Designation: D 5862 – 99a

An American National Standard

Standard Test Method for Evaluation of Engine Oils in Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine[1]

This standard is issued under the fixed designation D 5862; 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 (see Annex A1). 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 this test method. (See Annex A1.)

1. Scope

1.1 This test method describes a two-stroke cycle diesel engine test procedure for evaluating engine oils for certain high-temperature performance characteristics, particularly cylinder liner scuffing and piston ring face distress, but also including port plugging, slipper bushing, and piston skirt distress. Such oils include both single viscosity SAE grade and multiviscosity SAE grade oils used in diesel engines. It is commonly known as the 6V92TA test. (See Note 1.)

NOTE 1—Companion test methods used to evaluate other engine oil performance characteristics for specification requirements are discussed in Engine Oil tests—SAE J304.[3]

1.2 *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.* Specific hazard statements are given in Section 8, Section 10, Section 13, and Section 14.

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

1.4 This test method is arranged as 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.B0.02 on Heavy Duty Engine Oils.

Current edition approved Dec. 10, 1999. Published January 2000. Originally published as D 5862 – 95. Last previous edition D 5862 – 99.

[2] ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206-4489. This test method is supplemented by Information Letters and memoranda issued by the TMC. Users of this test method shall contact the TMC to obtain the most recent of these. This edition incorporates revisions in all Information Letters through No. 99–2.

[3] This standard is not available separately; see Footnote 10. Other information about Test Method D 5862 can be found in the ASTM Research Report RR: D02-1319, available from ASTM Headquarters.

2. Referenced Documents

2.1 *ASTM Standards:*

D 86 Test Method for Distillation of Petroleum Products[4]

D 92 Test Method for Flash and Fire Points by Cleveland Open Cup[4]

D 240 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter[4]

D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)[4]

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)[4]

D 482 Test Method for Ash from Petroleum Products[4]

D 613 Test Method for Cetane Number of Diesel Fuel Oil[5]

D 2622 Test Method for Sulfur in Petroleum Products by X-Ray Spectrometry[4]

D 2709 Test Method for Water and Sediment in Distillate Fuels by Centrifuge[4]

D 2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography[4]

D 4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants[6]

D 4485 Specification for Performance of Engine Oils[6]

D 4683 Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered Bearing Simulator[6]

D 4739 Test Method for Base Number Determination by Potentiometric Titration[6]

D 5185 Test Method for the Determination of Additive Metals, Wear Metals and Contaminants in Used Lubricating Oils by Inductively-Coupled Plasma Atomic Emission Spectrometry[6]

E 344 Terminology Relating to Thermometry and Hydrometry[7]

G 40 Terminology Relating to Wear and Erosion[8]

2.2 *SAE Standards:*[9]

SAE J183 Engine Oil Performance and Engine Service Classification

SAE J304 Engine Oil Tests

2.3 *Military Specifications:*[10]

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

3. Terminology

3.1 *Definitions:*

3.1.1 *additive*, *n*—a material added to another, usually in small amounts, to impart or enhance desirable properties or to suppress undesirable properties. **(D 4175)**

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

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

3.1.4 *corrosion*, *n*—the chemical or electrochemical reaction between a material, usually a metal surface and its environment, that can produce a deterioration of the material and its properties. **(D 5844)**

3.1.5 *debris*, *n—in internal combustion engines*, solid contaminant materials unintentionally introduced into the engine or resulting from wear.

3.1.6 *engine oil*, *n*—a liquid that reduces fricton 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.

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

3.1.7 *free piston ring*, *n— in internal combustion engines*, a piston ring that will fall in its groove under its own weight when the piston, with the ring in a horizontal plane, is turned 90° (putting the ring in a vertical plane). **(Subcommittee B Glossary[11])**

3.1.8 *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)**

[4] *Annual Book of ASTM Standards*, Vol 05.01.

[5] *Annual Book of ASTM Standards*, Vol 05.05.

[6] *Annual Book of ASTM Standards*, Vol 05.02.

[7] *Annual Book of ASTM Standards*, Vol 14.03.

[8] *Annual Book of ASTM Standards*, Vol 03.02.

[9] This standard is not available separately. Either order the SAE Handbook Vol 3, or the SAE Fuels and Lubricants Standards Manual HS 23 from: Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.

[10] Available from the Standardization Documents Order Desk, Building 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094.

[11] Available from the Secretary of the ASTM D02.B0 Subcommittee.

3.1.9 *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)**

3.1.10 *lubricant*, *n*—any material interposed between two surfaces that reduces the friction or wear, or both, between them.

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

3.1.12 *plugging*, *n*—the restriction of a flow path due to the accumulation of material along the flow path boundaries.

3.1.13 *reference oil*—an oil of known performance characteristics, used as a basis for comparison. **(D 5844)**

3.1.13.1 *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.

3.1.14 *scoring*, *n*—*in tribology*, a severe form of wear characterized by the formation of extensive grooves and scratches in the direction of sliding. **(G 40)**

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

3.1.16 *soot*, *n*—*in internal combustion engines*, sub-micron size particles, primarily carbon, created in the combustion chamber as products of incomplete combustion.

3.1.17 *tight piston ring*, *n*— *in internal combustion engines*, a piston ring that will not fall in its groove under its own weight when the piston, with the ring in a horizontal plane, is turned 90° (putting the ring in a vertical plane); by subsequent application of moderate finger pressure, the ring will be displaced.

(Subcommittee B Glossary[11])

3.1.18 *used oil*, *n*—any oil that has been in a piece of equipment (for example, an engine, gearbox, transformer, or turbine), whether operated or not. **(D 4175)**

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

3.1.19.1 *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. **(D 5302)**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *liner scuffing*, *n*—scuffing characterized by vertical markings in the direction of piston motion which obscure visual detection of the honing crosshatch pattern of the liner.

3.2.2 *test*, *n*—any engine run-time accumulated beyond the break-in conducted according to this test method.

4. Summary of Test Method

4.1 A 500 horsepower 6V92TA diesel engine[12] is completely disassembled, solvent-cleaned, measured, and assembled using new parts as specified.

4.2 The engine is installed on a test stand equipped with the appropriate accessories for controlling speed, load, and various other engine operating parameters.

4.3 The engine is charged with the test oil and operated for 6 h and 10 min on a break-in cycle. An airbox inspection is made after break-in to determine cylinder liner scuffing as a measure of the suitability of the engine build.

4.4 Following the break-in, the engine is operated under steady state conditions at both high load and high power for 7 cycles, totaling 100 h running time. Each cycle includes a heat soak and cool-down portion. This test stresses the lubricant thermally and mechanically to duplicate the service typical of these types of engines in use today.

4.5 Used oil samples are taken every 16 h with viscometric characteristics, metals, and base number (TBN) measured on a fixed schedule.

4.6 At the end of the test, the engine is disassembled, and the rings, liners, slipper bushings, and piston skirts are visually inspected for those signs of distress that relate to overall engine life.

5. Significance and Use

5.1 This test method was developed to evaluate diesel engine oils for protection against ring and liner distress caused by high thermal and mechanical loading.

5.2 Liner scuffing and ring distress experienced in this test method are measures of the oil's ability to protect against scuffing and scoring under high power and high load conditions typical of service experienced by engines in use today.

5.3 Piston pin slipper bushing wear, piston skirt tin removal, and liner port plugging are also examined in this test for distress which relates to overall engine life.

5.4 This test method was developed to correlate with field experience using oils of known good and poor protection against ring and liner distress.

5.5 The 6V92TA engine oil test is used in specifications and classifications of engine lubricating oils, such as the following:

5.5.1 Specification D 4485,

5.5.2 Military Specification MIL-L-2104, and

5.5.3 SAE Classification J 183.

6. Apparatus—General Description

6.1 The test engine is based on an 9 L Detroit Diesel 6V92TA, turbo-supercharged, aftercooled, two-stroke cycle diesel engine.

6.2 Use an engine test stand equipped to control engine speed and load, various temperatures, and other parameters.

6.3 Use appropriate air conditioning or heating apparatus, or both, as necessary to control the temperature of the intake air.

6.4 Use an appropriate fuel supply system.

7. Apparatus—Laboratory and Test Stand Requirements

7.1 *Laboratory*—Observe the following laboratory conditions to ensure good control of test operations and good repeatability:

7.1.1 Maintain the ambient laboratory atmosphere relatively free of dirt, dust, and other contaminants.

7.1.2 Control the temperature of the room in which parts measurements are made so that the temperature for after-test

[12] A Detroit Diesel 6V92TA engine shall be used; purchase it from a local Detroit Diesel Distributor. If it is necessary to locate a distributor, contact the Test Developer: Attention: Sequence 6V92TA Test Developer, Detroit Diesel Corporation, Fuels and Lubricants, 13400 West Outer Drive, Detroit, MI 48239-4001.

measurements is within a range of ±3°C (±5°F) relative to the temperature for the before-test measurements. If difficulty of parts fit during engine assembly is encountered, consider the effects of temperature coefficient of expansion.

7.2 *Engine Stand Requirements*—A typical test stand is shown in Annex A2 (Fig. A2.1).

7.2.1 *Engine Speed and Load Control*— Dynamometer shall be able to maintain engine speeds of 1200 and 2300 r/min at the torques of 1850 N-m and 1550 N-m, respectively (approximately 373 kW). Load ramping is not required.

7.2.2 *Engine Cooling System*—Use a suitable external engine cooling system to maintain the specified engine coolant temperature during both the operating and cool-down portions of the test. The system shall incorporate the following features:

7.2.2.1 Cooling capacity of 370 kW (21 000 Btu/min).

7.2.2.2 Flow capacity of 760 L/min (200 gal/min).

7.2.2.3 Temperature control with coolant out temperature maintained at 84 ± 2°C (183 ± 4°F).

7.2.3 *Air Inlet System*:

7.2.3.1 Shall have a capacity of 34 m^3/min (1200 cfm), at a temperature of 35 ± 3°C (95 ± 5°F).

7.2.3.2 Shall utilize 13-cm (5-in.) inside diameter pipe as shown in Fig. 1.

7.2.7 *Fuel System*—Use a fuel system with 11 500 L (3000 gal) capacity. It shall have a mass flow capability of 92 kg/h (202 lbm/h) minimum.

7.3 *Drawings*—Obtain the equipment drawings referenced in the Annex A1 of this test method from the ASTM Test Monitoring Center. Because the drawings may not be to scale, when using them to fabricate special parts, use the dimensions specified. Do not use a drawing as a pattern. Drawing dimensions are considered to be correct when the temperature of the equipment is 22°C (72°F), unless otherwise specified.

7.4 *Specified Equipment*—Use the equipment specified in the procedure whenever possible. Substitution of equivalent equipment is allowed, but only after equivalency has been proven to the satisfaction of the ASTM Test Monitoring Center. See Annex A2 (Fig. A2.1) for a view of the engine and attached apparatus used in this test method.

8. Apparatus—Test Engine

8.1 *The Test Engine*—Detroit Diesel 6V92TA 9 L500 horsepower (rating for evaluation of lubricants) turbo-supercharged, aftercooled, two-stroke cycle diesel engine is procured from the recommended source.[12] Rebuild the engine as specified in this test method. It is based on the Industrial Engine Model Number 8063-7408 which has the power rating of 410 kW (550 bhp) at 2300 r/min. Engine timing: 1.484 in., Lash 0.016 in.

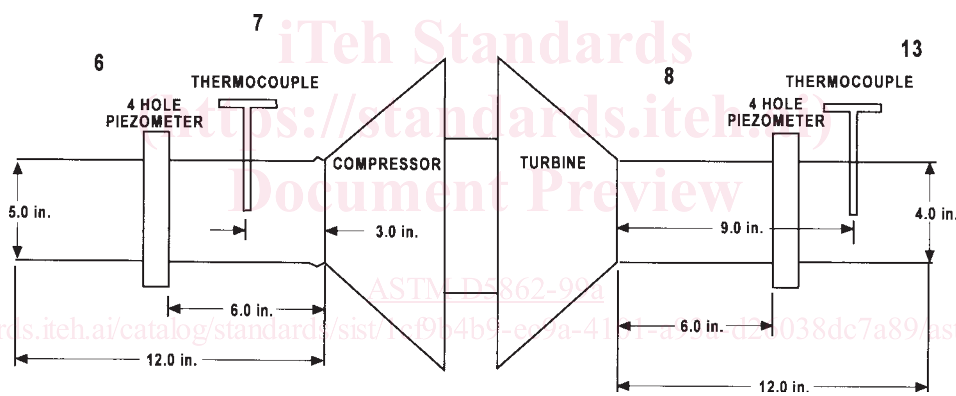

FIG. 1 Inlet and Exhaust Pressure and Temperature Sensor Locations

7.2.3.3 Shall have an air inlet restriction of 2.5 ± 0.7 kPa (10 ± 3 in. H_2O).

7.2.4 *Exhaust System*:

7.2.4.1 Shall have a flow capacity of 85 m^3/min (3000 cfm) at 510°C (950°F).

7.2.4.2 Shall utilize a 10-cm (4-in.) inside diameter pipe as shown in Fig. 1.

7.2.4.3 Shall have backpressure of 3.2± 0.8 kPa (0.95 ± 0.25 in. Hg).

7.2.5 *External Oil Cooling System*—Incorporate the external oil cooling system shown in Annex A2 (Fig. A2.2). A bracket for this system is shown in Annex A2 (Fig. A2.3). The oil gallery set-point is to be 102 ± 1°C (216 ± 2°F) during the load mode, and 111 ± 1°C (232 ± 2°F) during the power mode. The table in Annex A2 (A2.1) describes the parts required for the external cooler.

7.2.6 *Adjustable Dipstick*—Shall be used to monitor oil consumption. The construction of this dipstick is shown in Annex A2 (Fig. A2.4).

8.2 *Engine Parts*—Engine parts which are to be used for intermittent overhauls required in conducting this test procedure are listed in Annex A3. Critical parts are discussed under 8.2.4 and 8.2.5. Subassemblies are listed by complete subassemblies only; not by parts making up the subassemblies. Such parts are not replaced routinely and can be obtained from the Detroit Diesel Distributor.

8.2.1 Use all engine parts as received from the supplier; either the special kits from the Detroit Diesel Distributor (see 8.2.4), or original equipment manufactured by Detroit Diesel, unless defects in the parts require that they be returned to the supplier.

8.2.2 Do not divert to other applications parts obtained for use in 6V92TA testing.

8.2.3 Special tools are required for over-haul and measurement of the engine. Unless otherwise specified in this standard, these tools are available from the supplier and part numbers are listed in the Service Manual.[13]

8.2.4 *Service Part Kit*—Use the service parts (see Annex A3) and special parts in 8.2.5 and build-up procedures appropriate to the 6V92TA test engine stated in the service manual. Engine build-up and overhaul cannot be easily accomplished without this manual. Special service test cylinder kits (23508936) comprise parts that shall be replaced after each test and are available by order from any Detroit Diesel Distributor. These parts have undergone 100 % inspection by the test developer and orders for these uniquely numbered parts are linked by computer to a centrally controlled supply. The parts that replaced each test are included in these special service kits. They shall be used with no substitutions. Any difficulties experienced in ordering these pre-inspected parts should be referred to the test developer.[12]

8.2.5 *Required New Engine Parts*—See Table 1.

TABLE 1 Replace Listed Parts Each Test

Part Name	Part Number
Cylinder liner	23508937
Piston dome	23508938
Seal—dome to skirt	8923729
Piston skirt	23508940
Piston pin	5101120
Piston pin retainer	5180250
Slipper bushing	23501687
Oil control ring upper groove	23509097 top ring 23509098 bottom ring
Oil control ring lower groove	23509099 2 rings required
Oil ring expander	23509101
Fire ring	23508939
Compression rings	23509100 2 rings required per kit
Connecting rod upper bearing shell[A]	5107200
Connecting rod lower bearing shell[A]	5148936
Oil filter (12 μm)[A]	23518524 2 required

[A] Parts not in 23508936 cylinder kits.

8.2.6 *Parts Replaced As Needed*—See Table 2. Not routinely replaced, these parts have normal service part numbers and shall be used.

8.2.7 *Cylinder Liners*—The following measurements and directives shall be followed for free standing cylinder liners.

8.2.7.1 Measure diametrical cylinder bore:

13 mm (0.5 in.) from the top
25 mm (1 in.) above ports
25 mm (1 in.) below ports
13 mm (0.5 in.) from bottom

[13] Service Manuals, Sections 1–3 and Sections 4–15 are identified as 06SE0379 (two volumes) and can be purchased from Robot Printing Inc., Detroit Diesel Corporation, 25215 Glendale Ave., Redford, MI 48239-2675.

TABLE 2 Parts To Be Replaced as Needed

Part Name	Part Number
Connecting rod	5104501
Fuel injector 145 mm^3(6 required)	5226555[A]
Turbocharger (1.23 A/F OTM MNT, 4 in. IN)	23502746
Blower	23505854
Plate oil cooler	8547237
Water pump	892236

[A] For rebuilt injectors see 8.2.15.

Specified range is 122.911 to 122.974 mm (4.8390 to 4.8415 in.). Measure and report on two axes (eight total measurements). Use Form 11 in Annex A5 (Fig. A5.12) for reporting these measurements.

8.2.7.2 Average surface finish:[14] maintain 1.1–1.7 μm (45–65 μ-in.) R_a above the ports. Use Form 11 in Annex A5 (Fig. A5.12) for reporting these measurements.

8.2.7.3 Sort liners by flange height, identified by *L* or *H*. Use only the same flange heights on each side of the engine; however both sizes may be used in the same engine.

8.2.8 *Piston Ring Measurement*—Measure all rings as follows:

8.2.8.1 Measure radial thickness for all fire and compression rings. Measure in five locations, two at 25 mm each side of the ring gap, one opposite the gap, and two more locations mid-distance between the gap and opposite the gap. Average the measurements and record on Form 10 in Annex A5 (Fig. A5.11).

8.2.8.2 Measure end gaps using 123.0 mm (4.840 in.) gage.[15]

(*1*) *Fire and Compression Rings*—1.016 ± 0.127 mm (0.040 ± 0.005 in.).

(*2*) *Oil Control Rings*—Upper 0.4064 ± 0.025 mm (0.016 ± 0.001 in.). Lower 0.5842 ± 0.051 mm (0.023 ± 0.002 in.).

8.2.8.3 Weigh all rings in grams. Use Form 10 in Annex A5 (Fig. A5.11) for reporting these measurements.

8.2.9 *Piston Skirt Measurements and Clearances*:

8.2.9.1 Diameter of the piston shall be 122.667 to 122.733 mm (4.8294 to 4.8320 in.) measured[16] at 13 mm (0.5 in.) toward the top of the piston skirt 90° from the piston pin hole. This dimension includes tin plate.

8.2.9.2 Tin plate thickness for pistons supplied in the test kit shall be measured and verified to be in specification by the test kit supplier.

8.2.9.3 Piston skirt to liner clearance shall fall between 0.1778 and 0.3048 mm (0.007 and 0.012 in.), to be determined by subtracting diameters. Use Form 11 in Annex A5 (Fig. A5.12) for reporting these measurements.

8.2.10 *Piston Pin Slipper Bushing*—Weigh to ±0.001 g. Use Form 10 in Annex A5 (Fig. A5.11) for reporting these measurements.

8.2.11 *Main Bearings*—Inspect main bearing shells prior to each test and replace every three tests or sooner, if necessary.

8.2.12 *Rocker Arm Bushings Injector Position*—Measure[17] the inside diameter and record on Form 11 in Annex A5 (Fig. A5.12).

8.2.13 *Valves*—Leak check prior to each test. Regrind or replace valves every five tests. See 8.4.2.2.

[14] A Taylor Hobson (Form Talysurf) has been found suitable for this purpose. It is available from Rank Precision Industries, 411 East Jarvis Ave., Des Plaines, IL 60018.

[15] A Hemco Master 4.840 Class Y Ring Standard has been found suitable for this purpose. It is available from Rex Supply Corporation, 8539 North East Loop 410, San Antonio, TX 78216.

[16] A Mitutoyo (4–5 in.) C Clamp micrometre #293-751-10 has been found suitable for this purpose. It is available from L. Dewitt McCarter, Inc., 318 East Nakoma, San Antonio, TX 78216.

[17] A Mitutoyo Inside Micrometre #568-406 has been found suitable for this purpose.

8.2.14 *Connecting Rods*—Install a new set of six connecting rods at least every tenth test. It is recommended that all six connecting rods be replaced following a cylinder kit failure.

8.2.15 *Injectors*—Check injector output every test. These data may be recorded on the form in Appendix X3, (Fig. X3.10Fig. X3.10) or a similar form. Replace with new or rebuilt injectors if injector requirements are not met. These are described in Section 2.0 of the Shop Notes.[13] A special tool, J22410 is called for.

8.2.15.1 If injector rebuilding is selected, use the following injector exchange program, ASTM Injector Exchange Program, Detroit Diesel Remanufacturing—West, Inc., 100 Lodestone Way, Tooele, UT 84074. Attention: ASTM Injector Exchange Administrator.

8.2.16 *Ordering Information*:

8.2.16.1 Refer to Part Number 5226555 ASTM.

8.2.16.2 Delivery will be ten days after ordering.

8.2.16.3 Injectors will be identified with "ASTM" conspicuously stamped on the injector body.

8.2.16.4 It is recommended that laboratories maintain 12 working and calibrated injectors per engine minimum.

8.2.17 *Additional Information*:

8.2.17.1 Injectors will be disassembled and cleaned.

8.2.17.2 A new spray tip assembly will be installed.

8.2.17.3 Plunger and bushing to be machined to new part specifications.

8.2.17.4 Output flow specification 140 to 145 cc.

8.2.17.5 All injectors to be visually inspected for visual and functional defects.

8.3 *Special Cleaning Procedures*—Before any major disassembly, drain the engine of lubrication oil, water and fuel. Before removing any subassemblies from the engine (but after removal of the electrical equipment) thoroughly clean the exterior of the engine. Then, after each subassembly is removed and disassembled, clean the individual parts as necessary. Engine build-up forms are provided in Appendix X3 and may be used to organize the cleaning, parts measurements, and engine build-up tasks.

8.3.1 *Engine Block Cleaning*—Complete disassembly of the block may not be required, provided adequate cleaning is accomplished. This modification shall be included in the test report. If disassembly is required, the following procedure should be used. Note that a new service replacement cylinder block shall be cleaned with Penetone[18] to remove the rust preventive and the oil galleries shall be blown out with compressed air. (**Warning**—In addition to other precautions, to prevent possible personal injury, wear adequate eye protection. Penetone is a solvent and should not be ingested, nor come into contact with eyes or more than casual contact with the skin; spray goggles and hand protection are recommended. Use an airgun meeting OSHA standards.)

8.3.1.1 If judged necessary, the engine block should be completely disassembled and cleaned thoroughly by solvent spraying[19] with Varsol 3139.[20] Alternatively, the block may be soaked in Penetone for about 12 h. (**Warning**—Health hazard.)

8.3.1.2 Scrape all gasket material from the cylinder block. (**Warning**—In addition to other precautions, unless it is known otherwise, treat all gasket material in the engine and subassemblies as though it contains asbestos. When stripping gaskets from parts, do not grind or file off the material or abrade it off with a wire brush or wheel. Use a putty knife to remove the gasket after it has been wetted with water or oil.)

8.3.1.3 Before each run, all oil gallery plugs and core hole plugs (except cup plugs) should be removed to allow the cleaning solution to contact the inside of the oil and water passages. This permits more efficient cleaning. As a minimum, the engine may be solvent flushed while remaining on the test stand.

8.3.1.4 Rinse the block in hot water to remove cleaning solution.

8.3.1.5 Dry the cylinder block with compressed air. (**Warning**—In addition to other precautions, to prevent possible personal injury, wear adequate eye protection. Use an airgun that conforms to OSHA requirements.)

(*1*) The above procedure may be used on all ordinary cast iron and steel parts of the engine, unless specifically mentioned.

8.3.2 *Cylinder Head Cleaning*—After the cylinder head has been disassembled and all of the plugs (except cup plugs) have been removed, thoroughly solvent clean the head and dry with compressed air. Do not soak heads in Penetone because it will deteriorate the fuel injector tube seals. Instead use an aliphatic hydrocarbon to wash the heads. (**Warning**—In addition to other precautions, aliphatic hydrocarbons and should not be ingested, nor come into contact with eyes or more than casual contact with the skin. Spray goggles and hand protection are recommended.)

8.3.3 *Piston Ring Cleaning*—Remove heavy carbon from the piston rings by using an ultrasonic bath with Oakite Rust Stripper[21] as a cleaning medium. A concentration of 150 g/L has been found effective. Agitate for 1 h and rinse with hot water. Rinse rings with EF-411 as soon as possible to prevent rusting. (**Warning**—Health hazard.) (**Warning**—In addition to other precautions, the rust stripper is caustic. Use eye and hand protection.)

8.3.4 *Air Box Cleaning*—Special attention shall be given to the airbox area to ensure that there is no residual debris that could be ingested through the liner ports in subsequent tests. A check for air flow from the air box drain tubes should be made as outlined in the service manual.

8.3.5 *Oil Heat Exchanger Cleaning*—Disassemble and flush oil side with Varsol 3139. Water side may be cleaned as necessary.

8.3.6 *Blower Cleaning*—Remove rear cover and drain all oil, then wash front and rear with Varsol or equivalent.

[18] Penetone (specifically Penmul L-460) is a product of Penetone Corp., P.O. Box 22006, Los Angeles, CA 90022.

[19] A Flex-Rite Spray Gun has been found suitable for this purpose. It is available from Snap-On, Dan Rodgers, 114 Storywood, San Antonio, TX 78217.

[20] Aliphatic hydrocarbons are available at local petroleum product suppliers.

[21] Oakite Rust Stripper, OF, has been found suitable for this purpose. It can be obtained from Wrico, 4835 Whirlwind, San Antonio, TX 78217.

8.3.7 *Turbocharger Cleaning*—Do not routinely wash or clean turbocharger; just drain oil.

8.3.8 *Crankshaft*—Blow out drilled passages in the crankshaft.

8.4 *Periodic Maintenance Inspections*—Use forms equivalent to those shown in Appendix X3. As contrasted with the inspections and test part measurements made in 8.2, make the following inspections only at periodic intervals based on the overhaul experience of the laboratory; not necessarily after each test. However they should be done after each failure where obvious overheating occurred.

8.4.1 *Cylinder Block Inspection*—Remove liners with the special tool described in the service manual. Do not attempt to push the liner out by inserting a bar in the liner ports and rotating the crankshaft, otherwise the piston may be damaged or the upper ring groove may collapse.

8.4.1.1 *Inspect Block Bores*—Because most of the engine cooling is accomplished by heat transfer through the cylinder liners to the water jacket, a good liner-to-block contact must exist when the engine is operating. After the cylinder liners are removed from the engine, the block bores shall be inspected as outlined in the service manual.

8.4.1.2 *Check for Flatness*—The cylinder head contact surfaces shall be checked for flatness with an accurate straight edge and a feeler gage. The cylinder head deck surfaces of the block shall not vary more than 0.003 in. (0.076 mm) transversely and not over 0.006 in. (0.152 mm) longitudinally.

8.4.1.3 *Check Counterbore Depth*—Make sure the cylinder liner counterbores in the block are clean and free of dirt. Then check the depth. They shall be either 0.4755 to 0.4770 in. (12.078 to 12.116 mm) or 0.4905 to 0.4920 in. (12.459 to 12.497 mm) and shall not vary more than 0.0015 in. (0.0381 mm) throughout the entire circumference. Tool J22273[22] or equivalent is recommended for this measurement.

8.4.1.4 *Check Main Bearing Bores*—Check the bore diameters[23] with the main bearing caps in their original positions. The specified main bearing bore diameter is 4.812 to 4.813 in. (122.225 to 122.250 mm). If the bores do not fall within these limits, the block shall be rejected. Main bearing bores are line-bored with the bearing caps in place and thus are in longitudinal alignment. If a main bearing bore is more than 0.001 in. (0.025 mm) maximum overall misalignment or 0.0005 in. (0.013 mm) misalignment between adjacent bores, the block shall be line-bored or scrapped.

8.4.1.5 The cylinder block main bearing bore measurements should be made with the block in an upside down position on a flat surface rather than on an engine overhaul stand.

8.4.1.6 *After Inspection*—If the cylinder block is not to be used immediately, spray the machined surfaces with EF-411.[24]

8.4.2 *Cylinder Head Inspection*:

8.4.2.1 It is good practice to inspect cylinder heads for cracks after each test. A number of methods are described in the service manual for this purpose. A service replacement cylinder head is available which includes the exhaust valve guides, valve seat inserts, water nozzles, injector tubes, pilot sleeves, bridge guides, valve spring seats and the necessary plugs. The head shall be rebuilt at least every five runs. If the plugs are replaced separately, coat the threads with Locktite Pipe Sealant with Teflon®[25], install the necessary plugs and tighten to torque specified in the service manual.

8.4.2.2 Leak test valves after each test. Commercial testers[26] are specifically manufactured for this purpose.

8.4.2.3 Check exhaust valve to head protrusion/recession after each test and log the results on forms equivalent to those shown in Fig. X3.10. If valve recession exceeds 0.711 mm (0.028 in.) replace valve seats.[27]

8.4.3 *Rocker Arm Bushing, Injector Position*—Check inside diameter of the bushing and record on Form 11 in Annex A5 (Fig. A5.12). Replace if rocker arm shaft to bushing clearance exceeds 0.102 mm (0.0040 in.).

8.4.4 *Other Part and Sub-Assembly Inspection*—Other parts and subassemblies should be inspected less frequently, based on laboratory experience. Procedures are outlined in detail in the service manual for the inspection of all parts and subassemblies. Particular attention should be paid to making visual inspections of such items as the turbocharger aftercooler and turbine wheel assembly where deposit build-up is gradual and therefore performance deterioration is difficult to detect.

8.5 *Engine Build-up Procedures*:

8.5.1 *General*—Assembly procedures and the numerous special tools required are not detailed in the following, but should be done in accordance with the instructions in the service manual.

8.5.2 *Parts Selection*—Instructions concerning the use of new or used parts are given under 8.2.

8.5.3 *Engine Measurement Records*—Record engine parts measurements on data sheets equivalent to those shown in Appendix X3. Certain critical parts measurements are also recorded in Annex A5.

8.5.4 *Build-up Lubrication*—Lubricate all engine parts with EF-411 during assembly.

8.5.5 *Sealing Compounds*—During rebuilding, cylinder head bolts and main bearing bolts which are torqued to specific settings shall be first coated with International Compound No. 2.[28] Be sure that no excess is left on the bolts. However, all bolts, plugs, fittings or fasteners, (including studs) that intersect with a through hole and come in contact with oil, fuel or coolant shall have a sealer applied to the threads. It is recommended that Loctite J26558-92 Pipe Sealant with Teflon,

[22] Specialized overhaul tools can be purchased from Detroit Diesel distributors. A listing of such tools necessary for the overhaul of the engine used in this test method can be provided by referring to footnote 12.

[23] A Sunnen Model CF-1000 Bore Gage has been found suitable for this purpose. It is available from Sunnen Products, 7910 Manchester, St. Louis, MO 63143.

[24] EF-411 is supplied by Mobil Oil Corp., Att: Illinois Order Board, P.O. Box 66940, AMF-O'Hare, IL 60666. Request P/N 47503–8.

[25] Locktite J26558-92 is available from local distributors of Permatex products, or may be found by contacting Permatex Company, Inc. (Locktite Corporation), 18731 Cranwood Parkway, P.O. Box 7138, Cleveland, OH 44128-7137.

[26] A Sioux 1630K Vacuum Tester has been found suitable for this purpose. It is available from Sioux Tools Inc., 2909 Floyn Boulevard, Sioux City, IA 51102.

[27] A Kwik-Way Out-of-Round Tool P/N 049-0340-24 has been found suitable for seat out of round measurements. It is available from Kwik-Way, 500 57th Street, Marion, IA 52302.

[28] International Compound No. 2 is available from IRMCO, 2117 Greenleaf Street, Evanston, IL 60202.

or equivalent, be used. Exercise care to use International Compound No. 2 only when specified in the service manual.

8.5.6 *Gaskets and Seals*—Use new gaskets and seals as necessary at all locations during each engine assembly. Utilize gasket kit No. 23512684. The gasket between the turbocharger and blower (No. 8925778) shall be renewed each test.

8.5.7 *Engine Assembly*:

8.5.7.1 *Install Connecting Rods to Pistons*—Torque connecting rod bolts to 55–60 lbf·ft (75–81 N·m). Use International Compound No. 2 on threads when torquing.

8.5.7.2 *Install Pistons into Cylinder Liners*—With the piston assembled to the connecting rod and the piston rings in place, lubricate the piston, rings, and inside surface of the piston ring compressor J2422 as described in the service manual. Use EF-411 to lubricate the surfaces.

8.5.7.3 *Install Liners into Block*—Slide the piston, rod, and liner assembly into the block bore until the liner flange rests against the insert in the counterbore in the block. Ensure that the various matchmarks described in the service manual are in line.

8.5.7.4 *Install Lower Bearing Shell*—Tighten the connecting rod bolt nuts to 60–70 lbf·ft (81–95 N·m).

8.5.7.5 *Assemble and Install Cylinder Head*—After cleaning and inspection, assemble and install the cylinder head as described in the service manual. Note that a special lifting tool is required. Note that the bolt tightening sequence described shall be followed.

8.5.7.6 *Install Subassemblies*—Complete the engine assembly by installing all remaining accessories, fuel lines, electrical connections, controls, etc.

9. Measurement Instrumentation

9.1 *Temperature Measurement*—Use iron-constantan (Type J) thermocouples or platinum resistance thermocouples for temperature measurement.[29] Other temperature sensors that give the same results may be used, provided that they are approved by the ASTM Test Monitoring Center.

9.1.1 *Thermocouple Location*—Locate the sensing tip of all thermocouples in the center of the stream of the medium involved, unless otherwise specified.

9.1.2 *Oil Gallery*—Locate thermocouple on the right front of block in turbocharger oil feed line, flush with block face. See Fig. 2, location No. 2.

9.1.3 *Fuel In*—Locate thermocouple at the fuel filter. See Fig. 3, location No. 3.

9.1.4 *Coolant In*—Locate thermocouple at coolant inlet to coolant pump. See Fig. 3, location No. 4.

9.1.5 *Coolant Out*—Locate thermocouple after right and left thermostat housing outlets join. See Fig. 4, location No. 5.

9.1.6 *Air Inlet*—Locate thermocouple before compressor. See Fig. 1, location No. 7.

9.1.7 *Air Box*—Locate thermocouple right bank, rear air box cover. Tip of thermocouple should be 32 mm (1¼ in.) inside air box cover.

[29] Thermocouples and packing glands (Part MPG-125-A-T) have been found suitable and are available from the Sales Department of Conax Corporation, 2300 Walden Ave., Buffalo, NY 14225.

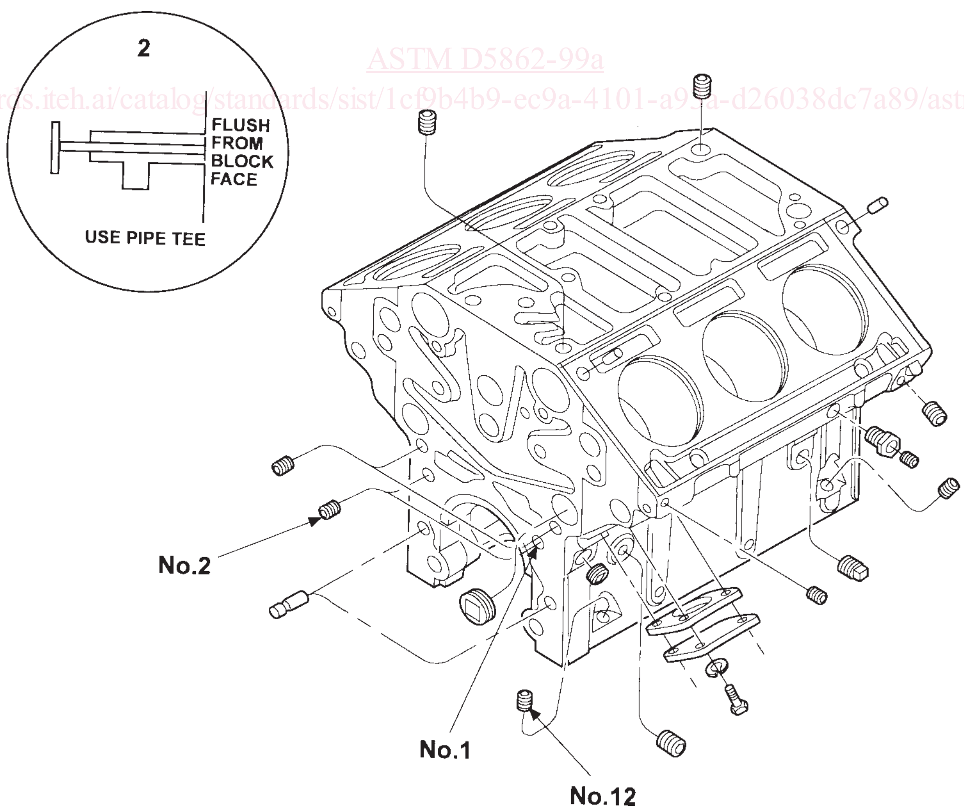

FIG. 2 Position of Pressure and Temperature Sensors

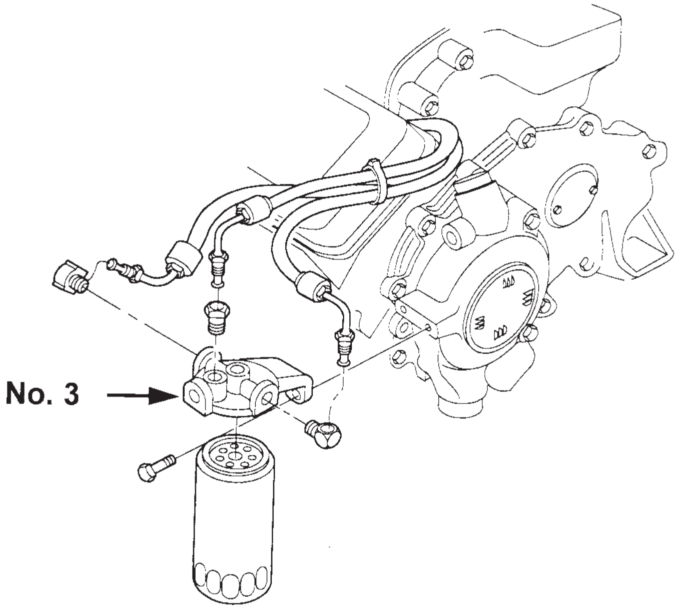

FIG. 3 Position of Pressure and Temperature Sensors

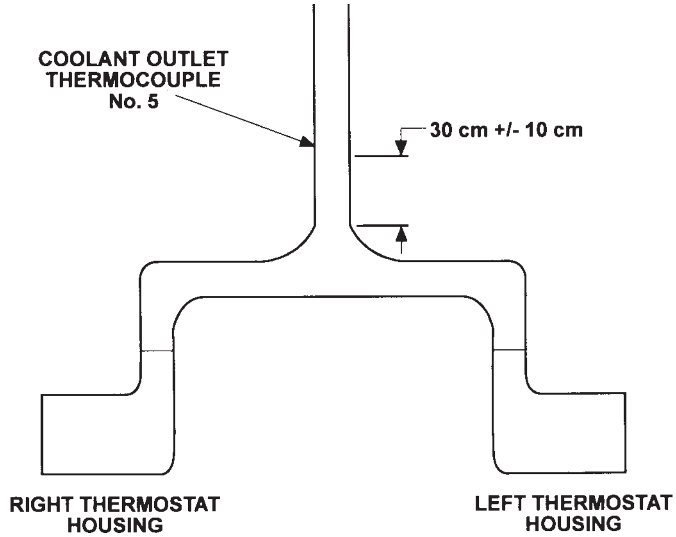

FIG. 4 Coolant Outlet Thermocouple Location

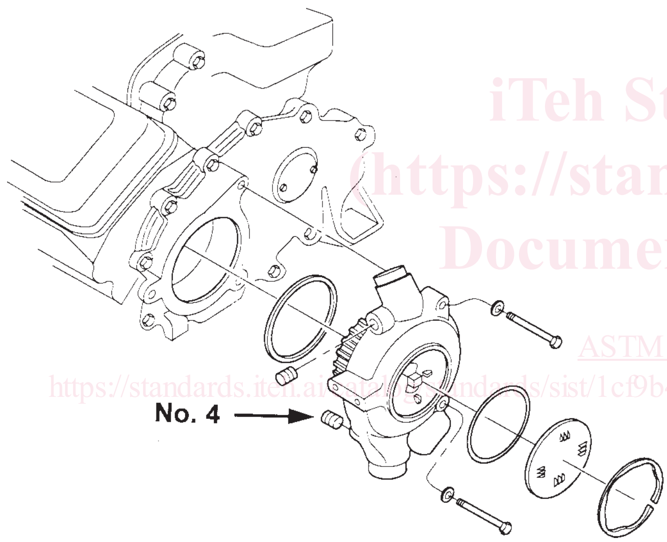

FIG. 3 *(continued)*

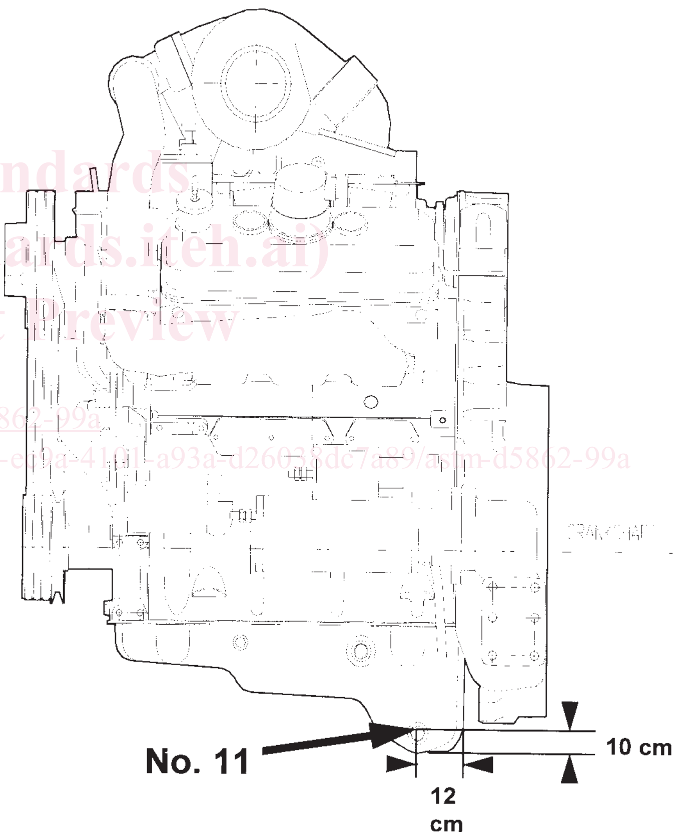

FIG. 5 Oil Sump Temperature Sensor Location

9.1.8 *Oil Sump*—Locate thermocouple in left side of oil sump, 50 to 120 mm (2 to 5 in.) from back and 50 to 100 mm (2 to 4 in.) from bottom of oil pan. See Fig. 5, location No. 11.

9.1.9 *Exhaust*—Locate thermocouple as shown in Fig. 1, location No. 13.

9.2 *Pressure Measurement*—Use pressure sensors such as pressure gages or manometers, or electronic transducers, located as indicated, and following the established guidelines.[30]

9.2.1 *Pressure Sensor Location*—Locate pressure sensors in the center of flow unless otherwise specified.

9.2.2 *Oil Gallery*—Locate pressure sensor on the left front of block. See Fig. 2, location No. 1.

9.2.3 *Air Inlet*—The air inlet restriction sensor (4-hole piezometer) is located in the air inlet, 150 ± 25 mm (6 ± 1 in.) from turbocharger as shown in Fig. 1, location No. 6.

9.2.4 *Exhaust Back Pressure*—Locate 4-hole piezometer in exhaust stream as shown in Fig. 1, location No. 8.

9.2.5 *Air Box*—Locate sensor in right bank, rear air box cover.

9.2.6 *Crankcase Pressure*—The sensor may be located in the front dipstick hole on the left side of the engine as shown in Fig. 2, location No. 12. This measurement is optional.

[30] See the 1987-04-02 Instrumentation Task Force Report to the ASTM Committee D02.B0.08 Technical Guidance Committee (RR:D02-1218).

10. Reagents and Materials

10.1 *Test Fuel*—Use ASTM 2D Fuel or equivalent. It shall have the specific properties shown in Annex A4 (Table A4.1). (**Warning**—Combustible. Health hazard.)

10.1.1 Make certain that all tanks used for transportation and storage are clean before they are filled with test fuel.

10.1.2 Verify that at least 11 300 L (3000 gal) of test fuel is available before starting the test.

10.2 *Test Oil*:

10.2.1 *Selection*—The supplier of the test oil sample shall determine that it is representative of the lubricant formulation being evaluated and that it is not contaminated.

10.2.2 *Quantity*—The supplier of the test oil shall provide approximately 100 L (25 gal) of the test oil sample.

10.2.3 *Identification*—The oil sample shall be clearly identified with the name of the test sponsor, the oil formulation, and the batch code. The code number from the container is to be entered on the test report.

10.2.4 *Storage Prior to Test*—The test laboratory shall store the test oil sample in a covered building to prevent both contamination by rainwater and excessive heat exposure.

10.3 *Coolant Composition*—A 50 % concentration of regular grade ethylene glycol type antifreeze[31] in distilled water is to be used. (**Warning**—Combustible. Health hazard.)

10.4 *Sealing and Anti-seize Compounds*—The following sealing and anti-seize compounds are required for this test method:

10.4.1 *For All Bolts Under Specified Torque*—Use International Compound No. 2 to achieve proper fastener torque. Use minimum quantities and remove all excess, as discussed in 8.5.5.

10.4.2 All bolts, plugs, fittings or fasteners, (including studs) that intersect with a through hole and come in contact with oil, fuel or coolant shall have a sealer applied to the threads. It is recommended that Loctite J26558-92 Pipe Sealant with Teflon® be used, as discussed in 8.5.5.

10.5 *Cleaning Materials*—The following cleaning materials are required in the procedure. The use of alternative materials requires approval by the ASTM TMC.

10.5.1 *For Block Cleaning*—Use Penetone (specifically Penmul L-460), as discussed in 8.3.1.

10.5.2 *For Head Cleaning*—Use an aliphatic carbon, as discussed in 8.3.2.

10.5.3 *For Piston Ring Cleaning*—Use Oakite Rust Stripper OF, as discussed in 8.3.3.

10.5.4 *For Coolant System Cleaning*—Use Nalprep 2001,[32] as discussed in 13.1.2.

11. Hazards

11.1 *General*—The environment involved with any engine test is inherently hazardous. Serious injury of personnel and damage to facilities can occur if adequate safety precautions are not taken. However, as evidenced by the fact that many thousands of engine tests are successfully conducted each year it is possible to take adequate precautions.

11.2 *Caveat*—The following paragraphs do not cover all possible safety-related problems associated with 6V92TA testing.

11.3 *Personnel*—Carefully select and train personnel who will be responsible for the design, installation, and operation of 6V92TA test stands. Make certain that the test operators are capable of handling the tools and facilities involved and in observing all safety precautions, including avoiding contact with either moving or hot test parts.

11.4 *Personnel Protection Facilities*—Provide the following personnel protection facilities:

11.4.1 Provide safety shower and eye-rinse equipment in close proximity to the facilities used for parts cleaning, engine assembly, engine test operation, and parts rating.

11.4.2 Provide, and require the use of, appropriate face masks, eye protection, chemical breathers, gloves, and so forth, in all aspects of 6V92TA testing.

11.4.3 Provide dry chemical fire extinguishers for putting out fires.

11.4.4 Advise personnel not to use water to attempt to extinguish fires involving fuel, oil, or glycol.

11.4.5 Equip test stands with automatic fire extinguishing equipment.

11.4.6 Install suitable guards around all external moving parts, or hot parts.

11.4.7 Advise personnel not to work alongside the engine and coupling shaft when the engine is operating at high speeds.

11.4.8 Provide barrier protection between the engine and coupling shaft, and operating personnel.

11.4.9 Prohibit the wearing of loose or flowing clothing by personnel working near a running engine.

11.5 *Safety Equipment and Practices*—Observe the following in order to establish and maintain safe working conditions for 6V92TA testing:

11.5.1 Provide the proper tools for conducting the 6V92TA test.

11.5.2 Require regular inspection and approval by the laboratory safety department of the facilities used for 6V92TA testing.

11.5.3 Properly install all fuel lines, oil lines, and electrical wiring. Maintain them in good condition.

11.5.4 Select and install coolant hoses and clamps with special care in order to prevent coolant leaks and possible fires.

11.5.5 Do not permit tripping hazards to exist in any of the areas involved with 6V92TA testing.

11.5.6 Keep the outer surfaces of the engine, other equipment, and the floor area free from fuel and oil.

11.5.7 Do not allow the accumulation of containers of oil or fuel in 6V92TA areas.

11.5.8 Demand that personnel be alert for leaking fuel, exhaust gas, oil, or coolant, and that they take action to stop such leaks.

11.5.9 Equip the test stand with an automatic fuel shutoff valve designed to turn off the fuel supply to the engine whenever the engine is not running.

[31] Ethylene glycol, if not available locally, is available from Dow Chemical Company, 2040 Dow Center, Midland, MI 48674.

[32] Nalprep 2001 has been found suitable for this purpose. It is available from Detroit Diesel Corporation, Part Number 23507863, or Penn Ray Companies, Inc., 1801 Estes Ave., Elkgrove Village, IL 60007.

11.5.10 Make provision for manual, remote operation of the fuel shutoff valve.

11.5.11 Install suitable interlocks to shut down the engine when any of the following develop: loss of dynamometer field current, engine overspeeding, loss of engine oil pressure, failure of the exhaust system, failure of the room ventilation, activation of the fire protection system, excessive vibration, and so forth.

11.5.12 In case of injury, seek medical attention immediately, and report the incident to the proper administrative people.

12. Laboratory and Test Stand Calibration

12.1 *Frequency of Calibration*—To maintain test precision and avoid bias, 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 ASTM Test Monitoring Center. See 12.5.1.

12.2 *Reference Oils*—The reference oils used to calibrate 6V92TA test stands have been formulated or selected to represent specific chemical types or performance levels, or both. They are available from the TMC. The Test Monitoring Center will assign reference oils for calibration tests. These oils are supplied under code numbers (blind reference oils).

12.2.1 Reference oils and subsequent reblends that have been used in this test method are:

TMC 861 (REO 217), SAE 15W-40
TMC 862, SAE 30

12.3 *Test Numbering*—Each 6V92TA test shall be numbered to identify the test stand number, the test stand run number, engine number and number of runs made on engine. See 15.1 for test numbering protocol.

12.4 *New Laboratories and New Test Stands*:

12.4.1 A new stand is defined as a test 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 not part of the stand calibration.

12.4.2 A new laboratory shall have consecutive calibration test passes to be considered calibrated.

12.4.3 A laboratory not running a 6V92TA test for twelve 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 oil tests conducted during an extended time allowance shall be annotated on Form A5.15 in Annex A5 (Fig. A5.16).

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

12.5 *Calibrated Laboratories and Test Stands*:

12.5.1 A calibration test on a reference oil assigned by the TMC is required after no more than ten operationally valid non-reference oil tests starts or after six months from the start date of the last acceptable calibration test (whichever comes first).

12.6 *Calibration Test Acceptance Bands*:

12.6.1 Calibration test targets and acceptance bands are published every six months by the TMC. These acceptance bands, based on a 90 % confidence level, are calculated using reference oil tests completed during the previous six-month period or ten tests, whichever is greater. Calibration status of a test laboratory is based upon the calibration test acceptance bands in effect at the time of completion of the calibration test.

12.6.2 The specified test parameters for determination of the test acceptance bands are:

12.6.2.1 Cylinder liner, % area scuffing,

12.6.2.2 Fire ring face distress, demerits, and

12.6.2.3 Second and third ring average ring face distress, demerits.

12.7 *Failing Calibration Tests*:

12.7.1 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.

12.7.2 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.

12.7.3 If non-standard tests are conducted on the calibrated test stand, the stand may be required to be re-calibrated prior to running standard tests, at the discretion of the TMC.

12.8 *Non-reference Oil Test Result Severity Adjustment*:

12.8.1 Fixed non-reference oil test pass criteria are published in Specification D 4485. Provision is made in this test procedure to adjust non-reference oil test results to compensate for test severity deviations from the original severity levels. Non-reference test adjustment factors represent the shift in the means of average liner scuffing, fire ring distress, and 2nd and 3rd ring face distress of Reference Oil 862 (and subsequent reblends) and are based on a moving average of the five most recent operationally valid tests on that oil.

12.8.2 Adjustment factors for non-reference tests are published semiannually by the TMC. Adjustment factors are applied (added) to individual test results based on the time period in which a 6V92TA test is completed. In the case of a single test, these adjusted results are compared to the fixed pass limits for a one-test program. In two-test or three-test programs, the adjusted test results are first averaged and then compared to the appropriate two-test or three-test fixed pass limits. Test results are recorded in the appropriate spaces on the form shown in Annex A5 (Fig. A5.21).

12.9 *Reporting Reference Results*:

12.9.1 *Final Report Forms*—Final report forms are shown in Annex A5. Use these report forms when reporting data to both the TMC and to users of the test. Transmit the calibration test results by facsimile to the ASTM Test Monitoring Center (fax number 412-365-1045) immediately after completion of the test analysis using forms in Annex A5 (Fig. A5.1, Fig. A5.2, Fig. A5.5, Fig. A5.6, Fig. A5.15, Fig. A5.16, and Fig. A5.17). Electronic data transfer is discussed in 15.4. Adhere to the variable formats (significant digits) listed in Annex A6 when reporting test results regardless of transfer medium. Referee results should be reported to the TMC on form as shown in Annex A5 (Fig. A5.8) within ten working days of test completion. The TMC will review all calibration test results to determine test acceptability. If the test is judged acceptable, the reference oil code along with the industry average for the reference oil will be disclosed by the TMC. In the event the reference oil test is not acceptable, an explanation of the problem relating to the failure should be provided by the test laboratory. If the problem is not obvious, all test related equipment shall be rechecked. If no explanation of the problem is presented, it will be assumed the problem is laboratory related and another reference oil will be assigned. One copy of the standard final test report with photographs, one copy of the daily and operational log sheets, and one copy of the rating work sheets for each 6V92TA reference oil test shall be forwarded as soon as possible to the following and shall be received within 30 days of test completion: ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206-4489.

12.10 *Analysis of Reference Oils*—Do not submit reference oils to physical or chemical analyses, or both, for identification purposes prior to testing. Identifying the oils by analyses prior to testing 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 analyses other than those specified within this procedure (see 13.3.1.1) unless specifically authorized by the ASTM Test Monitoring Center. In such cases where analyses beyond the test procedure are authorized, written confirmation of the circumstances involved, the data obtained, and the name of the person authorizing the analysis shall be supplied to the ASTM Test Monitoring Center.

13. Test Procedure

13.1 *Pre-Test Procedure*:

13.1.1 *Oil Charging*—Test severity can be affected by the volume of oil maintained in the engine during this test. Additionally, oil consumption is a condition of test validity.

13.1.1.1 Oil filling is accomplished with the use of an electric or air driven gear pump suitable for this purpose. Reasonable care should be exercised to ensure that the test oil, as delivered from the pump, is clean and free of contamination. Previous test oils shall be thoroughly flushed from the pump and delivery lines.

13.1.1.2 The recommended location for oil filling is at the remote oil cooler filter adapter. See Annex A2 (Fig. A2.2). This location also may be used for oil sampling.

13.1.1.3 For dry engine oil charge, pump 22.0 ± 0.3 kg (48.5 ± 0.7 lb) of test oil into the engine through the oil filter adapter.

13.1.1.4 Start the engine and idle for 10 min or until the oil gallery temperature reaches 60°C (140°F).

13.1.1.5 Stop the engine and wait 25 min.

13.1.1.6 Set the full mark on the adjustable dipstick to the oil level. The adjustable dipstick is described in Annex A2 (Fig. A2.4). Remove the dipstick and place in a location where this setting will not be altered. Cap the dipstick tube opening.

13.1.1.7 Complete the break-in as described in 13.1.2.

13.1.1.8 For wet engine oil charge, pump 18 kg (40 lb) of test oil into the engine.

13.1.1.9 Start the engine and idle for 10 min or until the oil gallery temperature reaches 60°C (140°F).

13.1.1.10 Stop the engine and wait 25 min.

13.1.1.11 Add additional test oil until the oil level reaches the full mark. This represents the initial oil charge.

13.1.1.12 Oil additions are made at the end of each test cycle after the engine has stopped for 25 min. Determine the approximate oil volume needed to return to the full mark indicated on the adjustable dipstick using the intermediate scribe lines.

13.1.1.13 Weigh the oil make-up and add to the engine. Record the weight in the test log.

13.1.1.14 At the end of the test, estimate the weight of oil needed to return to the full mark, but do not add fresh oil at this point.

13.1.1.15 The total oil consumed in the test is determined by the sum of the oil additions, included the estimated addition described in 13.1.1.14. It does not include the initial oil charge or the final quantity of oil in the engine. Record as grams per hour (g/h) on forms as shown in Annex A5 (Fig. A5.2 or Fig. A5.3) as appropriate.

13.1.2 *Coolant Flush Procedure*—Fill the engine coolant system with cleaning agent[21] just previous to start-up for engine break-in. (**Warning**—Health hazard.)

13.1.2.1 At the start of break-in, fill the coolant system as follows:

(*1*) Check that all drain cocks are closed.

(*2*) Fill the coolant system (approximately 45 L) with clean water and add 1 L of Nalprep 2001 to the surge pot as it is filling up.

(*3*) Fill the system until the coolant level is to the top of the sight glass.

(*4*) Install the red cap.

13.1.2.2 Flush the cleaning agent from the coolant system prior to start-up for a test. Proceed as follows:

(*1*) Drain the cleaning solution from the engine.

(*2*) Fill and drain the cooling system two times with clean water.

(*3*) Fill the cooling system with clean water.

(*4*) Run the engine to do oil leveling at idle until the oil sump temperature is >60°C; then shut down the engine.

(*5*) Drain the water from the engine.

(*6*) Fill the coolant system with a premixed 50/50 solution of ethylene glycol type antifreeze in distilled water.

13.1.3 *Engine Break-in*—Perform engine conditioning using the test oil, reference or non-reference. Make an oil and filter change following break-in. The specific engine operating conditions for break-in are provided in Table 3.

TABLE 3 Engine Operating Conditions for Break-in

Speed, r/min	Torque, Nm	Power, kW	Duration, min	Coolant Out Temperature, °C Nominal	Oil Pressure, kPa Nominal
1000	Nominal	15	10	Report	200
1200	320	40	10	78	220
1500	320	50	20	78	337
1500	640	100	30	78	337
1500	960	150	30	78	337
2100	960	211	90	78	404
2100	1360	299	180	78	404

13.1.4 *Power Check*—At the conclusion of break-in, but before shutting down engine, verify that engine output is adequate by performing a power check. Increase engine speed to 2300 r/min and increase torque until a nominal fuel flow rate of 90 kg/h is obtained. Observe and record engine power, which shall be at least 373 kW. If the engine fails to reach this power level, and repairs cannot remedy the power loss, the test should not be started. The duration of the power check should be only long enough to determine engine power output.

13.1.5 *Air Box Inspection*—At the conclusion of break-in and after the power check, an air box inspection shall be made. See 13.3.2.

13.2 *Engine Operating Procedure*:

13.2.1 *Test Procedure*:

13.2.1.1 At the completion of break-in and following service to the lubricant and filters, start the engine and allow it to warm up for 10 min, maintaining an idle. Increase engine speed to 1200 r/min. Apply load and adjust fuel flow until the conditions for Mode 1 (Torque), as is shown in Table 4, are set. Maintain this setting for 8 h.

13.2.1.2 At the end of Mode 1 (Torque) increase engine speed to 2300 r/min. Adjust the fuel flow to obtain the fuel flow range specified in Table 4. Maintain this condition for 8 h. Upon completion of this mode, return engine to idle for 5 min, then stop engine. Oil sampling shall be done during this 5-min period. See 13.3.1 for oil sampling procedure and schedule.

13.2.1.3 The third mode is a heat soak period and is an integral portion of the test procedure. During this period however, airbox inspections, oil sampling and oil leveling may be performed. This mode of the test may be longer, but cannot be shorter than 3 h. Heat soak after the seventh cycle is not necessary.

13.2.1.4 Table 5 summarizes the 100-h test sequence by segment.

13.3 *Periodic Measurements and Functions*:

13.3.1 *Oil Additions and Used Oil Sampling*:

13.3.1.1 Take samples of the test oil according to the schedule shown in Table 6 as a means of test quality control and possible problem diagnosis. Where applicable, ASTM test methods are recommended for this analysis and are identified in Table 6.

13.3.1.2 Take oil samples from the oil filter adapter of the remote oil cooler, Annex A2 (Fig. A2.2), while the engine is idling. This shall be done during the 5-min cool down after completion of a test mode. (**Warning—**In addition to other precautions, oil samples taken in this manner will be hot and can cause severe burns. Proper safety precautions to avoid skin contact, including the use of gloves, apron and safety glasses, are recommended.)

13.3.1.3 Take oil samples by first purging the sample line of 100 mL (approximately 3.4 fl oz) of test oil. This purge oil is immediately returned to the engine before oil leveling. Then draw the sample into the appropriate clean, engine oil compatible container as required by the analytical laboratory. All sample volumes should be within 10 % of 100 mL, except for a 500-mL sample taken at 96 h.

13.3.1.4 Take samples prior to any oil leveling or makeup.

13.3.2 *Air Box Inspections*:

13.3.2.1 Perform airbox inspections by removing small covers on the engine block exposing the liner port area. With the use of a bore scope or similar device, a limited inspection of the ring faces and liner inside diameter are possible. Such inspections are useful as a diagnostic tool to provide interim test part conditions and identify impending engine failure. It is not intended for prediction of failing oil performance.

13.3.2.2 An airbox inspection for liner and ring distress is required after break-in. Make an estimate of cylinder liner scuffing and report on Form 16 in Annex A5 (Fig. A5.17). Exercise extreme care when removing the airbox covers and working in the liner port area so as not to disturb any soot accumulation in the liner parts, which, if accidentally spilled into the cylinder, can cause ring and liner scuffing. Use a bore

TABLE 4 Test Parameters

(Means and Ranges)

Controlled Conditions	Torque Mode	Power Mode
Engine speed, r/min	1200 ± 10	2300 ± 10
Oil gallery temperature, °C	102.0 ± 1.1	111.0 ± 1.1
Fuel temperature, °C	38.0 ± 2.8	38.0 ± 2.8
Fuel rate, kg/h	52.0 ± 1.8	90.0 ± 1.8
Coolant ΔT, °C	6.0 ± 2.7	6.0 ± 2.7
Air inlet restriction, kPa	Report only	2.5 ± 0.7
Exhaust backpressure, kPa	Report only	3.2 ± 0.8
Air inlet temperature, °C	35.0 ± 2.8	35.0 ± 2.8
Engine coolant out, °C	84.0 ± 2.2	84.0 ± 2.2
Non-Controlled Conditions	**Torque Mode**	**Power Mode**
Engine power, kW	216–238	364–379
Oil sump temperature, °C	111–119	120–131
Oil gallery pressure, kPa	207–310	345–482
Oil consumption max, g/h	340	340

TABLE 5 6V92TA 100-Hour Test Summary

Segment	Mode	Length
	Break-in	6 h 10 min
	Power check	Only long enough to determine output
	Cool down	5 min
	Oil and filter change	...
1	Start-up	10 min
	Torque mode	8 h (test begins)
	Power mode	8 h
	Cool-down	5 min
	Heat soak	3 h minimum
2–6	Repeat number 1 (5 times)	
7	Start-up	10 min
	Torque mode	2 h
	Power mode	2 h
	Cool-down	5 min
	End of test	

TABLE 6 Oil Sampling Schedule

Analytical Tests	New Oil	Break-in	Engine Test Hours 16	32	48	64	80	96
Viscosity, cSt (D 445)								
40°C	X	X	X		X		X	X
100°C	X	X	X		X		X	X
Wear metals, ppm (D 5185)								
Fe, Sn, Pb, Cu, Cr, Al, Si	X	X	X	X	X	X	X	X
Additive metals, ppm								
B, Ca, Mg, Zn, P, Mo, Na, S	X	X	X		X		X	X
Base number (D 4739)	X	X	X		X		X	X
Viscosity HTHS								
10^6 s^{-1} 150°C (D 4683)	X							
Volatility at 371°C								
(D 2887)	X							X

scope[33] for this inspection. Excessive liner scuffing after break-in could be indicative of a test problem. A test may be aborted at the discretion of the laboratory.

13.3.2.3 Due to the potential of introducing soot and combustion debris, which can initiate liner and ring scuffing, airbox inspections are not recommended during the test unless one or more of the following conditions exist:

(*1*) A sudden increase in crankcase pressure or blowby occurs.

(*2*) Used oil iron content exceeds 500 ppm.

(*3*) Power output is below 364 kW (488 bhp) during the power mode immediately preceding the inspection.

13.3.2.4 Report all airbox inspections on Form 16 in Annex A5 (Fig. A5.17). Note the cause for the inspection in the appropriate area of the form.

13.4 *Diagnostic Data Review*—This section outlines significant characteristics of specific engine operating parameters. The parameters can directly influence the test or may be used to indicate normalcy of other parameters.

13.4.1 *Exhaust Temperatures*—Deviations for individual exhaust temperatures are used to indicate incorrect combustion, a sign of injector malfunctioning.

13.4.2 *Crankcase Pressure*—Higher crankcase pressure than normal can indicate scuffed cylinders, a leak in the seal between the piston dome and skirt, or a blower seal failure.

13.4.3 *Airbox Pressure*—Low boost pressure can indicate a damaged turbocharger (either broken vanes or a bearing failure), exhaust system leaks or blower malfunction.

13.5 *End of Test Procedure*:

13.5.1 Estimate the amount of oil necessary to bring oil to full mark, and add this amount to the cumulative oil make-up for a final oil consumption figure. Do not actually add the oil to the engine.

13.5.2 After taking end-of-test oil sample, drain oil, fuel, and water from the engine.

13.5.3 Remove engine to cleaning area and clean all surfaces as necessary to remove loose dirt, etc. before removing sub-assemblies.

13.5.4 Mount engine on overhaul stand and remove all required subassemblies, cleaning each individual part after removal. Pistons, rings, and liners, and bearings shall be cleaned as outlined in 8.3. Take care to identify and maintain all locations for test parts. Cut liners as exactly in half as possible, along the crankshaft center line, taking special care not to disturb deposits. This is accomplished by use of a suitable saw and done after cleaning with Varsol 3139 and before rating.

14. Interpretation of Test Results

14.1 *Parts Rating Area—Environment*:

14.1.1 Ensure that the ambient atmosphere of the parts rating area is reasonably free of contaminants and the temperature maintained at 75 ± 5°F (24 ± 3°C).

14.1.2 Rate all engine parts under cool white fluorescent lighting with an illumination level of 350 to 500 fc (3800–5400 lx). Ensure that all background and adjacent surfaces are flat white.

14.2 *Piston Rings*:

14.2.1 Measure radial ring thickness, mm.

14.2.2 Measure end gap all rings, mm.

14.2.3 Measure percent ring collapse based on reduction of freestanding ring gap, report to nearest 25 %.

14.2.4 Measure ring weight change, g.

14.2.5 Visually rate for ring distress in demerits as follows.

14.2.5.1 *Ring Face Distress*—Rate the rings using the scale shown in Table 7. To obtain a numerical ring demerit, multiply the distress value by the percentage of the affected area in relation to the total ring face. Determine area of distress to the nearest 1 %. Broken rings are assumed to have a distressed area of 100 % and are therefore assigned 1.00. Report results on Form 6 as shown in Annex A5 (Fig. A5.7). (**Warning**—Due to extreme collapsing, rings broken near the tips may not be recognized as broken. Measurement of ring weights or outside diameter, or both, may be necessary to confirm ring breakage.)

14.3 *Cylinder Liner*:

14.3.1 Visually rate for liner distress (scuffing):

14.3.1.1 For rating purposes, cut the liner in half vertically along the crankshaft center line. Only the area below 30 mm (1³⁄16 in.) from the top of the liner and above 12.7 mm (0.5 in.) from the top of ports is rated. The area removed by the cut is normally 1 % of the area on each side. The scuff rating of this missing area is estimated based on the rating of the adjacent areas. If the adjacent area is scuffed, the area removed by the cut is rated as scuffed and vice versa. If a liner is not cut exactly into 50 % halves, the percentage of scuffed area will be

TABLE 7 Ring Distress Rating Scale[A]

Demerit Factor	Distress Type	Definition
0.00	Non-distress	Non-contact area or contact area with no scratches or discoloration.
0.25	Light distress	Discoloration or light vertical scratches with no discoloration.
0.50	Medium distress	Light vertical scratches with discoloration.
0.75	Heavy distress	Deep vertical scratches with discoloration.
1.00	Extreme distress	Deep vertical scratches or scoring with discoloration. Indications of blowby, broken, or hot sticking.

[A] On the rare occasions when piston ring surface shows a color tint rather than a distinct color change, the ring will be called discolored.

[33] An Olympus Model 1LK-5 and 1FD-10 (both parts needed) has been found suitable for this purpose. It is available from Olympus Corporation, Industrial Fiberoptics, 4 Nevada Drive, Lake Success, NY 11042-1179.