Designation: D5598 – 20

Standard Test Method for Evaluating Unleaded Automotive Spark-Ignition Engine Fuel for Electronic Port Fuel Injector Fouling[1]

This standard is issued under the fixed designation D5598; 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.

INTRODUCTION

This test method is based on a test procedure developed by the Coordinating Research Council (CRC) and maintains as much commonality as possible with the original test. A similar test method is described in the California Air Resource Board (CARB) report, "Test Method for Evaluating Port Fuel Injector Deposits in Vehicle Engines."

Driveability problems in PFI automobiles were first reported in 1984. These driveability problems were caused by deposits in the tips of pintle-type fuel injectors. In response to this problem, the CRC developed a program to evaluate a method of testing PFI deposit-forming tendencies in gasolines. D235-h test cycle consisting of 15 min of operation at 88 kph (55 mph) followed by a 45 min soak period was used for the program. This test cycle showed statistically significant differences in deposit-forming tendencies of the test fuels on the vehicles' fuel injectors. The results of the CRC program are discussed in CRC Report No. 565,[2] and SAE Paper 890213.[3]

1. Scope*

1.1 This test method covers a vehicle test procedure to evaluate the tendency of an unleaded spark-ignition engine fuel to foul electronic port fuel injectors (PFI).

1.2 The test method is applicable to unleaded spark-ignition engine fuels which may contain antioxidants, corrosion inhibitors, metal deactivators, dyes, deposit control additives, and oxygenates.

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

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given throughout this test method.

NOTE 1—If there is any doubt as to the latest edition of Test Method D5598, contact ASTM Headquarters. Other properties of significance to spark-ignition engine fuel are described in Specification D4814.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

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

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D4814 Specification for Automotive Spark-Ignition Engine Fuel

D5500 Test Method for Vehicle Evaluation of Unleaded

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

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[2] CRC Report No. 565 "A Program to Evaluate a Vehicle Test Method for Port Fuel Injector Deposit-Forming Tendencies of Unleaded Base Gasolines," February 1989. Available from Coordinating Research Council, Inc., 5755 North Point Parkway Suite 265 Alpharetta, GA 30022, www.crcao.org.

[3] Tupa, Taniguchi, Benson, "A Vehicle Test Technique for Studying Port Fuel Injector Deposits—A Coordinating Research Council Program," Society of Automotive Engineers (SAE) Technical Paper Series: Paper No. 890213, 1989, Available from Society of Automotive Engineers International, 400 Commonwealth Dr., Warrendale, PA 15096.

[4] 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.

*A Summary of Changes section appears at the end of this standard

Automotive Spark-Ignition Engine Fuel for Intake Valve Deposit Formation

2.2 *ANSI Standard:*[5]

MC 96.1 Temperature Measurement Thermocouples

2.3 *Other Standards:*

"Test Method for Evaluating Port Fuel Injector (PFI) Deposits In Vehicle Engines," State of California—Air Resources Board (CARB), Stationary Source Div., March 1, 1991 (incorporated by reference in California Code of Regulations, Title 13, Section 2257).[6]

Title 1— Provisions for Attainment and Maintenance of National Air Quality Standards, Clean Air Act Amendments of 1990 Public Law 101-549, Nov. 15, 1990.[7]

3. Terminology

3.1 For general terminology, refer to Terminology D4175.

3.2 *Definitions:*

3.2.1 *base fuel, n—in automotive spark-ignition engine fuels*, a material composed primarily of hydrocarbons that may also contain oxygenates, anti-oxidants, corrosion inhibitors, metal deactivators, and dyes but does not contain deposit control or lead additives. **D5500**

3.2.1.1 *Discussion*—A jurisdiction may set limits on lead content from all sources.

3.2.2 *deposit control additive, n*—material added to the fuel to prevent or remove deposits in one or more of the engine fuel, intake, and combustion systems. **D5500**

3.2.2.1 *Discussion*—For the purpose of this test method, the performance evaluation of a deposit control additive is limited to the electronic port fuel injector tip areas.

3.2.3 *driveability, n—in vehicles equipped with internal combustion engines*, the quality of a vehicle's performance characteristics under a range of conditions as perceived by the operator. **D4814**

3.2.3.1 *Discussion*—The operating conditions may include cold starting and warm-up, acceleration, idling, and hot start. The performance characteristics may include engine hesitation, stumble, and stall. **D4814**

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *electronic port fuel injector (PFI), n*—an electromechanical device used to control fuel flow in an internal combustion engine.

3.3.2 *fouling, v*—formation of carbonaceous deposits on the pintle or metering surfaces of an electronic fuel injector, which reduces fuel flow rate.

3.3.3 *pintle, n*—needle-like metering device, that is part of an electronic fuel injector, which controls flow rate and spray pattern.

3.3.4 *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.

4. Summary of Test Method

4.1 This test method describes a procedure for evaluating the formation of deposits in port fuel injectors of a modern spark-ignition engine. This test method described herein utilizes a 2.2 L Chrysler turbocharged engine equipped with an overhead camshaft, two valves per cylinder, and electronic port fuel injection. This test method includes a procedure for running a vehicle on a prescribed test cycle to form deposits in the port fuel injectors and a procedure for determining the resultant flow loss of a set of standardized injectors of known flow rate.

4.2 Each test begins with a new set of standardized fuel injectors which have previously been flow rated. All routine maintenance is performed in accordance with the Chrysler service manual.[8] The entire fuel system is flushed and filled with the new test fuel. To ensure compliance with the established test procedure, a data logger is active at all times after the test has begun, during all mileage accumulation and soak times.

4.3 The vehicle is operated on a cycle consisting of 15 min at a speed of 88 kph (55 mph) and an engine soak time of 45 min. This cycle is repeated for a total of 16 100 km (10 000 miles).

4.4 After the required mileage has been accumulated, the port fuel injectors are removed from the engine and the end-of-test flow rate is measured. The resultant flow loss is then calculated by comparing both end and start of test flow rates. Operational and mechanical criteria are then reviewed to determine if the test shall be considered valid.

5. Significance and Use

5.1 *Test Method*—Deposits are prone to form on the metering surfaces of pintle-type electronic fuel injectors. These deposits reduce fuel flow through the metering orifices. Reductions in metered fuel flow result in an upset in the air-fuel ratio, which can affect emissions and driveability. When heavy enough, these deposits can lead to driveability symptoms such as hesitation, hard starting, loss of power, or a combination thereof, that are easily noticed by the average driver and lead to customer complaints. The mechanism of the formation of deposits is not completely understood. It is believed to be influenced by many factors, including driving cycle, engine design, port fuel injector design, and composition of fuel used. The procedure in this test method has been found to build deposits in injectors on a consistent basis. The deposits formed by this procedure are similar to the deposits experienced in the field in terms of composition and in amount of deposition. This procedure can be used to evaluate differences in unleaded base fuels and fuel additives.

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

[6] Available from California Air Resources Board, P.O. Box 2815, Sacramento, CA 95812, http://www.arb.ca.gov.

[7] Clean Air Act Amendments of 1990, Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[8] Available from Chrysler Corp. Service Publications, 25999 Lawrence Ave., Center Line, MI 48015.

TABLE 1 Allowable Vehicle List

Chrysler	Dodge	Plymouth
Laser	Daytona	Caravelle
LeBaron	600	Lancer
LeBaron GTS	Charger	Sundance
New Yorker	Shadow	Omni GLH

5.1.1 *State and Federal Legislative and Regulatory Action*—Legislative and regulatory activity, primarily by the state of California[6] and the Federal Government[7] necessitate the acceptance of a standard test method to evaluate the port fuel injector 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 must 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 Section 10 will result in a void test. Engineering judgment must 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 has met the quality control inspection requirements in accordance with 8.2.

6. Apparatus

6.1 *Automobile*—The vehicle to be used for this test method is a Chrysler Corp. vehicle equipped with a 2.2 L, 4-cylinder turbocharged engine. An intercooled turbocharged engine may also be used. Vehicles equipped with either manual or automatic transmissions are acceptable. Hood vents shall be plugged on vehicles so equipped. Only vehicles from model years 1985 through 1987, inclusive, shall be used. Allowable vehicle models are shown in Table 1.

6.1.1 *Electronic Port Fuel Injectors*—Only Bosch EV1.1A pintle-style injectors with plastic caps shall be used. These injectors are Bosch part number 0280150360.[9] The corresponding Chrysler Corp. part number is 4306024 and is clearly marked on the injector. All tests shall begin with new, flow-tested injectors. Each new injector shall be qualified for leak rate prior to testing using the procedure in Annex A1.

6.1.2 *Tires*—All tires shall be of the same size and as specified by the vehicle manfacturer. Tires shall be inflated to the manufacturer's recommended pressure or up to a maximum pressure of 310 kPa ± 10 kPa (45 psi ± 0.5 psi) for chassis dynamometer use.

6.1.3 *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.

[9] Available from Robert Bosch Corp., 2800 S. 25th Ave., Broadview, IL 60153.

TABLE 2 Frequently Replaced Parts List

Part	Part No.
Air conditioning belt	4343523
Air filter	4342801
Distributor cap (1987)	5226546
Distributor rotor (1987)	5226535
Exhaust pipe hanger	4150798
Fan relay package	4419169
Fuel injector	4306024
Fuel injector O-ring	5277919
Oil filter (1986)	4419970
Oil filter (1987)	4105409
Oxygen Sensor	5227368
Positive crankcase ventilation (PCV) hose	4387387
Positive crankcase ventilation (PCV) valve (1987)	3671076
Power steering belt	4343490
Radiator cap	3781830
Spark plug	RN12YC[A]
Spark plug wires	4419359
Temperature sensor	5226374
Timing chain cover	4105714
Voltage regulator	4275313
Water pump	4293898
Water pump with O-ring	5203542
Fuel pressure regulator	4275313

[A] Champion, or equivalent.

6.1.4 *New Engine/Vehicle Parts List*—Table 2 contains those frequently replaced parts with the corresponding Chrysler/Mopar part number to be used for the buildup of the vehicle as required by this test method. Part numbers suggested in Table 2 or listed by the manufacturer may vary from model-to-model.

6.2 *Laboratory Facilities:*

6.2.1 *Fuel Injector Testing Area*—The ambient atmosphere of the fuel injector testing area shall be reasonably free of contaminants. The temperature shall be maintained at a uniform temperature between 21 °C and 27 °C (70 °F and 80 °F). Uniform temperature is necessary to ensure repeatable injector flow measurements. (**Warning—**Provide adequate ventilation and fire protection in areas where flammable or volatile liquids, or both, and solvents are used. Suitable protective clothing is recommended.)

6.2.2 *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 detergent additives are handled. Suitable protective clothing is recommended.) (**Warning—**Adequate ventilation and fire protection are necessary concerning the venting of the vehicle exhaust and when working on vehicle fuel systems. Suitable protective clothing is recommended.)

6.2.3 *Chassis Dynamometer*—A chassis dynamometer may be used for mileage accumulation. The dynamometer shall be calibrated before the beginning of each series of tests and monitored throughout each test. Both single- and dual-roll dynamometers are acceptable for use.