



Designation: D7422 – 22

Standard Test Method for Evaluation of Diesel Engine Oils in T-12 Exhaust Gas Recirculation Diesel Engine¹

This standard is issued under the fixed designation D7422; 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 an engine test procedure for evaluating diesel engine oils for performance characteristics, including lead corrosion and wear of piston rings and cylinder liners in an engine equipped with exhaust gas recirculation and running on ultra-low sulfur diesel fuel.² This test method is commonly referred to as the Mack T-12.

1.1.1 This test method also provides the procedure for running an abbreviated length test, which is commonly referred to as the T-12A. The procedures for the T-12 and T-12A are identical with the exception of the items specifically listed in **Annex A9**. Additionally, the procedure modifications listed in **Annex A9** refer to the corresponding section of the T-12 procedure.

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 *Exception*—Where there is no direct SI equivalent, such as the units for screw threads, National Pipe Threads/diameters, tubing size, and single source supply equipment specifications.

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 A6** for specific 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 Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:³

- 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)
- D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)
- 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
- 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)
- D2500 Test Method for Cloud Point of Petroleum Products and Liquid Fuels
- 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

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.

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² The ASTM Test Monitoring Center will update changes in this test method by means of Information Letters. Information letters may be obtained from the ASTM Test Monitoring Center, 203 Armstrong Drive, Freeport, PA 16229, www.astmtmc.org, Attention: Director. This edition incorporates revisions in all Information Letters through No. 21-1.

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.

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

- D3338 Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
- 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
- D4485 Specification for Performance of Active API Service Category Engine Oils
- 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)⁴
- D6896 Test Method for Determination of Yield Stress and Apparent Viscosity of Used Engine Oils at Low Temperature
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E178 Practice for Dealing With Outlying Observations
- 2.2 *National Archives and Records Administration*.⁵
Code of Federal Regulations Title 40 Part 86.310-79

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 from the test facility. **D4175**
- 3.1.2 *blowby*, *n*—*in internal combustion engines*, that portion of the combustion products and unburned air/fuel mixture that leaks past piston rings into the engine crankcase during operation.
- 3.1.3 *calibrate*, *v*—to determine the indication or output of a device (for example, thermometer, manometer, engine) with respect to that of a standard.
- 3.1.4 *candidate oil*, *n*—an oil that is intended to have the performance characteristics necessary to satisfy a specification and is intended to be tested against that specification. **D4175**

⁴ The last approved version of this historical standard is referenced on www.astm.org.

⁵ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

3.1.5 *exhaust gas recirculation (EGR)*, *n*—the mixing of exhaust gas with intake air to reduce the formation of nitrogen oxides (NO_x). **D4175**

3.1.6 *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**

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

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

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

3.1.10 *oxidation*, *n*—*of engine oil*, the reaction of the oil with an electron acceptor, generally oxygen, that can produce deleterious acidic or resinous materials often manifested as sludge formation, varnish formation, viscosity increase, or corrosion, or combination thereof.

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

3.1.11.1 *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**

3.1.12 *sludge*, *n*—*in internal combustion engines*, a deposit, principally composed of insoluble resins and oxidation products from fuel combustion and the lubricant, that does not drain from engine parts but can be removed by wiping with a cloth. **D4175**

3.1.13 *standard test*, *n*—a test on a calibrated test stand, using the prescribed equipment in accordance with the requirements in the test method, and conducted in accordance with the specified operating conditions.

3.1.14 *test parameter*, *n*—a specified component, property, or condition of a test procedure.

3.1.14.1 *Discussion*—Examples of *components* are fuel, lubricant, reagent, cleaner, and sealer; of *properties* are density, temperature, humidity, pressure, and viscosity; and of *conditions* are flow rate, time, speed, volume, length, and power. **D4175**

3.1.15 *varnish*, *n*—*in internal combustion engines*, a hard, dry, generally lustrous deposit that can be removed by solvents but not by wiping with a cloth. **D4175**

3.1.16 *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. **D4175**

4. Summary of Test Method

4.1 The test operation involves use of a Mack E-TECH V-MAC III diesel engine with Exhaust Gas Recirculation

(EGR). A warm-up and a 1 h break-in are followed by a two-phase test consisting of 100 h at 1800 r/min and 200 h at 1200 r/min, both at constant speed and load.

4.2 Take oil samples periodically and analyze for viscosity increase and wear metals content.

4.3 Rebuild the engine prior to each test. Disassemble, solvent-clean, measure, and rebuild, the engine power section using all new pistons, rings, cylinder liners, and connecting rod bearings, in strict accordance with furnished specifications.

4.4 Solvent-clean the engine crankcase and replace worn or defective parts.

4.5 Equip the test stand with appropriate accessories for controlling speed, torque, and various engine operating conditions.

5. Significance and Use

5.1 This test method was developed to evaluate the wear performance of engine oils in turbocharged and intercooled four-cycle diesel engines equipped with EGR and running on ultra-low sulfur diesel fuel. Obtain results from used oil analysis and component measurements before and after test.

5.2 The test method may be used for engine oil specification acceptance when all details of the procedure are followed.

6. Apparatus

6.1 General Description:

6.1.1 The test engine is a Mack E-TECH V-MAC III, electronically controlled fuel injection with six electronic unit pumps, using 2002 cylinder heads, P/N 11GBA81025 ([Annex A2](#)). It is an open-chamber, in-line, six-cylinder, four-stroke, turbocharged, charge air-cooled, and compression ignition engine. The bore and stroke are 124 mm by 165 mm, and the displacement is 12 L.

6.1.2 The ambient laboratory atmosphere shall be relatively free of dirt and other contaminants as required by good laboratory standards. Filtering air, controlling temperature, and controlling humidity in the engine buildup area helps prevent accumulation of dirt and other contaminants on engine parts and aids in measuring and selecting parts for assembly.

6.2 Test Engine:

6.2.1 *Mack T-12 Test Engine*—The engine is available from Mack Trucks, Inc. A complete parts list is shown in [Table A2.1](#). Use test parts on a first-in/first-out basis.

6.2.2 Engine Cooling System:

6.2.2.1 Use a new Mack coolant conditioner shown in [Table A2.1](#), every test, to limit scaling in the cooling system. Pressurize the system at the expansion tank to 103 kPa. Use the coolant described in [7.3.1](#).

6.2.2.2 Use a closed-loop, pressurized external engine cooling system composed of a nonferrous core heat exchanger, reservoir, and water-out temperature control valve. The system shall prevent air entrainment and control jacket temperatures within the specified limit. Install a sight glass between the engine and the cooling tower to check for air entrainment and uniform flow in an effort to observe and prevent localized boiling. Block the thermostat wide open.

6.2.2.3 Use a closed-loop, pressurized external EGR cooling system composed of a nonferrous core heat exchanger, reservoir, and coolant-out temperature control valve. The system shall prevent air entrainment and control jacket temperatures within the specified limit. Install a sight glass between the EGR coolers and the cooling tower to check for air entrainment and uniform flow in an effort to observe and prevent localized boiling. The coolant flow direction is to be parallel (concurrent) with the EGR gas flow. Every reasonable attempt should be made to ensure that the EGR temperatures leaving the coolers are very similar. [Fig. A1.3](#) shows the coolant flow to and from the EGR coolers, respectively.

6.2.3 Auxiliary Oil System:

6.2.3.1 To maintain a constant oil level in the pan, provide an additional 9.5 L sump by using a separate closed tank connected to the sump. Circulate oil through the tank with an auxiliary pump. The system schematic is shown in [Fig. A1.1](#). The supply line to the tank from the sump is to have an inside diameter of 13 mm. The return line from the tank to the sump is to have an inside diameter of 10 mm. Use a vent line with a minimum inside diameter of 13 mm.

6.2.3.2 Locate the auxiliary oil system suction line on the exhaust side of the oil pan, down from the oil pan rail 127 mm, and back from the front of the pan 178 mm. This location is directly above the oil sump temperature thermocouple. Refer to [Fig. A1.4](#). Connect the auxiliary oil system return line to the power steering pump cover on the front timing gear cover. Refer to [Fig. A1.5](#). Connect the auxiliary oil scale vent line to the top of the auxiliary oil sump bucket and the dipstick tube opening.

6.2.3.3 Use Viking Pump Model SG053514 as the auxiliary oil pumps. Pump speed is specified as 1725 r/min.⁶

6.2.4 Oil Cooling System:

6.2.4.1 Use the oil cooler adapter blocks to mount the oil cooler to the engine. The adapter blocks are available from the supplier list in [A2.6](#).

6.2.4.2 Use the oil filter housing (part number 27GB525M) shown in [Fig. A1.8](#).

6.2.5 *Blowby Meter*—Use a meter capable of providing data at a minimum frequency of 6 min. To prevent blowby condensate from draining back into the engine, ensure the blowby line has a downward slope to a collection bucket. Ensure the collection bucket has a minimum volume of 18.9 L. Locate the blowby meter downstream of the collection bucket. The slope of the blowby line downstream of the collection bucket is unspecified.

6.2.6 *Air Supply and Filtration*—Use the Mack air filter element and the Mack filter housing shown in [A2.3](#). Replace filter cartridge when ΔP of 2.5 kPa is reached. Install an adjustable valve (flapper) in the inlet air system at least two pipe diameters before any temperature, pressure and humidity

⁶ The sole source of supply of the apparatus known to the committee at this time is Viking Pump, Inc., a unit of IDEX Corporation, 406 State Street, P.O. Box 8, Cedar Falls, IA 50613-0008. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.