Designation: D 5967 – 04

An American National Standard

Standard Test Method for Evaluation of Diesel Engine Oils in T-8 Diesel Engine[1]

This standard is issued under the fixed designation D 5967; 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 viscosity increase and soot concentrations (loading).[2] This test method is commonly referred to as the Mack T-8.

1.2 This test method also provides the procedure for running an extended length T-8 test, which is commonly referred to as the T-8E and an abbreviated length test, which is commonly referred to as T-8A. The procedures for the T-8E and the T-8A are identical to the T-8 with the exception of the items specifically listed in Annex A8 and Annex A9 respectively. Additionally, the procedure modifications listed in Annex A8 and Annex A9 refer to the corresponding section of the T-8 procedure.

1.3 The values stated in either SI or inch-pound units are to be regarded separately as the standard. Within the text, the inch-pound units are generally shown in parentheses when combined with SI units, and vice versa.

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 and health practices and determine the applicability of regulatory limitations prior to use.* See Annex A6 for specific safety precautions.

1.5 A Table of Contents follows:

[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.

Current edition approved Nov. 1, 2004. Published November 2004. Originally approved in 1996. Last previous edition approved in 2003 as D 5967–03.

[2] The ASTM Test Monitoring Center will update changes in this test method by means of Information Letters. This edition incorporates revisions contained in all information letters through 03–1. Information letters may be obtained from the ASTM Test Monitoring Center, 6555 Penn Avenue, Pittsburgh, PA 15206-4489, Attention: Administrator.

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 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)

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

D 235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)

D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

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

D 446 Specifications and Operating Instructions for Glass Capillary Kinematic Viscometers

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

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 2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge

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

D 4485 Specification for Performance of Engine Oils

D 4737 Test Method for Calculated Cetane Index by Four Variable Equation

D 5185 Test Method for Determination of Additive Elements, Wear Metals, and Contaminants in Used Lubricating Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

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

D 6278 Test Method for Shear Stability of Polymer-Containing Fluids Using European Diesel Injector Apparatus

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance With Specifications

E 344 Terminology Relating to Thermometry and Hydrometry

2.2 *SAE Standard:*

SAE J1995 Engine Power Test Code—Spark Ignition and Compression Ignition—Gross Power Rating[5]

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. **Sub. B Glossary**

3.1.2 *blowby*, *n*—in internal combustion engines, the combustion products and unburned air-and-fuel mixture that enter the crankcase. **D 5302**

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

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. **D 4485**

3.1.5 *heavy-duty engine*, *n*—in internal combustion engines, one that is designed to allow operation continuously at or close to its peak output. **D 4485**

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

3.1.7 *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. **Sub. B Glossary**

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

3.1.9 *reference oil*, *n*—an oil of known performance characteristics, used as a basis for comparison. **Sub. B Glossary**

3.1.9.1 *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.

3.1.10 *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. **D 5302**

3.1.11 *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. **Sub. B Glossary**

[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 15096-0001.

3.1.11.1 *Discussion*—The specified operating conditions in some test methods include requirements for determining a test's operational validity. These requirements are applied after a test is completed, and can include (*1*) mid-limit ranges for the *average* values of primary and secondary parameters that are narrower than the specified control ranges for the *individual* values, (*2*) allowable *deviations* for *individual* primary and secondary parameters from the specified control ranges, (*3*) downtime limitations, and (*4*) *special* parameter limitations.

3.1.12 *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. **D 5302**

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

4. Summary of Test Method

4.1 The test operation involves use of a Mack E7-350 diesel engine with a warm-up, a 2-h flush for each test, and then a constant speed and load conditions that are held for the remainder of the test. Reference oil test length is 300 h. Non-reference oil test length is 250 h.

4.2 Oil samples are taken periodically and analyzed for viscosity increase.

4.3 Engine rebuild frequency is based on the degradation of test parameters and is left to the discretion of the test laboratory. At rebuild, the power section of the engine is disassembled, solvent-cleaned, measured, and rebuilt, using all new pistons, rings, cylinder liners, and valve guides, in strict accordance with furnished specifications.

4.4 The engine crankcase is solvent-cleaned, and worn or defective parts are replaced.

4.5 The test stand is equipped with appropriate accessories for controlling speed, load, and various engine operating conditions.

5. Significance and Use

5.1 This test method was developed to evaluate the viscometric performance of engine oils in turbocharged and intercooled four-cycle diesel engines. Results are obtained from used oil analysis.

5.2 The test method is 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 E7-350 mechanically governed engine, P/N 11GBA77623 (see Annex A5). It is an open-chamber, in-line, six-cylinder, four-stroke, turbocharged, charge air-cooled, compression ignition engine. The bore and stroke are 124 by 165 mm (4⅞ by 6½ in.), and the displacement is 12 L (728 in.^{3}). The engine is rated at 261 kW (350 bhp) at 1800 r/min governed speed (see SAE J1995).

6.1.2 The ambient laboratory atmosphere should be relatively free of dirt, dust, and other contaminants as required by good laboratory standards. Additionally, it is recommended that the atmosphere in the engine buildup area be filtered and controlled for temperature and humidity to prevent accumulation of dirt or dust on engine parts. Uniform temperature control will also aid in measuring and selecting parts for assembly.

TABLE 1 Low Sulfur Reference Diesel Fuel Specifications

Property	Test Method	Min[A]	Max[A]
Sulfur, % weight	D 2622	0.03	0.05
Gravity, °API	D 287 or D 4052	32	36 (37)
Hydrocarbon composition			
Aromatics, % volume	D 1319 (FIA)	(27) 28	35
Olefins	D 1319 (FIA)	Report	
Saturates	D 1319 (FIA)	Report	
Cetane index	D 4737	Report	
Cetane number	D 613	42	48
Copper strip corrosion	D 130		3
Flash point, °C	D 93	54	
Cloud point, °C	D 2500		−12
Pour point, °C	D 97		−17
Carbon residue, %	D 524 (10 % bottoms)		0.35
Water and sediment, % volume	D 2709		0.05
Ash, % weight	D 482		0.01
Viscosity, cSt at 40°C	D 445	2.0	3.2
Distillation, °C	D 86		
IBP		(171) 177	199 (204)
10 %		(204) 210	232 (238)
50 %		(243) 249	277 (282)
90 %		(293) 299	327 (332)
EP		(321) 327	360 (366)

[A] Min and max numbers in parentheses are EPA Certification Fuel Specifications.

6.1.3 Use the low sulfur reference diesel fuel shown in Table 1.

6.2 *The Test Engine*:

6.2.1 *Mack Test Engine*—The engine is available from Mack Trucks, Inc. A complete parts list is shown in Table A5.1.

6.2.2 *Engine Cooling System*:

6.2.2.1 A new Mack coolant conditioner shown in Table A5.1 is required every test to limit scaling in the cooling system. Pressurize the system to 103 kPa (15 psi) at the expansion tank.

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 should 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 prevent localized boiling. Block the thermostat wide open.

6.2.3 *Engine Oil System*—A schematic of the engine oil system is shown in Fig. A2.9.

6.2.4 *Auxiliary Oil System*—To maintain a constant oil level in the pan, provide an additional 9.5-L (10-qt) sump by the use of a separate closed tank connected to the sump. Circulate oil through the tank at a rate of 5.7 ± 1.9 L/min (1.5 ± 0.5 gpm) with an auxiliary pump. A typical auxiliary oil system is shown in Fig. A2.9. The No. 6 and No. 8 Aeroquip[6] lines should have inside diameters of 10 mm (⅜ in.) and 13 mm (½ in.), respectively. The vent line size is specified as a minimum No. 8 line size. Equivalent lines may be substituted for Aeroquip lines provided they have the proper inside diameters.

[6] Aeroquip lines are available at local industrial hose suppliers.

6.2.5 *Crankcase Aspiration*—A simple squirrel cage blower will suffice to control crankcase pressure within the test limits.

6.2.6 *Blowby Meter*—Use a displacement type gas meter, or equivalent, to measure blowby.

6.2.7 *Air Supply and Filtration*—Use an intake air filter with an initial efficiency of 99.2 %. Replace filter cartridge when 2.5 kPa (10 in. H_2O) ΔP is reached. Install an adjustable valve (flapper) in the inlet air system at least two pipe diameters before any temperature, pressure, and humidity measurement devices. Use the valve to maintain inlet air restriction within required specifications.

6.2.8 *Fuel Supply*—Heating or cooling, or both, of the fuel supply may be required and a recommended system is shown in Fig. A2.11.

6.2.9 *Intake Manifold Temperature Control*—Control intake manifold temperature with the use of a slave intercooler.

7. Engine Fluids

7.1 *Test Oil*—Approximately 151 L (40 gal) of test oil are required for the test.

7.2 *Test Fuel*—The recommended fuel with the properties and tolerances are shown in Table 1.

7.3 *Engine Coolant*—Use demineralized water with less than 0.03 g/L (2 grains/gal) of salts or distilled water (do not use antifreeze solutions or other coolant additives).

7.4 *Cleaning Materials*—Use a solvent meeting Specification D 235, Type II, Class C for cleaning parts. Other materials, such as diesel fuel, may be required by some labs to ensure parts cleanliness. (**Warning—**Use adequate safety precautions with all solvents and cleaners.)

8. Preparation of Apparatus at Rebuild

8.1 *Cleaning of Parts*:

8.1.1 *Engine Block*—Thoroughly spray the engine with solvent (see 7.4) to remove any oil remaining from the previous test, and air dry.

8.1.2 *Rocker Covers and Oil Pan*—Remove all sludge, varnish, and oil deposits. Rinse with solvent, and air dry.

8.1.3 *Auxiliary Oil System*—Flush all oil lines, galleries, and external oil reservoirs with solvent to remove any previous test oil, and air dry.

8.1.4 *Oil Cooler and Oil Filter*—If heavy deposits are present or suspected, flush the oil cooler and filter lines with solvent to remove any previous test oil, and air dry.

8.1.5 *Cylinder Head*—Clean the cylinder heads using a wire brush to remove deposits and rinse with solvent to remove any sludge and oil, and air dry.

8.2 *Valves, Seats, Guides, and Springs*—Visually inspect valves, seats, and springs for defects and replace, if defective.

8.2.1 Replace and ream guides to 0.9525 ± 0.0013 cm (0.3750 ± 0.0005 in.).

8.3 *Cylinder Liner, Piston, and Piston Ring Assembly*:

8.3.1 *Cylinder Liner Fitting*—To ensure proper heat transfer, fit cylinder liners to the block in accordance with the procedure outlined in the Mack Service Manual (see Annex A5).

8.3.2 *Piston and Rings*—Cylinder liners, pistons, and rings are provided as a set and should be used as a set. Examine piston rings for any handling damage. Measure piston ring end gaps for conformance with Mack specifications and record.

8.4 *Injectors and Injection Pump*:

8.4.1 *Injectors*—Servicing of injectors is recommended every 1000 h. Resetting of injector opening pressure is allowed if pressure is below specification.

8.4.2 *Injection Pump*—The removal of the injection pump is not recommended unless a problem is noted during a test. Removing the injection pump invalidates the test stand calibration. Replacing injection pumps at each calibration is recommended. Only new injection pumps, which have never been serviced or rebuilt, are permitted. High pressure flow calibration equipment, such as a Bacharach No. 72-7010 standard injector tester, is available from Mack approved dealers. Kent-Moore[7,8] tool numbers J29539 top dead center indicator and J37077 position sensor are recommended for setting the injection timing.

8.5 *Assembly Instructions*:

8.5.1 *General*—The test parts specified for this test method are intended to be used without material or dimensional modification. Exceptions, for example, a temporary parts supply problem, shall be approved by the Test Monitoring Center (TMC), and noted in the test report. All replacement test engine parts shall be genuine Mack Trucks, Inc. parts. Assemble all parts as illustrated in the Mack Service Manual (see A5.2), except where otherwise noted. Target all dimensions for the means of the specifications. Use the buildup oil (see Annex A5) for lubricating parts during assembly.

8.5.1.1 *Thermostat*—Block the thermostat wide open using an all thread rod.

8.5.1.2 *Rod Bearings*—Check the condition of the connecting rod bearings. Replacement of the connecting rod bearings is at the laboratory's discretion.

8.5.1.3 *Main Bearings*—Check the condition of the main bearings. Replacement of the main bearings is at the laboratory's discretion.

8.5.1.4 *Piston Undercrown Cooling Nozzles*— Take particular care in assembling the piston undercrown cooling nozzles to ensure proper piston cooling (as outlined in the Mack Service Manual).

NOTE 1—Proper oil pressure is also important to ensure sufficient oil volume for proper cooling.

8.5.2 *New Parts*—Install the following new parts for each rebuild (see Table A5.1, Annex A5, for part numbers):

8.5.2.1 Cylinder liners,

8.5.2.2 Pistons,

8.5.2.3 Piston rings,

8.5.2.4 Overhaul gasket set,

8.5.2.5 Oil filters (also after each test),

8.5.2.6 Engine coolant conditioner (also every test),

[7] The sole source of supply of the tools known to the committee at this time is Kent-Moore Corp., 29784 Little Mack, Roseville, MI 48066.

[8] 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 technical committee,[1] which you may attend.

8.5.2.7 Primary fuel filter (also every test),
8.5.2.8 Secondary fuel filter (also every test),
8.5.2.9 Valve guides, and
8.5.2.10 Valve stem seals.

8.6 *Measurements*:

8.6.1 *Calibrations*—Calibrate thermocouples, pressure gages, speed, and fuel flow measuring equipment prior to each reference test or at any time readout data indicates a need. Conduct calibrations with at least two points that bracket the normal operating range. Make these calibrations part of the laboratory record. During calibration, connect leads, hoses, and read-out systems in the normally used manner and calibrate with necessary standards. Immerse thermocouples in calibration baths. Calibrate standards with instruments traceable to the National Institute of Standards and Technology on a yearly basis.

8.6.2 *Temperatures*:

8.6.2.1 *General*—Measure temperatures with thermocouples and conventional readout equipment or equivalent. For 0 to 150°C (0 to 300°F) range, calibrate temperature measuring systems to ±0.5°C (±1°F) at 100 ± 1°C (210 ± 2°F) and to± 0.5°C (±1°F) at 0 ± 1°C (32 ± 2°F). Insert all thermocouples so that the tips are located midstream of the flow unless otherwise indicated.

8.6.2.2 *Ambient Air*—Locate thermocouple in a convenient, well-ventilated position between 2 and 3 m (approximately 6 and 10 ft) from the engine and hot accessories.

8.6.2.3 *Coolant*—Locate thermocouple in water manifold prior to thermostat housing. Locate in center of water stream (refer to Fig. A2.5).

8.6.2.4 *Oil*—Locate thermocouple on the right side of the engine on the top of the accessory drive, as shown in Fig. A2.5.

8.6.2.5 *Intake Air*—Locate sensors for dry bulb temperature measurement and humidity in center of air stream at the turbocharger inlet as shown in Fig. A2.3. It is not necessary to control intake air humidity, but measurements are recommended.

8.6.2.6 *Fuel In*—Locate thermocouple in center of fuel line between secondary filter and injection pump, as shown in Fig. A2.4.

8.6.2.7 *Pre-Turbine Temperatures*—Locate one thermocouple in each side of exhaust manifold tee section (see Fig. A2.3). The exhaust manifold (pre-turbine) thermocouples and pressure taps are located on the same tee.

8.6.2.8 *Exhaust (Tailpipe) Temperature*— Locate thermocouple in exhaust pipe downstream of turbine in accordance with Fig. A2.7.

8.6.2.9 *Intake Manifold*—Locate thermocouple at tapped fitting on intake air manifold, as shown in Fig. A2.6.

8.6.2.10 *Additional*—Monitor any additional temperatures the test lab regards as helpful in providing a consistent test procedure.

8.6.3 *Pressures*:

8.6.3.1 *Before Filter Oil Pressure*—Locate pickup at tapped hole on oil cooler fitting (see Fig. A2.2).

8.6.3.2 *After Filter/Main Gallery Oil Pressure*—Locate pickup at tapped hole on top of oil filter pad above centrifugal oil filter (see Fig. A2.2).

NOTE 2—The E7 engine has only one oil gallery, which serves as both a main gallery and a piston cooling gallery.

8.6.3.3 *Pre-Turbine Exhaust Pressure*—Locate pickup in each side of exhaust manifold tee section (same tap as pre-turbine pressure), Fig. A2.3.

8.6.3.4 *Intake Air Boost*—Take measurement at tapped fitting provided on intake manifold, as illustrated in Fig. A2.6.

8.6.3.5 *Intake Air Total Pressure*—Measure with a Keil Probe[8,9] (p/n No. KDF-8-W recommended) located at the turbo inlet (see Fig. A2.3).

8.6.3.6 *Exhaust Back Pressure*—Locate pickup in exhaust pipe after turbocharger in center of exhaust stream. Measure exhaust back pressure in a straight section of pipe, 30.5 to 40.6 cm (12 to 16 in.) downstream of the turbo with a 1/16 NPT tread pressure tap hole, as shown in Fig. A2.3.

8.6.3.7 *Crankcase Pressure*—Locate pickup at dipstick tube fitting or other suitable opening direct to the crankcase.

8.6.3.8 *Barometric Pressure*—Locate barometer approximately 1.2 m (4 ft) above ground level in convenient location in the lab.

8.6.4 *Engine Blowby*—Connect the metering instrument to the blowby line coming from the valve cover crossover tube (P/N 191GC418A).

8.6.5 *Fuel Consumption Measurements*— Place the measuring equipment in the fuel line before the primary fuel filter. Install the primary fuel filter before the fuel transfer pump and install the secondary filter before the injection pump. Accurate fuel consumption measurements require proper accounting of return fuel. (**Warning—**Fuel return lines should never be plugged.)

8.6.6 *Humidity*—Place the measurement equipment between the inlet air filter and compressor in such a manner so as not to affect temperature and pressure measurements. Measure humidity at 8-h intervals and report (see Annex A1).

9. Laboratory and Engine Test Stand Calibration/Non-Reference Requirements

9.1 *Calibration Frequency*:

9.1.1 To maintain test consistency and severity levels, engine test stand calibration is required at regular intervals. The frequency of calibration is dependent on the laboratories' previous calibration experience or at the discretion of the TMC.

9.1.2 Engine test stand calibration is required when the injection pump is removed from the engine, when cylinder heads are replaced, or when pistons, rings, and liner are changed. Cylinder heads can be rebuilt without re-calibrating. If a piston, piston rings, or cylinder liner are changed, then re-calibration is necessary.

9.2 *Calibration Reference Oils*:

9.2.1 The reference oils used to calibrate test stands have been formulated or selected to represent specific chemical types or performance levels, or both. They can be obtained

[9] The sole source of supply of Keil Probes known to the committee at this time is United Sensor Corp., 3 Northern Blvd., Amherst, NH 03031.

from the TMC. The TMC will assign reference oils for calibration tests. These oils are supplied under code numbers (blind reference oils).

9.2.2 *Reference Oils Analysis*—Reference oils are not to be submitted to either physical or chemical analysis, for identification purposes. Identifying the oils by analysis could undermine the confidentiality required to operate an effective blind reference oil system. Therefore, reference oils are supplied with the explicit understanding that they will not be subjected to analysis other than those specified within this procedure unless specifically authorized by the TMC. In such cases in which analysis is authorized, written confirmation of the circumstances involved, the data obtained, and the name of the person authorizing the analysis shall be supplied to the TMC.

9.3 *Test Numbering*—Number each test to identify the test stand number, the test stand run number, engine serial number, and engine block hours at the start of the test. The sequential stand run number remains unchanged for reruns of aborted, invalid, or unacceptable calibration tests. However, the sequential stand run number shall be followed by the letter A for the first rerun, B for the second, and so forth. For calibration tests, engine block hours are the test hours since last engine rebuild. For non-reference tests, engine block hours are the test hours accumulated since last reference. For example, 58-12A-2H0380-500 defines a test on stand 58 and stand run 12 as a calibration test that was run twice on engine 2H0380 (serial number), which has run 500 h since the last engine rebuild.

9.4 *New Laboratories and New Test Stands*:

9.4.1 A new stand is defined as an engine, dynamometer/cell and support hardware that has never been previously calibrated under this test procedure. On both new and existing stands the test engine is part of the stand calibration. A new engine in a existing test stand only requires one successful calibration test.

9.4.2 A new test stand shall have two acceptable calibration tests to be considered calibrated.

9.4.3 A laboratory not running a test for 12 months from the start of the last test is considered a new laboratory. Under special circumstances (that is, extended downtime due to industry-wide parts shortage or fuel outages) the TMC may extend the lapsed time requirement. Non-reference tests conducted during an extended time allowance shall be annotated (see Annex A1), Downtime and Comments Summary.

9.4.4 The TMC may schedule more frequent reference oil tests at their discretion.

9.5 *Calibrated Laboratories and Test Stands*:

9.5.1 A calibration test on a reference oil assigned by the TMC is required after 3000 h of non-reference test time, ten operationally valid non-reference oil tests, or nine months, whichever comes first, have elapsed since the starting date of the last calibration test. A non-reference test may be started in a test stand provided at least 1 h remains in its calibration period.

9.6 *Calibration Test Acceptance*:

9.6.1 Use the TMC's Lubricant Test Monitoring System (LTMS)[10] for calibration test targets and acceptance criteria.

9.6.2 The specified test parameter for determination of test acceptance is Viscosity Increase in cSt, at 100°C and 3.8 % Thermal Gravimetric Analysis (TGA) soot, as shown in Annex A3 and Annex A4.

9.6.2.1 Calculate Viscosity Increase at 3.8 % TGA, using linear interpolation from the minimum viscosity that occurs during the test. Do not use the 25-h, 75-h, and 125-h oil sample results to calculate Viscosity Increase at 3.8 % TGA soot.

9.6.3 *Soot Requirements*—All operationally valid calibration tests on TMC oil 1004-1 shall produce a TGA soot level between 4.0 to 4.6 % at 250 h. All operationally valid calibration tests on TMC oil 1004-2 shall produce a TGA soot level between 4.0 to 4.8 % at 250 h. A laboratory may terminate a calibration test that is projected to miss the 250 h test soot window. Calibration tests with soot levels outside the 250 h soot window are considered operationally invalid.

9.7 *Failing Calibration Tests*:

9.7.1 Failure of a reference oil test to meet test acceptance bands can be indicative of a false alarm, testing stand, testing laboratory, or industry-related problem. When this occurs, the laboratory, in conjunction with the TMC, shall attempt to determine the problem source.

9.7.2 The TMC will decide, with input as needed from industry expertise (testing laboratories, test developer, ASTM Technical Guidance Committee, Surveillance Panel, and so forth), if the reason for any unacceptable blind reference oil test is isolated to one particular stand or related to other stands. If it is decided that the problem is isolated to an individual stand, calibrated testing on other stands can continue throughout the laboratory. Alternatively, if it is decided that more than one stand may be involved, the involved stands will not be considered calibrated until the problem is identified, corrected, and an acceptable reference oil test completed in one of the involved stands.

9.7.3 If nonstandard tests are conducted on the referenced test stand, the stand may be required to be recalibrated prior to running standard tests at the discretion of the TMC.

9.8 *Non-Reference Oil Test Requirements*—Non-reference oil tests shall produce a minimum 3.8 % TGA soot level at 250 h. Tests shall run to 250 h regardless of meeting the 3.8 % soot level prior to 250 h. Tests that do not reach 3.8 % soot at 250 h are deemed not interpretable.

NOTE 3—Fixed non-reference oil pass criteria are published in Specification D 4485.

9.8.1 *Non-Reference Oil Test Result Severity Adjustments*—This test method incorporates the use of a severity adjustment (SA) for non-reference oil test results. A control chart technique, described in the LTMS, has been selected for the

[10] The lubricant test monitoring system may be obtained from the ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206-4489. Attention: Administrator.