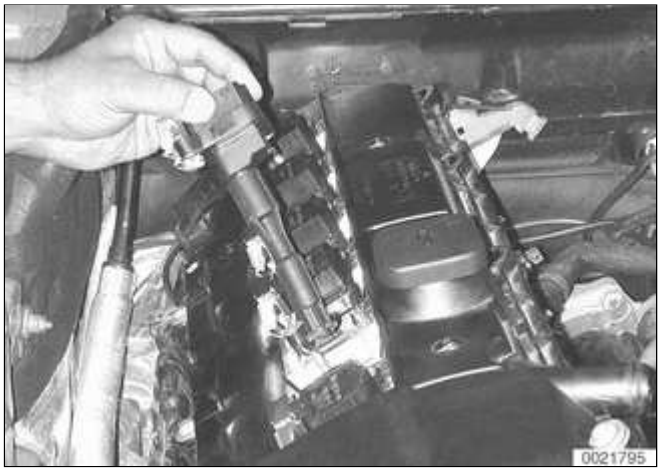
- Disconnect hose at one-way valve (**A**).
- Remove bolts at support bracket on strut tower (**arrows**).
- Lift up pump and disconnect electrical harness from bottom of pump. Remove pump.
- Unbolt and remove pump bracket from strut tower.

Cylinder head cover, removing



➢ Remove cylinder head top cover:

- Remove plastic trim covers (**arrows**).
- Remove cover hold down nuts and lift off cover.



- Remove ignition coils.
  - Disconnect ignition coil harness connectors.
  - Remove coil mounting fasteners.
  - Remove coils.
  - Remove ground straps.
  - Set coil harness to left side of engine compartment.
  - Remove cylinder head cover mounting fasteners and remove cylinder head cover.

Note:

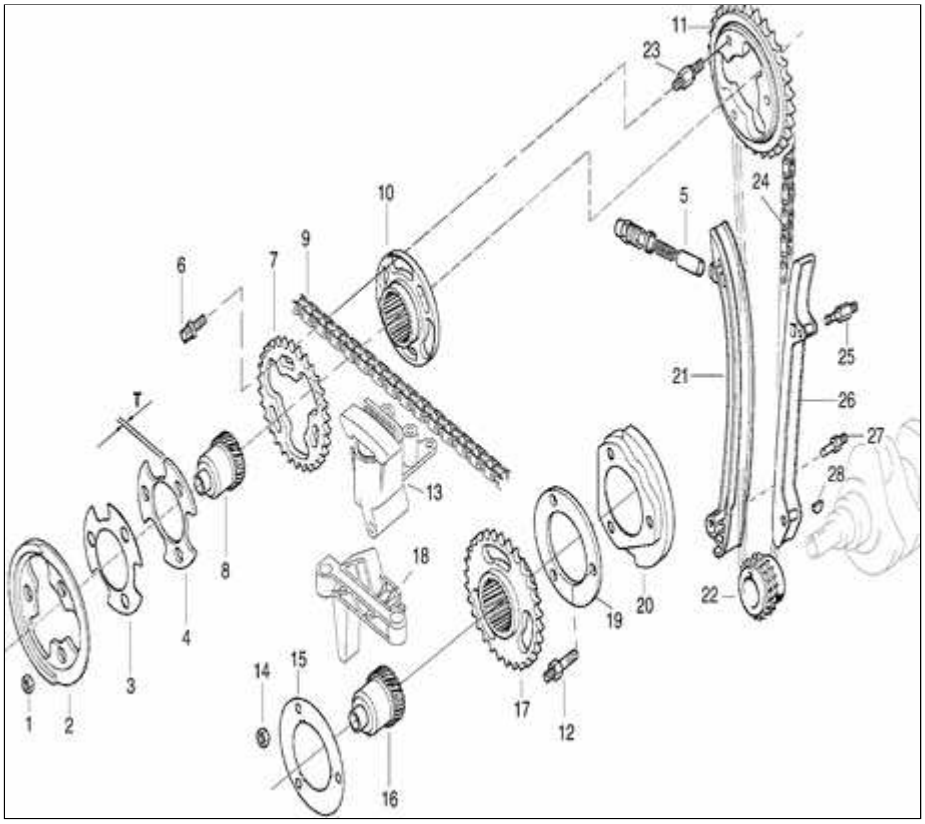
The cylinder head cover mounting bolt insulators and gaskets should be reinstalled in their original locations. The three grounds mount to the first, second and fourth central studs. Make note of their arrangement during removal.

- Remove spark plugs.

CAUTION!

Stuff clean lint free rags into open intake ports to prevent any foreign matter from falling into the ports.

- Remove oil baffle cover from above intake camshaft.



Double VANOS components (M52 TU, M54 engine)

1 - Impulse wheel mounting nut

2 - Exhaust camshaft impulse wheel

3 - Spring plate

4 - Thrust spacer (T = 3.5 mm)

5 - Splined shaft

6 - Torx screw

7 - Exhaust secondary sprocket

8 - Secondary timing chain

9 - Splined sleeve

10 - Primary sprocket

11 - Threaded locating stud

12 - Secondary chain tensioner

13 - Secondary chain lower guide

14 - **Sprocket mounting nut**

15 - **Spring plate**

16 - **Splined shaft**

17 - **Intake camshaft sprocket**

18 - **Locating stud**

19 - **Thrust spacer**

20 - **Intake camshaft impulse wheel**

21 - **Chain tensioner rail**

22 - **Crankshaft sprocket**

23 - **Primary chain tensioner**

24 - **Primary chain**

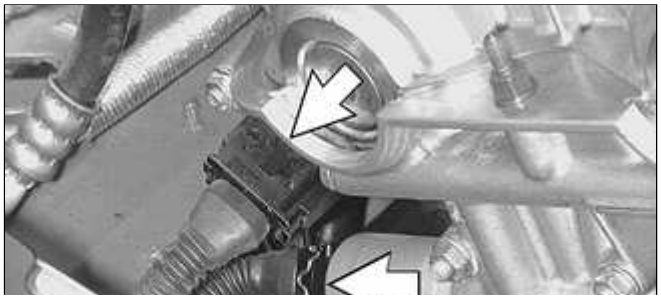
25 - **Locating stud**

26 - **Guide rail**

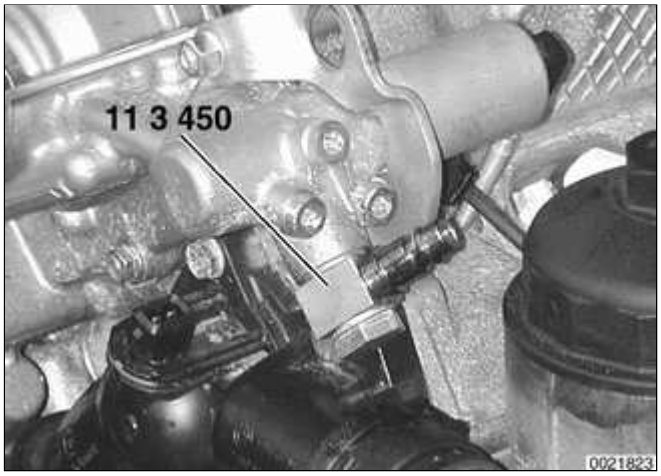
27 - **Locating stud**

28 - **Woodruff key**

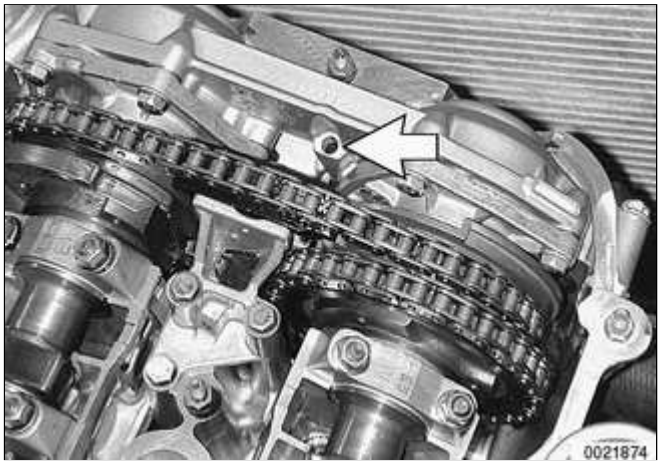
VANOS control unit, removing



- Disconnect electrical connections at exhaust camshaft position sensor and exhaust camshaft VANOS control valve (**arrows**).

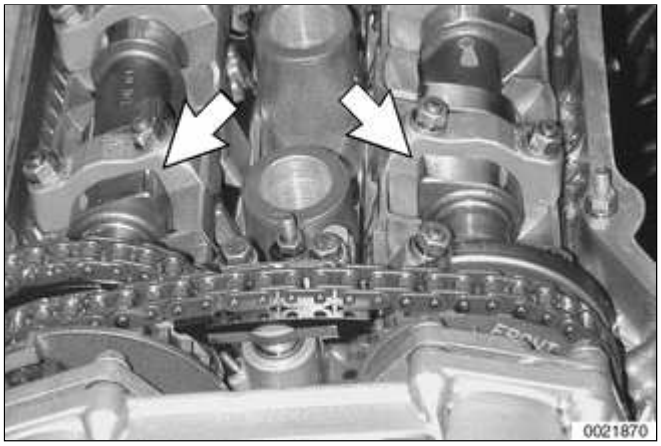


- Remove banjo bolt from VANOS unit oil pressure line. Use banjo bolt to attach BMW special tool 11 3 450 (compressed air fitting) to VANOS control unit.



- Cover oil hole (**arrow**) in VANOS unit with shop towel to capture oil which will spray when compressed air is applied.

  - Connect compressed air line to air fitting. Apply air pressure set to 2 - 8 bar (30 - 110 psi).

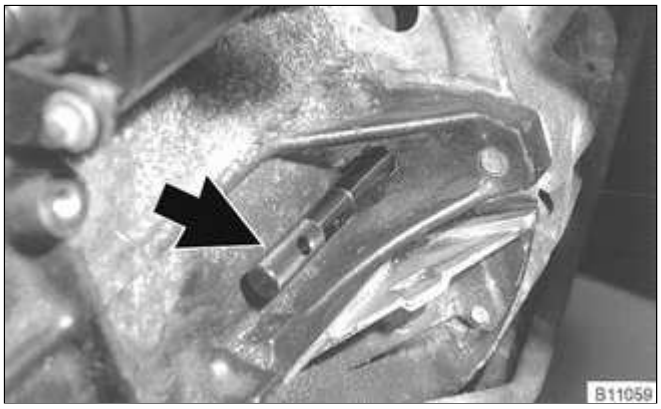


- With compressed air line connected, rotate engine in direction of rotation (clockwise) until cylinder 1 intake and exhaust camshaft lobes face each other (**arrows**) in the top dead center (TDC) position for cylinder 1.

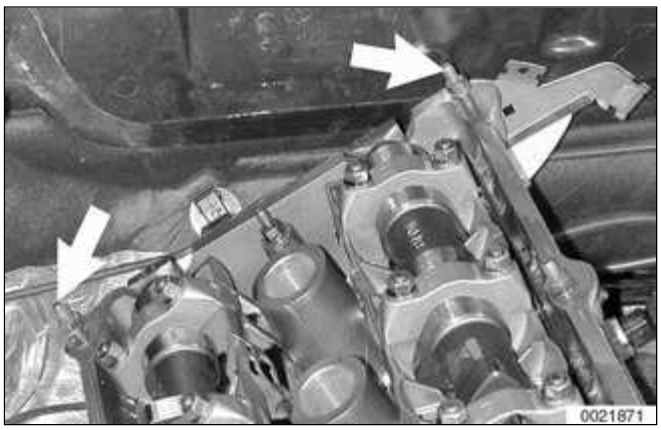
  - Rotate engine at least twice, leaving the cylinder 1 intake and exhaust camshaft lobes facing each other, as shown.

CAUTION!

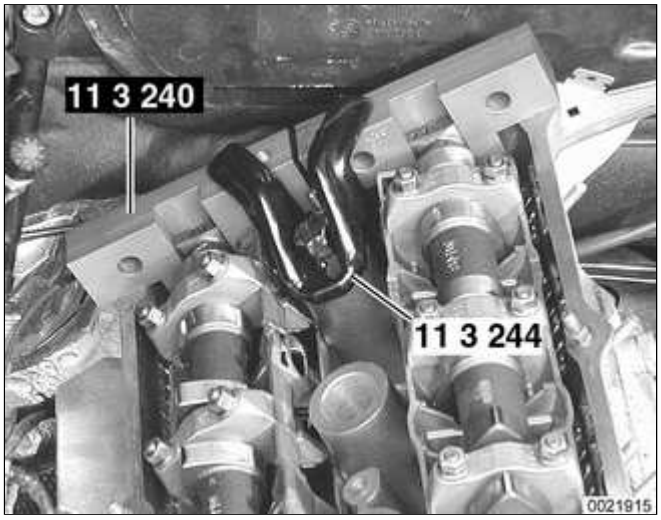
Do not rotate engine counterclockwise to reach the top dead center position. Instead, complete another two complete rotations.



- Remove sealing plug from special tool bore on lower left side of engine block near flywheel. Secure crankshaft in TDC position with BMW special tool 11 2 300 (**arrow**).



- Unscrew and remove two cylinder head cover studs (**arrows**) at rear of cylinder head.

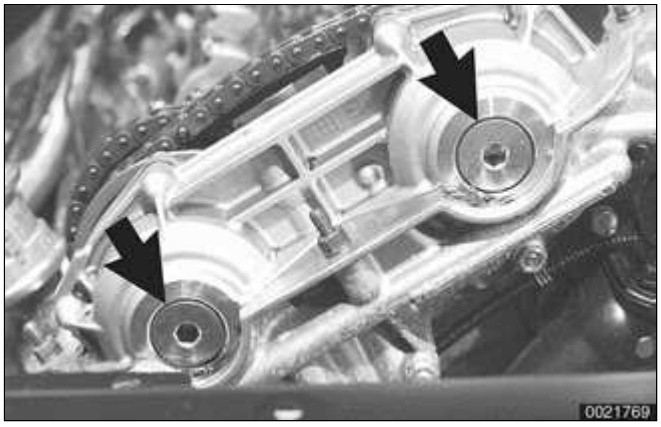


- Secure camshafts in TDC position using BMW special tools 11 3 240 and 11 3 244.

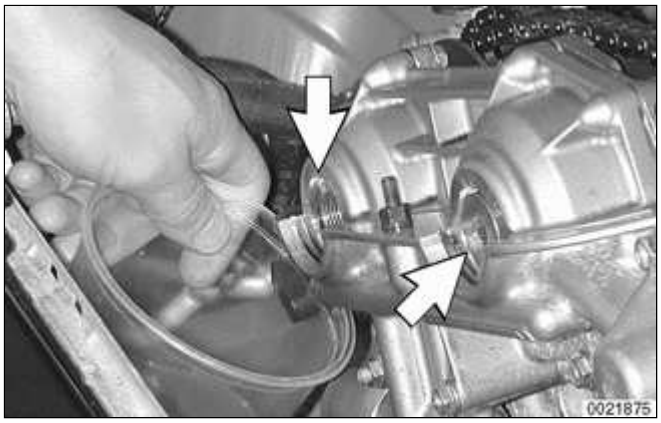
  - Disconnect compressed air line, leaving compressed air fitting attached to VANOS unit.

CAUTION!

Oil will drain from pressure line. Have a drain container and rags ready. Do not allow oil to run onto drive belts.



- Unscrew sealing plugs (**arrows**) from VANOS unit.



- Oil will drain from plugs (**arrows**) when removed. Have a container and rags ready. Do not allow oil to run onto drive belts.

- Pull sealing caps straight out of VANOS unit with BMW special tool 11 6 170, or with short nose pliers.

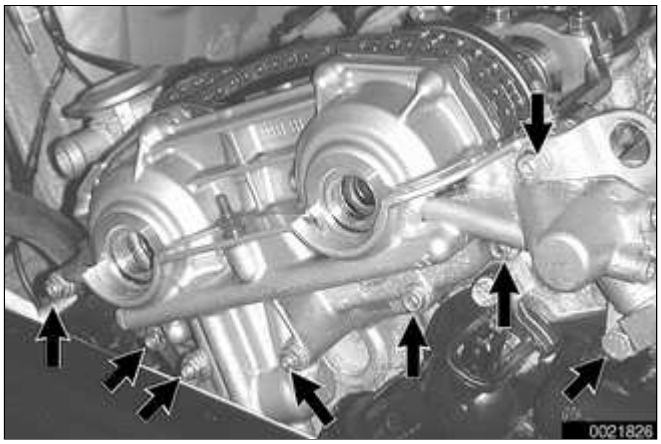
Note:

Additional oil may drain from VANOS unit.

- Remove set screws (left-hand thread) on ends of intake and exhaust camshafts.

CAUTION!

Set screws have left hand threads. Remove in clockwise motion.



- Remove VANOS unit:

  - Remove engine support eye fasteners from side of VANOS unit.

  - Remove VANOS mounting nuts (**arrows**) from cylinder head and pull VANOS unit and metal gasket off.

CAUTION!

Do not crank the engine with VANOS unit removed. The splined shaft on the intake camshaft might slip out of the VANOS spline teeth, causing the intake cam to no longer be positively connected to the timing chain, allowing for possible piston/valve interference.

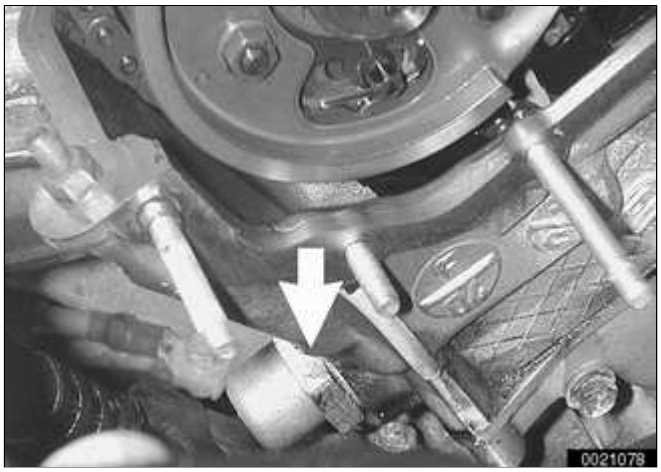
Note:

The VANOS unit will contain a small quantity of oil. Place shop towels to catch oil as unit is removed or tilted.

CAUTION!

If the VANOS adjustment unit is replaced, or if operations are completed that may change the timing of the camshafts, the camshaft timing must be checked as described later in this chapter.

Camshafts and valvetrain, removing

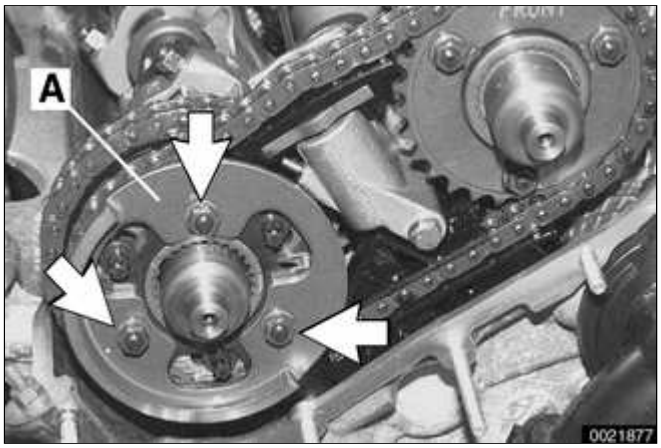


- Remove primary camshaft chain tensioner cylinder (**arrow**).

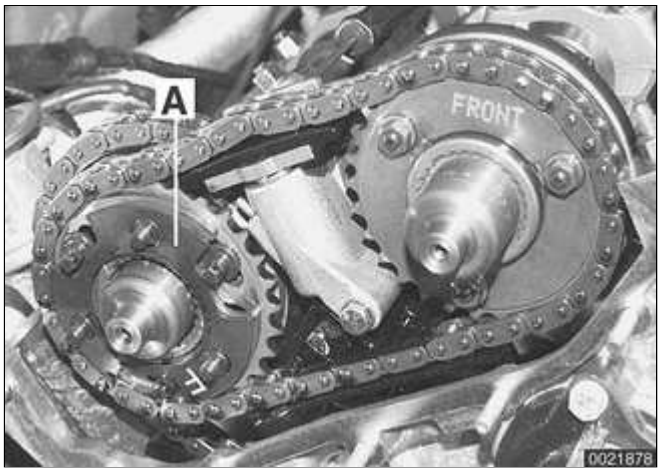
CAUTION!

Primary camshaft chain tensioning piston is under spring pressure.

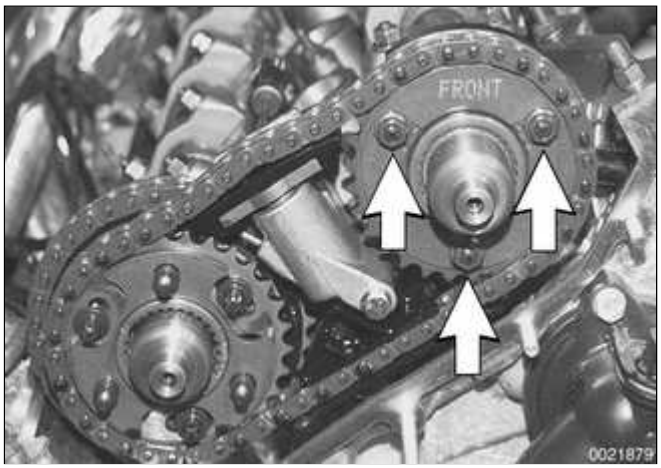
- Press down on secondary chain tensioner and lock into place using BMW special tool 11 3 292 or a similar size pin.



- Remove exhaust camshaft impulse wheel mounting nuts (**arrows**). Remove impulse wheel (**A**).

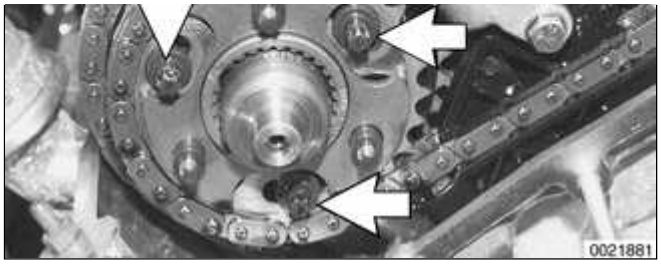


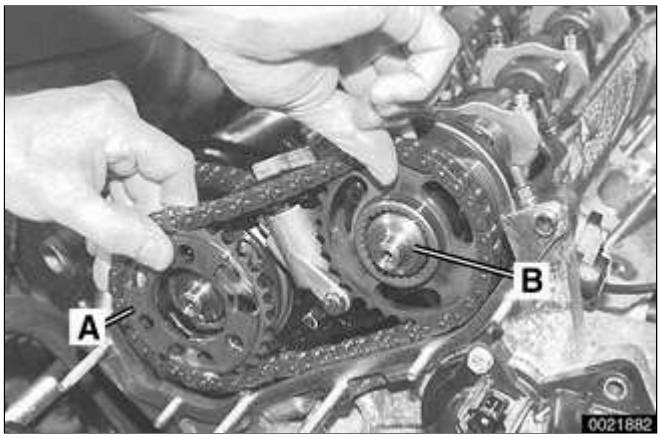
- Remove spring plate (**A**).



- Remove intake camshaft sprocket mounting nuts (**arrows**) and remove spring plate (labelled **FRONT**).

- Remove torx screws from exhaust camshaft sprocket (**arrows**).

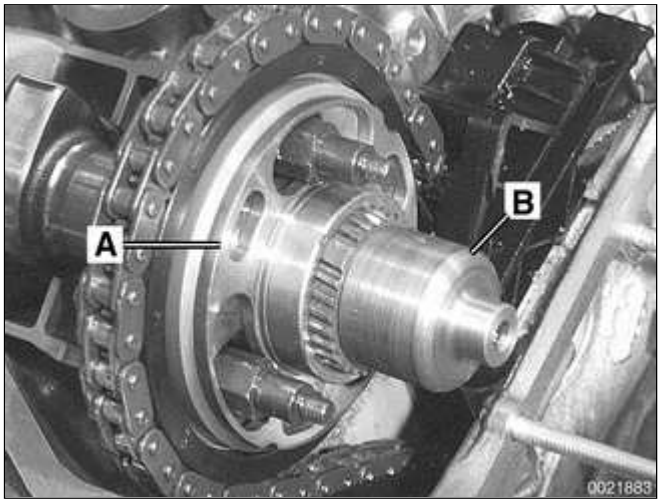




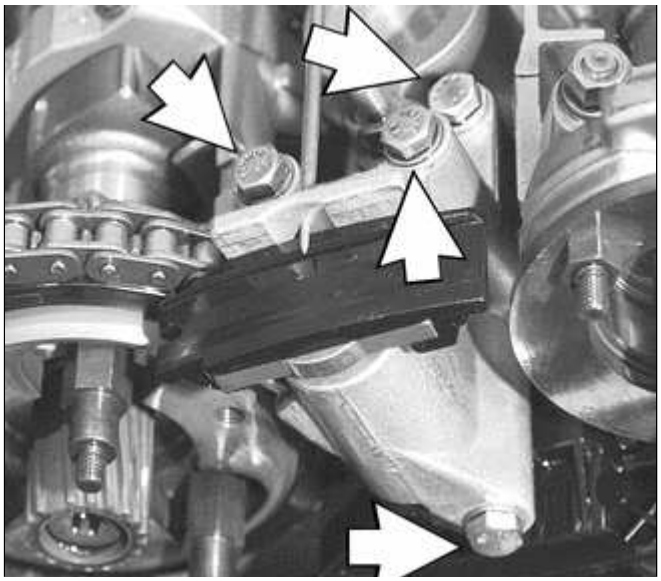
- Lift off exhaust and intake sprockets together with secondary chain, thrust spacer (**A**) from exhaust camshaft, and splined shaft (**B**) from intake camshaft.

CAUTION!

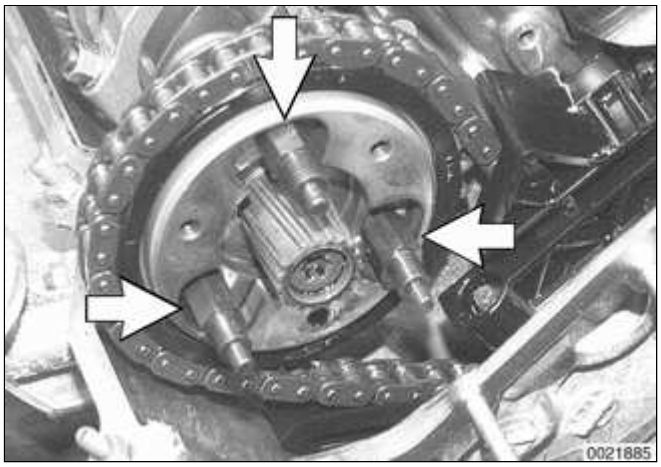
Splined shafts share the same part number for both intake and exhaust camshafts. Remove and mark used splined shafts in order and reinstall in original locations.



- Remove exhaust camshaft splined sleeve (**A**) and shaft (**B**).

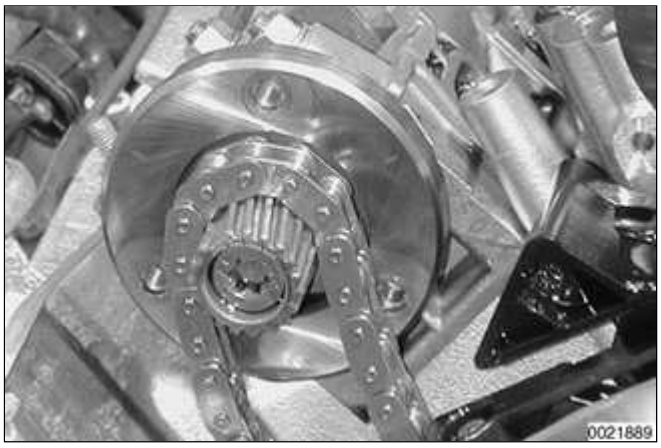


- Remove secondary chain tensioner mounting bolts (**arrows**). Remove tensioner from between camshafts while keeping retaining pin in place.

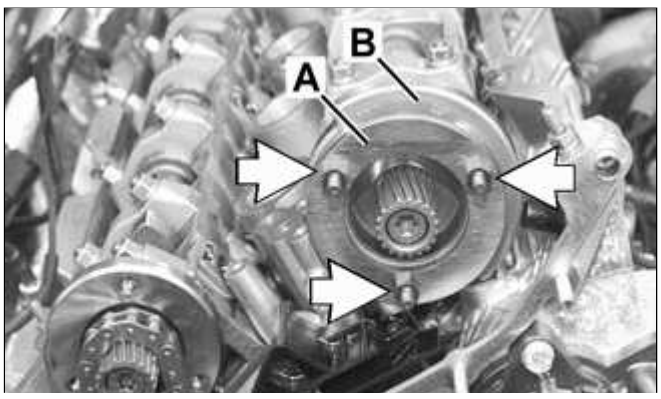


- Remove primary chain sprocket mounting studs (**arrows**) on exhaust camshaft.

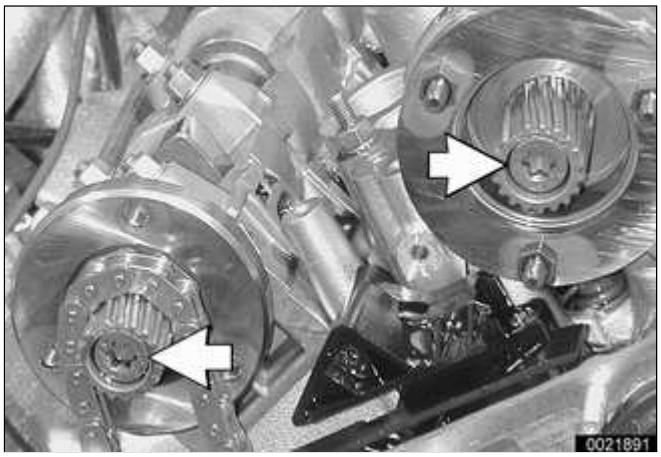
- Lift primary chain sprocket off exhaust camshaft. Remove sprocket from chain.



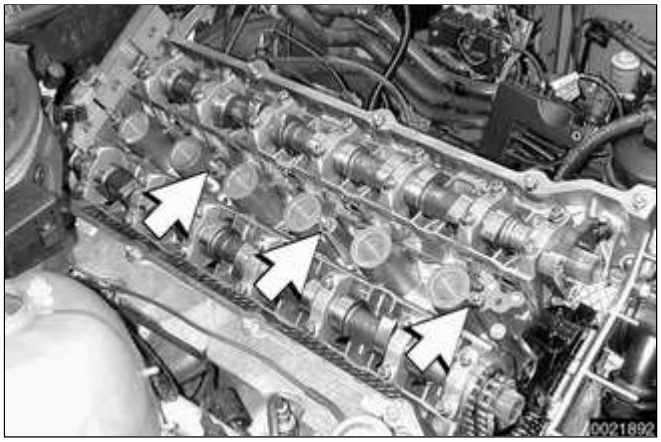
- Place timing chain on end of exhaust camshaft.



- Remove locating studs (**arrows**) from intake camshaft. Lift off intake camshaft thrust spacer (**A**) and impulse wheel (**B**).

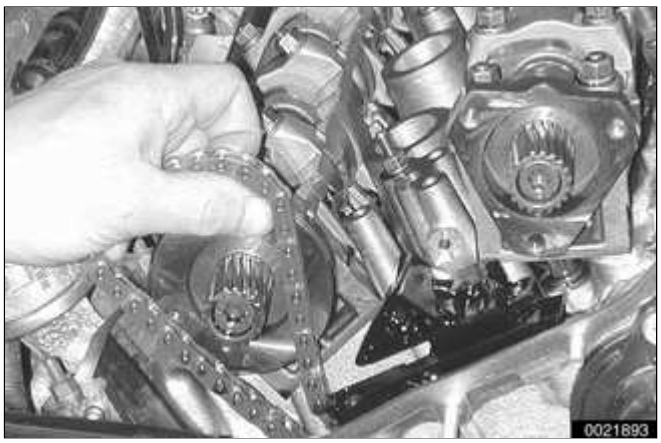


- Do not remove end spline retaining screws from camshafts (**arrows**).



- Remove cylinder head cover mounting studs (**arrows**) from center of cylinder head.

  - Remove flywheel locking tool from transmission bellhousing so that crankshaft is no longer secured.



- Lift primary chain and hold under tension, then rotate engine against direction of rotation (counterclockwise) approximately 30°.

  CAUTION!

  To prevent damaging valves while working on camshafts, no pistons should be in the TDC position.

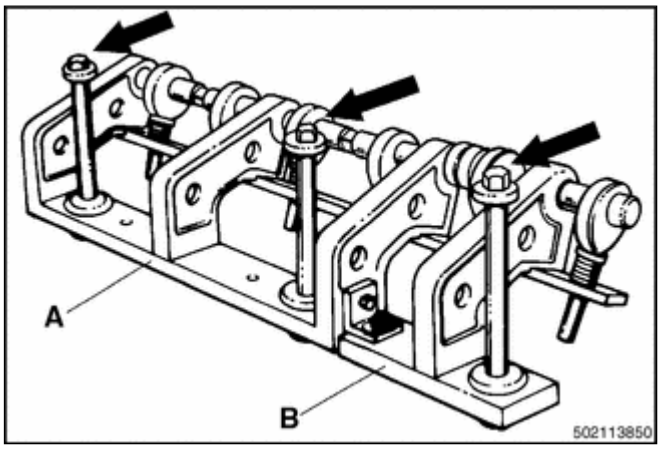
  - Remove BMW special tools 11 3 240 and 11 3 244 from rear of cylinder head.

- Remove retaining nuts (**arrows**) and bearing cap 1 of intake camshaft.

  CAUTION!

  Intake camshaft bearing cap 1 is

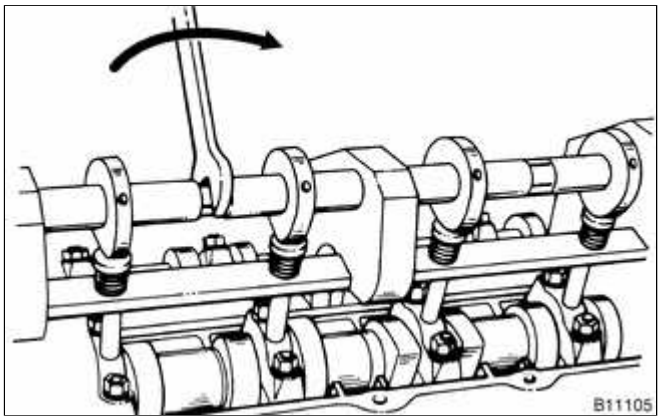
centered with adapter sleeves. To avoid camshaft damage, it must be removed before any other caps.



- Fit BMW special tools 11 3 260 (**A**) and 11 3 270 (**B**) to cylinder head and screw long bolts (**arrows**) into spark plug threads. Tensioners will align with the bearing caps on the intake camshaft.

CAUTION!

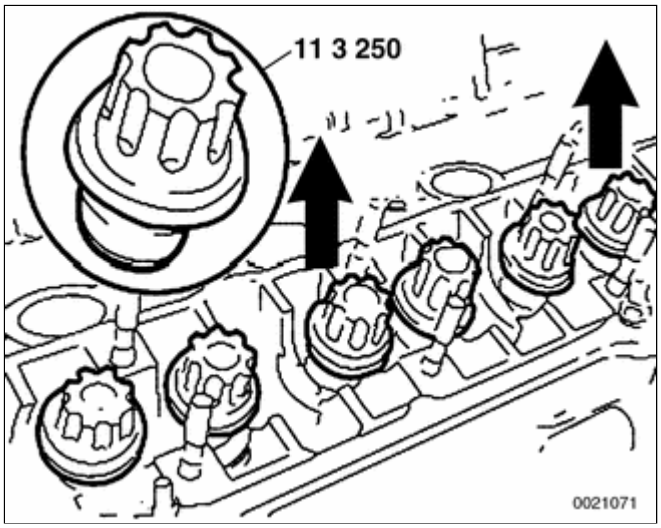
Do not over torque bolts into spark plug holes.



- Turn eccentric shaft of special tool to pretension intake camshaft bearing caps. Remove nuts on remaining bearing caps.

  - Release tension on eccentric shaft and remove BMW special tools 11 3 260 and 11 3 270. Remove bearing caps and set aside in order. Remove camshaft and store safely.

  - Repeat procedure for exhaust camshaft.



- Secure hydraulic lifters in lifter bores using BMW special tool 11 3 250, or remove lifters using a magnetic pick-up tool. With lifters secure or removed, lift out camshaft bearing carriers from cylinder head.

CAUTION!

- ***Do not let the hydraulic lifters fall out as the camshaft carrier is removed.***