Designation: D 6618 – 04

An American National Standard

Standard Test Method for Evaluation of Engine Oils in Diesel Four-Stroke Cycle Supercharged 1M-PC Single Cylinder Oil Test Engine[1]

This standard is issued under the fixed designation D 6618; 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 can be used by any properly equipped laboratory, without outside assistance. However, the ASTM Test Monitoring Center (TMC)[2] provides reference oils and an assessment of the test results obtained on those oils by the laboratory. By this means, the laboratory will know whether their use of the test method gives results statistically similar to those obtained by other laboratories. Furthermore, various agencies require that a laboratory utilize the TMC services in seeking qualification of oils against specifications. For example, the U.S. Army imposes such a requirement, in connection with several Army engine lubricating oil specifications.

Accordingly, this test method is written for use by laboratories that utilize the TMC services. Laboratories that choose not to use those services may simply ignore those portions of the test method that refer to the TMC.

This test method may be modified by means of Information Letters issued by the TMC. In addition, the TMC may issue supplementary memoranda related to the test method.

1. Scope

1.1 This test method covers a four-stroke cycle diesel engine test procedure for evaluating engine oils for certain high-temperature performance characteristics, particularly ring sticking, ring and cylinder wear, and accumulation of piston deposits. Such oils include both single viscosity SAE grade and multiviscosity SAE grade oils used in diesel engines. It is commonly known as the 1M-PC test (PC for Pre-Chamber) and is used in several API oil categories, notably the CF and CF-2 and the military category described in MIL-PRF-2104 (see Note 1).

NOTE 1—Companion test methods used to evaluate other engine oil performance characteristics for API oil categories CF and CF-2 are discussed in SAE J304. The companion tests used by the military can be found in MIL-PRF-2104.

1.2 The values stated in either SI units or other units are to be regarded separately as the standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other, without combining values in any way.

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.*

1.4 This test method is arranged as follows:

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[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.B0 on Automotive Lubricants. The test engine sequences were originally developed in 1956 by ASTM Committee D02. Subsequently, the procedures were published in an ASTM Special Technical Publication.

Current edition approved Nov. 1, 2004. Published November 2004. Originally approved in 2000. Last previous edition approved in 2000 as D 6618–00.

[2] ASTM Test Monitoring Center, 6555 Penn Avenue, Pittsburgh, PA 15206-4489. The TMC issues Information Letters that supplement this test method. This edition incorporates revisions contained in all information letters through No. 03-1.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure

D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester

D 97 Test Method for Pour Point of Petroleum Products

D 130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

D 445 Test Method for Kinematic Viscosity for Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)

D 482 Test Method for Ash from Petroleum Products

D 524 Test Method for Ramsbottom Carbon Residue of Petroleum Products

D 613 Test Method for Cetane Number of Diesel Fuel Oil

D 664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D 1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption

D 1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)

D 2422 Classification of Industrial Fluid Lubricants by Viscosity System

D 2425 Test Method for Hydrocarbon Types in Middle Distillates by Mass Spectrometry

D 2500 Test Method for Cloud Point of Petroleum Products

D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter

D 4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectroscopy

D 4485 Specification for Performance of Engine Oils

D 4863 Test Method for Determination of Lubricity of Two-Stroke-Cycle Gasoline Engine Lubricants

D 5302 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation and Wear in a Spark-Ignition Internal Combustion Engine Fueled with Gasoline and Operated Under Low-Temperature, Light-Duty Conditions[4]

D 5844 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Rusting (Sequence IID)[4]

D 5862 Test Method for Evaluation of Engine Oils in the Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine

D 6202 Test Method for Automotive Engine Oils on the Fuel Economy of Passenger Cars and Light-Duty Trucks in the Sequence VIA Spark Ignition Engine

E 344 Terminology Relating to Thermometry and Hydrometry

2.2 *SAE Standard:*[5]

SAE J304 Engine Oil Tests

2.3 *Military Standard:*[6]

MIL-PRF-2104 Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service

[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.

[4] Withdrawn.

[5] Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

[6] Available from Standardization Documents Order Desk, Building 4, Section D, 700 Robbins Avenue, Philadelphia, PA 19111-5904, Attn: NPODS.

3. Terminology

3.1 *Definitions:*

3.1.1 *calibrate*, *v*—to determine the indication or output of a measuring device with respect to that of a standard. **E 344**

3.1.2 *candidate oil*, *n*—an oil that is intended to have the performance characteristics necessary to satisfy a specification and is tested against that specification. **D 5844**

3.1.3 *clogging*, *n*—the restriction of a flow path due to the accumulation of material along the flow path boundaries. **D 5844**

3.1.4 *engine oil*, *n*—a liquid that reduces friction or wear, or both, between the moving parts within an engine; removes heat, particularly from the underside of pistons; and serves as a combustion gas sealant for the piston rings. **D 5862**

3.1.4.1 *Discussion*—It may contain additives to enhance certain properties. Inhibition of engine rusting, deposit formation, valve train wear, oil oxidation, and foaming are examples.

3.1.5 *non-reference oil*, *n*—any oil other than a reference oil: such as a research formulation, commercial oil, or candidate oil. **D 5844**

3.1.6 *purchaser*, *n—of an ASTM test*, a person or organization that pays for the conduct of an ASTM test method on a specified product. **D 6202**

3.1.6.1 *Discussion*—The preferred term is *purchaser*. Deprecated terms that have been used are *client*, *requester*, *sponsor*, and *customer*.

3.1.7 *reference oil*, *n*—an oil of known performance characteristics, used as a basis for comparison **D 5844**

3.1.7.1 *Discussion*—Reference oils are used to calibrate testing facilities, to compare the performance of other oils, or to evaluate other materials (such as seals) that interact with oils.

3.1.8 *scuffing*, *n—in lubrication*, damage caused by instantaneous localized welding between surfaces in relative motion that does not result in immobilization of the parts. **D 4863**

3.1.9 *wear*, *n*—the loss of material from, or relocation of material on, a surface. **D 5302**

3.1.9.1 *Discussion*—Wear generally occurs between two surfaces moving relative to each other and is the result of mechanical or chemical action or by a combination of mechanical and chemical actions.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibration test*, *n*—an engine test conducted on a reference oil under carefully prescribed conditions whose result is used to determine the suitability of the engine stand/laboratory to conduct such tests on non-reference oils.

3.2.1.1 *Discussion*—In this test method, it can also refer to tests conducted on parts to ensure their suitability for use in reference or non-reference tests.

3.2.2 *test*, *n*—any test time accumulated in accordance with this test method.

4. Summary of Test Method

4.1 Prior to each test run, the power section of the engine (excluding piston assembly) is completely disassembled, solvent-cleaned, measured, and rebuilt in strict accordance with furnished specifications. A new piston, piston ring assembly, and cylinder liner are installed each test. The engine crankcase is solvent-cleaned, and worn or defective parts are replaced. The test stand is equipped with appropriate accessories for controlling speed, fuel rate, and various engine operating conditions. A suitable system for supercharging the engine with humidified and heated air shall also be provided.

4.2 Test operation involves the control of the supercharged, single-cylinder diesel test engine for a total of 120 h at a fixed speed and fuel rate, using the test oil as a lubricant. A 1 h engine break-in precedes each test. At the conclusion of the test, the piston, rings, and cylinder liner are examined. Note the degree of cylinder liner and piston ring wear, the amount and nature of piston deposits present, and whether any rings are stuck.

5. Significance and Use

5.1 The test method is designed to relate to high-speed, supercharged diesel engine operation and, in particular, to the deposit control characteristics and antiwear properties of diesel crankcase lubricating oils.

5.2 The test method is useful for the evaluation of diesel engine oil quality and crankcase oil specification acceptance. This test method, along with others, defines the minimum performance level of the API categories CF and CF-2 (detailed information about passing limits for these categories is included in Specification D 4485). It is also used in MIL-PRF-2104.

5.3 The results are significant only when *all details* of the procedure are followed. The basic engine used in this test method has a precombustion chamber (as compared to direct injection) and is most useful in predicting performance of engines similarly equipped. This factor should be considered when extrapolating test results. It has been found useful in predicting results with high sulfur fuels (that is, greater than 0.5 wt %) and with certain preemission controlled engines. It has also been found useful when correlated with deposit control in two-stroke cycle diesel engines.

6. Apparatus

6.1 *Test Engine*—A single-cylinder Caterpillar diesel oil test engine having a 2.2 L (134.1 in.^{3}) displacement is required. Bore and stroke are 13.0 cm (5.125 in.) and 16.5 cm (6.5 in.) respectively. The engine arrangement is shown in Fig. A1.1. The supply of test engines and parts is discussed in 6.22. The engine is equipped with the accessories or equipment listed in 6.2 through 6.24.

6.2 *Air Pressure*—Use a supercharging blower or other device arranged to control air pressure.

6.3 *Air Intake System*—Use the 1Y38 surge chamber and the air heater mechanism (see Annex A1) or its equivalent.

6.4 *Humidity*—Use a system to control humidity to the specified test conditions.

6.5 *Cooling System*—Use a closed, pressurized, circulating cooling system having an engine-driven centrifugal water pump.

6.6 *Speed/Load Controls*—Use a dynamometer or suitable loading device to control engine speed and measure load.

6.7 *Starting*—Use a suitable starting arrangement capable of 420 N·m (310 lbf·ft) breakaway and 373 N·m (275 lbf·ft) sustained torque at approximately 200 r/min.

6.8 *Exhaust System*—Use an exhaust system using piping and an exhaust barrel as specified in Annex A1. A restriction valve down stream of the barrel maintains the exhaust gases at a given back pressure as specified in the test conditions.

6.9 *Data Acquisition*—Configure all stands to acquire data automatically for speed, fuel flow, intake air pressure, intake air temperature, coolant temperature, oil-to-bearing temperature, and oil-to-jet pressure (as a minimum) with closed loop control on speed, intake air temperature, coolant temperature, and oil-to-bearing temperature (as a minimum).

6.10 *Cylinder Head and Cylinder Assemblies*—Only cylinder head and cylinder assemblies that have previously passed a calibration test are acceptable for non-reference testing.

6.11 *Piston Cooling Nozzle*:

6.11.1 *Oil Jet Pressure Measurement*—The following is required to allow for measurement of the piston cooling nozzle pressure:

6.11.1.1 Replace the 3B9407 fitting with a ¼ in. tee fitting, and reconnect the 1Y6 oil line.

6.11.1.2 Modify the 1Y8199 oil pan to provide access for the pressure pickup.

6.11.1.3 Use oil pressure gage 8M2743, or equivalent.

6.11.1.4 Only piston cooling jets that have been flow-checked by the specified industry standard are approved for use. See footnote 11 for supplier. Fig. A1.2 shows the suggested modification of the 1Y8199 oil pan and necessary hardware for the cooling nozzle pressure pickup. All test engines with serial numbers greater than 2511252 will be provided with the pressure pickup modification.

6.11.2 *Piston Cooling Jet Supplier*—To improve precision, Perkin Elmer Automotive Research and Southwest Research Institute (SWRI) have agreed to provide flow-checked 1M-PC P-tubes to the industry. Perkin Elmer Automotive Research will flow and serialize the units and determine if they are within specification and will maintain records, while SWRI will coordinate the redistribution. Send P-tubes to be inspected to Perkin Elmer Automotive Research.[7]

6.11.2.1 The P-tubes will be flowed, using EF-411 oil at 37.8 ± 0.6°C (100 ± 1°F) and 165.5 ± 0.5 kPa (24 ± 0.5 psi) as measured at the location shown in Fig. A1.2. The acceptable flow range is 1.89 to 2.27 L/min (0.50 to 0.60 gal/min).

6.11.2.2 To maintain impartiality in selecting P-tubes, only acceptable assemblies will be forwarded to SWRI as unmarked units. These units will be randomly selected for redistribution. In cases in which the only units available are from a single order, only those units will be returned. Assemblies that fall outside of the specifications will not be returned. Instead, Perkin Elmer Automotive Research will generate a nonconformance report with an additional copy to be sent to the laboratory that supplied the P-tube. The failed units will be returned to Caterpillar for credit. Perkin Elmer Automotive Research will indicate on the nonconformance report that the appropriate credit be issued to the originating laboratory. Additional piston cooling assemblies will need to be supplied by the requesting laboratory and submitted to Perkin Elmer Automotive Research.

6.11.2.3 Perkin Elmer Automotive Research will enclose a statement with each unit inspected, disclaiming any liability for subsequent performance of the part. No attempt will be made to ensure that the tubing is properly configured or that any other physical property makes it suitable for use. Units damaged during shipment will not be tested, unless specifically requested. Include a packing list and separate purchase orders to Perkin Elmer Automotive Research and SWRI[8] with each shipment. Please specify a name and address where the parts are to be returned.

6.12 *Engine Oil Level Gage*—Lower the bayonet gage housing 5 cm (2.0 in.) to provide for more accurate oil level readings. Parts required for this modification are shown in Fig. A1.3.

6.13 *Crankcase Pressure Control Valve*—Install a pressure control valve (1Y479) at the crankcase breather outlet to stabilize crankcase pressure. Installation is shown in Fig A1.4.

6.14 *Oil Cooler Inlet Temperature*—Record the temperature of the oil cooler inlet by installing a thermocouple in the pipe-tapped hole provided on the rear side of the oil-cooler cover adjacent to the oil inlet port. Care should be taken to provide sufficient thermocouple insertion depth to provide a mid-stream oil temperature.

6.15 *Engine Oil System*—Use the *last chance* screen 1Y3549. Modify the oil pump as shown in Fig. A1.10. Add the external oil pump bypass line for safety and convenience factors to adjust oil pressure on engine break-in and warm-up.

6.16 *Cooling System*—Replace the 7.6 cm (3 in.) standard cooling tower with the 12.7 cm (5 in.) pressurized cooling tower as shown in Fig. A1.6. Modify the cooling system to accommodate the pressurized cooling tower, bypass flow control and flow meter as shown in Fig. A1.7 and Fig A1.8. Use a Barco Venturi Meter #BR 12705-16-31.[9,10] Use brass or stainless steel pipe that has chamfered ends (45°) into and out of the venturi meter [15.2 cm (6 in.) minimum into and 5.1 cm (2 in.) minimum out]. Orient the high pressure tap (the first seen by the flow) horizontally.

6.17 *Fuel System*—Use a standardized engine fuel system to ensure that fuel-line pressure transients are held to acceptable values and to minimize cranking times. Use a Micro Motion[10,11] flow meter having a range no greater than 0-90.7 kg/h (0-200 lb/h) to measure fuel flow rate.

6.17.1 The line lengths, line sizes, and fuel system components are shown in Fig. A1.5. Use this system without modification, with the possible exception that the fuel shut-off

[7] Send P-tubes to be inspected to Perkin Elmer Automotive Research, 5404 Bandera Road, San Antonio, TX 78238.

[8] Southwest Research Institute, 6220 Culebra Road, P.O. Drawer 28510, San Antonio, TX 78228-0510.

[9] Available from J. P. Bushnell, 3436 Lindell Blvd., St. Louis, MO.

[10] The sole source of supply of the apparatus known to the committee at this time is noted in the adjoining footnote. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible tecnical committee,[1] which you may attend.

[11] Available from Micro Motion, Inc., 7070 Winchester Circle, Boulder, CO 80301.