



Standard Test Method for Vehicle Evaluation of Unleaded Automotive Spark-Ignition Engine Fuel for Intake Valve Deposit Formation¹

This standard is issued under the fixed designation D5500; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a vehicle test procedure for evaluation of intake valve deposit formation of unleaded spark-ignition engine fuels. This test method uses a 1985 model BMW 318i² vehicle. Mileage is accumulated following a specified driving schedule on either public road or test track. This test method is adapted from the original BMW of North America/Southwest Research Institute Intake Valve Deposit test and maintains as much commonality as possible with the original test. Chassis dynamometers shall not be used for this test procedure as the BMW NA/SwRI IVD Test was not intended to be applicable to chassis dynamometers and no correlation between road operation and chassis dynamometers has been established.

NOTE 1—If there is any doubt as to the latest edition of Test Method D5500, contact ASTM International.

1.2 The values stated in SI units are to be regarded as standard. The values in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific statements on hazards are given throughout this test method.

2. Referenced Documents

2.1 ASTM Standards:³

D235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.A0.01 on Gasoline and Gasoline-Oxygenate Blends.

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² Originally obtained from BMW NA new car dealerships in the United States as a 1985 model year vehicle, the vehicle is currently available through the used vehicle market.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 ANSI Standard:

MC 96.1 American National Standard for Temperature Measurement Thermocouples⁴

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *alternate mileage accumulation (AMA) driving cycle, n*—a driving schedule that is based on the U.S. Environmental Protection Agency Durability Driving Schedule, which contains various driving patterns for durability testing of emission control systems.⁵

3.1.2 *base fuel, n*—unleaded automotive spark-ignition engine fuel that does not contain a deposit control additive, but may contain antioxidants, corrosion inhibitors, metal deactivators, and oxygenates.

3.1.3 *deposit control additive, n*—material added to the base fuel to prevent or remove deposits in the entire engine intake system.

3.1.3.1 *Discussion*—For the purpose of this test method, the performance evaluation of a deposit control additive is limited to the tulip area of intake valves.

3.1.4 *driveability, n*—the quality of a vehicle's performance characteristics as perceived by the operator in response to changes in throttle position.

3.1.4.1 *Discussion*—The performance characteristics may include cold starting and warm-up, acceleration, vapor lock, and hot starting.

3.1.5 *intake system, n*—components of the engine whose function it is to prepare and deliver an air/fuel mixture to the combustion chamber and includes the throttle, intake manifold hot spot and runners, exhaust gas recirculation (EGR) and positive crankcase ventilation (PCV) ports, cylinder head runners and ports, intake valves, and fuel injectors.

3.1.6 *intake valve deposit, n*—material accumulated on the tulip area of the intake valve, generally composed of carbon, other fuel, lubricant, and additive decomposition products, and atmospheric contaminants.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Code of Federal Regulations, Title 40, Part 86, Appendix IV.

3.1.7 *merit rating, n*—the visual evaluation by a trained rater of the volume of deposits accumulated on a specific engine component based on a comparison with a reference scale (see CRC Manual 16⁶).

3.1.8 *test fuel, n*—base fuel with or without the addition of a deposit control additive which is used to accumulate mileage as described in this test method.

3.1.9 *vehicle exhaust emissions (tailpipe), n*—combustion products from the test fuel including unburned hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO₂), oxygen (O₂), and oxides of nitrogen (NO_x).

4. Summary of Test Method

4.1 This test method utilizes a 1985 BMW 318i vehicle equipped with a four-speed automatic transmission and air conditioning. This vehicle is equipped with a four-stroke cycle, four-cylinder engine having a total displacement of 1.8 L. The cylinder head is an aluminum alloy casting and the cylinder block is cast iron. The engine features an overhead camshaft, hemispherical combustion chambers, two valves per cylinder, and electronic port fuel injection.

4.2 Each test begins with a clean, rebuilt cylinder head that meets a rigid set of specifications. New, weighed intake valves are used to rebuild the cylinder head. A standard engine oil is used for each test and a new oil filter is installed. All routine vehicle maintenance is performed in accordance with BMW Schedule I and Schedule II service lists. The test vehicle's fuel system is flushed of fuel from the previous test. The vehicle fuel tank is then filled with the new test fuel. The vehicle is subjected to a rigorous quality control procedure to verify proper engine and overall vehicle operation. To ensure compliance to the test objective, a data logger is active at all times after the test has begun, during all mileage accumulation and soak time.

4.3 The vehicle is operated on a cycle consisting of 10 % (based on mileage) city (part of the AMA driving schedule), 20 % suburban, and 70 % highway mode per day. This cycle is repeated to accumulate a minimum of 16 090 km (10 000 miles) but no more than 16 250 km (10 100 miles).

4.4 After the required mileage (see 10.4.5) has been accumulated, the cylinder head is removed from the engine and disassembled. The valves are weighed, visually assigned merit ratings, and photographed. Operational and mechanical criteria are then reviewed to determine if the test shall be considered valid.

5. Significance and Use

5.1 *Test Method*—It was determined through field testing that intake valve deposits could adversely affect the driveability of certain automobiles.⁷ Southwest Research Institute and BMW of North America (BMW NA) jointly conducted testing to develop this test method to determine an unleaded automotive spark-ignition engine fuel's propensity to form intake

valve deposits. This testing concluded that if an automotive spark-ignition engine fuel could keep intake valve deposits at or below a certain average weight per valve at the end of mileage accumulation, then that automotive spark-ignition engine fuel could be used in the BMW vehicle-engine combination for a specified period without intake valve deposits causing driveability degradation. Minimizing intake valve deposits may be necessary to maintain vehicle driveability and tailpipe emissions control.

5.1.1 *State and Federal Legislative and Regulatory Action*—Legislative activity and rulemaking primarily by California Air Resources Board⁸ and the Environmental Protection Agency⁹ necessitate the acceptance of a standardized test method to evaluate the intake system deposit forming tendency of an automotive spark-ignition engine fuel.

5.1.2 *Relevance of Results*—The operating conditions and design of the engine and vehicle used in this test method are not representative of all modern automobiles. These factors shall be considered when interpreting test results.

5.2 Test Validity:

5.2.1 *Procedural Compliance*—The test results are not considered valid unless the test is completed in compliance with all requirements of this test method. Deviations from the parameter limits presented in Sections 10 and 11 will result in an invalid test. Engineering judgment shall be applied during conduct of the test method when assessing any anomalies to ensure validity of the test results.

5.2.2 *Vehicle Compliance*—A test is not considered valid unless the vehicle met the quality control inspection requirements as described in Section 10.

6. Apparatus

6.1 *Automobile*—The test automobile used for this procedure is a 1985 model BMW 318i. The powerplant is a 1.8 L-line four-cylinder, four-stroke cycle engine with single overhead camshaft, two valves per cylinder, and electronic port fuel injection. Vehicles equipped with four-speed automatic transmissions and air conditioning are required for the test method. Both 49 state and California engine calibrations are allowed for this test method.

6.1.1 *Engine Cooling System*—Experience has shown that the original equipment cooling system has marginal performance at ambient conditions above approximately 35°C (95°F). To ensure engine coolant temperature compliance with test validity criteria in 10.4.3, the vehicle may be retrofitted with the radiator and other appropriate components as outlined in Annex A1.

6.1.2 *Electronic Port Fuel Injectors*—Prior to installation, all injectors shall be evaluated for conformance to spray-pattern and flow rate acceptance criteria (see 8.5). Injectors may be reused if the criteria are satisfied.

6.1.3 *Tires*—Tires shall be size P195/60R14, maintained at 190 ± 10 kPa (28 ± 1 psi).

⁶ CRC Manual 16, Carburetor and Induction System Rating Manual. Available from the Coordinating Research Council Inc., 219 Perimeter Center Parkway, Atlanta, GA 30346.

⁷ Bitting, B., et al., "Intake Valve Deposits-Fuel Detergency Revisited," SAE 872117, Society of Automotive Engineers, 1987.

⁸ State of California Air Resources Board-Stationary Source Division, Test Method for Evaluating Intake Valve Deposits (IVDs) in Vehicle Engines (California Code of Regulations, Title 13, Section 2257).

⁹ Clean Air Act Amendments of 1990.

6.1.4 *Miscellaneous Parts*—All powertrain components, front end accessory drive, air intake system, and exhaust system, except as specified, shall be original equipment, original equipment manufacturer replacement parts, or equivalent.

6.1.5 *New Engine Parts Required*—Table 1 contains those new parts with the corresponding BMW NA part number to be used for preparing the vehicle to run this test method.

6.1.5.1 Other parts may be necessary and are listed in Annex A2.

6.1.6 *Disable Cruise Control*—Disconnect cruise control cable from the throttle. The cruise control shall not be used for this test method.

6.1.7 *Reusable Engine Parts*—The parts listed in Table 2 may be reused. The replacement frequency is noted in the footnotes. All parts shall be discarded when they become unserviceable. See Annex A3 for guidelines regarding the reuse of parts.

6.2 Laboratory Facilities:

6.2.1 *Engine/Cylinder Head Build-up and Measurement Area*—The ambient atmosphere of the engine build-up and measurement area shall be reasonably free of contaminants and maintained at a uniform temperature $\pm 3^{\circ}\text{C}$ ($\pm 5^{\circ}\text{F}$) between 10 to 27°C (50 to 80°F). Uniform temperature is necessary to ensure repeatable dimensional measurements and deposit evaluation. The specific humidity shall be maintained at a uniform comfortable level.

6.2.2 *Part Rating and Intake Valve Weighing Area*—The ambient atmosphere of the rating and weighing area shall be reasonably free of contaminants. The induction system ratings shall be performed in accordance to CRC Manual 16, Carburetor and Induction System Rating Manual.

6.2.3 *Fuel Injector Testing Area*—The ambient atmosphere of the fuel injector testing area shall be reasonably free of contaminants. The temperature and humidity shall be maintained at a uniform level to ensure repeatable measurements. This area shall be ventilated for health and safety reasons in accordance with all regulations. (**Warning**—Provide adequate ventilation and fire protection in areas where flammable or volatile liquids and solvents, or both, are used. Suitable protective clothing is recommended.)

6.2.4 *Intake Valve Rinsing and Parts Cleaning Area*—The ambient atmosphere of the intake valve rinsing and parts cleaning area shall be reasonably free of contaminants. The temperature shall be maintained at $\pm 3^{\circ}\text{C}$ ($\pm 5^{\circ}\text{F}$) between 10 to 27°C (50 to 80°F). The specific humidity shall be maintained at a uniform comfortable level. Because of the delicate nature

TABLE 2 Reusable Engine Parts

Air flow meter	Idle control valve
Air pressure sensor	Ignition coil
Alternator	Ignition wire set ^A
Camshaft	Intake manifold
Camshaft drive	Intake, rocker shaft
Cylinder block assembly ^B	Lambda probe
Cylinder head	O ₂ sensor
Distributor	Pump, water
Distributor cap	Radiator
Electronic engine control computer unit	Radiator cooling fan
Engine wiring harness	Rocker arm
Exhaust rocker shaft	Rotor
Exhaust system	Sensor, temperature fan
Filter, air ^A	Sensor, vacuum advance
Fuel injectors	Throttle body
Front end accessory drive	Valve springs ^C
Idle control relay	

^A These parts shall be changed in accordance with BMW NA Service Schedule I (Annex A4), or more frequently.

^B The cylinder block can be reused for approximately ten tests (160 000 km) (100 000 miles), depending on condition of cylinder head bolt holes (radial cracks appear on the block deck) and cylinder bore wear. (Refer to the BMW 318i Service Manual which is available from BMW NA dealer service departments.)

^C Valve springs may be reused as long as they meet the procedural requirements for tension in 8.4.12.

of the deposits, do not subject the deposits to extreme changes in temperature or humidity. (**Warning**—See 6.2.3.)

6.2.5 *Garage/Maintenance Area*—The ambient atmosphere of the garage/maintenance area shall be reasonably free of contaminants. The temperature and humidity shall be maintained at a uniform, comfortable level. Because of the delicate nature of the deposits, do not subject the deposits to extreme changes in temperature or humidity. (**Warning**—Adequate ventilation and fire protection are necessary in areas where automotive spark-ignition engine fuel and deposit control additives are handled, and also when concerning the venting of the vehicle exhaust and working on vehicle fuel systems. Suitable protective clothing is recommended.)

6.2.6 *Test Fuel Blending Facilities*—Instead of supplying a finished test fuel, the test sponsor may supply concentrated additive in bulk to the test laboratory. The test requestor shall obtain concurrence from the test laboratory regarding the supply of base fuels and additives and their packaging. For those laboratories offering the capability of blending additive and base fuel, the laboratories shall have the ability to handle and blend the additive into fuel supplied in either bulk or 210-L (55-gal) drums, or both. The laboratory shall have an appropriate balance or graduated cylinder to blend the additive at the recommended concentrations expressed as a volumetric or mass ratio. The base fuel and additive shall be placed, at the appropriate ratio, into 210-L (55-gal) drums or bulk storage tanks and clearly labeled. Provisions to stir or recirculate the fuel/additive blend to ensure a homogeneous mixture are necessary. Safe, clean storage shall be provided for base fuel, additive, and test fuel. The ambient atmosphere of the additive blending facility area shall be reasonably free of contaminants. Retain a 1-L sample of the fuel blend. Hold this sample for one month or release to test requestor. (**Warning**—See 6.2.5.)

6.2.7 *Fuel Storage and Refueling Facilities*—Sufficient finished test fuel shall be stored at the refueling station in clearly labeled drums or dispensers. In laboratories that may run several different test methods concurrently, dispensers or hand

TABLE 1 New Engine Parts Lists

Part	Part No.
Filter, fuel	13 32 1 270 038
Filter, oil	11 42 1 278 059
Gasket, head set	11 12 1 287 381
Gasket, water	11 51 0 686 135
Jet valve, nozzle	11 12 1 250 937
Spark plug	12 12 1 272 128
Thermostat	11 53 1 468 056
Valve, intake	11 34 1 254 625

pumps for the drums shall not be switched between dissimilar test fuels. To ensure the test fuels are not contaminated either by other test fuels or foreign matter, a suitable structure shall be provided to contain the test fuels safely. The laboratory shall have a protocol to ensure the test vehicle receives the proper test fuel. (**Warning**—See 6.2.5.)

6.3 Laboratory Equipment:

6.3.1 *Data Acquisition*—A data acquisition device, capable of providing the raw data, as outlined in 10.4, is required.

6.3.2 *Temperature Measurement Equipment*—Temperature measurement equipment and locations for the required temperatures are specified in 6.3.2.1–6.3.2.4. Alternative temperature measurement equipment may be used if equipment performance can be demonstrated. The accuracy and resolution of the temperature measurement sensors and the complete temperature measurement system shall follow guidelines detailed in the Research Reports “Data Acquisition Task Force Report” and “Instrumentation Task Force Report to the ASTM Technical Guidance Committee.”¹⁰

6.3.2.1 If thermocouples are used, all thermocouples except the intake air thermocouple shall be premium, sheathed types. The intake air thermocouple may be an open-tip type. Thermocouples of 3.2, 4.8, or 6.4-mm (0.125, 0.1875, 0.25-in.) diameter may be used. However, 3.2-mm thermocouples are recommended at locations which require short immersion depths to prevent undesirable temperature gradients. Thermocouple, wires, and extension wires shall be matched to perform in accordance with the limits of error as defined by ANSI publication MC 96.1. Type J (Iron-Constantan), Type T (Copper-Constantan), or Type K (Chromel-Alumel) thermocouples are acceptable.

6.3.2.2 *Intake Air Temperature*—Install the tip of the temperature measuring device midstream in the intake air horn (see A4.1). A 6.4-mm (0.25-in.) thermocouple is adequate if an open-tip thermocouple is used.

6.3.2.3 *Engine Coolant Outlet*—Install the thermocouple tip at the center of the flow stream at the engine out radiator hose connection (see A4.1). The recommended thermocouple diameter is 3.2 mm (0.125 in.).

6.3.2.4 *Engine Oil Sump Temperature*—Install the thermocouple tip such that it extends 25 mm (1 in.) inside the oil sump mounted in the drain plug (see A4.1). The recommended thermocouple diameter is 3.2 mm (0.125 in.).

6.3.3 *Vehicle Speed*—A suitable sensor shall be utilized to measure vehicle speed ± 2 kph (± 1 mph).

6.3.4 *Engine-On Time*—A suitable interface shall be utilized to connect ignition power to the data acquisition equipment.

6.4 Garage Equipment:

6.4.1 *Timing Light*—A suitable adjustable timing light shall be used to check ignition timing as specified in 8.7.5.2.

6.4.2 *Multimeter*—A multimeter capable of measuring milliamperes is required to set idle mixture as specified in 8.7.5.4.

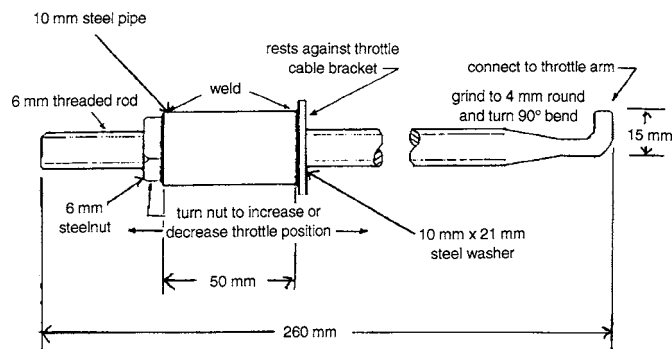


FIG. 1 Throttle Retainer

6.4.3 *BMW Service Test Unit*—A BMW Service Test Unit (Part Number 12 6 400) is necessary to adjust idle carbon monoxide as specified in 8.7.5.5.

6.4.4 *Computerized Diagnostic Machine*—A computerized diagnostic machine is used to verify proper engine operation by measuring vehicle tailpipe exhaust oxygen, carbon monoxide, carbon dioxide, hydrocarbons, ignition performance, and charging system performance. Typical values are given in 8.8.4.

6.4.5 *Throttle Retainer*—A device constructed as shown in Fig. 1 may be used to hold the throttle open during tune-up procedures.

6.5 Special Measurement and Assembly Equipment:

6.5.1 *Graduated Cylinder*—Blending of the deposit control additive may be required and the concentration may be given as a volumetric ratio. A 1000-mL graduate is recommended.

NOTE 2—Volumetric measurement of the deposit control additive is not recommended. Mass-based measurement is preferred.

6.5.2 *Analytical Balance*—Blending of the additive may be required and the concentration may be given as a mass ratio. An analytical balance capable of 0.01-g resolution with a maximum capacity of at least 2000 g is recommended. Also, a balance is required to determine intake valve weight, which is approximately 100 g, with accuracy of 0.25 % of full scale and resolution of 0.0001 g. The balance shall be calibrated following the manufacturer's procedure and frequency recommendations.

6.5.3 *Desiccator*—An airtight chamber with lid shall contain an adequate amount of desiccant to maintain a relatively moisture-free environment for intake valves with deposits (see 7.10).

6.5.4 *Oven*—A natural convection oven shall be used that is capable of maintaining $93 \pm 2^\circ\text{C}$ ($200 \pm 5^\circ\text{F}$) for evaporating the cleaning solvents from the valves. The oven shall have sufficient dimensions to stand the valve upright. There shall be no arcing contacts in the oven and the oven shall be installed in a fume hood.

6.5.5 *Power Wire Wheel*—A power wire wheel (bench grinder fitted with a fine, 15-cm (6-in.) diameter steel wire wheel) shall be used to clean the intake valves as specified. See 8.3.1 and 10.1.

6.5.6 *Walnut Shell Blaster*—Similar to a sand blaster, the walnut shell blaster uses shop air pressure; however, a fine, abrasive media of crushed walnut shells is used instead of sand.

¹⁰ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report D02-1210 and D02-1218.

The walnut shells are sufficiently abrasive to remove carbon while not removing metal from the surface being cleaned. The walnut shell blaster technique is more effective than solvents and generally preferred over a wire brush for removing carbon deposits from the valves and the cylinder head.

6.5.7 Valve Stem and Guide Measuring Equipment—Special equipment is necessary to measure valve stem-to-guide clearances in the cylinder head as required in this test method (see 8.4.1). Any of the methods listed below are acceptable for measuring valve stem-to-guide clearance. One method is specified in the BMW 318i Service Manual. Other commercially available automotive equipment may also be used. Alternatively, air bore gaging equipment can be used to measure the guide diameter, and a micrometer can be used to measure the valve stem diameter.

NOTE 3—Accurate measurements are mandatory to determine stem-to-guide clearance as this parameter can affect oil consumption and intake valve deposit accumulation.

6.5.8 Vernier Caliper—A vernier caliper is necessary to measure valve seat width of the cylinder head as required in this test method (see 8.4.4).

NOTE 4—Accurate measurement of valve seat width is required as this parameter can affect heat transfer from the valves, particularly the intake valve and the surface where deposits may accumulate, ultimately affecting deposit accumulation.

6.5.9 Valve Spring Compression Testing Machine—A valve spring compression testing machine capable of assessing valve spring condition as specified in 8.4.12 is required.

6.5.10 Cylinder Head Stand—A BMW NA cylinder head stand (BMW NA Part Number 11 1 047), or equivalent, shall be used to securely hold the cylinder head during assembly and disassembly.

6.5.11 Valve Lapping Tool—A device to rotate or oscillate the valves on the seat shall be used to lap the valves. Suitable valve lapping tools are available from automotive tool supply sources.

6.5.12 Valve and Valve Seat Cutting Equipment—Equipment may be needed to ensure valve and valve seat mating quality as outlined in 8.4.4. Acceptable equipment is available from automotive tool supply sources.

6.5.13 Blowby Meter—The blowby meter is a device to measure flow rate of the gas passing the piston rings and entering the crankcase. This flow rate is a method to evaluate the condition of the piston rings and cylinder bore and, therefore, is used as a quality assurance and test rejection criteria. The device shall have an accuracy of 5 % full scale and a resolution of 0.3 L/s (0.01 CFM).

6.5.14 Fuel Injector Test Rig—A suitable device capable of accurate, repeatable flow measurement of port fuel injectors is required. This device shall be capable of performing necessary port fuel injector evaluations as outlined in 8.5. No suitable commercially available apparatus has been identified.

6.5.15 Special BMW 318i Service Tools—Several special tools are necessary for rebuilding the cylinder head.

6.5.15.1 Rocker Shaft Removal Tool—A rocker shaft removal tool may be constructed as shown in Fig. 2.

6.5.15.2 Valve Stem Seal Installation Tool—BMW NA Part Number 11 1 200.

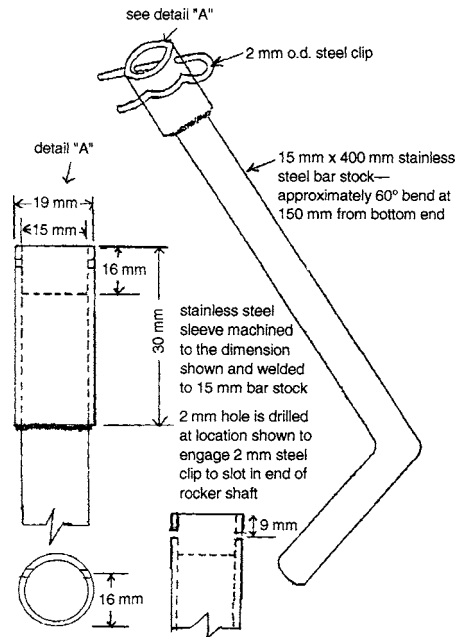


FIG. 2 Rocker Shaft Removal Tool

6.5.15.3 Valve Lash Adjustment Tool—BMW NA Part Number 11 3 070.

7. Reagents and Materials

7.1 Additive/Base Fuel—Some test requestors may require the test fuel be blended at the test laboratory and, therefore, will supply the neat deposit control additive and untreated base fuel. The test requestor shall supply the deposit control additive and base fuel in appropriate volumes and packaging to ensure safe and efficient handling. Blending instructions detailing the concentration ratio, either volumetric-based or mass-based, shall accompany all deposit control additives. Mass-based measurement is preferred. However, it is most desirable to have the additive supplied in premeasured, individual containers. The blended fuel shall be clearly identified.

7.1.1 Base Fuel—The base fuel used for this test procedure shall be typical of commercial unleaded automotive spark-ignition engine fuel. The base fuel may contain oxygenates typical of those being used commercially. The base fuel shall allow the vehicle to operate satisfactorily (that is, no knocking, surging, and so forth) creating no driver complaints.

7.1.2 Additive/Base Fuel Shipment and Storage—The additive shall be shipped in a container as dictated by safety and environmental regulations. The additive shall be stored in accordance with all applicable safety and environmental regulations.

7.2 Test Fuel—A blended test fuel shall be a homogeneous blend of additives and base fuel. Sufficient fuel shall be blended before the start of the test to complete a selected mileage interval which may be 10 000 miles or less. If the initial mileage interval is less than 10 000 miles, an additional fuel blend consisting of the same base fuel and same concentration/deposit control additive may be done if the vehicle is to complete the 10 000 mile test. The fuel may be stored in drums or tankage, and shall be clearly labeled to

prevent misfueling. Quantities of fuel and additive blended and dispensed shall be measured and recorded for use in determining the fuel consumption, which is one of the operational validity criteria. Approximately 1900 L (500 gal) of fuel are required for this test method.

7.3 Engine Oil/Assembly Lubricant—The standard engine oil and assembly lubricant used for all tests shall be IVD Reference Oil obtained from the Coordinating Research Council, Inc.¹¹ Test Method D5500 IVD Reference Oil is a commercial quality (API SG, EC II) SAE 15W40 multigrade oil. Approximately 10 L (10 qt) are needed for this test method, including engine assembly, initial crankcase fill, and 8000-km (5000-mile) change.

7.4 Engine Coolant—The coolant is a mixture of equal volumes of a commercial ethylene glycol-based low-silicate antifreeze and distilled or demineralized water. Do not use uninhibited ethylene glycol. The coolant should offer protection from aluminum corrosion (cylinder head) and deposition of aluminum salts (radiator).

7.5 Solvents and Cleaners:

7.5.1 Normal-Hexane or Cyclohexane Valve Rinse—The valves are rinsed with either *n*-hexane or cyclohexane. (**Warning**—See 6.2.3.)

NOTE 5—The California Air Resources Board specifically requires the use of *n*-hexane to rinse the intake valves. When conducting this test method for approval to market automotive spark-ignition engine fuels in the State of California, the test method shall be conducted using *n*-hexane as the valve rinse solvent.

NOTE 6—Reagent-grade chemicals will be used for all test procedures. Unless otherwise noted, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society,¹² where such specifications are available. Other grades may be used provided it is first ascertained that the reagent is of sufficient purity to permit its use without lessening the accuracy of the determination.

7.5.2 Aerosol Spray Cleaner—Wash all new intake valves and other parts (that is, valve train parts, cylinder head, intake manifold, throttle body) as required with an aerosol spray cleaner to remove any residue remaining from manufacture or deposits or fluid residues from the previous test.

7.5.3 Naphtha Solvent—Stoddard solvent conforming to Type I of Specification D235 is recommended. Proprietary solvents of this general type may be used. This fluid may be used for cleaning parts (that is, valve train parts cylinder head, intake manifold, throttle body) and as a fuel injector test fluid.

7.6 Fuel Injector Test Fluid:

7.6.1 Naphtha Solvent—See 7.5.3.

7.6.2 Isooctane—Reagent grade 2,2,4-Trimethylpentane may be used (see Note 6).

7.7 Sealing Compounds—Sealing compounds are not specified. Engineering judgment shall be used governing the use of

sealing components. (**Warning**—Silicone-based sealers may elevate the indicated silicone content of the used engine oil and cause problems with exhaust gas oxygen sensors. Allow sufficient curing time prior to running the engine.)

7.8 Valve Lapping Compound—Grade A280-grit valve lapping compound shall be used.

7.9 Crushed Walnut Shells—A walnut shell blaster may be used to remove carbon and deposits from the head. Clean, fresh walnut shells shall be used. This media is available commercially from industrial and automotive supply sources.

7.10 Desiccant—This granular form of anhydrous CaSO₄ is placed in an airtight container. The material absorbs moisture. The appropriate gradation shall be used.

8. Preparation of Apparatus

8.1 Cylinder Head Disassembly—This section is written under the assumption that the cylinder head has been removed from the engine as outlined in 9.5.1 and the intake and exhaust valves have been removed as outlined in 9.5.2. Any disassembly instructions not detailed in 8.1.1-8.1.5 shall be completed in accordance with the instructions in the BMW 318i Service Manual. Disassemble and thoroughly clean the head before each test using specified solvents (see 7.5) and walnut shell blaster (see 6.5.6).

8.1.1 Mount the cylinder head on the fixture (or equivalent) (see 6.5.10).

8.1.2 With the head in an upward position (combustion chamber down), remove the eight exhaust manifold bolts along with the manifold and gasket. Discard the gasket.

8.1.3 Remove the five bolts securing the distributor flange to the head and remove the flange. Remove any gasket material or deposits from the mating surfaces with a gasket scraper.

8.1.4 Remove and discard intake and exhaust valve stem seals.

8.1.5 Remove the head from the stand and place the head in a suitable area for cleaning.

8.2 Cleaning Components to Be Reused—Thoroughly clean the cylinder head, intake manifold, and throttle body before each test using specified solvents, walnut shell blaster, gasket scraper, or other means as appropriate. Avoid using a wire brush on cylinder heads and other aluminum alloy surfaces as this tool may reduce the useful life of the cylinder head.

NOTE 7—California Air Resources Board requires the use of a wire brush to clean cylinder heads. When conducting this test method for approval to market automotive spark-ignition engine fuels in the State of California, 8.2 shall be conducted using a wire brush.

8.2.1 Cylinder Head—Clean the intake and exhaust manifold mating surfaces of any gasket material or deposit using a gasket scraper, the appropriate solvent (see 7.5), or a walnut blaster, or both.

8.2.1.1 Clean the head by spraying it thoroughly with solvent to remove oil, fuel, and lapping compound. Pour solvent through all coolant and oil passages, and blow dry with compressed air. Be certain to blow air through all oil and coolant passages. (Warning—Wear eye protection and other protective clothing when spraying solvents and when using compressed air to blow debris from parts.)

¹¹ IVD Reference Oil is available from the Coordinating Research Council, Inc., 219 Perimeter Center Parkway, Suite 400, Atlanta, GA 30346.

¹² *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For Suggestions on the testing of reagents not listed by the American Chemical Society, see *Annual Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

8.2.1.2 Remove all hardened deposits from the cylinder head with a walnut shell blaster or a wire brush. Pay particular attention to the intake and exhaust ports and the combustion chambers. After all deposits are removed, blow the head out with compressed air to remove any residual walnut shell material from the water and oil passages.

8.2.1.3 Rinse the head, including the oil and coolant passages, again with solvents and blow dry with compressed air.

8.2.2 *Intake Manifold*—Clean the cylinder head and throttle body mating surfaces and fuel injector tips of any gasket material or deposit using a gasket scraper and the appropriate solvents (see 7.5) or a walnut shell blaster, or both.

8.2.2.1 Clean the intake runner with aerosol cleaner. Rest the intake manifold on its side as the cleaner is sprayed so that it will drain through the runner and out the side that attaches to the head. Continue to spray cleaner into the runner until the fluid draining out is clear. Be sure to spray and clean the fuel injector tips which are still installed in the runner with solvent only. Dry the inside of the runner with a clean rag.

8.2.2.2 The fuel rail and injectors are removed from the intake runner. Remove the injectors from the fuel rail by removing the retaining clips from the rail which secure the injectors.

8.2.3 *Throttle Body*—Clean the throttle body mating surfaces of any gasket material or deposit using a gasket scraper and the appropriate solvents (see 7.5) or a walnut shell blaster, or both.

8.2.3.1 Clean the throttle body with aerosol cleaner. Rest the throttle body on its side as the cleaner is sprayed so it will drain through the throttle bore and out the side which attaches to the head. Make sure to clean all areas of the throttle body. Continue to spray cleaner into the throttle body until the fluid draining out is clear. Dry the inside of the throttle body with a clean rag.

8.2.4 *Cylinder Block*—Clean the cylinder head mating surfaces and piston crowns of any gasket material or deposit, using a gasket scraper, the appropriate solvents (see 7.5), a walnut shell blaster, or other appropriate tools, or combination thereof.

8.2.4.1 Piston crowns shall be cleaned with a gasket scraper, fine wire brush, or similar tools. Do not allow debris to fall into the water jacket or oil passages. Care shall be exercised so that the piston crowns are not damaged during cleaning. A shop-type vacuum cleaner may be used to evacuate the loose carbon from the piston and piston/bore crevice.

NOTE 8—Before cleaning the piston crowns, ensure that photographs have been taken (if requested).

8.3 *Valve Preparation*—Clean the valves before assembly measurements are taken. After measurements are taken, the seating surfaces checked or adjusted, or both, and the valves lapped, the intake valves, not the exhaust valves, are weighed.

8.3.1 *Intake Valve Cleaning*—New intake valves shall be used.

8.3.1.1 Mark the new intake valves as shown in Fig. 3 in accordance with the test vehicle and cylinder in which they will be installed.

8.3.1.2 Before weighing the new intake valves, they shall be thoroughly buffed to remove any surface oxidation. Perform

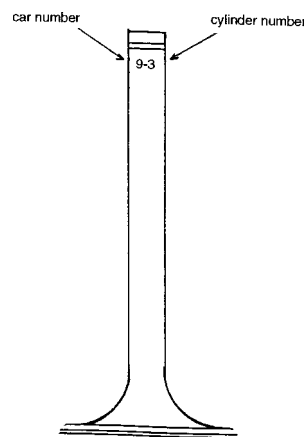


FIG. 3 Location of Valve Identification

this using a bench grinder fitted with a wire wheel brush (see 6.5.5). The entire valve shall be buffed, not just the tulip.

8.3.1.3 After buffing, spray the valve with *n*-hexane, cyclohexane, or an aerosol cleaner (see 7.5) and wipe completely with a dry, clean rag.

8.3.2 *Intake Valve Weighing*—Weigh the intake valve after completing the preparation of the intake valve seat area, including lapping (see 8.4.1-8.4.5).

8.3.2.1 *Valve Rinse*—Wash the valves gently with *n*-hexane or cyclohexane. This procedure shall be performed only once. The solvent is to be discharged from a hand squeeze bottle onto the valve. Gently rinse the valve starting at the top of the stem and proceeding towards the tulip section. While discharging the solvent, rotate the valve (which is held in gloved hand) to ensure removal of all oily residues. Continue the washing process until the solvent running off the valve is clear. Gently shake off any remaining solvent. (**Warning**—See 6.2.3 and Note 5.)

8.3.2.2 *Removing the Rinse*—Immediately after the wash is complete, place the intake valves inside an oven (see 6.5.4) for 5 min to remove any remaining solvent through vaporization. The oven temperature shall be $93 \pm 2^\circ\text{C}$ ($200 \pm 5^\circ\text{F}$).

8.3.2.3 *Warm Valve Handling Technique*—Use tongs to transfer the valves from the oven directly into a desiccator.

8.3.2.4 *Desiccator*—The valves shall remain in the desiccator for a minimum of 1 h while they cool to room temperature. Conduct a periodic check of the desiccant to ensure its proper functioning. Monitoring of color change is usually the method employed.

8.3.2.5 Weigh the valves to the nearest 0.0001 g using an analytical balance as specified in 6.5.2. Record the weights and other required data using the form in Fig. 4.

8.3.2.6 The repeatability of the balance between the start and the end of this procedure is to be confirmed by weighing and recording the weight of a reference weight before and after weighing the four valves. Reference shall range from 90 to 110 g. The *start* and *end* reference weighings shall not differ by more than 0.0010 g. If the absolute difference is greater than 0.0010 g, then repeat 8.3.2.5.

8.3.3 *Exhaust Valve Cleaning*:

8.3.3.1 Prepare the exhaust valves by buffing each with a free wire wheel to remove accumulated deposits. Unlike

Project No. _____				Technician: _____										
Buildup Data: _____				Date: _____										
Test No. _____				Vehicle No: _____										
MEASUREMENTS														
Cylinder Number	Position	IN Valve Guide		IN Valve Stem		IN Valve Clearance		EX Valve Guide		EX Valve Stem		EX Valve Clearance		Valve Seat Width
		0°	90°	0°	90°	0°	90°	0°	90°	0°	90°	0°	90°	
1	Top													
	Bottom													
2	Top													
	Bottom													
3	Top													
	Bottom													
4	Top													
	Bottom													
CYLINDER	INTAKE VALVE WEIGHTS													
1	Start of Test	_____						Clean, End of Test	_____					
	End of Test	_____						End of Test	_____					
	Deposit Weight	_____						Deposit Weight	_____					
2	Start of Test	_____						Clean, End of Test	_____					
	End of Test	_____						End of Test	_____					
	Deposit Weight	_____						Deposit Weight	_____					
3	Start of Test	_____						Clean, End of Test	_____					
	End of Test	_____						End of Test	_____					
	Deposit Weight	_____						Deposit Weight	_____					
4	Start of Test	_____						Clean, End of Test	_____					
	End of Test	_____						End of Test	_____					
	Deposit Weight	_____						Deposit Weight	_____					
Average Deposit Weight _____														
Start of Test Weigh Date: _____							End of Test Weigh Date: _____							
Reference Valve Weight Before: _____							Reference Valve Weight Before: _____							
Reference Valve Weight After: _____							Reference Valve Weight After: _____							
Delta: _____							Delta: _____							
Technician: _____							Technician: _____							
Comments: _____														

FIG. 4 Valve Measurements and Weights

procedures in 8.3.1 for the intake valves, clean all areas except the stem. Provided that the exhaust valves are still within specifications as described in 8.4.2, they may be reused.

8.4 Cylinder Head Preparation and Assembly—Assemble using intake and exhaust valves as prepared in 8.3. Refer to the manufacturer's specifications and procedures as specified in BMW 318i Service Manual for any additional information not provided in this test method. All parts for the reassembly shall be cleaned in accordance with the procedures outlined in 8.2 and 8.3. This section assumes the necessary parts have been cleaned and the cylinder head is mounted in the head stand.

8.4.1 Measure Stem-to-Guide Clearance—The intake and exhaust valve stem-to-guide clearances shall be determined.

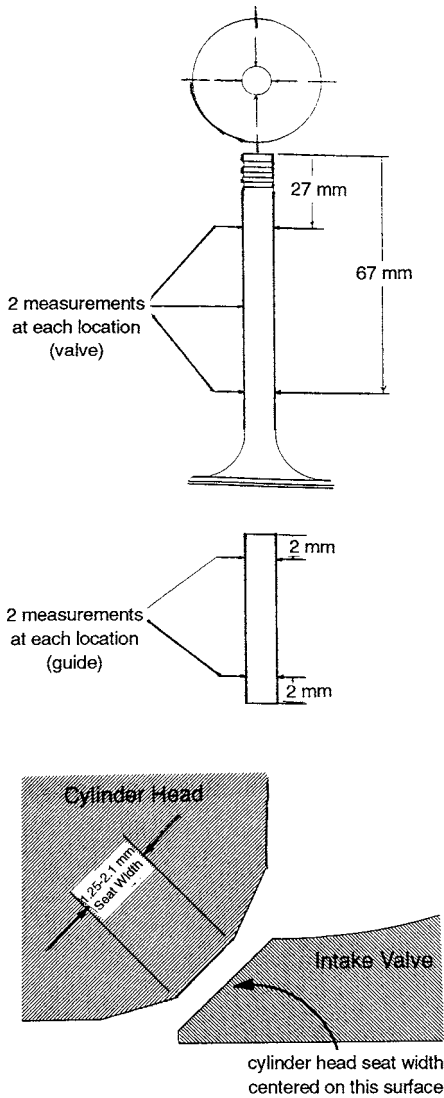
8.4.1.1 Measure intake and exhaust valve guides using an appropriate gage (see 6.5.7) to take two measurements 90° apart at positions 2 mm (0.08 in.) from the top and bottom of the valve guides. These four measurements shall be taken to the

nearest 0.025 mm (0.001 in.). Record on the form as shown in Fig. 4 and repeat for all cylinders.

8.4.1.2 Measure intake and exhaust valve stems using an appropriate gage (see 8.4.4) to take two measurements 90° apart at positions 2 mm from the top and bottom on the valve stems as shown in Fig. 5. These four measurements shall be taken to the nearest 0.025 mm (0.001 in.). Record on the form as shown in Fig. 4 and repeat for all cylinders.

8.4.2 Calculate Stem-to-Guide Clearance—Measurements taken in 8.4.1.1 and will be sufficient to check the taper and out-of-round of the guide. Calculation of stem-to-guide clearance is defined as the maximum guide diameter minus the minimum stem diameter. This calculation shall be executed for each valve and recorded as shown on the data sheet in Fig. 4.

8.4.2.1 With all of the measurements recorded, each valve stem clearance is determined as follows:



Proper Intake Valve Seat Orientation

FIG. 5 Location of Stem and Guide Measurements

$$\text{clearance} = \text{maximum guide diameter} - \text{minimum stem diameter} \quad (1)$$

8.4.2.2 *Specification*—Clearance for all valves shall be less than 0.15 mm (0.006 in.). Refer to BMW 318i Service Manual for minimum clearance.

8.4.2.3 If the maximum specification for clearance is not met for either intake or exhaust valves, the cylinder head shall not be used. Replacement of valve guides or refurbishing (that is, knurling and honing) is not permitted as any oil control change or heat transfer change may alter the deposit accumulation. If it is determined that a new head is required, a new head shall be obtained from BMW NA (see [Annex A2](#)).

8.4.3 *New Head Procedure*—If a new cylinder head is required, the cylinder head supplied will be unassembled. Thoroughly rinse the new cylinder head with a solvent (see [7.5](#)). Be sure to rinse all oil and coolant passages. Assemble the cylinder head in accordance with the procedures outlined in this section.

8.4.4 *Measurement of Valve Seat Quality*—Measure all valve and corresponding valve seats using a dye removal method.

8.4.4.1 Cover the seating surface of the intake valve with a thin film of dye, such as Prussian blue dye, and place it back into the corresponding guide. Rotate the valve by the stem not more than $\frac{1}{4}$ revolution ($\pm \frac{1}{8}$ revolution) while gently pulling it towards the seat. This rotation will rub dye off the valve face at the seating surface. Measure the maximum and minimum width of the etched circle on the valve face using a vernier caliper and record on the appropriate form (see [Fig. 4](#)).

8.4.4.2 The valve seat widths shall be between 1.25 and 2.1 mm (0.051 and 0.089 in.). The cylinder head seat shall contact the valve in the center of the machined valve face surface as shown in [Fig. 5](#).

8.4.4.3 The cylinder head valve seat or valve, or both, shall be adjusted to meet these requirements or the part shall be discarded. The cylinder head valve seat and valve shall be cut as outlined in the BMW 318i Service Manual with the appropriate equipment (see [6.5.12](#)).

8.4.4.4 Remove the cylinder head from the head stand and place it on a bench with the combustion chamber side up.

8.4.5 *Lap Valves*—Lap the valve in the proper cylinder as identified on the stem. Lap the valve until the seating surface is uniform.

8.4.5.1 Lightly coat the valve seat surface being lapped with lapping compound ([7.8](#)). Using a valve lapping tool (see [6.5.11](#)), lap the valve until the seating surface is uniform. Do not lap the valves more than is necessary for obtaining a uniform seating surface. After lapping is completed, remove the valve and wipe the compound off the valve and valve seats. Wipe any remaining blue dye off the seat and valve before continuing with assembly.

8.4.5.2 During the intake valve lapping procedure, check the seat contact width and orientation for adherence to the specification in [8.4.4.2](#). Adjust seat or valve, or both, if necessary (see [8.4.4.3](#)). If either the valve or the head cannot be adjusted to the specifications, replace the part with a new one (see [8.4.3](#)).

8.4.6 *Clean and Weigh Intake Valves*—Weigh the intake valves as described in [8.3.2](#) after recleaning in accordance with [8.3.1](#).

8.4.7 *Reinstall the Distributor Flange*—With the cylinder head fastened to the fixture (see [6.5.10](#)), reinstall the distributor flange using a new replacement gasket and tighten the bolts to the required torque ([A5.1.1](#)).

8.4.8 *Install Camshaft*—Coat the camshaft journals and bearings with assembly lubricant (see [7.3](#)) and carefully slide the camshaft into the head.

8.4.9 *Install Valves*—Position the head with the combustion chamber up. Cover the tip of each valve stem with assembly lubricant by dipping approximately 1 in. of each stem in a small container of the clean, fresh lubricant. Slide each valve into the proper guide. As the valve is slid into the guide, the lubricant will be spread over the entire stem.

8.4.10 *Orient Head*—Place the valve tray over the valves on the combustion side of the head and insert the pins to fasten the

tray to the stand. Rotate the head 180° (combustion chamber down) in preparation for installation of the valve stem seals and valve springs.

8.4.11 *Install Valve Stem Seals*—Cover the valve stem (Fig. 6) with a thin plastic sleeve to protect the seals from damage as the stems are inserted. Coat the inside of the valve stem seals with a thin film of assembly lubricant and slide it over the valve stem until it meets the head. Use the valve seal installation tool (see 6.5.15.2) to seat the seal properly on the head (see sections on removing and installing valves and valve stem seals in 1985

BMW 318i Service Manual). Repeat this procedure for all eight valves. Care shall be exercised so that the valve stem seal is not torn by the valve stem grooves. A damaged valve stem seal will increase oil consumption and affect deposit accumulation. If a valve stem seal is damaged, replace with a new seal.

8.4.12 *Inspect Valve Springs*—Test all of the intake and exhaust valve springs and replace any that do not require a minimum of 267 N at 37.6 mm (60 lbf at 1.48-in.) deflection.

8.4.13 *Install Valve Springs*—Position a spring (in accordance with 8.4.12) and bucket over a protruding valve stem and

Service-Information



GROUP 11 Engine	Bulletin Number 11 16 85 (1070) Page 1 of 2	
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SUBJECT: Grooved Viton® Valve Stem Seals
P/N 11 34 1 273 501 - M10, M30 engines
P/N 11 34 1 287 591 - M20 engines

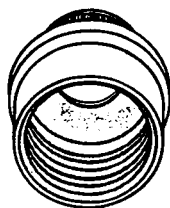
MODELS: All

Situation: Effective immediately, only the grooved Viton® valve stem seals are to be used when repairing/rebuilding cylinder heads and engines.

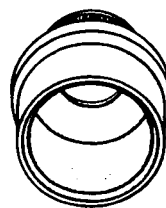
These seals exhibit greatly improved resistance to the hardening and cracking caused by high alcohol content in the fuel and have been used in production since August 21, 1984.

Identification:

The part number, engine application and identifying feature of the Viton® valve stem seals are as follows:



New Version
(grooved)



Old Version
(smooth)

Part Number
11 34 1 273 501
11 34 1 287 591

Engine
M10, M30
M20

Parts

Information: Stocks of all other valve stem seals (applicable to the M10, M20, M30 engines) are to be removed from inventory per instructions from the Parts Department (refer to Dealer Parts Bulletin VII-4 dated 8/85).

The new version seals are available immediately and may be ordered from your Parts Distribution Center.

NOTE: It is possible that old version valve stem seals will occasionally appear in a head gasket set. These sets will bear a red label (applied by the Parts Dept.) to indicate that the valve seals should be checked and, if necessary, replaced by new version seals.

FIG. 6 Service Bulletin for Valve Stem Seals

use the valve spring compressor attached to the head stand to compress and hold the spring while inserting the collets. Repeat this procedure until all eight valve springs have been installed.

8.4.14 Install Rocker Arms—Coat all lobes of the camshaft and tips of the valve stems with assembly lubricant in preparation to reinstall the rocker arms. Slide the intake rocker shaft into the head so that it just protrudes through the wall of the head about 13 mm (0.5 in.). Turn the camshaft such that the intake lobe of cylinder number one is down (towards the combustion chamber). Next position a rocker arm, a washer, a spring, and a thrust washer appropriately in front of the intake rocker and drive the rocker shaft into the head up to the next shaft support in the head. Use the rocker shaft removal tool (see 6.5.15.1) for leverage to turn and push the rocker shaft into place. Turn the camshaft so that the intake lobe for Cylinder Number Three is closed and follow the same procedure just outlined. Follow this procedure to install the rest of the intake rocker arms and exhaust rocker arms.

8.4.15 Install Circlips—After both rocker shafts are installed, put the eight circlips back in place to position the rocker arms.

8.4.16 Secure Thrust Plate—Reinstall the plate that secures the camshaft and rocker shafts. Position the plate and tighten the two bolts to the required torque (see A5.1.1).

8.4.17 Install Oil Line—Install the camshaft oil line and tighten the bolt to the required torque (see A5.1.1).

8.4.18 Set Backlash—Set the backlash of all intake and exhaust valves to 0.2 mm (0.008 in.) with the head cold. Loosen the nut on the rocker arm, rotate the eccentric with valve lash adjustment tool (see 6.5.15.3) until the clearance is within specification, and then torque the nut (see A5.1.1). Readjustment of backlash is acceptable at any time during the test as required.

8.4.19 Install Intake Manifold—Fasten the intake manifold, cleaned in accordance with 8.2.2 to the head. Use a new gasket and tighten the nuts to the required torque (see A5.1.1).

8.4.20 Install Fuel Rail and Injectors—Install a set of four injectors prepared as described in 8.5. Rotate each injector so that the electrical connector is easily accessible. Secure the injectors to the rail with the clips and install the fuel rail in the intake runner (see section on replacing fuel injector in 1985 BM 318i Service Manual).

8.4.21 Install Exhaust Manifold—Fasten the exhaust manifold to the head. Use a new gasket and tighten the nuts to the required torque (see A5.1.1).

8.4.22 Cylinder Head Installation—Install the cylinder head onto the engine using the installation procedure outlined in 8.6.1 (see section on removing and installing cylinder head in 1985 318i Service Manual).

8.5 Fuel Injector Preparations—Prior to engine installation, all injectors (new and used) shall be evaluated for spray-pattern and flow-rate using a suitable apparatus as defined in 6.5.14. The evaluation procedure is outlined in 8.5.1 to 8.5.4. Injectors may be cleaned and reused if the criteria outlined in 8.5.5 are satisfied.

8.5.1 Flush New Injectors—New injectors shall be flushed for 30 s to remove any assembly residue before flow testing.

8.5.2 Operating Flow Rig—Using a rig as described in 6.5.14, turn on the fuel pumps, the flow meter, and the timer. After the pumps are turned on, the test fluid (see 7.6) will start to flow through the slave injector. The test fluid pressure supplied to injector is maintained at 310 ± 1.4 kPa (45 ± 0.2 psi) during the entire test. The maintenance of this pressure is very critical because a small change in pressure will have a dramatic effect on the flow rate and spray pattern.

8.5.3 Flow Injectors—Each injector is flow tested for four 10-s periods. Record each of these measurements on the data sheet shown in Fig. 7. The final flow rate of the injector is based on the average of these four 10-s trials.

8.5.4 Observe Spray Quality—While the injector is flowing, a visual observation is made as to the spray pattern quality. Record this observation for each occurrence on the data sheet. Ideally the spray shall be a symmetric conical shape with proper atomization. Furthermore, there shall be no *fingers* in the spray. A *finger* can be seen in the pattern of injector (b) of Fig. 8. An ideal injector spray pattern is shown in Fig. 8 injector (d). Lastly, when the injector is not open, the injectors shall not leak or drip with the test fluid under pressure. Replace any injector that drips or leaks.

8.5.5 Acceptance Criteria—The following guidelines shall be met when selecting injectors to be used for this test method. Groups of injectors or individual injectors not meeting the following guidelines shall not be used.

8.5.5.1 Flow Specification—Individual Injectors—Individual injectors shall be flow tested at 310 ± 3.4 kPa (45 ± 0.5 psig) using Stoddard solvent or isooctane at 15 to 25°C (59 to 77°F). Individual injectors shall have flow rates as follows (310 kPa, 15.6°C):

isooctane	1.94 to 2.06 g/s (0.0684 to 0.0727 oz/s)
Stoddard solvent	1.89 to 2.01 g/s (0.0667 to 0.0709 oz/s)

Flow rates shall be adjusted to 15.6°C (60°F).

8.5.5.2 Flow Specification—Groups—Groups of four injectors shall not have any one injector deviate from the four injector average by more than 3 %.

8.5.5.3 Spray Pattern Specification—Spray pattern shall be conical in shape and be uniformly distributed with only a few fingers in the spray. Fingers are small pencil streams of fuel and are allowed only if very small in diameter and distributed throughout the cone. Spray pattern shall be better than the spray pattern shown in Photograph B in Fig. 8.

8.5.5.4 Visual Inspection Criteria—Injectors shall not leak or drip while under pressure for 30 s when the injectors are not open.

8.6 Engine Preparations and Assembly:

8.6.1 Install Cylinder Head—Having cleaned the cylinder block deck and piston crowns as described in 8.2.4, install on the test vehicle the cylinder head prepared in accordance with the procedures outlined in 8.4 using a new head gasket. Use only original equipment gaskets and seals. Torque the head bolts to the recommended torque (see A5.1.1).

8.6.2 Install Front End Accessory Drive—Install the front end accessory drive system in accordance with the BMW 318i Service Manual.

FUEL INJECTOR FLOW DATA

VEH. NO.:		PROJECT NO.:		ODOMETER:	
TEST NO.:		TEST PHASE:		TEST MILES:	
TECHNICIAN:			DATE COMPLETED:		
Trial	Volume (cc)	Time (sec)	Temperature (°F)	Tip/Spray Observation	
Injector #1					
1		10/30 (circle one)		Cone Spray	☐ Good ☐ Fair ☐ Poor
2				Fingers	☐ Yes ☐ No
3					
4				Leakage	☐ Yes ☐ No
Average					
Injector #2					
1				Cone Spray	☐ Good ☐ Fair ☐ Poor
2				Fingers	☐ Yes ☐ No
3					
4				Leakage	☐ Yes ☐ No
Average					
Injector #3					
1				Cone Spray	☐ Good ☐ Fair ☐ Poor
2				Fingers	☐ Yes ☐ No
3					
4				Leakage	☐ Yes ☐ No
Average					
Injector #4					
1				Cone Spray	☐ Good ☐ Fair ☐ Poor
2				Fingers	☐ Yes ☐ No
3					
4				Leakage	☐ Yes ☐ No
Average					

FIG. 7 Fuel Injector Data Form

8.6.3 *Connect Electrical Harness*—Connect all sensors and actuators to the electrical harness in accordance with the BMW 318i Service Manual.

8.6.4 *Reassemble Engine Cooling System*—Refer to sections on removing and installing the water pump, fan, and coolant thermostat in 1985 BMW 318i Service Manual.

8.6.4.1 *Thermostat Check*—Thermostat shall open at 78 to 85°C (172 to 185°F). If thermostat does not conform to this range, it shall be replaced.

8.6.5 *Install Fuel Filter*—Refer to BMW 318i Service Manual.

8.7 Vehicle Preparations:

8.7.1 *Install Coolant*—Completely flush the coolant system and refill using 12 L (12.7 qt) (capacity of system when using 325 radiator) of solution (7.4). Fresh solution shall be used at least every 50 000 km (30 000 miles).

8.7.1.1 Coolant system integrity shall be checked to conform to the following specifications:

Pressure valve opens at..... 90 to 110 kPa (13 to 16 psig)
Vacuum valve opens at..... 5.06 to 10.13 kPa (1.5 to 3.0 in. Hg)

8.7.2 *Install Engine Oil*—After installing a new oil filter (see section on removing and installing oil filter in 1985 BMW 318i Service Manual), place 4.12 kg (4.7 L or 5 qt) of reference oil (specified in 7.3) into engine crankcase. Weigh the amounts of oil added. No oil additions are allowed between changes.

8.7.3 *Flash Fuel System*—Flush the fuel system by placing 20 L (5 gal) of the test fuel in the vehicle tank. The tank was drained during the preceding test (*End of Test*) procedure (see 9.5). Start and run the car for 5 min to allow the new fuel to flow through the entire fuel system. After this 5-min flushing

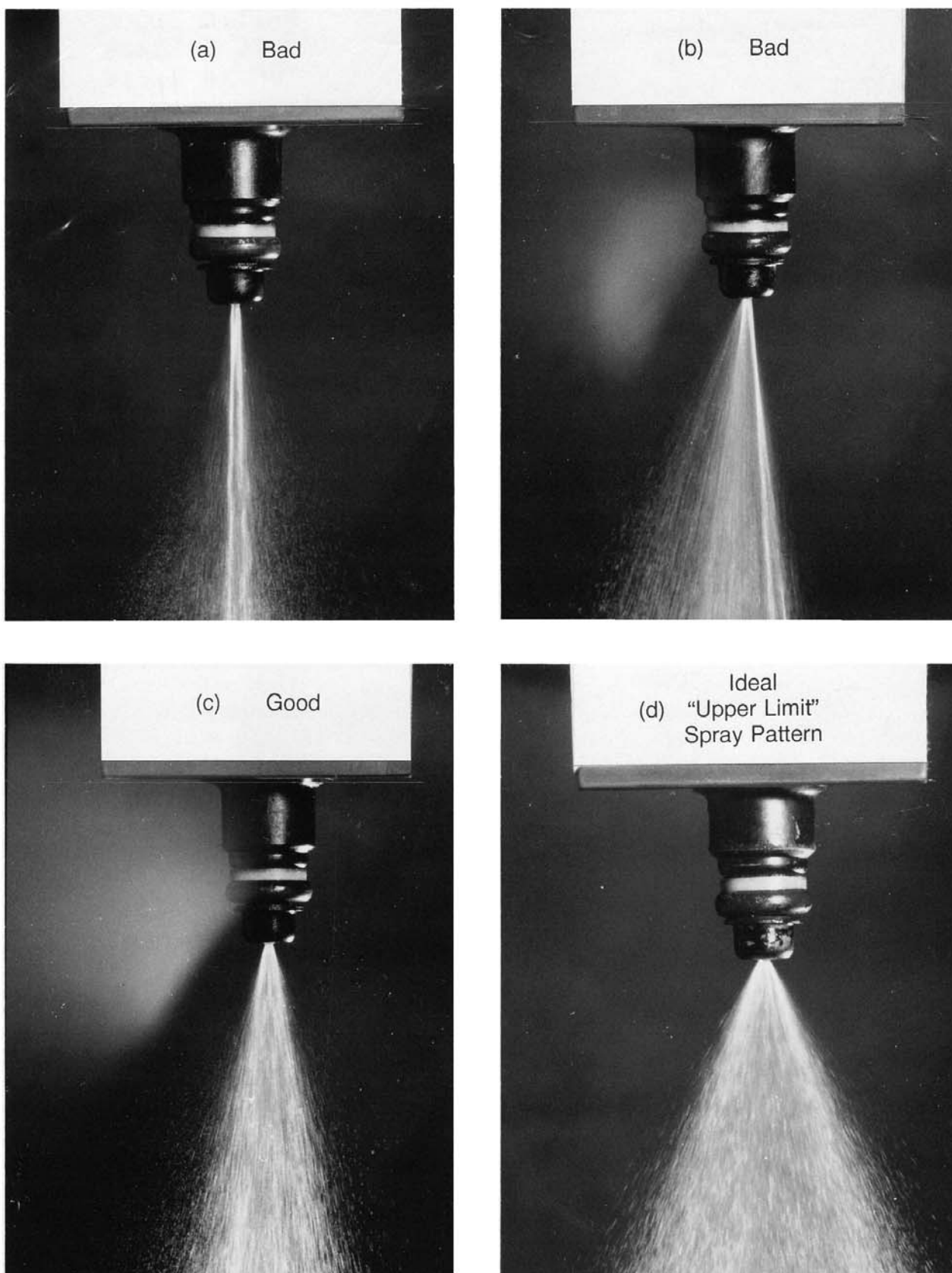


FIG. 8 Injector Flow Test Patterns

session, shut off the engine and drain the remaining fuel from the tank (see 9.5.1.1). (**Warning**—See 6.2.5.)

8.7.4 *Install Test Fuel*—After the fuel system is flushed (see 8.7.3), the vehicle is now refueled with the same test fuel.

8.7.5 *Initial Tune-Up*—After a cylinder head is reinstalled on an engine for a new test, the test car is given an initial tune-up. Use the checklist in Fig. 9 as a guide. The idle mixture, the integrator voltage (CO test), the timing, and the oxygen sensor are checked and set to the specified values in the BMW 318i Service Manual (see sections on checking engine idle speed and checking/adjusting interrogator voltage (CO test)).

8.7.5.1 Before setting the idle mixture and the integrator voltage, the car shall be at operating temperature, that is, the oil temperature at 60°C (140°F) or higher.

8.7.5.2 *Set the Initial Timing*—Connect the timing light to the battery and to the number one cylinder spark plug wire. Disable the vacuum timing advance by unplugging the vacuum line running to the vacuum advance diaphragm canister, located just below the distributor cap, and plug this line. Set the adjustable timing light to 26° before top dead center (BTDC)

and loosen the distributor flange. Start the engine and let the engine warm up to operating temperature, 82 to 93°C (180 to 200°F) coolant temperature. Set the throttle to 4000 rpm using the throttle retainer tool (see 6.4.5). Shine the timing light (see 6.4.1) through the timing hole on the top of the transmission bell housing and align the short timing peg located on the flywheel with the timing mark on the bell housing by rotating the distributor. Timing is set at 26° BTDC at 4000 rpm, vacuum advance disabled. When the peg is aligned with the bell housing mark, the engine is properly timed. Tighten the distributor, hold down, clamp, and recheck the timing again to make certain that the timing did not change. Connect the vacuum advance line and disconnect the timing light.

8.7.5.3 The idle mixture and CO shall be set simultaneously because each one directly affects the other. Connect both meters as described in 8.7.5.4 and 8.7.5.5, and monitor both readings as adjustments are made. Start by setting one of the parameters and then adjusting the other one until both are within specification.

8.7.5.4 *Set the Idle Mixture*—Interrupt the idle mixture circuit just before the idle control valve, and connect a

QUALITY ASSURANCE SERVICE CAMPAIGN

Vehicle Number _____

Test Number _____

Replace the following component systems before tune-up.

- _____ Radiator and cap, blow out A/C condenser.
- _____ Water pump.
- _____ Thermostat, check hose condition.
- _____ Fuel injectors.
- _____ Engine wire harness.
- _____ Oxygen sensor.
- _____ Mass air flow sensor.
- _____ Idle control valve.
- _____ Distributor cap, rotor and wires.
- _____ Spark plugs.
- _____ Barometric sensor on air box.
- _____ Fan clutch.
- _____ Check all belts, hoses, and fittings.

FIG. 9 Quality Assurance Checklist

multimeter (see 6.4.2) in series with the circuit as shown in Fig. 10. Set the multimeter so that it will meter current (use a scale that displays milliamperes). If the value of the current displayed on the multimeter is negative, reverse the position of the positive and negative leads in the interrupted circuit. Adjust the current flowing through the circuit by turning the adjustment screw located on the idle control valve. Turn the screw clockwise to decrease the amperage and counterclockwise to increase the amperage. Idle mixture is set at 460 mA at idle. Reconnect the circuit to its original configuration.

8.7.5.5 *Set the CO Adjustment*—Connect the BMW service test unit (6.4.3) to the diagnostic plug located toward the front of the engine near the valve cover. Ensure that the oxygen sensor is warm by running the engine for 30 s at 3000 rpm. Run the car at idle and monitor the display on the test unit. Adjust the CO level by turning the adjustment screw located on the mass air flow sensor. Turn the screw clockwise to decrease the voltage and counterclockwise to increase the voltage. Integrator voltage (CO test) is set such that the test meter reads 7.4 ± 1.0 V at idle.

8.7.5.6 *Check the Exhaust Gas Oxygen Sensor*—After the BMW service test unit (see 6.4.3) is connected to the engine, check the oxygen sensor by observing the flash of the light emitting diode (LED) on the test unit. The LED will flash approximately every 3 s after about a 10-s lag from plugging it in. If the light does not flash as described, check the timing. If this does not correct the problem, replace idle control valve. The oxygen sensor is functioning properly if the light on the BMW service test unit comes on in approximately 10 s and then flashes about every 3 s.

8.8 Final Tune-Up:

8.8.1 After the initial tune-up performed in 8.7.5, a computerized diagnostic machine (see 6.4.4) is used to verify the proper functioning of all systems. This test evaluates the engine's performance in areas such as manifold vacuum,

exhaust gas O₂, CO, CO₂, and HC emissions as well as alternator, battery, ignition performance, and cylinder balance.

8.8.2 Turn the computer diagnostic machine on and connect all of the leads to the engine as required. The vacuum source lead is connected to the fuel rail pressure regulator. Because the computer diagnostic machine may not facilitate ignition timing measurement on this vehicle, the handheld timing light shall be used.

8.8.3 Measure manifold vacuum, exhaust tailpipe gas, O₂ %, CO %, CO₂ %, and HC ppm emissions, ignition timing and performance, and cylinder balance. Compare against guidelines (see 8.8.4).

8.8.4 *Guidelines*—The following parameters shall be measured to check for engine conformance to given guidelines.

8.8.4.1 *Manifold Pressure Guideline*—At idle, manifold vacuum shall be 53 ± 6 kPa (15.5 ± 1.5 in. Hg) at an idle speed of 850 rpm (warm engine).

8.8.4.2 *Cylinder Balance Guideline*—After the engine has been brought to operating temperature, the difference between the high and the low cylinders shall not be more than 10 % rpm drop.

8.8.4.3 *Exhaust Tailpipe O₂ Guideline*—The tailpipe oxygen content of the exhaust at idle after the vehicle is brought to operating temperature shall be 0.6 ± 0.4 %.

8.8.4.4 *Exhaust Tailpipe HC Guideline*—The maximum tailpipe hydrocarbon content of the exhaust at idle after the vehicle is brought to operating temperature shall be 75 ppm.

8.8.4.5 *Exhaust Tailpipe CO Guideline*—The tailpipe carbon monoxide content of the exhaust at idle after the vehicle is brought to operating temperature shall be 0.0 to 0.3 %.

8.8.4.6 *Exhaust Tailpipe CO₂ Guideline*—The minimum tailpipe carbon dioxide content of the exhaust at idle after the vehicle is brought to operating temperature shall be 13 %.

8.8.5 *Blowby Flow Rate Measurement*—Blowby measurements will be taken under three engine conditions; idle and 3000 rpm (transmission in park) and idle (transmission in drive, parking brake applied, and foot brake depressed). Measurements shall be conducted on an engine that is at operating temperature.

8.8.5.1 Connect a blowby meter (see 6.5.13) in series with the crankcase vent running from the valve cover to the throttle body.

8.8.5.2 With the transmission in *park* and the engine at idle, measure the blowby for one minute.

8.8.5.3 With the transmission in *park*, raise engine speed to, and hold at, 3000 rpm. Measure the blowby for one minute.

8.8.5.4 With the transmission in *drive*, the parking brake applied, the foot brake firmly depressed, and the engine at idle, measure the blowby for one minute.

8.8.5.5 Blowby shall be no more than 0.24 L/s (0.5 CFM) nor less than 0.08 L/s (0.12 CFM). A blowby measurement at any of the test conditions exceeding this specification mandates the engine short block be replaced (see 8.10).

8.9 Data Acquisition Preparation:

8.9.1 *Calibration*—Calibrate all thermocouples, manifold pressure, and speed transducer before each test.

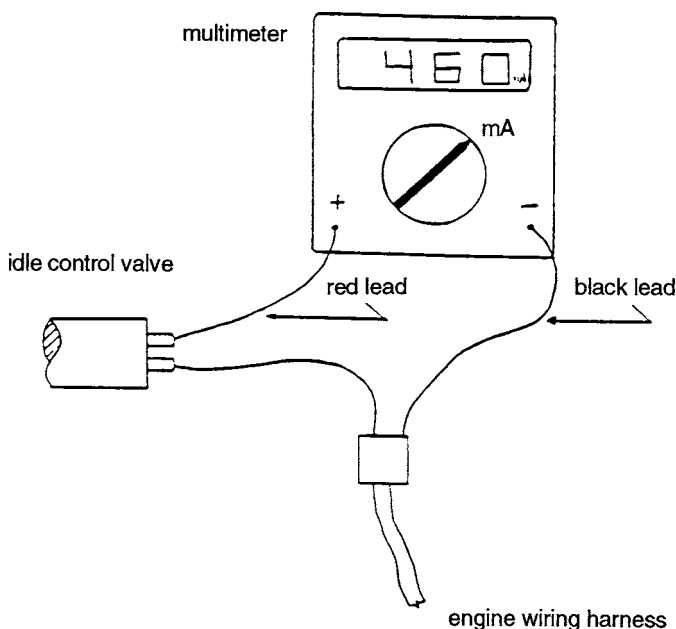


FIG. 10 Idle Speed Wire and Connection

8.9.1.1 *Temperature Measurement Calibration*—The temperature measurement sensors shall be calibrated before every test. The temperature measurement system shall indicate within $\pm 1^{\circ}\text{C}$ ($\pm 2^{\circ}\text{F}$) of the laboratory calibration standard.

8.9.1.2 *Pressure Measurement Calibration*—The manifold pressure measurement sensor shall be calibrated before every test. The pressure measurement system shall indicate within ± 1 kPa (± 0.25 in. Hg) of the laboratory calibration standard.

8.10 *New Short Block Break-In*—When a new short block is needed as determined from the various inspection and measurement procedures, the short block will need to be run through a *break-in* to circulate engine oil through the new assembly to remove contaminants, verify proper operation, and to allow the piston rings to break-in.

8.10.1 Using a functional cylinder head (it is not necessary that it be built following procedures in 8.4), assemble the engine in accordance with 8.6, and prepare the vehicle in accordance with 8.7. The vehicle shall be operated for a minimum of 8040 km (5000 miles) but not more than 8120 km (5050 miles) in accordance with 9.2.

8.10.2 After mileage accumulation, disassemble engine in accordance with 9.5.1. Clean and prepare apparatus in accordance with 8.1-8.9.

9. Test Procedure

9.1 Pre-Test Procedure:

9.1.1 Assemble the test vehicle following the procedure outlined in 8.6, using a cylinder head built following the procedure outlined in 8.4 and fuel injectors selected by the procedure outlined in 8.5.

9.1.2 Prepare and inspect the vehicle using the procedure outlined in 8.7.

9.1.3 Calibrate and verify operation of data acquisition equipment as outlined in 8.9.1.

9.1.4 Verify the proper test fuel is placed in the vehicle by checking fueling records, dispenser, and vehicle designations. Check that precautions have been taken to avoid misfueling during mileage accumulation.

9.2 *Vehicle Mileage Accumulation*—The mileage accumulation process for this test is structured to emulate consumer driving.

9.2.1 *Driving Cycle*—The driving cycle includes three modes for stop-and-start city service, higher-speed suburban service with infrequent stops, and high-speed interstate driving.

NOTE 9—The driving cycle should be conducted in a safe and lawful manner. Consideration shall be given to the traffic volume when using public roads and the ability to safely comply to the criteria outlined in this test method.

9.2.1.1 The modes of driving presented in Table 3 shall be

completed once per 24-h period. Two 10-h shifts per day are recommended for mileage accumulation. Each shift should contain the proportionate modes of the driving cycle (based on distance). The city mode shall be patterned after laps 1 through 9 of the AMA driving cycle (see 3.1.1). The values presented in Table 3 are to be used as a guideline and may be modified, but the test shall conform to the requirements of the Test Validation Criteria presented in 10.4.

NOTE 10—The driving mode percentages listed in Table 3 are based on mileage and the driving mode percentages in 10.4.2.1 are based on engine-on time; therefore, no direct comparison of these percentages should be made.

9.2.2 *Means of Mileage Accumulation*—Driving can be performed on public roads or test track. The air conditioner shall be switched on during all driving, although drivers may adjust the temperature for their comfort. The cruise control shall be deactivated.

9.2.3 *Unscheduled Down Time*—All vehicle downtime shall conform to 10.4. Complete all vehicle repairs in accordance with this test procedure or, when not specified, the BMW 318i Service Manual.

9.2.4 *Engine Oil Change*—Replace the engine oil (see 7.3) and filter (see sections on removing and installing oil filter in 1985 BMW 318i Service Manual) every 8000 km (5000 miles). No oil additions are allowed once mileage accumulation has begun. Weigh the amounts of oil filled and drained, including the volume remaining in the filter canister, to determine oil consumption.

9.3 *Refueling Procedure*—Refuel the vehicle after completion of the AMA city and suburban portions of the driving cycle and after completion of the highway portion, or as necessary.

9.3.1 *Misfueling Precautions*—The test laboratory shall have a protocol to ensure the vehicle receives the proper fuel during the test.

9.4 Periodic Measurements and Functions:

9.4.1 *Data Logging*—Appropriate data acquisition equipment (6.3) shall be used and operated to provide the data as described in 10.4.

9.4.2 *General Maintenance*—Maintain vehicle appropriately as outlined in this test procedure (Annex A3 and Annex A4) and BMW 318i Service Manual.

9.4.2.1 *Check Engine Oil*—Level may be monitored; however, no oil additions are allowed during the test.

9.4.2.2 *Check Tire Pressure*—Maintain tire pressure at 190 ± 10 kPa (28 ± 1 psig) measured when the tires are at ambient temperature.

9.4.2.3 *Check Transmission Fluid*—Maintain at indicated level using a fluid as recommended in the BMW 318i Service Manual.

9.4.3 *Supplemental Test Inspections (Optional)*—Borescope evaluation provides a partial view of the intake valve tulip area or the deposited area. To perform this procedure, the borescope is inserted through the fuel injector ports. The only disassembly of the engine permitted for this optional inspection is removal of the fuel injectors.

NOTE 11—Further engine disassembly before the completion of the mileage accumulation will result in an invalid test. No intake valve weights may be obtained prior to the end of mileage accumulation.

TABLE 3 Test Method Driving Cycle

Mode	Driving Cycle				
	Total Distance %	Average Speed		Distance	
		kph	mph	km	miles
City	10	58	36	129	80
Suburban	20	64	40	257	160
Highway	70	105	65	901	560
Total	100	72	45	1287	800

9.5 End of Test Procedure:

9.5.1 Cylinder Head Removal—It is necessary to remove the head for final evaluation of intake valve deposit buildup. Any disassembly instructions not detailed in **9.5.1.1-9.5.1.4** shall be completed in accordance with the BMW 318i Service Manual.

9.5.1.1 Drain Fuel—Raise the vehicle with a floor lift (if necessary). Drain all remaining fuel at this time (installation of special drain plug at low point of fuel tank is recommended).

9.5.1.2 Drain Engine Oil—Drain the crankcase oil and obtain weight. Remove the oil filter, drain the oil from it, and obtain the oil weight. Add these two weights to obtain total oil weight. Retain a 250-mL sample to be analyzed if requested. Clearly label the sample utilizing laboratory procedures so that it may not be confused with samples from other tests. Scrap the remaining used engine oil in an environmentally acceptable, safe manner.

9.5.1.3 Drain Engine Coolant—Drain the radiator by way of the plug on the bottom of the radiator tank. After removing the plug and allowing the coolant to drain, reinstall the plug and tighten to the required torque (see **A5.1.1**). Coolant may be saved and reused (see **8.7.1**).

9.5.1.4 Cylinder Head Removal—The cylinder head is removed as outlined in the BMW 318i Service Manual (see sections on removing and installing cylinder head).

9.5.2 Head Disassembly—The valves shall be removed from the cylinder head using the procedures detailed in **9.5.2.1-9.5.2.5** and in the BMW 318i Service Manual (see sections on removing and installing valves and valve stem seals) before they are weighed. As they are disassembled, all parts shall be identified or otherwise prevented from becoming mixed with parts from other BMW vehicles.

9.5.2.1 Mount the cylinder head on the fixture (see **6.5.10**).

9.5.2.2 With the cylinder head on the stand mounted in an upward position (that is, combustion chamber down), remove the eight intake runner bolts, the intake runner, and coolant inlet port. Remove and discard the intake runner gasket.

9.5.2.3 Remove the single bolt that secures the oil line and remove the oil line.

9.5.2.4 Remove the two bolts which hold the plate that fastens the rocker shafts and remove the plate. Place a flat pry bar in the slot on the intake rocker shaft that was occupied by the fastener plate. Carefully apply sufficient force with the pry bar to start the rocker shaft sliding out of the head. Once the shaft is out of the head approximately 12.5 mm (0.5 in.), the special tool shown in **Fig. 2** is used to pull the shaft the rest of the way out of the head. While the rocker shaft is being pulled out of the head, place a rag over the head to catch any spring or thrust washers.

9.5.2.5 The intake valves are now removed using the appropriate attachments with the head stand. Install the valve holding tray in the head and install the pins to secure the tray. Compress each intake valve spring and remove the valve collets and retainer. Rotate the head fixture 180° (combustion chambers up), and remove the pins holding the valve tray. Remove the valve tray and slide each of the intake valves out of the head.

9.5.3 Handling the Intake Valves—Do not touch the deposits on the tulip area of the intake valve. When handling the valves during inspection, be careful not to drop or strike one valve against another. A mishandled valve (dropped on the floor, jarred or bumped, brushed or rubbed, and so forth) shall be noted in the test report.

9.6 Component Visual Inspection—While disassembling and working on the vehicle, any worn, broken, or suspect parts shall be noted in the test report.

9.6.1 Deck Inspection—After the cylinder head is removed, a thorough examination of the engine block at the surfaces which mate with the head is critical and shall be made. It has been found that cracks tend to propagate from the head bolt studs towards the water jacket as a result of repeated re-torquing of the head bolts. It is possible to detect these cracks before they have any effect on the test results if this inspection is carried out. An examination of the head gasket on the block-side surface usually shows the presence of cracks quite clearly. The impression left on the head gasket actually indicates a small crack more clearly than does inspection of the cylinder block directly. If a crack or cracks are found in the block, replace short block assembly and break-in in accordance with **8.10**.

9.6.2 Rocker Arm Tip Wear—Make a visual inspection of the rocker-arm tips that actuate the valves. The tip shall show no visible evidence of wear or distress. Normally this surface will be free of marks. Discard the rocker arm and replace if it shows wear.

10. Determination of Test Results

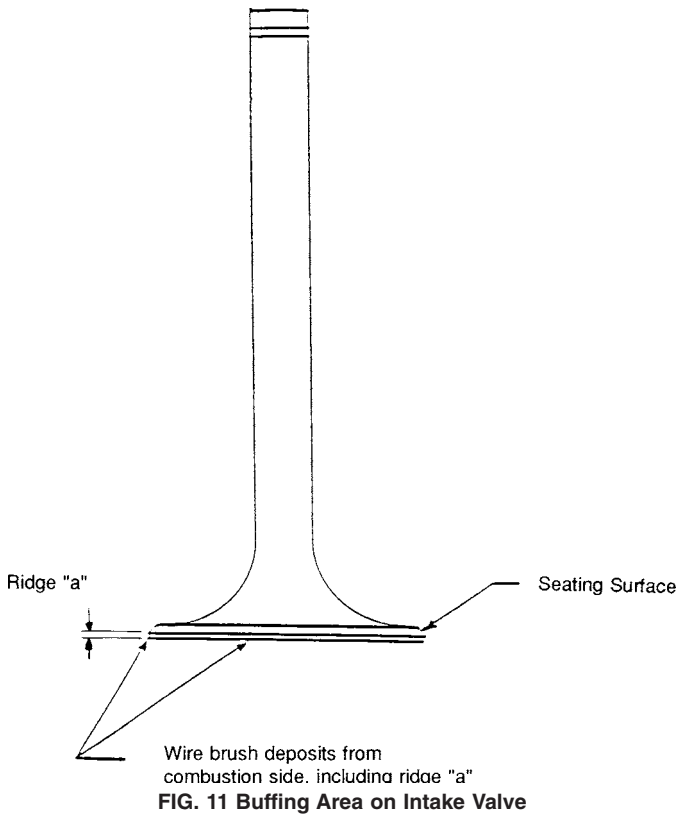
10.1 Post-Test Intake Valve Weighing Procedure—The intake valves are prepared for weighing using the following procedure. Remove carbon deposits from the combustion chamber side and edge of the intake valves as shown in **Fig. 11**, using a bench grinder fitted with fine steel brush. The buffing process shall be performed by rotating the valve and applying just sufficient pressure against the wire wheel to remove the deposits. Avoid removing deposits from any area not specified above.

10.1.1 Valve Rinse—Wash the valves gently with *n*-hexane or cyclohexane. This procedure shall be performed only once. The solvent is to be discharged from a hand squeeze bottle onto the valve. Gently rinse the valve starting at the top of the stem and proceeding towards the tulip section. While discharging the solvent, rotate the valve (which is held in gloved hand) to ensure removal of all oily residues. Continue the washing process until the solvent running off the valve is clear. Gently shake off any remaining solvent. (**Warning**—See **6.2.3** and **Note 5**.)

10.1.2 Removing the Rinse—Immediately after the wash is complete, place the intake valves inside an oven (see **6.5.4**) for 5 min to remove any remaining solvent through vaporization. The oven temperature shall be $93 \pm 2^\circ\text{C}$ ($200 \pm 5^\circ\text{F}$).

10.1.3 Warm Valve Handling Technique—Use tongs to transfer the valves from the oven directly into a desiccator.

10.1.4 Desiccator—The valves shall remain in the desiccator for a minimum of 1 h and not more than 48 h while they cool to room temperature. Conduct a periodic check of the



desiccant to ensure its proper functioning. Monitoring of color change is usually the method employed.

10.1.5 Weighing the Valves—After the valves have been dried and cooled in the desiccator, they are ready to be weighed. When the valves are transferred from the desiccator to the scale, clean gloves shall be worn to eliminate contamination and the addition of weight to the valve due to oil or debris from skin contact. Hold valves by the stems. Weigh the valves to the nearest 0.0001 g using a calibrated balance, and record the weights in the appropriate areas on a form as shown in Fig. 4.

10.1.5.1 The repeatability of the balance between the start and the end of this procedure is to be confirmed by weighing and recording the weight of a reference weight before and after weighing the four valves. Reference shall range from 90 to 110 g. The *start* and *end* reference weighings shall not differ by more than 0.0010 g. If the absolute difference is greater than 0.0010 g, then repeat 10.1.5.

10.1.6 Calculating Deposit Weight—The deposit weight shall be calculated by subtracting the start of test clean valve weight (obtained in 8.3.2.5) from the end of test weight (obtained in 10.1.5) for each valve. Use the form (Fig. 4) used in 10.1.5 and 8.3.2 for this calculation.

10.1.6.1 For deposit weights less than 0.0005 g (including negative values), valves shall be cleaned in accordance with 8.3.1 and reweighed in accordance with 8.3.2. This end of test clean valve weight shall be substituted for start of test clean valve weight to calculate the deposit weight on these valves. Photographs shall be taken before the valves are cleaned. Clean valves using a walnut shell blaster. Avoid using a wire brush.

Rinse residue from the cleaning in accordance with 10.1.1. Place in oven in accordance with 10.1.2 and follow 10.1.3-10.1.5.

10.1.6.2 If using the end of test, clean valve weight to calculate deposit weight (see 10.1.6.1), and the deposit weight is still found to be less than -0.0010 g, the valve weight will be invalid. Valves that have a deposit weight between -0.0010 g and 0.000 shall be noted and 0.0000 shall be used to calculate average deposit weight. No negative valve weights may be used to calculate average deposit weight.

10.1.7 Outlier Rejection—Criteria may not be used to omit deposit weights. Four valid intake valve deposit weights are necessary for a valid test.

10.2 Photographs of Parts—In order to better document the test results, photographs shall be taken. Photographs shall be of sufficient clarity to accurately assess the deposit area. The photographs shall be reproduced in color and 216 mm wide by 279 mm high (8½ in. wide by 11 in. high) in size, except as noted. Appropriate precautions shall be taken so photographing does not disrupt the deposits.

10.2.1 Intake Valves—Photographs of valves shall be taken after obtaining deposit weight. A photograph shall be taken of all four valves grouped sequentially, and individual photographs of each valve shall be taken from directly above the valve stem. The valves shall be marked according to their position in the engine. Example photographs are shown in Fig. 12.

10.2.2 Intake Ports—Photographs shall be taken of all four ports, viewed from the combustion chamber side. Individual photographs of each port shall be taken from directly in front of that particular cylinder. Example photographs are shown in Fig. 13. Individual port photographs may be combined with the corresponding runner photograph as shown in Fig. 13.

10.2.3 Intake Runners—Photographs shall be taken of the four runners, viewed from the intake manifold side of the cylinder head. Individual photographs of each runner shall be taken from directly in front of that particular runner. Example photographs are shown in Fig. 13.

10.3 Induction System Rating—The valves, intake runners, and intake ports shall be rated visually using the CRC Manual 16. Record observations on a data sheet as shown in Fig. 14.

10.4 Determination of Test Validity—Vehicle Conformance—During each test, conditions of the vehicle shall be strictly adhered to and monitored with data acquisition equipment capable of recording the following data at one-minute intervals. In addition to these specific parameters, the data acquisition equipment shall be utilized to monitor both engine-on and engine-off times. At a minimum, the data shown as follows shall be logged each minute:

Data to Be Logged	
coolant temperature	
vehicle speed	
Optional:	
engine speed	
intake air temperature	
oil sump temperature	
other temperatures as deemed necessary	

10.4.1 Engine-On Time—Total engine-on time shall be used to calculate average vehicle speed for mileage accumulation

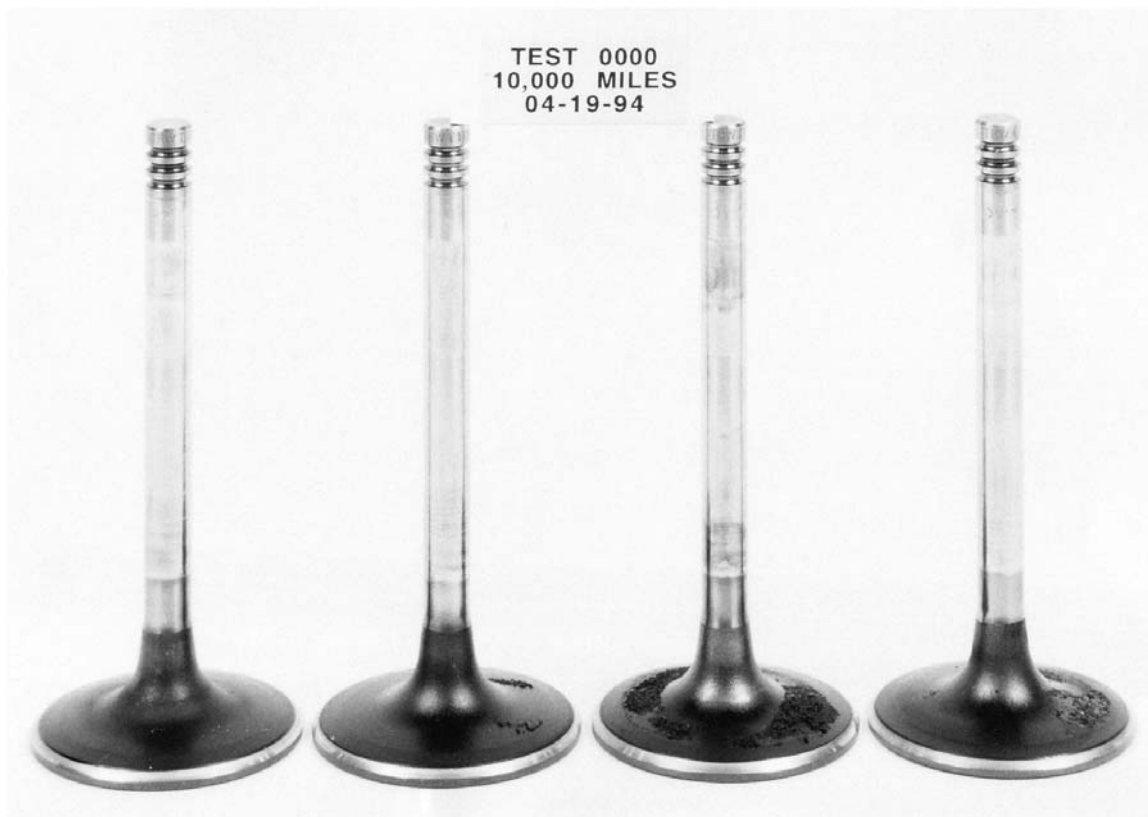


FIG. 12 Typical Photographs of Intake Valves

(reported in kilometre per hour) and engine-on time as a percentage of total elapsed time required for mileage accumulation.

10.4.1.1 *Test Validation Criteria*—Engine-on time shall not exceed 20 h per day.

10.4.2 *Vehicle Speed*—A histogram shall be used to graphically show the percentage of engine-on time at a vehicle speed less than 2 kph (1 mph), percentage of engine-on time between 2 to 48 kph (1 to 29 mph) vehicle speed, percentage of engine-on time between 49 to 86 kph (30 to 52 mph) vehicle speed, and percentage of engine-on time between 87 to 105 kph (53 to 65 mph) vehicle speed. The actual percentages shall be shown. The average vehicle speed per day shall be calculated.

10.4.2.1 *Test Validation Criteria*—The percentage of engine-on time shall be as follows:

- (1) Less than 5 % engine-on time shall be at less than 2 kph (1 mph) vehicle speed,
- (2) Between 8 and 18 % of engine-on time shall be between 2 to 47 kph (1 to 29 mph) vehicle speed,
- (3) Between 28 and 44 % of engine-on time shall be between 48 to 84 kph (30 to 52 mph) vehicle speed, and
- (4) Between 41 and 57 % of engine-on time shall be between 85 to 113 kph (53 to 70 mph) vehicle speed.

The average vehicle speed shall be between 71 to 80 kph (44 to 50 mph) based upon total test distance. If vehicle operation does not conform to this requirement, the test is invalid.

10.4.2.2 *Number of Accelerations*—Test mileage accumulation shall include a minimum of 100 accelerations from idle per

test day (based on 1290 km accumulated per day in accordance with the driving cycle in 9.2.1.1), from 0 kph (0 mph) to a minimum of 32 kph (20 mph). The number of accelerations per day shall be proportional to the mileage accumulated.

10.4.3 *Engine Coolant Temperature*—A histogram shall be used to graphically show the percentage of engine-on time coolant temperature is below 82°C (180°F), from 82 to 102°C (180 to 215°F), and above 102°C (215°F). The actual percentages shall be shown.

10.4.3.1 *Test Validation Criteria*—The percentage of engine-on time that coolant temperature occurs shall be as follows or the test is invalid: no more than 5 % engine-on time shall be at less than 82°C (180°F) coolant temperature, and no more than 5 % engine-on time shall be at a coolant temperature greater than 102°C (215°F).

10.4.4 *Total Test Fuel Consumed*:

10.4.4.1 *Test Validation Criteria*—Average fuel consumption shall be between 10.2 km/L to 12.8 km/L (24 to 30 mpg) for the test duration. If vehicle operation does not conform to this requirement, the test is invalid.

10.4.5 *Total Vehicle Test Mileage*:

10.4.5.1 *Test Validation Criteria*—Vehicle shall accumulate a minimum of 16 090 km (10 000 miles), but not more than 16 250 km (10 100 miles), using the same batch of test fuel.

10.4.6 *Engine Oil Consumption*—The engine oil consumed per oil drain interval shall be calculated from the oil fill and drain weights.

10.4.6.1 *Test Validation Criteria*—Maximum vehicle crankcase oil consumption allowed for a minimum 8040 km (5000

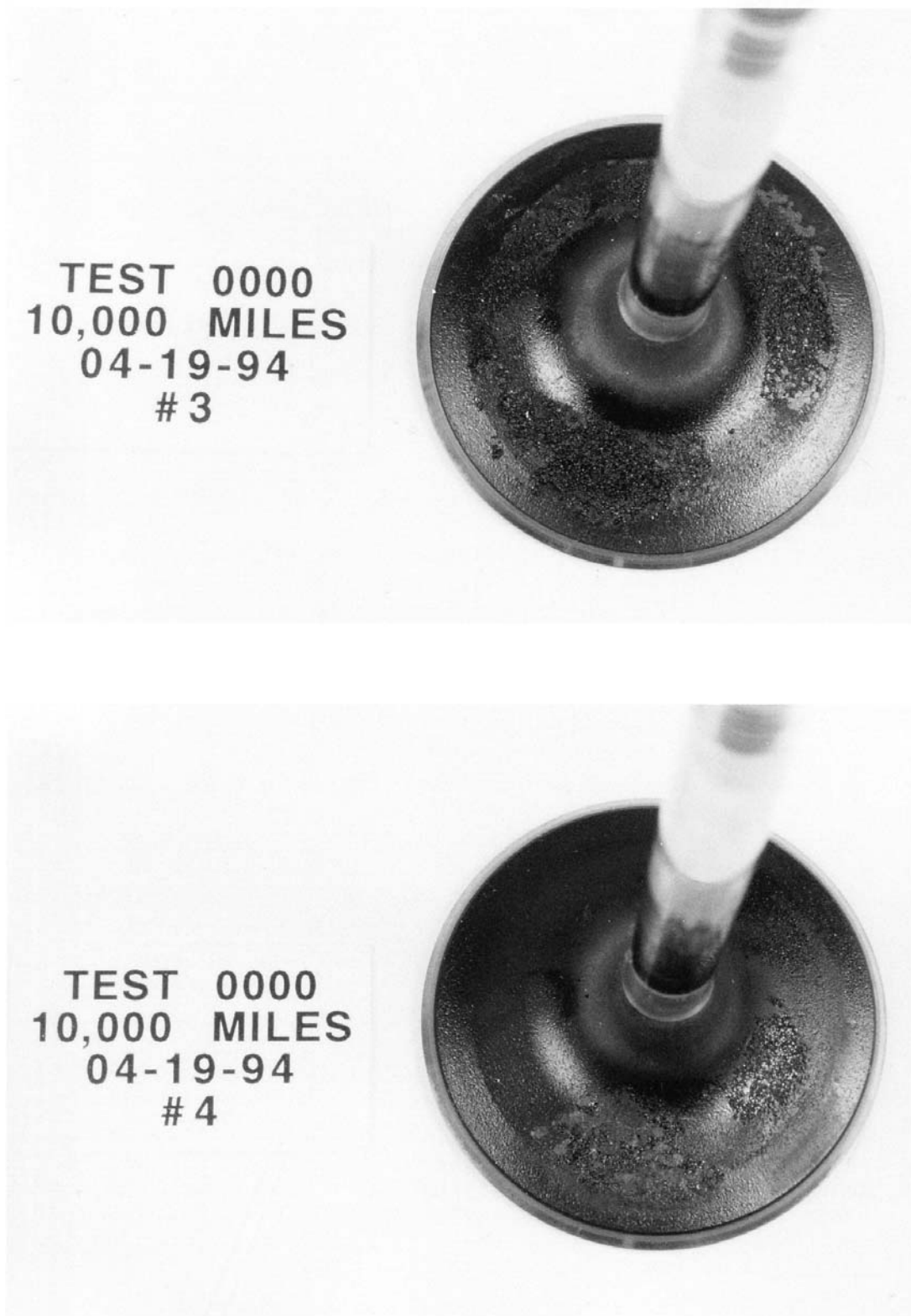


FIG. 12 Typical Photographs of Intake Valves (continued)

miles), but not more than 8120 km (5050 mile) segment, is 825 g. If this is not met, the test is invalid.

10.4.7 *Downtime*—Once the vehicle begins accumulating test miles, the test shall be completed with minimal downtime.

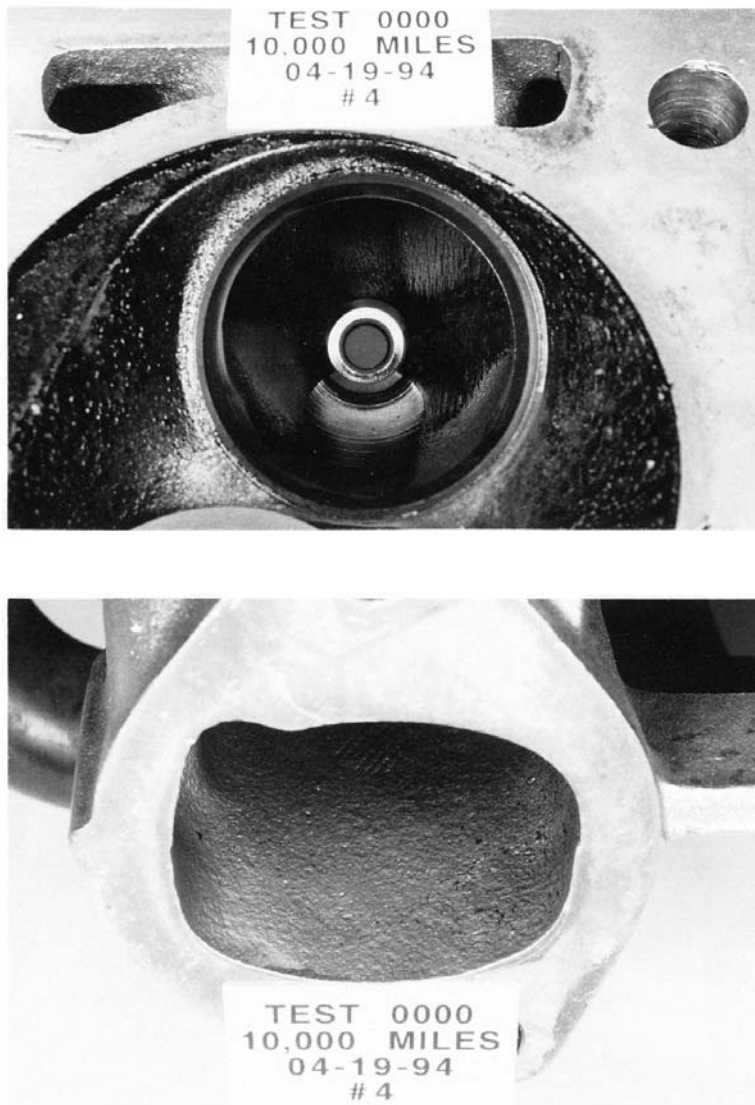


FIG. 13 Typical Photographs of Intake Ports and Runners

10.4.7.1 *Test Validation Criteria*—Total engine-off time (or downtime) cannot exceed three consecutive days or a total of more than 144 h during any test.

10.4.8 *Vehicle Termination*—If during a test the vehicle becomes unable to complete the specified mileage accumulation because of mechanical failure unrelated to engine operation, such as transaxle failure, the vehicle may be repaired. However, all criteria in this test method shall be satisfied. The engine may not be removed from the original vehicle and placed in another to continue this test method.

10.5 *Determination of Test Validity—Engine Protocol Conformance*:

10.5.1 *Engine Disassembly*—Engine disassembly other than specified in the procedure shall not be permitted for a valid test. The engine shall not be disassembled for inspection

during mileage accumulation. Borescope inspection is permitted in accordance with 9.4.3.

11. Final Test Report

11.1 The report shall be made to the organization supplying the deposit control additive or test fuel.

11.2 *Standard Report*—The standard test report shall include the sections listed from 11.2.1-11.2.7. Each section shall begin on a new page, and the sections shall be inserted in the order listed from 11.2.1-11.2.7. Deviations in the format are not permitted. However, additional details and data may be attached as an appendix.

11.2.1 Title page including name of testing laboratory and run number,



Project No. _____

Rater: _____

Date: _____

Test No. _____

Vehicle No. _____

	Intake	Ports		Intake	Valve	Valve		Manifold	Runners
	Area	Rate	Merit	Valves	Rerate	Weights (Grams)	Area	Rate	Merit
Cyl 1	_____	_____	_____				_____	_____	_____
1-1	_____	_____	_____	_____	_____	_____	_____	_____	_____
1-2	_____	_____	_____	_____	_____	_____	_____	_____	_____
	<i>Total</i>	_____	_____				<i>Total</i>	_____	_____
Cyl 2	_____	_____	_____				_____	_____	_____
2-1	_____	_____	_____	_____	_____	_____	_____	_____	_____
2-2	_____	_____	_____	_____	_____	_____	_____	_____	_____
	<i>Total</i>	_____	_____				<i>Total</i>	_____	_____
Cyl 3	_____	_____	_____				_____	_____	_____
3-1	_____	_____	_____	_____	_____	_____	_____	_____	_____
3-2	_____	_____	_____	_____	_____	_____	_____	_____	_____
	<i>Total</i>	_____	_____				<i>Total</i>	_____	_____
Cyl 4	_____	_____	_____				_____	_____	_____
4-1	_____	_____	_____	_____	_____	_____	_____	_____	_____
4-2	_____	_____	_____	_____	_____	_____	_____	_____	_____
	<i>Total</i>	_____	_____				<i>Total</i>	_____	_____
Cyl 5	_____	_____	_____				_____	_____	_____
5-1	_____	_____	_____	_____	_____	_____	_____	_____	_____
5-2	_____	_____	_____	_____	_____	_____	_____	_____	_____
	<i>Total</i>	_____	_____				<i>Total</i>	_____	_____
Cyl 6	_____	_____	_____				_____	_____	_____
6-1	_____	_____	_____	_____	_____	_____	_____	_____	_____
6-2	_____	_____	_____	_____	_____	_____	_____	_____	_____
	<i>Total</i>	_____	_____				<i>Total</i>	_____	_____
	<i>Average</i>	_____	_____				<i>Average</i>	_____	_____

FIG. 14 Intake System Deposit Data Sheet

11.2.2 Induction system merit rating and intake valve deposit weight summary,

11.2.3 Fuel inspection/blending data including identification of the test fuel/deposit control additive by the name of the submitting organization and its name or code, or both, provided by the submitting organization,

11.2.4 Summary of test validity criteria,

11.2.5 Operational summary including any special maintenance,

11.2.6 Fuel injector flow summary and ancillary test data, and

11.2.7 Photographs.

11.3 *Data Acquisition Summary Report*—The test validation criteria report, derived from the data acquisition equipment, shall include the sections listed in 11.3.1-11.3.6. Each section shall begin on a new page and the sections shall be inserted in the order listed from 11.3.1-11.3.6.

11.3.1 Engine-on time,

11.3.2 Vehicle speed,

11.3.3 Engine coolant temperature,

11.3.4 Total fuel consumed/total engine oil consumed,

11.3.5 Downtime, and

11.3.6 Number of accelerations.

11.4 *Photographs*—Photographs of engine parts shall be included in the order listed from 11.4.1 to 11.4.5. Photographs shall be taken in accordance with 10.2.

11.4.1 Intake valves—group,

11.4.2 Intake valve—Cylinder 1 and 2,

11.4.3 Intake valve—Cylinder 3 and 4,

11.4.4 Intake port and runner—Cylinder 1 and 2, and

11.4.5 Intake port and runner—Cylinder 3 and 4.

11.5 The intake valves from a test may be provided to the test requestor.

12. Precision and Bias

12.1 *Precision*—It is not practical to specify the precision in this test method for measuring intake valve deposits at this time because sufficient quantity of repeat tests under identical conditions are not available.

12.2 *Bias*—No estimate of bias is possible as the behavior of the fuel is determined only under the specific conditions of the test and no absolute standards exist.

internal combustion engines); driveability; intake valve deposits

13. Keywords

13.1 automotive spark-ignition engine fuel; BMW Intake Valve Deposit Test; deposit control additive; deposits (in

ANNEXES

(Mandatory Information)

A1. 325i RADIATOR RETROFIT

A1.1 Parts List for application of BMW 325i Cooling System to BMW 318i (layout shown in Fig. A1.1).

A1.1.1 P/N 11531722218

1986 BMW 325i Upper Hose

(Remove 50 mm of hose from engine side.)

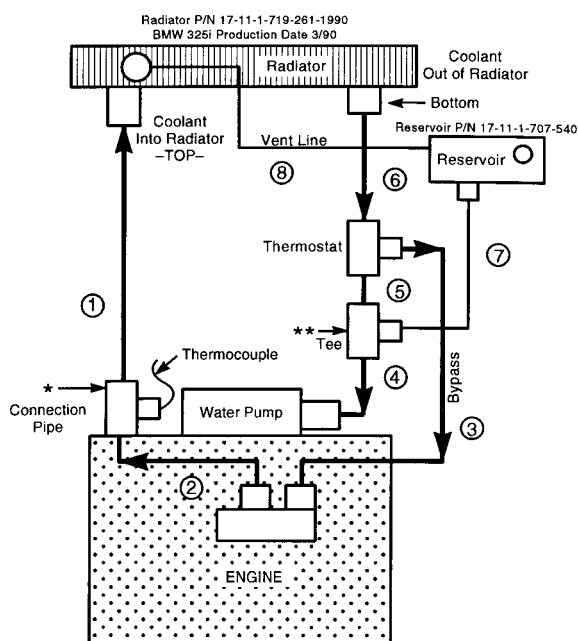


FIG. A1.1 325i Radiator Retrofit to 318i

A1.1.2 P/N 11531276542

1985 BMW 318i Hose

A1.1.3 P/N 11531276541

1985 BMW 318i Hose

A1.1.4 P/N 11531276542

1985 BMW 318i Hose

A1.1.5 P/N 11531276541

1985 BMW 318i Hose

(Use 70 mm of this hose.)

A1.1.6 P/N 04419960

1986 Chrysler Lower Radiator Hose

(Cut only amount necessary to couple lower radiator out port to lower BMW 318i thermostat.)

A1.1.7 P/N 11531289257

1986 BMW 325i Reservoir Hose

(Use 30 cm from reservoir side.)

A1.1.8 P/N 1712712736

325i Bulk Bypass Hose

(Use 2.5 m.)

A1.1.9 *Connection Pipe (one needed)*—Manufacture from mild steel pipe with 33-mm outside diameter by 75-mm long. A small fitting is welded in center of connection pipe that will accept a 1/8 in. pipe fitting. A 1/8 in. by 2 in. long K-type thermocouple is inserted into the connection pipe at one half the depth of the pipe.

A1.1.10 *Tee Connection (one needed)*—Manufacture from mild steel pipe with 33-mm outside diameter by 77-mm long. Tee is placed in center and welded to pipe. Tee dimensions are: 20-mm outside diameter by 33-mm long.

A2. PARTS AND PART NUMBERS

A2.1 Frequently used parts for the BMW 318i:

Part Name	BMW Part Number	Part Name	BMW Part Number
Air flow meter	13 62 1 279 664	EEC core charge	86 00 0 000 007
Air pressure sensor	13 62 1 286 679	EEC harness (48 state)	12 51 1 705 746
Alternator (remanufactured)	12 31 1 711 375	EEC harness (California)	12 51 1 706 464
Automatic transmission (core)	99 99 9 000 812	Engine, long block	11 00 1 705 553
Automatic transmission (remanufactured)	24 00 1 217 002	Exhaust, rocker shaft	11 33 0 634 105
Catalyst	11 76 1 706 326	Filter, air	13 72 1 271 254
Distributor (remanufactured)	12 11 1 289 845	Filter, fuel	13 32 1 270 038
Distributor cap	12 11 1 706 122	Filter, oil	11 42 1 278 059
ECC control unit	13 61 1 286 066	Fuel injector	13 64 9 061 538
		Fuel pump	16 14 1 179 232

Part Name	BMW Part Number	Part Name	BMW Part Number
Gasket, head set	11 12 1 287 381	Rotor	12 11 1 276 144
Gasket, intake	11 61 0 743 110	Sensor, temperature fan	61 31 1 364 273
Gasket, intake	11 61 1 274 510	Sensor, temperature fan	61 31 1 364 272
Gasket, water pump	11 51 0 686 135	Spark plug	12 12 1 272 128
Idle control relay	13 41 9 058 749	Thermostat	11 53 1 260 720
Idle control valve	13 41 9 058 752	Valve, cold start	13 64 1 285 087
Ignition coil	12 13 1 273 216	Valve, exhaust	11 34 1 251 063
Ignition wire set	12 12 1 705 697	Valve, intake	11 34 1 254 625
Intake, rocker shaft	11 33 0 634 100	Valve, seal	11 34 1 273 501
Lambda probe	11 78 1 707 391	Sensor, vacuum advance	12 62 1 285 073
O ₂ sensor	11 76 1 277 565	Cylinder head	11 12 1 273 918
Pump, water	11 51 1 721 477		
Radiator	17 11 1 712 041		
Radiator cap	17 11 1 152 060		
Rocker arm	11 33 1 271 833		

A2.1.1 The parts listed in **A2.1** may have been superseded. Check with the BMW part's supplier for the latest part numbers.

A3. QUALITY ASSURANCE SCHEDULE

A3.1 General—To prevent unscheduled downtime, the following maintenance schedule shall be followed. The components listed in **Annex A2** shall be replaced or checked as specified initially and every 32 000 km (20 000 miles) thereafter. Complete this work before the engine tune-up. Specific recommendations are outlined as follows:

A3.1.1 Blow out air conditioning condenser and radiator every 32 000 km (20 000 miles) using compressed air to remove bugs and debris.

A3.1.2 Engine wiring harness shall be replaced every 64 000 km (40 000 miles) (49 states BMW P/N 12 51 1 705 748, California BMW P/N 12 511 706 464). When the head is removed from the engine, as in **9.5.1**, the complete harness is attached to and removed with the head. Before the head is reinstalled on the engine, remove the old wiring harness from the connections on the head and replace it with a new one.

A3.1.3 Oxygen sensor shall be replaced every 32 000 km (20 000 miles) (BMW P/N 11 76 1 277 565). On the 49 state cars, pull the wire off the oxygen sensor located on the catalyst pipe under the fire wall. Unscrew and discard the sensor. Install a new sensor and connect the electrical wire. On the California cars, the replacement procedure is the same, except the location of the sensor is different. The California cars have a heated sensor in the exhaust manifold near the connection point of the manifold and the catalyst pipe.

A3.1.4 Mass air flow sensor shall be replaced every 32 000 km (20 000 miles) (BMW P/N 13 62 1 466 348). Disconnect the electrical wires running to the sensor. Loosen the hose clamp securing the air hose which runs to the throttle body. Pull off the air hose and remove the three mounting nuts. Slide the sensor out of the air box and discard it. Slide a new sensor into place; tighten the mounting bolts; connect the electrical wires; and reconnect and tighten the air hose clamp.

A3.1.5 Idle control valve shall be replaced every 32 000 km (20 000 miles) (BMW P/N 13 41 1 709 898). Disconnect the electrical wires. Loosen the two hose clamps securing the vacuum lines to the sensor, pull off the hoses, unclamp, and discard the old sensor. Clamp a new sensor in place, push the vacuum hoses back on the sensor, secure them with the hose clamps, and connect the electrical wires.

A3.1.6 Distributor cap (BMW P/N 12 11 1 706 122), rotor (BMW P/N 12 11 1 272 144), and wires (BMW P/N 12 12 1 705 697) shall be replaced every 32 000 km (20 000 miles). Unplug the four spark plug wires from the spark plugs, and the coil wire from the coil. Unlatch the two clips securing the distributor cap; pull it off and discard it. Pull off and discard the rotor. Snap on a new rotor; position a new distributor cap over the rotor, and latch the two mounting clips. Install four new spark plug wires and coil wire.

A3.1.7 Spark plugs (BMW P/N 12 12 1 272 128) shall be replaced every 32 000 km (20 000 miles). Remove and discard old spark plugs. Replace with Bosch WR 9 DS spark plugs gapped to the proper specification. Tighten them to the proper torque specification (see **A5.1.1**).

A3.1.8 Barometric sensor on air box (BMW P/N 13 62 1 286 679) shall be replaced every 32 000 km (20 000 miles). Disconnect the electric wire, unscrew the sensor and discard it. Secure a new sensor to the bracket by tightening the mounting screws. Connect the electrical wires.

A3.1.9 Fan clutch (BMW P/N 11 52 1 466 000) shall be replaced every 32 000 km (20 000 miles). Before installing a new radiator, remove the nut securing the fan to the water pump shaft, and remove the fan. This is a left-handed nut so turn the nut clockwise to remove it. Remove the four bolts securing the fan clutch to the fan, and discard the fan clutch. Position a new fan clutch properly and install the four mounting bolts. Position the fan assembly in front of the water pump and tighten the left-hand nut to the proper torque specification (see **A5.1.1**). The fan shall perform as follows:

Switching-on temperature.....	72 to 80°C (162 to 176°F)
Switching-off temperature.....	65 to 70°C (149 to 158°F)

A3.1.10 Water pump (BMW P/N 11 51 1 286 358) shall be replaced every 32 000 km (20 000 miles). With the fan removed, loosen the hose clamps on the coolant hoses attached to the water pump and pull off the hoses. Loosen the alternator to slacken the V-belt and remove the pulley and drive belt from the water pump. Remove the six bolts securing the water pump to the block and pull off and discard the old water pump. Scrape the mating surface on the block to remove any gasket material or silicon gasket sealant. Apply a thin film of silicon sealant to both sides of the new gasket and reinstall the water



pump. Install the pulley on the water pump, position the drive belt, and tighten the belt by adjusting the alternator. Push the

coolant hoses onto the new water pump and secure them by tightening the hose clamps.

A4. SERVICE SCHEDULES (I AN II)

A4.1 **Fig. A4.1** shows the service maintenance checklists.

BMW of North America, Inc. **1985/1986 Models** **SERVICE MAINTENANCE** **CHECK LISTS**



SERVICE INDICATOR EQUIPPED **MODELS ONLY**

Only operations that pertain to this vehicle will be performed.

NOTE: Any other requested repairs not listed or covered by the applicable BMW Limited Warranty will be charged to the owner and invoiced separately.

CUSTOMER'S NAME AND ADDRESS			
Chassis Number			
Selling Dealer			
Repair Order No.		Mileage	

★ **BMW 1,200 MILE (2,000 km) INSPECTION** DO NOT RESET SERVICE INDICATOR

TECHNICIAN'S SIGNATURE _____

- ☐ Check glove box for radio anti-theft packet – if present, remove and give to Service Advisor.
- ☐ Check the operation of the following items:
 - Lighting equipment: Headlights, parking, back-up, license plate, interior, glove box, engine and luggage compartment lights.
 - Headlights and alignment, adjust if necessary.
 - Warning equipment: Turn signals, hazard warning flashers, brake lights, horns, headlight dimmer and flasher switch. Check Control panel operation, ABS and SRS warning lights.
 - Instrument lighting, control lighting.
 - Windshield wipers and washers (including jet position).
 - Heater and air conditioner blowers, rear window defroster.
- ☐ Check foot brake.
- ☐ Inspect and adjust valves.
- ☐ Check cooling system and all connections and heater hoses for leaks. Check coolant level and concentration; add coolant if necessary.
- ☐ Check windshield washer reservoir level and fluid antifreeze protection. Correct if necessary.
- ☐ Check fluid level in reservoir for clutch and hydraulic brake system.
- ☐ Check power steering oil level, add oil as required. Check for leaks.

- ☐ Check oil level in Automatic Transmission.
- ☐ It is recommended, in California only, to check and adjust idle mixture if necessary. (1.8, 2.7 L only)
- ☐ Change engine oil and oil filter while engine is at normal operating temperature.
- ☐ Change oil in manual transmission only while at normal operating temperature. (3.5 L only)
- ☐ Change oil in rear axle while at normal operating temperature.
- ☐ Check condition, position, mountings and tightness of exhaust system.
- ☐ Examine brake lines and connections for leaks, damage or distortion.
- ☐ Retorque chassis nuts and bolts (see Repair Manual specifications for correct tightening torques); steering, brakes, wheel bolts.
- ☐ Check brakes, steering, clutch or automatic transmission while driving in and out of service stall. Preburnish parking brake according to specifications (vehicles with rear disc brakes only).
- ☐ BMW 524td: Check operation of telltale lights for preheat time and readiness to start.
- ☐ Check all tire pressures and adjust as necessary (including spare tire).

★ **BMW ENGINE OIL SERVICE**

TECHNICIAN'S SIGNATURE _____

REQUIRED

- ☐ Change oil and oil filter while engine is at normal operating temperature.
- ☐ Reset Service Indicator.
- ☐ BMW 524td: Empty fuel filter water trap.

Reminder:

Change brake fluid at least once annually.
(Use only DOT 4 brake fluid.)
Change coolant every two years.
Change oxygen sensor every 30,000 miles or 50,000 miles as specified.

ADDITIONAL RECOMMENDED SERVICES

To be invoiced separately.

- ☐ Check steering:
Steering box, steering linkage, joint disc, threaded connections, tightness and oil level.
- ☐ Check brakes:
Brake pads and brake discs (remove and install wheels), check level of brake and clutch fluid in reservoir. Add fluid if required. (NOTE: Change brake fluid at least once a year.) Check brake hoses and connections for leaks and distortion.
- ☐ Check parking brake and adjust parking brake cables. Check all tire pressures and adjust if necessary (including spare tire).
- ☐ Check lighting:
Headlights, parking, back-up, license plate, interior, glove box, engine and luggage compartment lights. Turn signal,

hazard warning flashers, brake lights, horns, headlight dimmer and flasher switch. Check Control panel operation, instrument lighting, control lighting, ABS and SRS lights.

- ☐ Headlights and alignment. Adjust if necessary.
- ☐ Check accessory drive (V-) belt tension and condition.
- ☐ Check windshield wipers and washers:
Adjust washer jet position if necessary, check level and fluid antifreeze protection in reservoir.
- ☐ Check intensive-cleanser level, add as required, if equipped.
- ☐ Check seat belts:
Condition and correct operation.
- ☐ Clean cassette tape head, capstan, and pinch rollers.
- ☐ Road test for vehicle operation and safety items.

FIG. A4.1 Service Maintenance Check Lists-BMW 1985

**BMW INSPECTION I**

TECHNICIAN'S SIGNATURE _____

- ☐ Check the operation of the following items:
 - Lighting equipment: Headlights, parking, back-up, license plate, interior, glove box, engine and luggage compartment lights.
 - Headlights and alignment, adjust if necessary.
 - Warning equipment: Turn signals, hazard warning flashers, brake lights, horns, headlight dimmer and flasher switch. Check Control panel operation, ABS and SRS warning lights.
 - Instrument lighting, control lighting.
 - Windshield wipers and washers (including jet positions) and top off reservoir.
 - Heater and air conditioner blowers, rear window defroster.
- ☐ BMW 524td: Check operation of telltale lights for preheat time and readiness to start.
- ☐ Check valve clearances. Adjust as necessary.
- ☐ Check cooling system and all connectors and heater hoses for leaks. Check coolant level and concentration: add coolant if necessary. *Important:* Coolant must be drained completely and replaced every 2 years.
- ☐ Check steering gear or power steering for leaks and correct oil level. Add oil as required.
- ☐ Check battery acid level and add distilled water as required.
- ☐ Check level of brake and clutch fluid in reservoir. Add fluid if required. *NOTE:* Change brake fluid at least once a year.
- ☐ Check windshield washer reservoir level and fluid antifreeze protection.
- ☐ Check wipers and washer system: wiper blades, washer jet position.
- ☐ Apply grease to the bearing points and moving parts of the throttle butterfly linkage.
- ☐ Check steering for absence of play in straight ahead position. Adjust if necessary.
- ☐ Check air conditioner for operation and proper Freon® charge.
- ☐ Sunroof: lube slide rails (if equipped).
- ☐ It is recommended, in California only, to check and adjust idle mixture if necessary. (1.8, 2.7 L only)
- ☐ Check all tire pressures (including spare). Correct if necessary. Check condition of tires; in case of uneven tread wear, readjust wheel alignment if requested (to be invoiced separately). *Note:* If desired, rotate all four road wheels as instructed and re-balance (invoice separately).
- ☐ Tighten nuts and bolts of door locks and striker plates.
- ☐ Oil hinges of doors, door catches and striker plates. Check operation of each component.
- ☐ Check condition and function of the seat belts.
- ☐ Check for free movement of parking brake cables. Adjust parking brake if necessary.
- ☐ Change engine oil and oil filter while engine is at normal operating temperature.
- ☐ Change automatic transmission strainer and fluid while at normal operating temperature. (Only in Inspection I, not required during Inspection II.)
- ☐ Check manual transmission oil level. Add oil as required.
- ☐ Check oil level in rear axle: add oil as required.
- ☐ Visually check fuel tank, lines and connections for leaks.
- ☐ Check condition of suspension track rods, front axle joints, steering box linkage and joint disc.
- ☐ Check condition, position and mounting of exhaust system. Examine for leaks.
- ☐ Remove, check and install front and rear disc/brake pads for overall thickness (invoice separately if replacement is required). Examine brake disc surfaces. Check brake system connections and lines for leaks, damage and incorrect positioning. Inspect wheel brake calipers and dust seals for leaks.
- ☐ Grease wheel centering hubs, reinstall wheels.
- ☐ Tighten A/C compressor mount bolts.
- ☐ Final inspection, road test with check of brakes, steering, clutch or automatic transmission and rear view mirrors. Prebush parking brake according to specifications. (Vehicles with rear disc brakes only.)
- ☐ Reset Service Indicator.
- ☐ Check ground connection of SRS front-sensor screws to body.

**BMW INSPECTION II**

Includes all items listed under Inspection I, and the following additional checks and maintenance operations:

TECHNICIAN'S SIGNATURE _____

- ☐ Replace main fuel filter. Reduce interval if fuel contamination is encountered or prevalent. Recommended in California, required in all other states.
 - ☐ Replace intake air cleaner filter element. Reduce replacement interval in dusty operating conditions.
 - ☐ Check clutch driving plate for wear.
 - ☐ Check tension and condition of all accessory drive (V-) belts. Correct tension if necessary. Replacement to be invoiced separately.
 - ☐ Check camshaft drive (timing) belt tension (2.7 L). If loose, replace. Replacement to be invoiced separately.
 - ☐ Replace spark plugs.
 - ☐ Check front wheel bearing play.
 - ☐ Change oil in manual transmission while at normal operating temperature.
 - ☐ Check oil in automatic transmission.
 - ☐ Rear disc brakes: Check thickness of parking brake linings.
 - ☐ Half-shafts: Check for leaks at flexible boots.
 - ☐ Change oil in rear axle while at normal operating temperature.
- 524td (additional items)
- ☐ Check static timing & idle speed.
 - ☐ Check tension of camshaft drive (timing) belt.
- With every second Inspection II:
- ☐ Replace glow plugs*
*Required in 49 states, recommended in California.
- With every second Inspection II or every 4 years for cars with low mileage:
- ☐ Change camshaft drive (timing) belt (2.7 L and 524td). Invoice separately.

**BMW ANNUAL CHECK***Note:* Repairs required as a result of this check are at additional charge.

TECHNICIAN'S SIGNATURE _____

Brake Fluid

- ☐ Change brake fluid annually. (Use only DOT 4 brake fluid.)
- ☐ Brakes: Check operation of master cylinder and servo, and inspect for leaks.

Coolant

- ☐ Change coolant every two years.

Anti-Corrosion Warranty Inspection

- ☐ Inspect body according to the terms of the six-year BMW limited warranty against perforation by rust.

Additional Annual Services Recommended

- ☐ Check and adjust headlights and auxiliary driving lights.
- ☐ Check steering: Lock angle limits, threaded connections, power assistance.

**BMW OXYGEN SENSOR SERVICE**

(Required at 30,000 Mile Intervals or 50,000 miles as specified.)

TECHNICIAN'S SIGNATURE _____

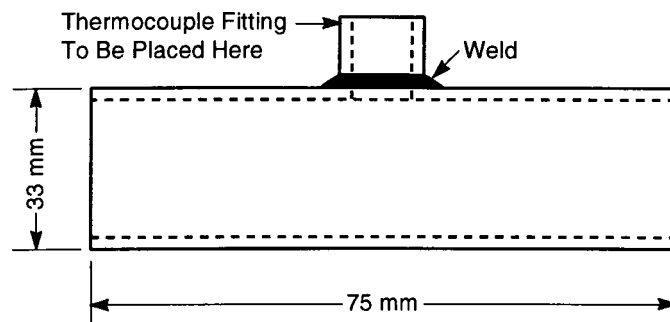
- ☐ Replace oxygen sensor.

FIG. A4.1 Service Maintenance Check Lists-BMW 1985 (continued)

A5. COOLANT TEMPERATURE MEASUREMENT LOCATION

A5.1 Engine Coolant Temperature Thermocouple Location:

A5.1.1 Pipe connection used for upper radiator hose. Weld 1/8-in. pipe coupling cut in half to the straight mild steel pipe connection. This will then accept the 1/8-in. thermocouple fitting. See Fig. A5.1.



NOTE—Figure is not to scale.

FIG. A5.1 Engine Coolant Temperature Thermocouple Location

A6. FASTENER TORQUE SPECIFICATIONS

A6.1 Fastener Torque Specifications:

Fuel tank drain plug	15 to 18 ft-lb (21 to 25 Nm)	Cylinder head bolts	Step 1	25 to 29 ft-lb (34 to 40 Nm)
Distributor flange			Step 2	42 to 45 ft-lb (58 to 62 Nm)
Cam/rocker shaft plate				Wait 20 min
Camshaft oil line	8 to 9 ft-lb (11 to 13 Nm)		Step 3	56 to 59 ft-lb (78 to 82 Nm)
Bolt in rocker arm	7 to 8 ft-lb (9 to 11 Nm)			Run engine warm.
Intake manifold to cylinder head	16 to 17 ft-lb (22 to 24 Nm)		Step 4	torque angle $25 \pm 5^\circ$
Radiator to body	6 to 6.5 ft-lb (8 to 9 Nm)	Drain plug on radiator		1.1 to 2.2 ft-lb (1.5 to 3 Nm)
Fan cowl to radiator	1.2 to 1.6 ft-lb (1.7 to 2.2 Nm)	Exhaust pipe to exhaust manifold		31 to 35 ft-lb (43 to 48 Nm)
Spark plug	17 to 20 ft-lb (24 to 28 Nm)	Sprocket to cam shaft flange		5 ft-lb (7 Nm)
Spark plug gap	0.028 + 0.004 in. (0.7 + 0.1 mm)	Timing case covers		7 to 8 ft-lb (9 to 11 Nm)
Exhaust manifold to cylinder head	22 to 24 ft-lb (30 to 33 Nm)	Oil drain plug	17 mm	22 to 25 ft-lb (30 to 35 Nm)
A/C hose connections	5/8 in. 10 to 14 ft-lb (14 to 20 Nm)	Oil filter	19 mm	43 to 46 ft-lb (58 to 62 Nm)
	3/4 in. 24 to 28 ft-lb (33 to 39 Nm)			Hand tighten; then follow directions on filter.
	7/8 in. 26 to 30 ft-lb (36 to 42 Nm)	Radiator drain plug		1.1 to 2.2 ft-lb (1.5 to 3 Nm)
	1 1/16 in. 29 to 35 ft-lb (40 to 48 Nm)	Fan coupling nut		36 ft-lb (50 Nm)

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