Designation: D7549 – 23

Standard Test Method for Evaluation of Heavy-Duty Engine Oils under High Output Conditions—Caterpillar C13 Test Procedure[1]

This standard is issued under the fixed designation D7549; 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

Any properly equipped laboratory, without outside assistance, can use the test procedure described in this test method. The ASTM Test Monitoring Center (TMC)[2] provides calibration and an assessment of the test results obtained on those oils by the laboratory. By this means the laboratory will know whether its use of the test method gives results statistically similar to those obtained by other laboratories. Furthermore, various agencies require that a laboratory utilizes the TMC services in seeking qualification of oils against specifications. For example, the U.S. Army has such a requirement in some of its engine oil specifications. Accordingly, this test method is written for those laboratories that use the TMC services. Laboratories that choose not to use these services should ignore those portions of the test method that refer to the TMC. Information letters[2] issued periodically by the TMC may modify this test method. In addition the TMC may issue supplementary memoranda related to the test method.

ASTM International policy is to encourage the development of test procedures based on generic equipment. It is recognized that there are occasions where critical/sole-source equipment has been approved by the technical committee (surveillance panel/task force) and is required by the test procedure. The technical committee that oversees the test procedure is encouraged to clearly identify if the part is considered critical in the test procedure. If a part is deemed to be critical, ASTM encourages alternative suppliers to be given the opportunity for consideration of supplying the critical part/component providing they meet the approval process set forth by the technical committee.

An alternative supplier can start the process by initiating contact with the technical committee (current chairs shown on ASTM TMC website). The supplier should advise on the details of the part that is intended to be supplied. The technical committee will review the request and determine feasibility of an alternative supplier for the requested replacement critical part. In the event that a replacement critical part has been identified and proven equivalent, the sole-source supplier footnote shall be removed from the test procedure.

1. Scope*

1.1 The test method covers a heavy-duty engine test procedure under high output conditions to evaluate engine oil performance with regard to piston deposit formation, piston ring sticking and oil consumption control in a combustion environment designed to minimize exhaust emissions. This test method is commonly referred to as the Caterpillar C13 Heavy-Duty Engine Oil Test.[3]

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.2.1 *Exceptions*—Where there are no SI equivalent such as screw threads, National Pipe Treads (NPT), and tubing sizes.

[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.B0 on Automotive Lubricants.

Current edition approved July 1, 2023. Published July 2023. Originally published in 2009. Last previous edition approved in 2021 as D7549 – 21. DOI: 10.1520/D7549-23.

[2] The ASTM Test Monitoring Center will update changes in this test method by means of Information Letters. This edition includes all information letters through No. 23-1. Information Letters may be obtained by from the ASTM Test Monitoring Center, 203 Armstrong Drive, Freeport, PA 16229, Attention: Director.

[3] Caterpillar Inc., Engine System Technology Development, PO Box 610, Mossville, IL 61552-0610.

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

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* See Annex A1 for general safety precautions.

1.4 *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]

D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure

D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester

D97 Test Method for Pour Point of Petroleum Products

D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

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

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D482 Test Method for Ash from Petroleum Products

D524 Test Method for Ramsbottom Carbon Residue of Petroleum Products

D613 Test Method for Cetane Number of Diesel Fuel Oil

D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D975 Specification for Diesel Fuel

D976 Test Method for Calculated Cetane Index of Distillate Fuels

D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption

D2274 Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)

D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry

D2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge

D3524 Test Method for Diesel Fuel Diluent in Used Diesel Engine Oils by Gas Chromatography

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

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

D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry

D4739 Test Method for Base Number Determination by Potentiometric Hydrochloric Acid Titration

D5185 Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

D5186 Test Method for Determination of the Aromatic Content and Polynuclear Aromatic Content of Diesel Fuels By Supercritical Fluid Chromatography

D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence

D5967 Test Method for Evaluation of Diesel Engine Oils in T-8 Diesel Engine

D6078 Test Method for Evaluating Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator (SLBOCLE) (Withdrawn 2021)[5]

D6681 Test Method for Evaluation of Engine Oils in a High Speed, Single-Cylinder Diesel Engine—Caterpillar 1P Test Procedure

D6987/D6987M Test Method for Evaluation of Diesel Engine Oils in T-10 Exhaust Gas Recirculation Diesel Engine (Withdrawn 2022)[5]

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E178 Practice for Dealing With Outlying Observations

2.2 *Other ASTM Document:*

ASTM Deposit Rating Manual 20 (formerly CRC Manual 20)[6]

3. Terminology

3.1 *Definitions:*

3.1.1 *blind reference oil, n*—a reference oil, the identity of which is unknown by the test facility.

3.1.1.1 *Discussion*—This is a coded reference oil that is submitted by a source independent of the test facility. **D4175**

3.1.2 *blowby, n—in internal combustion engines*, the combustion products and unburned air-and-fuel mixture that enter the crankcase. **D4175**

3.1.3 *calibrate, v*—to determine the indication or output of a measuring device with respect to that of a standard. **D4175**

3.1.4 *heavy duty, adj—in internal combustion engine operation*, characterized by average speeds, power output, and internal temperatures that are close to the potential maximums. **D4175**

3.1.5 *heavy-duty engine, n—in internal combustion engine types*, one that is designed to allow operation continuous at or close to its peak output.

3.1.5.1 *Discussion*—This type of engine is typically installed in large trucks and buses as well as farm, industrial, and construction equipment. **D4175**

[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.

[5] The last approved version of this historical standard is referenced on www.astm.org.

[6] For Stock #TMCMNL20, visit the ASTM website, www.astm.org, or contact ASTM International Customer Service at service@astm.org.

3.1.6 *non-reference oil, n*—any oil other than a reference oil, such as a research formulation, commercial oil, or candidate oil. **D4175**

3.1.7 *non-standard test, n*—a test that is not conducted in conformance with the requirements in the standard test method, such running on an uncalibrated test stand, using different test equipment, applying different equipment assembly procedures, or using modified operating conditions. **D4175**

3.1.8 *reference oil, n*—an oil of known performance characteristics, used as a basis for comparison.

3.1.8.1 *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. **D4175**

3.1.9 *test oil, n*—any oil subjected to evaluation in an established procedure.

3.1.9.1 *Discussion*—It can be any oil selected by the laboratory conducting the test. It could be an experimental product or a commercially available oil. Often, it is an oil that is a candidate for approval against engine oil specifications (such as manufacturers' or military specifications, and so forth). **D4175**

3.1.10 *wear, n*—the loss of material from a surface, generally occurring between two surfaces in relative motion, and resulting from mechanical or chemical action or a combination of both.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *overhead, n—in internal combustion engines*, the components of the valve train located in or above the cylinder head.

3.2.2 *tote, n*—a container, smaller in capacity than a gallon.

3.2.3 *valve train, n—in internal combustion engines*, the series of components, such as valves, crossheads, rocker arms, push rods and camshaft that open and close the intake and exhaust valves.

3.3 *Abbreviations and Acronyms:*

3.3.1 *ACERT*—Advanced Combustion Emission Reduction Technology

3.3.2 *ATGC*—average top groove carbon

3.3.3 *ATGCO*—average top groove carbon offset

3.3.4 *CARB*—California Air Resources Board

3.3.5 *CAT*—acronym for Caterpillar

3.3.6 *CRC*—Coordinating Research Council

3.3.7 *DACA*—Data Acquisition and Control Automation

3.3.8 *ECM*—engine control module

3.3.9 *EOT*—end of test

3.3.10 *HC*—heavy carbon

3.3.11 *IMP*—intake manifold pressure

3.3.12 *LC*—light carbon

3.3.13 *LTMS*—Lubricant Test Monitoring System

3.3.14 *MC*—medium carbon

3.3.15 *NPT*—National Pipe Thread

3.3.16 *OC*—oil consumption

3.3.17 *P/N*—part number

3.3.18 *QI*—quality index

3.3.19 *RPTGC*—reference relative top groove carbon profile

3.3.20 *SDTGCO*—standard deviation top groove carbon outlier

3.3.21 *TGC*—top groove carbon

3.3.22 *ULSD*—ultra low sulfur diesel

4. Summary of Test Method

4.1 This test method uses a Caterpillar production C13 diesel engine (see Annex A3 for ordering information and list of engine build parts). Test operation includes a 60 min engine warm-up and break-in, followed by a 4 h cool down and valve lash adjustment. After the valve lash adjustment and any other needed adjustments, a 500 h test is begun. The engine is operated under steady-state, rated-power conditions known to generate excessive piston deposits or oil consumption or both in field service. Report the total engine oil consumption as the sum of the measured volumes in 50 h increments.

4.2 Equip the test stand with the appropriate instrumentation to control engine speed, fuel flow, and other operating parameters.

4.3 Determine the engine oil performance by assessing piston deposits and ring sticking, and oil consumption.

4.3.1 Prior to each test, clean and assemble the engine with new cylinder liners, pistons, piston rings, bearings and certain valve train components. All aspects of the assembly are specified. After the test, dismantle the engine and examine and rate the parts.

4.3.2 A sample of engine oil is removed and an oil addition is made at the end of each 50 h period. The volume of the oil addition is the sum of the volume of sample plus the volume of oil consumed by the engine.

5. Significance and Use

5.1 This test method assesses the performance of an engine oil with respect to control of piston deposits and maintenance of oil consumption under heavy-duty operating conditions selected to accelerate deposit formation in a turbocharged, intercooled four-stroke-cycle diesel engine equipped with a combustion system that minimizes federally controlled exhaust gas emissions.

5.2 The results from this test method may be compared against specification requirements to ascertain acceptance.

5.3 The design of the test engine used in this test method is representative of many, but not all, diesel engines. This factor, along with the accelerated operating conditions, needs to be considered when comparing test results against specification requirements.

6. Apparatus

6.1 *Test Engine Configuration:*

6.1.1 *Test Engine*—The test engine is a production 2004 Caterpillar 320 kW C13 engine, designed for heavy duty