Designation: D8447 – 22ε1

Standard Test Method for Determination of Turbo Charger Deposits by Thermo-Oxidation Engine Oil Simulation Test[1]

This standard is issued under the fixed designation D8447; 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.

ε[1] NOTE—Editorially corrected 1.1 in May 2022.

1. Scope

1.1 This test method covers the procedure to determine the amount of deposits formed by automotive engine oils utilizing the thermo-oxidation engine oil simulation test (TEOST[2]).[3] The range and applicability of the TEOST Turbo[2] test method as derived from an interlaboratory study is approximately 5 mg to 90 mg. However, experience indicates that deposit levels of up to 150 mg or greater can be obtained.

1.2 This test method uses a patented instrument, method and patented, numbered, and registered depositor rods traceable to the manufacturer[4] and made specifically for the practice and precision of the test method.

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

1.3.1 Milligrams (mg), grams (g), milliliters (mL), and liters (L) are the units provided because they are an industry accepted standard.

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.*

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. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *ceramic isolator, n*—the fitting that compresses the O-ring into the depositor rod casing and isolates the depositor rod casing from the voltage applied to the depositor rod.

2.1.2 *depositor rod*[4], *n*—a patented, specially made, numbered, and registered steel rod (used once for each test) on which the deposits are collected; it is resistively heated and controlled by a thermocouple inserted to a pre-determined depth in the hollow rod.

2.1.3 *drain tube, n*—the tube connecting the lower end cap of the glass mantle to the reactor chamber.

2.1.4 *end cap, n*—the fitting used to tighten the ceramic isolators onto the O-rings at both ends of the glass mantle.

2.1.5 *filter deposits, n*—the mass in milligrams of the deposits collected after test on a special multi-layer filter cartridge used once for each test.

2.1.6 *glass mantle, n*—the glass sleeve that surrounds the depositor rod.

2.1.7 *pump, n*—the gear pump that is used to control the flow rate of the test oil through the depositor rod casing.

2.1.8 *pump inlet tube, n*—the tube connecting the reactor chamber to the pump.

2.1.9 *pump outlet tube, n*—the tube connecting the pump to the glass mantle.

2.1.10 *reactor chamber, n*—the heated reservoir that contains the 20 mL test oil sample circulated past the deposit rod during the test; the reactor is equipped with a magnetic stir-bar to continuously mix the chamber contents.

2.1.11 *rod deposits, n*—the mass, in milligrams, of the deposits collected on the depositor rod.

2.1.12 *rod O-rings, n*—the O-rings that seal the outside of the rod and the depositor rod casing to prevent sample leaks.

[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 D02.09 on Oxidation of Lubricants.

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[2] TEOST and TEOST Turbo are registered trademarks of the Tannas Co., 4800 James Savage Rd., Midland, MI 48642.

[3] The Development of Thermo-Oxidation Engine Oil Simulation Test (TEOST), Society of Automotive Engineers (SAE No. 932837), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

[4] The sole source of supply of the item known to the committee at this time is Tannas Co., 4800 James Savage Rd., Midland, MI 48642. 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, which you may attend.

2.1.13 *thermocouple lock collar, n*—a fitting that tightens on the thermocouple to ensure the thermocouple is at the correct depth when placed inside the rod.

2.1.14 *total deposits, n*—the rod deposits plus the filter deposits.

3. Summary of Test Method

3.1 To a 30 mL aliquot of engine oil, 0.44 g of 6 % ferric naphthenate catalyst are added then stirred for 10 min. The catalyzed test oil is then transferred to the reactor chamber set to a temperature of 100 °C and 10 mL catalyzed oil is used to flush the pump. This catalyzed oil is pumped over a tared depositor rod that is resistively heated to 290 °C for 18 h with a 1.5 min pre-programmed thermal spike to 320 °C. When the temperature program is complete, the depositor rod is rinsed of oil residue and dried, and the gross rod mass obtained. The remaining test oil sample, including the remaining washes from the deposit rod, is flushed from the system and filtered through a tared filter. The mass of deposits on the rod plus the mass of deposits on the filter is recorded as the total deposit mass.

4. Significance and Use

4.1 The test method is designed to predict the elevated temperature deposit forming tendencies of an engine oil subject to the added oxidizing stress of a turbocharger. This test method can be used to screen oil samples or as a quality assurance tool.

5. Apparatus

5.1 *Thermo-oxidation Engine Oil Simulation Test (TEOST) Turbo Test Instrument*[4]—See Fig. 1.

5.2 *Balance,* capable of weighing to the nearest 0.1 mg.

5.3 *Vacuum Source,* floor model or house.

5.4 *Magnetic stirrer and stir bars.*

5.5 *Digital timer.*

5.6 *Petroleum and temperature resistant O-rings.*

5.7 *Ceramic isolators.*

5.8 *End-cap, Upper,* holds the upper end of the glass mantle and depositor rod in place and allows air and oil to enter the deposit-forming zone separately.

5.9 *End-cap, Lower,* holds the lower end of the glass mantle and depositor rod in place and provides an outlet for the oil to pass into the sample flask and subsequently to the recirculating pump inlet tubing.

5.10 *Glass Mantle*—The glass casing that surrounds the depositor rod and promotes condensation of the oil.

5.11 *Filtering Flask,* 1000 mL.

5.12 *Graduated Filter Funnel,* 500 mL with Luer lock fitting.

5.13 *Beaker,* large enough to clean the depositor rod casing (for example, 600 mL).

5.14 *Graduated Cylinder,* 10 mL.

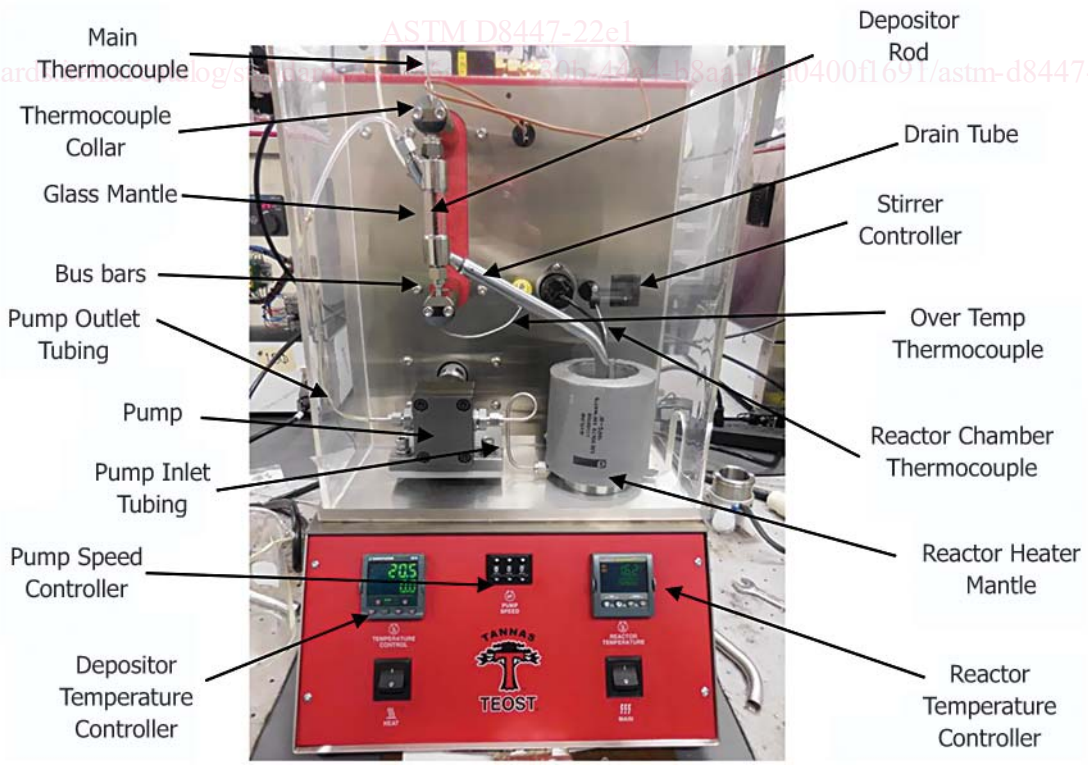

FIG. 1 Thermo-oxidation Engine Oil Simulation (TEOST) Turbo Test Apparatus

5.15 *Adjustable hex wrench.*

5.16 *Pipe cleaners,* 3 mm × 304.8 mm.

5.17 *Steel Wool,* 4/0 (ultra-fine).

5.18 *Glass Syringe,* 100 µL.

5.19 *One-piece disposable multi-layer cartridge filters*[4].

5.20 *Flow Meters,* capable of measuring 0 mL⁄min to 10 mL⁄min of gas.

5.21 *Weighing Boat*—Light, circular or oblong open container, preferably made of aluminum with a diameter or length of approximately 7 cm to 10 cm and notched in two diametrically opposed places to prevent the rod from rolling or similar suitable weighing container to prevent rolling and the loss of deposits (see Fig. 2).

5.22 *Wire Rod*—A clean, thin (about 1 mm diameter), somewhat flexible, stainless steel wire rod (approximately 150 mm in length) for dislodging any deposits adhering to the filter funnel walls into the filter cartridge.

6. Reagents and Materials

6.1 *Moist Air*—Hydrocarbon-free air regulated to 10 mL⁄min ± 0.2 mL⁄min before entering the flow meter and then bubbled through approximately 30 mL of water in a small Erlenmeyer flask before entering the glass mantle.

6.2 *Ferric Naphthenate*—6 % iron content in mineral spirits.

6.3 *Cyclohexane, Heptane, or Other Alkane Hydrocarbon Solvent of Equivalent Volatility*—Reagent grade. (**Warning—** Flammable.) Cyclohexane is the only allowed naphthenic hydrocarbon. Do not use other naphthenic or any aromatic hydrocarbons. Throughout the further description of the test, the solvent selected is referred to as hydrocarbon solvent.

6.3.1 The volatility of the hydrocarbon solvent selected should ensure timely evaporation from the deposits on the rod and filter. In general, the higher the purity of the solvent, the more quickly the solvent should evaporate.

6.4 *Reference Oil—MDF Turbo* reference oil[4] is a petroleum oil capable of generating total deposits in the 20 mg to 30 mg range. The acceptable deposit range of a specific lot is provided by the supplier of that lot.

6.5 *Varnish Cleaning Liquid*—Used in cleaning varnish from mantle, end-caps, and other components of the equipment after test. Other glass cleaners with varnish removing capabilities also may be used.

6.6 *Combination Pump Calibration and Temperature Control Thermocouple Depth Setting Oil, TPC-1*[4]—A highly deposit-resistant oil used in setting pump calibration and temperature control calibration without forming significant deposits on the depositor rod during these calibrations.

7. Preparation of Apparatus

7.1 *Pump Speed Calibration*—The pump speed should be calibrated using the instructions found in the operations manual. It is recommended that this calibration be done every six months.

7.2 *Thermocouple Depth*—The thermocouple depth setting (distance from tip to locking collar) should be determined using the procedure in the operations manual. The depth setting should be checked daily and should be re-determined whenever a new thermocouple is installed.

7.3 *Thermocouple Calibration*—The thermocouple shall be calibrated every six months or when replaced. This can be done by placing the thermocouple into a liquid or sand bath while simultaneously measuring the temperature by a certified liquid or digital thermometer. The temperature controller shall then be offset to display the correct temperature.

7.4 *Flow Calibration*—Ensure the proper operation of the flow meters by connecting a digital flow meter to the output. The flow for the air shall be 10 mL⁄min ± 0.2 mL⁄min. Verify semiannually.

7.5 *PID Settings*—Consult the operations manual for further guidance.

7.6 Verify that the temperature program is set to 18 cycles consisting of 1 h at 290 °C followed by 1.5 min at 320 °C.

8. Assembly of Apparatus

8.1 Assemble the TEOST system by placing the reactor chamber on the disc within the drip tray.

8.2 Connect the pump inlet tube to the outlet connection of the reactor chamber and the inlet connection of the pump. Finger tighten the connections.

8.3 Connect the pump outlet tube to the outlet connection of the pump and place the open end of the pump outlet tube into a 10 mL graduated cylinder.

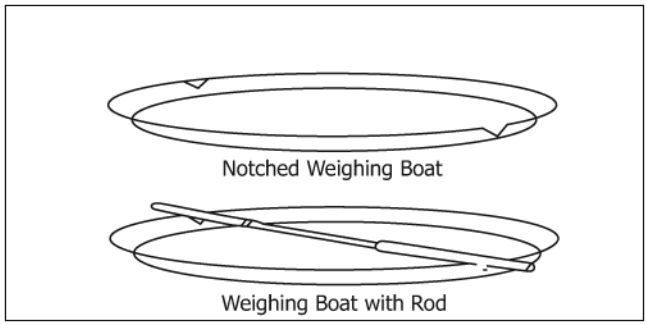

FIG. 2 Weighing Boat and Rod

8.4 On the main panel of the instrument, connect the thermocouples to the labeled connections, and plug in and twist the heater cable clockwise for proper connection. Use the reactor temperature controller to set the temperature of the reactor chamber to 100 °C.

9. Calibration and Standardization

9.1 The TEOST instrument is calibrated by performing the procedure described in Section 7. At that point, a reference oil shall be run. The results shall be within the repeatability limits established by the supplier of the reference oils.

9.2 The calibration should be performed a minimum of every six months, as recommended by the instrument manufacturer.

9.3 If the repeatability is not within the established limits, the instrument setup steps in Section 7 should be performed. Then the reference oil should be rerun.

10. Sample Preparation

10.1 After thoroughly mixing the test sample, use a graduated cylinder to measure 30 mL ± 1 mL of the fluid and pour it into a large beaker until only drips are coming from the graduated cylinder. Use a glass syringe to add 0.44 g ± 0.01 g of the 6 % ferric naphthenate solution to the 30 mL of test fluid. Use a magnetic bar and stirrer to mix the oil and ferric naphthenate for at least 5 min but not more than 15 min. Make certain that a vortex is not created.

10.2 After the stirring is completed, inspect the oil solution by holding it up to a light to make sure it is homogenous. If not, stir for additional 5 min increments until homogeneous.

11. Procedure

11.1 When the reactor chamber is 100 °C ± 5 °C, pour the test sample, along with the stirrer bar, into the reactor chamber. Using the speed control on the right side of the instrument, turn on the stirrer. The sample temperature should reach 100 °C in approximately 15 min.

11.2 Set the pump speed to 999, using the dial on the front panel of the instrument. Allow the pump to flush out 10 mL of fluid into the 10 mL graduated cylinder placed at the open end of the pump outlet tube. When flushing is complete, set the pump dial to 000 to stop the pump. Discard the 10 mL of oil.

11.3 Use hydrocarbon solvent to rinse off an unused rod, both on the outside and down the center. Rinse the rod with acetone inside and out. Using a pipe cleaner soaked in acetone, clean the interior of the rod. Repeat the interior cleaning with a clean pipe cleaner through the rod in the opposite direction. Dry the rod with a vacuum or blowing dry air while holding the rod between the thumb and index finger. Make sure to dry the center of the rod as well. Handle the rod as little as possible to avoid adding mass from oils on the skin and be sure not to set the rod down until after a mass is taken. Take extra care not to touch the center area of the rod where the deposits are formed.

11.4 Weigh the rod to 0.1 mg and record as the initial mass once the rod mass has come to equilibrium.

11.5 Inspect the bus bars to make sure they are clean. If not, clean the bus bars according to the operations manual. Secure the upper end cap and the lower end cap onto the clean glass mantle. Slide the pre-weighed depositor rod into the glass mantle assembly.

11.6 Place two Viton O-rings over each end of the depositor rod to the glass mantle, followed by the ceramic isolators. These O-rings need to be checked and replaced when worn out.

11.7 Start securing the end nuts, but do not tighten.

11.8 Align the rod in the glass mantle to ensure proper alignment with the bus bars. When this is achieved, the end nuts are finger-tightened. Connect the top end by placing the depositor rod into the indentation of the bus bar and swinging the cap over the depositor rod.

11.9 Place the glass mantle assembly vertically in the bus bars protruding from the instrument. Slip one end of the depositor rod into the bottom bus bar over the over-temp thermocouple.

11.10 Insert the hex screw to begin the securing process.

11.11 Tighten all four hex screws with a 5⁄32 in. Allen wrench until snug. A solid contact between the depositor rod and the bus bars is all that is required. The top of the depositor rod should be approximately 2 mm above the bus bar.

11.12 Place the controlling thermocouple down the center of the depositor rod through the top at the test depth determined by the thermocouple hot spot calibration. This depth is indicated by a small collar on the thermocouple wire.

11.13 The open end of the pump outlet tube can now be connected to the upper end cap. Attach the outlet from the air source to the fitting on the back to the upper end cap.

11.14 The drain tube may now also be connected to the lower end cap. The unit assembly is now complete.

11.15 Check the air supply is set to 10.0 mL⁄min and adjust as needed.

11.16 Turn on the main heat switch on the front panel of the instrument to start the test, and press the RUN button on the controller.

11.17 Once temperature reaches 200 °C, adjust the sample flow rate to the setting determined during the pump speed calibration to correspond to 0.25 g⁄min.

12. Test Completion

12.1 Test time is 18 h and 27 min. When the test is complete, the heat function will discontinue, and the rod will go back to room temperature. Turn off the main heat switch, set the pump dial to 000, turn off the reactor chamber heater control, unplug and remove the reactor chamber heating jacket. (**Warning—**The reactor and the reactor heater mantle are hot.)

12.2 Disconnect the drain tube from the lower end cap. Rinse the drain tube with hydrocarbon solvent into a 600 mL beaker and set the tube aside.

12.3 Remove reactor chamber heater jacket.