INTERNATIONAL

**Designation: ~~D2847 – 07 (Reapproved 2012)~~ D2847 – 14**

# Standard Practice for Testing Engine Coolants in Car and Light Truck Service[1]

This standard is issued under the fixed designation D2847; 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 practice covers ~~the~~ an updated procedure for evaluating corrosion protection and performance of an engine coolant in passenger ~~car and light truck service.~~ car, light and heavy duty truck service that closely imitates current vehicle and engine manufacturers practices.

NOTE 1—Coolant evaluation in vehicle service may require considerable time and expense; therefore, the product should be pretested in the laboratory for general acceptability. ~~Tests may~~Typical tests vary from small, closely controlled tests, to large tests where close control is not always practical. The most often referenced protocols for laboratory testing are defined in Specifications D3306, D6210, D7517, D7518, D7714, and D7715.

1.2 The units quoted in this practice are to be regarded as standard. The values given in parentheses are approximate equivalents 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 precautionary statements are given in Section 7 ~~and Note A1.1~~.

## 2. Referenced Documents



2.1 *ASTM Standards:*[2]

D1121 Test Method for Reserve Alkalinity of Engine Coolants and Antirusts

D1287 Test Method for pH of Engine Coolants and Antirusts

~~D1384~~D2809 Test Method for ~~Corrosion Test for Engine Coolants in Glassware~~Cavitation Corrosion and Erosion-Corrosion Characteristics of Aluminum Pumps With Engine Coolants

D3306 Specification for Glycol Base Engine Coolant for Automobile and Light-Duty Service

D3321 Test Method for Use of the Refractometer for Field Test Determination of the Freezing Point of Aqueous Engine Coolants

D4725 Terminology for Engine Coolants and Related Fluids

D5827 Test Method for Analysis of Engine Coolant for Chloride and Other Anions by Ion Chromatography

D6130 Test Method for Determination of Silicon and Other Elements in Engine Coolant by Inductively Coupled Plasma-Atomic Emission Spectroscopy

~~D1881~~D6210 ~~Test Method for Foaming Tendencies of Engine Coolants in Glassware~~Specification for Fully-Formulated Glycol Base Engine Coolant for Heavy-Duty Engines

D7517 Specification for Fully-Formulated 1,3 Propanediol (PDO) Base Engine Coolant for Heavy-Duty Engines

D7518 Specification for 1,3 Propanediol (PDO) Base Engine Coolant for Automobile and Light-Duty Service

D7714 Specification for Glycerin Base Engine Coolant for Automobile and Light-Duty Service

D7715 Specification for Fully-Formulated Glycerin Base Engine Coolant for Heavy-Duty Engines

## 3. Terminology

~~3.1 *Definitions:*~~

~~3.1.1 *engine coolant*—a fluid used to transfer heat from an engine to the radiator, usually containing specific amounts of glycols, water, corrosion inhibitors, and a foam suppressor.~~

3.1 *Definitions*—Refer to Terminology D4725.

[1] This practice is under the jurisdiction of ASTM Committee D15 on Engine Coolants and Related Fluids and is the direct responsibility of Subcommittee D15.10 on Dynamometer and Road Tests.

Current edition approved ~~Oct. 1, 2012~~Dec. 1, 2014. Published ~~November 2012~~January 2015. Originally approved in 1969. Last previous edition approved in ~~2007~~2012 as ~~D2847 – 07.~~D2847 – 07(2012). DOI: ~~10.1520/D2847-07R12.~~10.1520/D2847-14.

[2] 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.

## 4. Summary of Practice

4.1 ~~Standard metal corrosion specimens, mounted in special holders, are installed in the coolant flow of the test vehicles.~~Test coolant shall be a new coolant. The coolant is tested at the recommended concentration in ~~a specified test water.~~ an aqueous solution made with water that complies with the water recommendation published in Specifications D3306 and D6210. A minimum of five test vehicles per coolant ~~is required. The test duration in terms of time or mileage should be consistent with the recommended service life of the coolant. The vehicle, corrosion specimens,~~are required, ten are recommended, but this number may be adjusted by agreement between customer and supplier. The test vehicles shall have been in service less than 3 months, 3000 miles, or 500 operating hours. Alternate specific requirements may always be agreed between customer and supplier. Customer and supplier may also choose to follow requirements published in Original Engine Manufacturer (OEM) specifications. The cooling system components and coolant are inspected according to a prescribed schedule to provide the basis for coolant ~~evaluation.~~ performance evaluation.

4.2 A detailed cleaning and conditioning procedure is essential to obtain statistically significant and reproducible results.~~ New, or nearly new, vehicles are preferred for field tests.~~

## 5. Significance and Use

5.1 The data obtained from the use of this practice will provide a basis for the evaluation of coolant performance in passenger ~~car and light truck service.~~ car. light and heavy duty truck service (according to the test vehicles chosen). The data obtained may also be used to provide added significance to the data obtained from simulated service and engine dynamometer tests.

## 6. Apparatus

6.1 *Test Vehicles*—In selecting ~~vehicles to be used to conduct field tests of coolants intended for automobiles and light trucks, consideration~~ vehicles, refer to OEM recommendations. Consideration should be given to the current range of cooling system designs and materials. ~~It is advisable to include both brazed aluminum and soldered copper/brass radiators as well as engines made of cast iron and those with aluminum heads or blocks, or both.~~ Engines specified should be reasonably available for the test, which is to say of current production design and materials. A matrix including every possible variable combination of such features is not ~~required, especially if vehicles representing the extremes are included in the field tests. This includes aluminum engine with aluminum radiator and heater core, cast iron engine with copper/brass radiator and heater core, and a cast iron engine with an aluminum radiator and a copper/brass heater core. Pressurized surge tanks as well as unpressurized coolant overflow reservoirs should be tested. Select vehicles that will be subjected to a wide range of operating schedules. These ranges should include high-usage vehicles which accumulate miles rapidly, vehicles operationally biased toward higher temperatures, and low-mileage vehicles (<1000 miles/month) that can develop accelerated localized corrosion due to non-flowing coolant. No single operating schedule is preferred over another. New, or nearly new, vehicles are preferred because of possible difficulties, explained in~~ required.~~9.2.1, in cleaning older cooling systems prior to test.~~



~~6.2 *Metal Corrosion Specimens*—The description, specification, preparation, cleaning, and weighing of the metal corrosion specimens used in this practice are given in detail in Test Method D1384. The metal specimens are assembled for test as shown in Fig. 1. Each set of specimens is mounted in a canvas reinforced phenolic tube illustrated in Fig. 2. The specimen and tube assembly are placed in a capsule which is mounted in the vehicle cooling system. Two types of specimen capsules may be used; the by-pass (partial-flow) heater circuit type (Fig. 3) is the standard capsule, and the full-flow type (Fig. 4) is optional. The partial-flow heater circuit capsule is located between the heater supply and the heater-return line and shall contain two or more sets of specimens. The full-flow capsule is installed in the upper radiator hose and contains one or more sets of specimens.~~

~~6.2.1 The schematic of the specimen holder installation is shown in Fig. 5. Fig. 6 is a photograph of a typical installation of test capsules. The optional full-flow capsule should be mounted as low as possible in the upper radiator hose to ensure coolant coverage of the metal specimens when the vehicle is not in use. The partial-flow capsule must be mounted vertically to avoid trapped air. A pair of fabricated copper tees with ⅜-in (9.5-mm) outside diameter copper tubing side taps (Fig. 7) are spliced into the heater hose lines to provide a constant bypass flow through the specimen capsule. The circuit must be so arranged that coolant flows through the capsule whenever the vehicle is in operation. On air-conditioned vehicles with a vacuum-operated heater flow control valve, the by-pass tee must be installed ahead of the flow control valve to insure constant flow.~~

## 7. Safety Precautions

7.1 All coolant concentrates and their solutions should be considered harmful or fatal if swallowed.

7.2 ~~Caution~~ (**Warning—**Do not remove pressure caps from systems when the engine is hot.~~should be used when removing the radiator cap from a hot cooling system.~~)

7.3 All installations shall be made with the engine cooled to ambient air temperature to avoid burns.

7.4 Disconnect the hot (positive) battery lead to prevent the engine from starting to avoid hand injury by drive belts or fan blades.

7.5 The engine exhaust should be vented when the engine is run indoors at normal temperatures to check for cooling system leaks.

## 8. Sampling

8.1 Coolant samples ~~are~~ may be removed from the test vehicle ~~through the sample valve mounted on the partial-flow capsule. The 6-oz (180-mL)~~ by any convenient means, such as a bulb and pipette. The 100-mL (~3.5 oz) coolant samples are kept in polyethylene bottles equipped with screw caps and suitable labels. A reserve supply of pre-mixed coolant is used to replace the coolant samples. ~~If foaming tendency is not checked, a 2-oz (60-mL) sample is adequate.~~Coolant added to the system for any reason is recorded in the test vehicle log.

## 9. Preparation of Apparatus

9.1 ~~*Engine Reconditioning:*~~ Obtain an initial sample of the coolant for laboratory analysis. This is the "0" miles sample. Record the odometer reading, date and time of initial sampling. Record other data as agreed between customer and supplier. Follow OEM or manual instruction, or both, for deaeration to ensure engine is properly deaerated at start of the field test.

~~9.1.1 Inspect the engine of the test vehicle carefully and complete any necessary repairs. Check the cooling system for the following common defects: cylinder head gasket failure resulting in exhaust gas contamination of the coolant, and air inducted into the coolant due to a worn coolant pump face seal or defective lower radiator hose connection.~~

9.2 ~~*Cooling System Preparation:*~~ Label the radiator and expansion reservoir fill caps conspicuously to show a coolant test is being conducted, and include instructions with whom to contact in case coolant additions are needed or other problems occur.

~~9.2.1 Vehicles subject to field tests must have cooling systems that can be satisfactorily cleaned initially with mild chelate or detergent type commercial cleansers. Such cleaners may allow small concentrations of some chemicals to carry over into the coolant to be tested, and this factor may be appraised from analyses of the initial and periodic coolant samples. New, or nearly new, vehicles are preferred to minimize cleaning and possible carryover problems. It is possible to clean older cooling systems with oxalic acid, and a procedure for that alternative is included in the appendixes. However, considerable caution must be exercised in cleaning, neutralizing, and inspecting systems cleaned with oxalic acid. Some researchers have reported deleterious carryover effects that persist during tests conducted after oxalic acid cleaning. Engines that have cooling systems that are heavily rusted, pitted, or porous are more susceptible to such carryover. The presence of oil or grease accumulations in the cooling system may justify exclusion of the vehicle from test if the oil cannot be removed by the cleaner selected.~~



~~9.2.2 In addition to monitoring changes in the properties of the coolant and measuring corrosion rates by means of the metal coupons, an appraisal of the long term effects on the cooling system parts may be an added objective. This may include an evaluation of radiator tube plugging, solder blooming, seal leakage, accumulations of sediment and the effects on iron and aluminum engine parts subjected to higher thermal stress than on the corresponding metal coupons. Parts of the cooling system of particular interest may appropriately be replaced with new parts during the initial preparations.~~

~~9.2.2.1 A Cooling System Flush and Fill Kit[3] (see Fig. A1.1) will permit quick and effective flushing of the system.~~

~~9.2.2.2 With system filled with tap water, pressure test to check for external leaks.~~

~~9.2.2.3 Pressure test radiator cap and examine radiator filler neck seat for dents or nicks. The pressure rating of the cap and filler neck combination may be tested by removing the temperature sensing unit and attaching the pressure tester to a suitable threaded fitting.~~

~~9.2.2.4 Drain cooling system as thoroughly as possible.~~

~~9.2.2.5 Repair any leaks. Examine radiator, heater, and coolant recovery reservoir hoses, and replace if necessary. Install new hose for evaluation of coolant effects on elastomeric materials.~~

~~9.2.2.6 Install the by-pass tees, the extra hoses and the full and partial flow capsules, but not the coupons, as illustrated in Fig. 5 and Fig. 7. This will allow cleaning of these components at the same time the rest of the cooling system is cleaned.~~

~~9.2.2.7 Clean the cooling system with a commercial automotive chelate or detergent-type cleaner, following the manufacturer's directions. The expansion reservoir must also be drained and cleaned. Follow this by flushing the system twice with distilled or deionized water. Then drain the cooling system as completely as possible. By opening appropriate hose connections, the heater core and the by-pass capsule hoses may be blown out with dry, oil free, compressed air. Inspect the interior surfaces of the cooling system. This may require some disassembly such as removal of the coolant outlet, the coolant pump, and accessible core hole plugs. Fiber optic inspection equipment may be useful. The extent of such inspections shall be commensurate with the test requirements and must necessarily be in accordance with agreement of the parties involved.~~

~~9.2.2.8 Remove the flushing tee and reassemble the cooling system for normal operation. The preweighed metal coupons should be installed in the full flow and partial flow capsules.~~

~~9.2.2.9 Fill the cooling system with test coolant prepared with glycol antifreeze and corrosive water as described in Test Method D1384. The glycol concentration should give a freeze point of − 20 ± 2°F (−29 ± 1°C), which corresponds to 44 % by volume of ethylene glycol (or other percentages of other glycols) unless climatic extremes require lower freeze points. The expansion reservoir shall be filled to the marked level with the same coolant solution. Run the engine long enough to ensure that any air trapped in the system is expelled, and check the system for leaks. Upon cool down, the coolant level in the expansion reservoir will need to be checked and brought to the proper level.~~

9.2.2.10 Label the radiator and expansion reservoir fill caps conspicuously to show a coolant test is being conducted, and include instructions with whom to contact in case coolant additions are needed or other problems occur. Obtain the initial coolant sample and record the start-of-test date, odometer reading, and engine hour reading.

## 10. Procedure

10.1 Test the coolant being evaluated in a minimum of five vehicles at the recommended concentration.concentration (typically 50 % antifreeze and 50 % water as recommended in Specifications D3306, D6210 but may be adjusted as agreed between customer and supplier).

10.2 Vehicle operating conditions may vary considerably in any test fleet; therefore, record fleet. Record the type of service for each vehicle. Mileage accumulation rates may vary considerably; therefore,considerably. Therefore, the recommended inspections in 10.5 may be difficult to schedule. Alternative inspection and sampling schedules may be developed to suit the needs and circumstances of the test.as agreed between customer and supplier.

10.3 The recommended concentration for coolant is listed below. Weather conditions in Northern areas may require testing at a higher concentration. Evaluate other cooling system products at the recommended or implied concentration, in the product use directions. Coolant concentrations and normal coolant operating temperature ranges are as follows:All tests to determine the necessity of adding SCA or an extender should be logged as well as the addition of the SCA or an extender. Field testing

| | |
|---|---|
| Concentration, volume %, or | 44 |
| Freezing point, °F (°C) | −20 (−29) |
| Range for normal operating temperature of engine coolant, °F (°C) | 180 to 235 (82 to 113) |

can be done by using Test Strips.

10.4 Use a synthetic corrosive water as described inwater that complies with Annex A2Specifications D3306, D6210 to dilute the antifreeze (field testing can be done with water quality test strips), and blend the test coolant. Additions to the cooling system during the test should be the prescribed mixture of 50 % coolant meeting Specifications D3306, D6210and corrosive water., and volumes added shall be recorded in the vehicle test log.

10.5 Perform periodic inspections throughout the test per minimum requirements as given in Table 1. or recommendations of OEM or agreed to by customers and supplier.



## 11. Calculation

11.1 Record the corrosion data in milligrams per specimen. If it is desired to convert these values to millimetres of metal penetration for the given period of test, use the following formula and the densities listed for the metals used in the test. This calculation is based upon the assumption that uniform corrosion occurred over the entire exposed surface.

$$\text{Millimetres penetration per total time of test exposure (Note 2)} = \frac{}{(\text{metal weight loss, mg/mm}^3/\text{metal density, mg/mm}^3)}$$



Density of metals meeting the requirements of Test Method D1384, in milligrams per cubic millimetre, are as follows:

| | |
|---|---|
| Copper | 8.9 |
| Solder (Note 4) | 9.7 |
| Brass | 8.5 |
| Steel | 7.9 |
| Cast iron | 7.2 |
| Aluminum | 2.7 |

NOTE 2—Millimetres penetration can be converted to inches penetration by dividing the millimetre penetration figure by 25.4.

NOTE 3—When solder-coated brass is used, the density given is not valid if solder coating is penetrated by corrosion. Solders of different compositions are used in industry. The density varies according to the following tabulation:

| Lead % | Tin % | Density mg/mm³ |
|---|---|---|
| 50 | 50 | 8.9 |
| 70 | 30 | 9.7 |
| 80 | 20 | 10.2 |
| 95 | 5 | 11.0 |

## 11. Inspection

11.1 Harvest three tubes from the top, center and bottom of the radiator. Open the tubes by removing one edge and "butterflying" the tube. Inspect and photograph the tubes. Record observations. As agreed between customer and supplier, a more extensive inspection and analysis may be performed on the radiator components.

11.2 Inspect, rate and photograph the water pump. Refer to Test Method D2809 for inspection and rating guidelines. Water pumps differ in construction and materials, so the exact procedures in Test Method D2809 may need to be adjusted as agreed between customer and supplier.

**TABLE 1 Periodic Inspections**

| Occurrence | Operational Sequence |
|---|---|
| Initial 15 to 30 min, 10 h or 500 miles (800 km), 100 engine hours or 5 000 miles (8 000 km) thereafter | Take a 6-oz (180-mm) coolant sample [2 oz (60 mL)] if foaming tendency is not measured) and replace with reserve coolant. Analyze the samples for pH (Test Method D1287), reserve alkalinity (Test Method D1121), foaming tendencies,[A] and freezing protection.[B] |
| Initial 15 to 30 min and 10 h or 800 km (500 miles), Light & Medium Duty: 40 000 km (25 000 miles) thereafter Heavy Duty: 80 000 km (50 000 miles) thereafter | Take a 100-mL (~3.5 oz) coolant sample and replace with reserve coolant. Analyze the samples for pH (Test Method D1287), reserve alkalinity (Test Method D1121), inhibitor concentrations (Test Methods D5827, D6130, etc.) and freezing protection. (Test Method D3321) FP by refractometer for field use. Perform other tests as agreed between customer and supplier. |
| After each 50 engine hours or 2 500 miles (4 000 km) | Check coolant level at operating temperature and, if required, adjust to proper level in coolant reservoir. |
| After each refueling | Without opening the system, and only if possible, visually check coolant level at operating temperature. If required, allow the system to cool to ambient temperature. Adjust to proper level in coolant reservoir and record the volume of coolant added in the vehicle test log. Do not overfill the cooling system. |
| After each 100 engine hours or 5 000 miles (8 000 km) | Remove the 5 000-mile (8 000-km) set of corrosion specimens (upstream set in the bypass capsule) and replace with a weighed new set which will be removed at the end of the next 5 000-mile (8 000-km) accumulation. |
| At OEM recommended filter change interval | Inspect filter media for rust, debris or other deposits (may require to cut the filter canister) |
| At the end of test or at approximately 600 engine hours or 30 000 miles (48 000 km) | Terminate test. Check cooling system for aeration and cylinder head gasket failure. Retain a 1-gal (4-L) coolant sample. Remove all corrosion test specimens. Remove test sections of radiator hose. Remove coolant outlet and coolant pump and inspect these and the visible interior surface of the engine. Inspect the radiator. If warranted by the objectives of the test, a more extensive inspection and analysis can be performed on the engine components. Record necessary vehicle data and review maintenance records. See 11.1, 11.2, and 11.3. |
| At the end of test or as agreed between customer and supplier) | Terminate test. Check cooling system for aeration and cylinder head gasket failure. Retain a 4-L (1-gal) coolant sample. Remove and retain all radiator and heater hoses. Remove and retain coolant (water) pump and inspect these and the visible interior surface of the engine. Remove and retain the radiator. As agreed between customer and supplier, a more extensive inspection and analysis may be performed on the engine components. Record necessary vehicle data and finalize maintenance records in the test vehicle log. See 11.1 – 11.3. |
| Follow OEM's recommendation | |

[A] Test Method D1881. This laboratory test may be omitted if desired.
[B] Several methods are available: specific gravity, direct freezing, refractive index, or Karl Fischer water determination.



11.3 Harvest sections from the radiator and heater hoses. Open the hoses and spread the tubes to permit interior inspection. Inspect and photograph the hose materials. Record observations. As agreed between customer and supplier, a more extensive inspection and analysis may be performed on the hose components.

11.4 In heavy duty engines cylinder liners must be inspected for pitting corrosion, - Rated - Pass/Fail per agreement of customer and supplier.

11.5 Additional engine inspections may be performed as agreed between customer and supplier (water passages in block/heads, and thermostats/thermostat housing for rust/corrosion or deposits, or both).

## 12. Report

12.1 *Test Equipment and Operating Conditions:*
12.1.1 Test period and location.
12.1.2 Vehicle make, model, and type service.
12.1.3 Engine displacement, coolant capacity, condition of cooling system and points of inspection, aluminum metallurgy of engine accessories, and and cooling system components, and relevant inspection data.
12.1.4 Radiator make, model, and its condition after fleet test. Document final condition with photographs.
12.1.5 Radiator hose make and type and its condition after test. Document final condition with photographs.
12.1.6 Initial and final odometer readings.
12.1.7 Initial and final engine hour totalizer readings (if used).
12.1.8 Any relevant remarks regarding unusual cooling system maintenance or vehicle use.
12.1.9 Initial and final pressure test data on cap and system.
12.1.10 Coolant temperature and operating conditions.

12.2 *Coolant Information:*
12.2.1 Freezing point (or concentration of products other than antifreeze).

NOTE 4—Methods of determination based on refractive index, relative density, or Karl Fischer water may be used.

12.2.2 pH of all samples.

12.2.3 Reserve alkalinity of all samples.

12.2.4 Foaming tendency of allfinal samples (optional).

12.2.5 Required additions of test coolant.

12.2.6 Change in solution appearance, that is, dye fading, accumulation of rust, sediment, etc.

12.2.7 Odor development.

12.2.8 Copper, Lead, Aluminum and Iron concentration.

12.2.9 Corrosion inhibitors concentrated.

12.3 *Corrosion Inhibitor Data:*

12.3.1 Record any pitting, etching, copper plating, metal surface phenomena, erosion, cavitation, or crevice corrosion.

12.3.2 Record any visible corrosion in the radiator and engine interior; also, any visible corrosion, erosion, or cavitation damage of the coolant pump and coolant outlet.

12.3.3 Determine the average cleaning loss for each metal in one set of unused corrosion specimens. These cleaning losses are subtracted from the total losses of the exposed test specimens to establish net weight losses due to corrosion.Report and plot behavior of additive concentrations plots time or miles.

12.3.4 Report metal corrosion in milligrams per specimen. Uniform corrosion may be calculated and reported as millimetres penetration per test period. Gains in weight are reported.Calculate and report percent of additive depleted, correcting for additions of coolant during the test period.

12.3.5 Where the data are contradictory, discard the inconsistent data only with sufficient justification.

12.4 *Cleaning Procedure*—If the recommended cleaning procedure is not followed, the The exact cleaning procedure of any components shall be described.

## 13. Keywords

13.1 antifreeze; coolant evaluation; metal corrosion; vehicle service



## ANNEXES

(Mandatory Information)

### A1. DETECTION OF EXHAUST GAS LEAKAGE AND AIR SUCTION



**A1.1 Detection of Cylinder Head Gasket Failure (Exhaust Gas Leakage Test):**

A1.1.1 Cylinder head gasket failure resulting in exhaust gas contamination of the coolant may be detected with a carbon monoxide detector. The carbon monoxide detector is used for checking gases deaerating from the coolant after operation of the engine at road loads for at least 15 min. With the radiator cap off, gas samples can be taken near the surface of the coolant in the top tank. The following" quick-check" can be performed for confirmation or as an alternative.

A1.1.2 Start the "quick-check" test with the engine cold. Remove the fan belt from the drive pulley, or disconnect the water pump coupling, to prevent pump operation. Drain the system until the coolant is approximately level with the top of the engine block. Remove the upper radiator hose, thermostat housing, and thermostat. With the thermostat housing either removed or in place, fill the block completely by pouring water into the radiator to remove trapped air. To load engine: (*1*) On cars with manual transmission, jack up the rear wheels, run the engine in high gear, and load by gradually applying throttle and brakes simultaneously. (*2*) On cars with automatic transmissions, set the parking brake firmly, block the wheels, place the selector lever in drive position, apply the foot brake, and intermittently load engine by depressing the accelerator.

NOTE A1.1—**Caution:** The engine should not be loaded in drive for more than 15 s at a time or for more than two sequences. Disregarding this warning may result in overheating of the transmission fluid with possible damage to the seals and other transmission parts. *Do not allow anyone in front of the car while making this test!*

A1.1.3 Appearance of bubbles or a sudden rise of liquid at the block outlet to the radiator indicates exhaust gas leakage.

A1.1.4 Conduct the test quickly before boiling starts since steam bubbles give misleading results.