INTERNATIONAL

Designation: D6709 – 15a

Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence VIII Spark-Ignition Engine (CLR Oil Test Engine)[1]

This standard is issued under the fixed designation D6709; 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] offers a very valuable service to the test laboratory; the Center provides reference oils and an assessment of the test results obtained on those oils by the laboratory (see Appendix X1). 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 American Petroleum Institute (API) imposes such a requirement, in connection with several 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 the test method (see Annex A3).

1. Scope*

1.1 This test method covers the evaluation of automotive engine oils (SAE grades 0W, 5W, 10W, 20, 30, 40, and 50, and multi-viscosity grades) intended for use in spark-ignition gasoline engines. The test procedure is conducted using a carbureted, spark-ignition Cooperative Lubrication Research (CLR) Oil Test Engine (also referred to as the Sequence VIII test engine in this test method) run on unleaded fuel. An oil is evaluated for its ability to protect the engine and the oil from deterioration under high-temperature and severe service conditions. The test method can also be used to evaluate the viscosity stability of multi-viscosity-graded oils. Companion test methods used to evaluate engine oil performance for specification requirements are discussed in the latest revision of Specification D4485.

1.2 Correlation of test results with those obtained in automotive service has not been established. Furthermore, the results obtained in this test are not necessarily indicative of results that will be obtained in a full-scale automotive spark-ignition or compression-ignition engine, or in an engine operated under conditions different from those of the test. The test can be used to compare one oil with another.

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

1.3.1 *Exceptions*—The values stated in inch-pounds for certain tube measurements, screw thread specifications, and sole source supply equipment are to be regarded as standard.

1.3.1.1 The bearing wear in the text is measured in grams and described as weight loss, a non-SI term.

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.* Specific precautionary statements are provided throughout this test method.

1.5 This test method is arranged as follows:

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.B0.01 on Passenger Car Engine Oils.

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[2] Until the next revision of this test method, the ASTM Test Monitoring Center will update changes in this test method by means of Information Letters. Information Letters may be obtained from the ASTM Test Monitoring Center, 6555 Penn Avenue, Pittsburgh, PA 15202-4489, Attention: Administrator. This edition incorporates revisions in all Information Letters through No. 14–3.

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure

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

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

D240 Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter

D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)

D381 Test Method for Gum Content in Fuels by Jet Evaporation

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

D525 Test Method for Oxidation Stability of Gasoline (Induction Period Method)

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

D2422 Classification of Industrial Fluid Lubricants by Viscosity System

D2699 Test Method for Research Octane Number of Spark-Ignition Engine Fuel

D2700 Test Method for Motor Octane Number of Spark-Ignition Engine Fuel

D3231 Test Method for Phosphorus in Gasoline

D3237 Test Method for Lead in Gasoline by Atomic Absorption Spectroscopy

D3343 Test Method for Estimation of Hydrogen Content of Aviation Fuels

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

D4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants

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

D4485 Specification for Performance of Active API Service Category Engine Oils

D4815 Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C_1 to C_4 Alcohols in Gasoline by Gas Chromatography

D7422 Test Method for Evaluation of Diesel Engine Oils in T-12 Exhaust Gas Recirculation Diesel Engine

[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.

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E191 Specification for Apparatus For Microdetermination of Carbon and Hydrogen in Organic and Organo-Metallic Compounds
2.2 *SAE Standards:*[4]
J183 Engine Oil Performance and Engine Service Classification (Other Than "Energy-Conserving")
J304 Engine Oil Tests

3. Terminology

3.1 *Definitions:*

3.1.1 *air-fuel ratio, n—in internal combustion engines*, the mass ratio of air-to-fuel in the mixture being induced into the combustion chambers. **D4175**

3.1.2 *automotive, adj*—descriptive of equipment associated with self-propelled machinery, usually vehicles driven by internal combustion engines. **D4485**

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

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

3.1.4 *blowby, n—in internal combustion engines*, that portion of the combustion products and unburned air/fuel mixture that leaks past piston rings into the engine crankcase during operation. **D4175**

3.1.5 *critical parts, n*—those components used in the test that are known to affect test severity.

3.1.6 *noncompounded engine oil, n*—a lubricating oil having a viscosity within the range of viscosities of oils normally used in engines, and that may contain anti-foam agents or pour depressants, or both, but not other additives. **D4175**

3.1.6.1 *Discussion*—In this test method noncompounded oil is also known as build-up oil.

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. **D4175**

3.1.8 *test start, n*—introduction of test oil into the engine. **D4175**

3.1.9 *wear, n*—the loss of material from a surface, generally occurring between two surfaces in relative motion, and resulting from mechanical or chemical action or a combination of both. **D7422**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *accessory case, n*—the mounting base containing the balancing mechanism, flywheel, and final driveshaft for the power section of the CLR engine.

3.2.2 *build-up oil, n*—see 3.1.6, noncompounded engine oil.

3.2.3 *calibrated power section/test stand combination, n*—one that has completed an operationally valid reference oil test within the previous six months, the results of which fall within industry severity and precision limits as published by the TMC.

3.2.4 *conditioning test run, n*—a full-length Sequence VIII test using a TMC-designated reference oil in a new or newly rebuilt power section to prepare the cast iron parts before conducting routine standard tests with the power section.

3.2.5 *emergency shutdown, n*—the procedure for turning off the engine's ignition without using the prescribed engine cool-down period.

3.2.6 *full-length test, n*—a test of an engine oil conducted using a power section and a test stand that runs 4.5 h run-in, 2 h flush and 40 h at test conditions. (See 10.1.3.1, exception for 10 h stay in grade test).

3.2.7 *new power section, n*—an engine power section consisting of either a new crankcase or complete power section that has no previous oil test history.

3.2.8 *off-gas, n*—gas exiting the power section crankcase breather.

3.2.9 *off-test time, n*—any time that the engine is not operating at the prescribed test conditions.

3.2.10 *oil gallery side cover plate, n*—crankcase cover plate that contains the oil gallery and provision for mounting and driving the oil pump and ignition assembly.

3.2.11 *operationally valid test, n*—an engine oil test that has been conducted in accordance with the conditions listed in this test method.

3.2.12 *power section, n*—the combination of the crankcase assembly, the cylinder block assembly, and the cylinder head assembly, all of which are attached to the accessory case.

3.2.13 *reconditioned power section, n*—an engine power section which has been disassembled, cleaned, and reassembled according to the detailed procedures[5] after completion of either a conditioning test run or a full-length CLR engine oil test.

3.2.14 *reference oil test, n*—a standard Sequence VIII engine oil test of a reference oil designated by the TMC, conducted to ensure that power section and test stand severity falls within industry limits.

3.2.15 *run-in and flush, n*—the initial 4.5 h operation of a new, rebuilt, or reconditioned power section at the beginning of either a conditioning test run or a full-length test.

3.2.16 *scheduled downtime, n*—off-test time that is specifically allowed to include warm-up and cool-down periods as well as shutdown and intermediate bearing weight loss measurements.

3.2.17 *shutdown, n*—the procedure for turning off the engine's ignition following the prescribed engine cool-down period.

[4] Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096. Request SAE Handbook Vol 3. This standard is not available separately.

[5] Refer to Instructions for Assembly and Disassembly of the CLR Oil Test Engine, available from Test Engineering, Inc., 12718 Cimarron Path, San Antonio, TX 78249.

TABLE 1 Power Section Run-in Schedule

Speed, r/min (±25)	Power W (±150)	Spark Advance, ° BTDC (±1)	Time, min (±2)	Total Time, h
1500	1500	25	60	1
2000	3000	25	60	2
2500	3700	35	60	3
3150	3700	35	60	4

3.2.18 *standard test, n*—an operationally valid, full-length Sequence VIII test conducted with a calibrated power section and test stand in accordance with the conditions listed in this test method.

3.2.19 *stay-in-grade (stripped viscosity), n*—the viscosity of the test oil after removal of volatile components and solids, according to the procedure shown in Annex A14.

3.2.20 *test oil, n*—an oil subjected to a Sequence VIII engine oil test.

3.2.20.1 *Discussion*—It can be any oil selected by the laboratory conducting the test. It could be an experimental oil or a commercially available oil. Often, it is an oil that is a candidate for approval against engine oil specifications.

3.2.21 *test stand, n*—the engine accessory case connected to a dynamometer, both mounted to a suitable foundation (such as a bedplate) and equipped with suitable supplies of electricity, compressed air, and so forth, to provide a means for mounting and operating a power section in order to conduct a Sequence VIII engine oil test.

3.3 *Acronyms:*

3.3.1 *BTDC, adj*—before top dead center

3.3.1.1 *Discussion*—It is used with the degree symbol to indicate the angular position of the crankshaft from its position at the point of uppermost travel of the piston in the cylinder.

3.3.2 *EWMA, n*—exponentially-weighted moving average

3.3.3 *LTMS, n*—Lubricant Test Monitoring System

3.3.3.1 *Discussion*—An analytical system in which ASTM calibration test data are used to manage lubricant engine test precision.

3.3.4 *SIG, adj*—stay-in-grade

3.3.4.1 *Discussion*—Capability of multiviscosity-graded oil to stay in grade under test conditions (see 4.5).

3.3.5 *TDC, adj*—top dead center

3.3.5.1 *Discussion*—It is used with the degree symbol to indicate the angular position of the crankshaft from its position at the point of uppermost travel of the piston in the cylinder.

4. Summary of Test Method

4.1 Before every Sequence VIII engine oil test, thoroughly clean the power section of the CLR oil test engine, and measure the power section parts. Install a new or clean used piston, a complete set of new piston rings, a set of new copper-lead connecting rod test bearing inserts (from a batch approved by the ASTM D02.B0.01 Sequence VIII Test Surveillance Panel), and other specified parts as required.

4.2 The power section is installed on an accessory case/test stand. Unleaded fuel is used for the test.

4.3 The engine is first operated for 4 h according to a run-in schedule shown in Table 1 (see 11.1).

4.4 The engine is then operated under specified conditions for 40 h (Table 2). At the end of each 10 h of test conditions, a sample of the test oil is drained from the power section and fresh oil is returned to the power section for continuation of the test.

4.5 An oil sample is taken at the end of the first 10 h of test conditions. When multiviscosity-graded oils are being tested, this sample is used to determine the stay-in-grade (SIG) capabilities of the test oil.

4.6 At the completion of the test, the connecting rod bearing weight loss is determined.

5. Significance and Use

5.1 This test method is used to evaluate automotive engine oils for protection of engines against bearing weight loss.

5.2 This test method is also used to evaluate the SIG capabilities of multiviscosity-graded oils.

5.3 Correlation of test results with those obtained in automotive service has not been established.

5.4 *Use*—The Sequence VIII test method is useful for engine oil specification acceptance. It is used in specifications and classifications of engine lubricating oils, such as the following:

5.4.1 Specification D4485.

5.4.2 API Publication 1509 Engine Oil Licensing and Certification System.[6]

5.4.3 SAE Classification J304.

6. Apparatus

6.1 *Test Engineering, Inc.*—The document "Instructions for Assembly and Disassembly of the CLR Test Engine"[5] provides detailed parts listings, modification instructions, assembly/ disassembly instructions, maintenance procedures, and parts replacement requirements. The following is a descriptive listing of some of the test engine and associated parts.

6.1.1 *Test Engine*—Obtain the test engine from Test Engineering Inc. (TEI).[7,8] The test engine is known by various

[6] American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005.

[7] The sole source of supply of the test engine known to the committee at this time is Test Engineering, Inc., 12718 Cimarron Path, San Antonio, TX 78249.

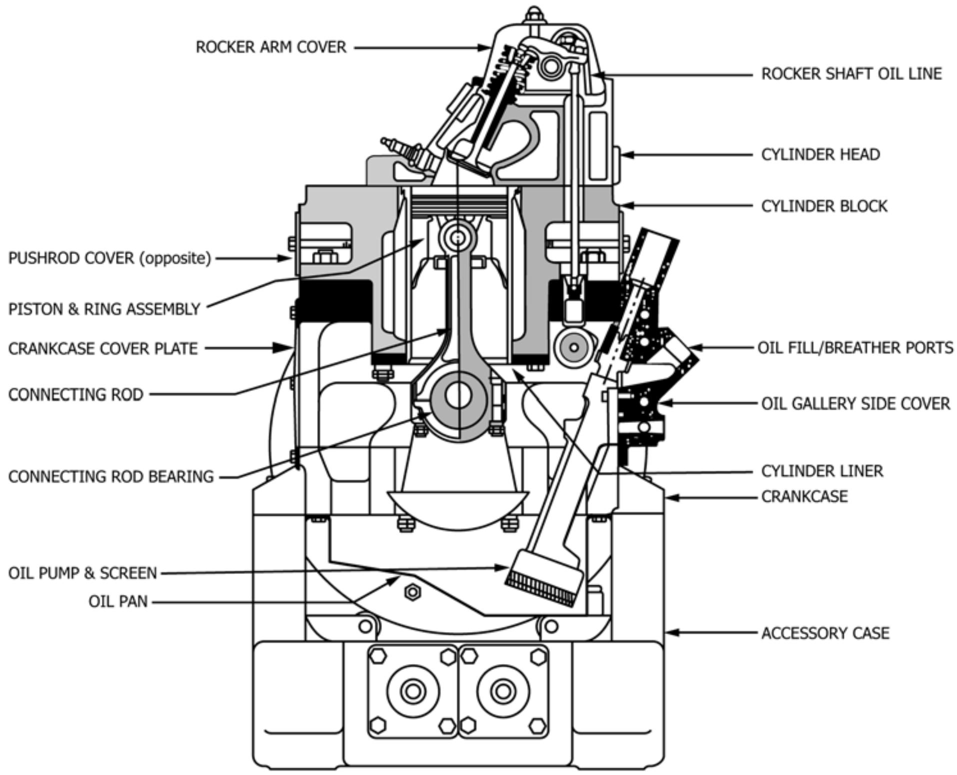


FIG. 1 Sequence VIII Power Section

TABLE 2 Test Operating Conditions

Item	Setting
Speed, r/min	3150 ± 25
Power, W	Adjust power to provide proper fuel flow at specified air-fuel ratio.
Fuel flow, kg/h	2.25 ± 0.11
Air-fuel ratio	13.43 ± 0.5
Jacket outlet coolant Temperature, °C	93.5 ± 1
Difference between jacket Inlet and jacket outlet Coolant temperatures, °C	5.6 ± 1
Gallery oil temperature, °C	
SAE 0W, 5W, 10W	135 ± 1
SAE 20, 30, 40, 50, and multi-viscosity-graded oils	143.5 ± 1
Spark advance, °BTDC	35 ± 1
Oil pressure, kPa	276 ± 14
Crankcase vacuum, Pa	500 ± 120
Exhaust back pressure, Pa	0 to 3.4
Crankcase off-gas, SLH	850 ± 28
Blowby, SLH	record

designations such as the L-38 engine, the CLR engine, or the Sequence VIII engine (as used in this test method). It comprises two principal units, the power section and the accessory case (Fig. 1). The power section is a single-cylinder, spark-ignition unit with a cylinder bore of 3.80 in. and a piston stroke of 3.75 in., and displacing 42.5 in.^{3}.

6.1.2 *Test Bearing*—SAE H-24 alloy connecting rod bearing, TEI Part No. 100034-1, from a batch approved by the ASTM Sequence VIII Test Surveillance Panel.

6.1.3 *Test Engine Crankshaft*—Obtain a crankshaft for the CLR test engine, Part No. 100039-1, from TEI. If desired, the crankshaft may be refinished in one of the following two manners:

6.1.3.1 The oil seal and main bearing journals may be refinished by welding material to the journals and regrinding the journals to the original specifications. Do not refinish the connecting rod journal using this procedure.

6.1.3.2 The crankshaft may be refinished by chrome plating[9,8] the oil seal, connecting rod journal, and main bearing journals. When refinishing a crankshaft using this procedure, chrome plate all journals listed.

6.1.3.3 To identify the crankshaft being used in a power section the following identification is required:

(1) S = standard crankshaft,

(2) C = chrome crankshaft, and

(3) R = reconditioned crankshaft.

6.1.4 *Test Engine Piston*—Obtain a piston for the CLR test engine, TEI Part No. 2405, from TEI. If desired, a piston may be reused if it meets the piston-to-liner clearance specifications. A 0.010 in. oversized piston, TEI Part No. 2405-1, may also be used in the Sequence VIII test, provided it meets the piston-to-liner clearance specifications. Do not reuse pistons used in the CLR test engine for L-38 testing or any other

[8] If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[9] The sole source of supply of crankshaft refinishing by chrome plating known to the committee at this time is OH Technologies, Inc., P.O. Box 5039, Mentor, OH, 44061-5039.

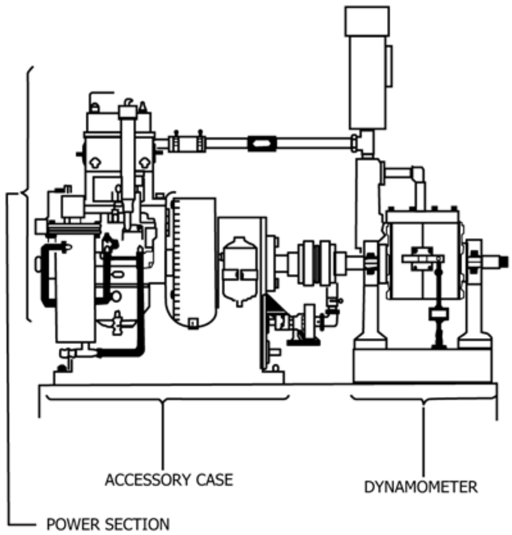


FIG. 2 Typical Sequence VIII Engine Test Stand

testing with leaded fuel in Sequence VIII testing. Clean used pistons according to the following procedure before installation in the test engine.

6.1.4.1 Clean the piston crown of any carbon deposits using aliphatic naphtha and 3M fine-grade Scotch Brite pads. Wet the cleaning pad in the solvent and scrub the deposit. Repeat until all carbon is removed.

6.1.4.2 Spray piston with clean solvent and air dry.

6.1.5 *Piston Ring Assembly*—Use a Dana/Perfect Circle piston ring assembly, Part No. 41274, in the Sequence VIII test engine.[10,8] Hastings Piston Ring, Part No. 41274R , available from TEI, may be used provided that the test laboratory has first completed an acceptable reference oil test using this ring.

6.1.6 *Test Engine Camshaft*—Obtain a camshaft for the CLR test engine, Part No. 8211, from TEI. A remanufactured camshaft, Part No. 8211R may be used if new camshafts are no longer available, provided that the test laboratory has first completed an acceptable reference oil test using a remanufactured camshaft. Obtain remanufactured camshafts from TEI.

6.2 *Fabricated or Specially Prepared Items:*

6.2.1 A typical Sequence VIII engine test stand configuration is shown in Fig. 2.

6.2.2 *Crankcase Ventilation System*—Fig. 3 is a schematic of the required configuration of the crankcase ventilation measurement and control system.

6.2.2.1 Fabricate the airtight rocker cover air and off-gas condensate trap/surge tanks shown in Fig. 3, with provisions for draining and cleaning. The volume of the rocker cover air tank shall be 3.8 L to 5.7 L. The volume of the off-gas tank shall be 38 L to 45 L. Fabricate both tanks from noncorrosive material. Locate the tanks as shown in Fig. 3.

6.2.2.2 *Rocker Cover Air Flow*—Measure the air flow into the rocker cover by using a Sierra Side Track Model 830 flow meter[11,8] capable of measuring 0 L/min to 20 L/min. An optional Dwyer rotameter, Model No. RMC-101,[12,8] with a range of 0 L/h to 1420 L/h may be used for ease of adjustments; however, take actual measurements with the Sierra flow meter. All piping and tubing used to flow air into the rocker cover shall be nominal ID of 9.5 mm.

6.2.2.3 When a closed loop automated control system is employed, use a Badger meter research control valve, Model No. 1002-GCN36-SVCSC-LN36,[13,8] (see Note 1) to control the rocker cover air flow. When using a manual control system instead of the automated system, install a Swagelok ⅜-in. metering valve, Part No. SS-6L,[14] to control the air flow into the rocker cover.

NOTE 1—The letter prior to the last dash in the model number defines the trim size. Use the trim that gives the best system control.

6.2.2.4 Install a reservoir to facilitate oil additions during test operation at the rocker cover inlet for the crankcase ventilation air. The construction of the reservoir is left up to the laboratory, but the reservoir needs to be airtight between oil additions and have an outlet to attach to the rocker cover air control system.

6.2.2.5 Construct the off-gas breather[14] as shown in Fig. 4 using American Standard Schedule 40, or equivalent, non-galvanized pipe fittings. Apply sealant to the threads during assembly. Install the breather in the breather port of the oil gallery side cover (see Fig. 5) of the engine power section. Fig. A8.1 shows freeze plug detail in an alternative configuration to that in Fig. 4.

6.2.2.6 *Crankcase Off–Gas Flow*—Measure the crankcase off-gas flow by using a Daniels Honed Orifice Flange Flow Section, Model No. H1905T-½ in.,[15,8] with orifice plate, F-150-⅛ in., and a Rosemount differential pressure transducer, Model No. 1151DP-3-S-22-D1B2.[16,8] Mount the flow section horizontally. The transducer may be set up as square root extracting to aid in interfacing with the readout. Locate temperature and pressure measurement devices at the inlet of the off-gas measurement apparatus as shown in Fig. 3.

6.2.2.7 When a closed loop automated control system is employed, use a Badger meter research control valve, Model No. 1002-TCN36-SVCSA-LN36, to control the crankcase vacuum. When using a manual control system instead of the automated control system, install a Swagelok ⅜-in. metering

[10] The sole source of supply of the Dana/Perfect Circle piston ring assembly Part No. 41274 known to the committee at this time is Dana Corp., Perfect Circle Division, 1883 E. Laketon Ave., Product Distribution Center, Muskegon, MI 49442-6123.

[11] The sole source of supply of Sierra Side Track flow meters known to the committee at this time is Sierra Instruments Inc., 5 Harris Ct, Building L, Monterey, CA 93940.

[12] The sole source of supply of Dwyer instrumentation known to the committee at this time is Dwyer Instruments Inc., P.O. Box 60725, Houston, TX 77205.

[13] The sole source of supply of Badger valves known to the committee at this time is Badger Meter Industrial Div., 6116 East 15th St., P.O. Box 581390, Tulsa, OK 74158-1390.

[14] Except for the stainless steel wool and screens, parts for the construction of the crankcase breather may be obtained from many commercial sources. The part numbers given identify the components available from McMaster Carr, Chicago, IL.

[15] The sole source of supply of Daniels flow sections known to the committee at this time is Daniel Flow Products Inc., Flow Measurement Products Div., P.O. Box 19097, Houston, TX 77224.

[16] The sole source of supply of Rosemount transducers known to the committee at this time is Rosemount Inc., 4001 Greenbriar, Ste 150B, Stafford, TX 77477.

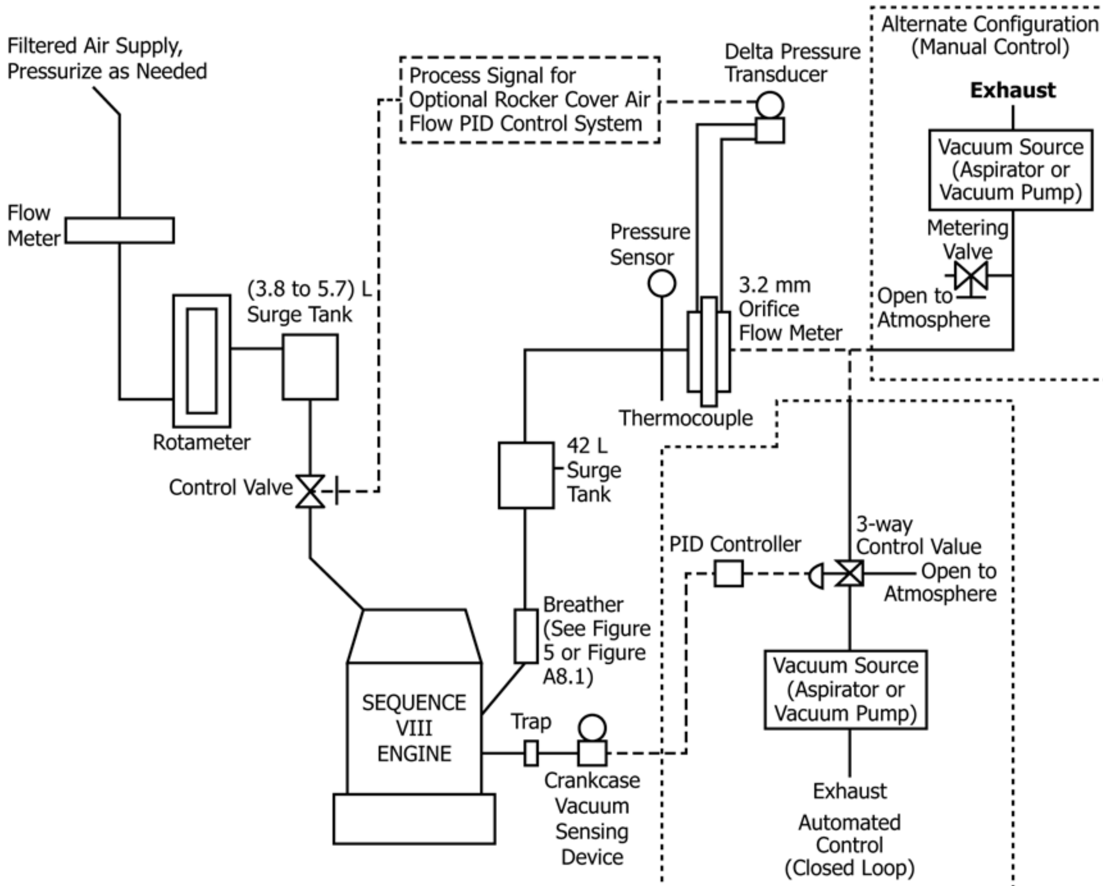


FIG. 3 Standard Crankcase Ventilation System for the Sequence VIII Power Section

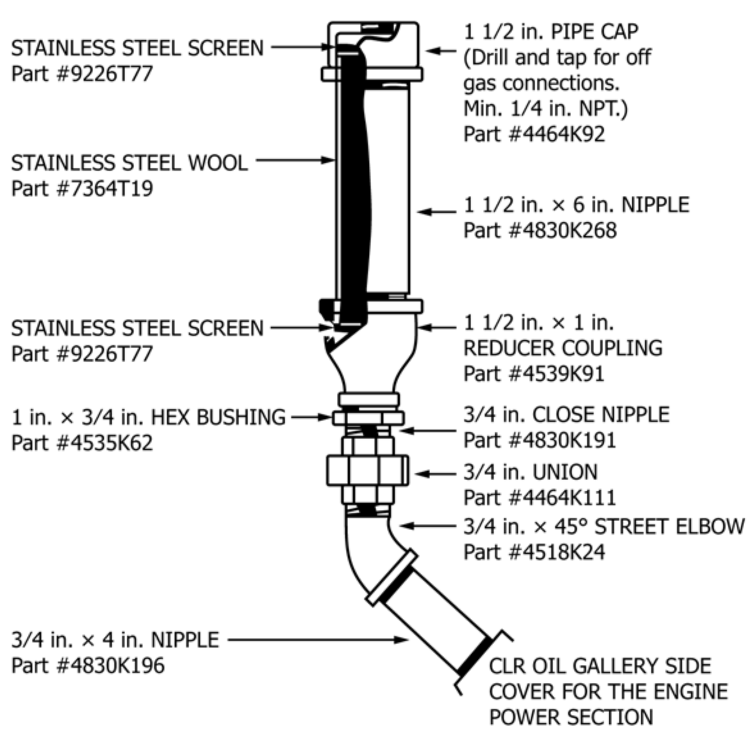


FIG. 4 Crankcase Breather Detail

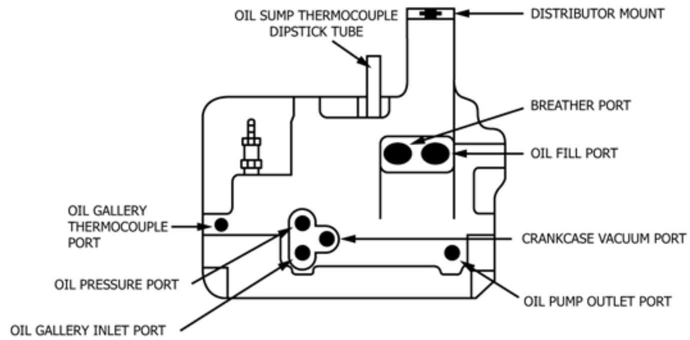


FIG. 5 Oil Gallery Side Cover

valve, Part No. SS-6L, to control the crankcase vacuum. Both systems are shown in Fig. 3.

6.2.2.8 Use a Vaccom vacuum aspirator, Model No. JD-90M,[17,8] or a vacuum pump as a vacuum source.

6.2.2.9 *Crankcase Off–Gas Inlet Pressure*—Use a Dwyer Magnehelic, Model No. 2320, or a Sensotech pressure transducer, Model No. TJE-756-05, to measure the off-gas air pressure. Locate the sensor at the inlet of the off-gas air flow apparatus as shown in Fig. 3.

6.2.2.10 *Crankcase Off–Gas Inlet Temperature*—Measure the off-gas temperature with a J-type thermocouple, 3.2 mm in diameter. Position the thermocouple tip in the middle of the air stream and expose no more than 50 mm of the sheath to ambient air. Locate the thermocouple at the inlet of the off-gas flow measurement apparatus as shown in Fig. 3.

6.2.3 *Oil Filter*—Install a Racor, Model LFS-62 or LFS-55, [18,8] oil filter as shown in Fig. 6. Use suitable hydraulic hose and fittings.[19]

6.2.3.1 *Oil Drain Valves*—Locate oil drain valves at points no higher than the bottom of the oil pan or the vertically mounted oil heater.

6.2.4 *Oil Heater*—Install the oil heater as shown in Fig. 7. Use suitable hydraulic hose and fittings.[19]

6.2.5 *Power Section Cooling System*—Install a non-pressurized cooling system consisting of a heat exchanger, water pump, coolant throttling valve, sight glass, and tower (see Fig. 8). Use American Standard Schedule 40, or equivalent, non-galvanized pipe fittings 20 mm in diameter and apply sealant to the threads during assembly.

6.2.5.1 Use a water-cooled heat exchanger. A heat exchanger of this type, suitable for this application, is available as American Heat Exchanger, Part Number 5-030-03014-011.[20,8]

6.2.5.2 Install a gate-type coolant throttling valve 20 mm in diameter on the output side of the coolant pump to maintain the specified temperature differential between the coolant flowing into, and that flowing out of, the power section jacket.

6.2.5.3 The coolant pump is an electrically driven centrifugal pump with a flow of approximately 18.9 L/min at water head pressure of 95.5 kPa. The Grainger[21] Part No. 1P831 has been found suitable.

6.2.5.4 Install a sight glass[22,8] located downstream of the cylinder head to permit detection of air entrainment.

6.2.5.5 Fabricate the tower using non-galvanized metal. Make it approximately 90 mm in diameter and 410 mm long. Fashion a loose-fitting cover for it. Install a level gage, positioned to give a mid-scale reading when the system is filled. The system shall have a minimum capacity of 7.5 L.

6.2.6 *Exhaust System*—Use either a water-quenched system or a dry system.

6.2.7 *Ignition System*—An electronic ignition system is required. The required system is illustrated in Figs. A10.1-A10.10. The TMC and the Sequence VIII Surveillance Panel review and approve other electronic ignition system configurations prior to use.

6.3 *Instruments and Controls:*

6.3.1 *Dynamometer*—Use a dynamometer and control system capable of maintaining the specified engine operating test conditions (see Section 11). Speed measurement shall have a minimum accuracy of ±0.5 % of reading, and power minimum measurement accuracy of ±2 % of reading.

6.3.2 *Fuel Flowmeter or Fuel Weigh System*—Use a system with a range of 0 kg/h to 4.5 kg/h, and having a minimum accuracy of 1 % of reading and a repeatability of 0.5 %.

6.3.3 *Air–Fuel Ratio Measurement System*—Use a system with a calibration capability of the equivalent of ±0.5 air-fuel ratio number. The following are acceptable methods for determination of air-fuel ratio:

6.3.3.1 *Calibrated Electronic Exhaust Gas Analyzer*—Use sample gases for the calibration. Follow the directions in Annex A12 to determine air-fuel ratio.

6.3.3.2 *AFR Analyzer/Lambda Meter*—The air fuel ratio (AFR) analyzer shall have a measurement range of 11.00 to 18.00 for AFR with 1.85 H/C and 0.00 O/C, where: H is hydrogen, C is carbon and O is oxygen.

[17] The sole source of supply of Vaccom aspirators known to the committee at this time is McKenzie Air Industries, 18523 IH 35 North, Shertz, TX 78108.

[18] The sole source of supply of the oil filters known to the committee at this time is Parker Hanifin Corp., Racor Division, 3400 Finch Road, Modesto, CA 95354.

[19] Aeroquip ⅜ in. (10 mm) (inside diameter) hydraulic hose has been used successfully to plumb the oil filter and oil heater; select hose of a specification to cover temperatures and pressures encountered in Sequence VIII engine oil testing.

[20] The sole source of supply of the heat exchanger known to the committee at this time is Compressor Engineering, 625 District Dr., Itasca, IL 60143.

[21] Any Grainger national branch location.

[22] The sole source of supply of a sight glass of this type, suitable for this application (Gitts-Part No. 3063-27) known to the committee at this time is Edward Fisher Co., 118 S. Wabash, Chicago, IL 60616.

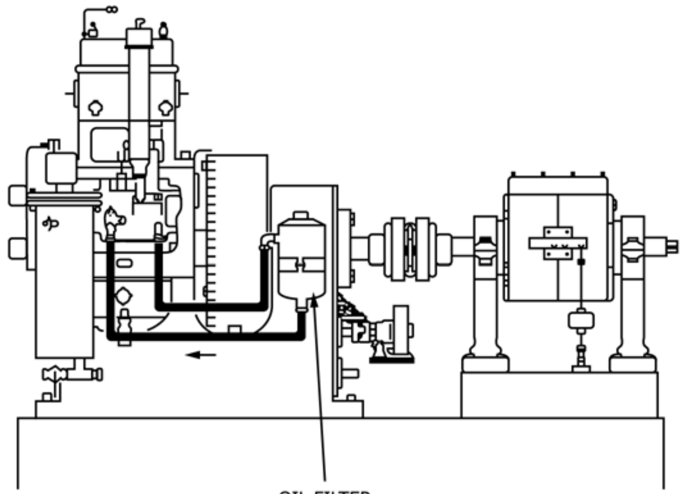


FIG. 6 Oil Filter Installation

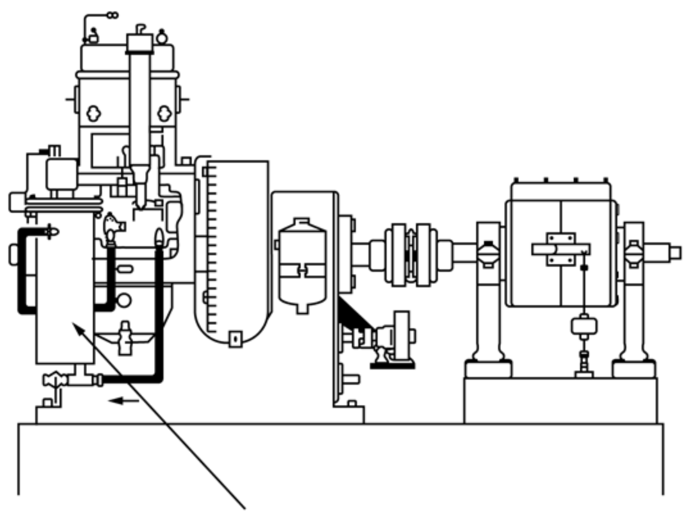


FIG. 7 Oil Heater Installation

6.3.3.3 When a Lambda meter is used, locate the exhaust sensor within 150 mm ± 50 mm of the cylinder head exhaust outlet mating surface.

6.3.4 *Pressure Measurement:*

6.3.4.1 *Crankcase Vacuum*—As shown in Fig. 3, connect a line trap and an appropriate sensor to the crankcase at the hole above and to the right of the oil heater inlet hose connection on the oil gallery side cover. See Fig. 5 for the location of the crankcase vacuum port. Measurement resolution of 50 Pa and an accuracy of 1 % in the specified range of 0.500 kPa ± 0.120 kPa are required.

6.3.4.2 *Exhaust Back Pressure*—Connect an appropriate sensor to the exhaust back-pressure tap at a point within 100 mm of the cylinder head exhaust flange. Sensor accuracy of ±10 % of reading and resolution of 340 Pa are required.

6.3.4.3 *Intake Manifold Vacuum*—Measure the intake manifold vacuum at the elbow of the intake manifold by means of a sensor having an accuracy of 1 % and a resolution of 680 Pa.

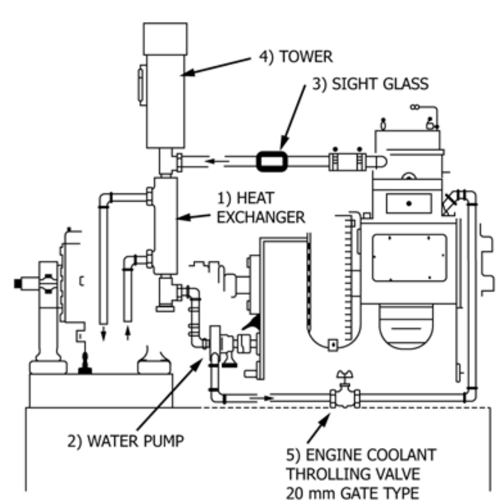


FIG. 8 Cooling System

6.3.4.4 *Oil Pressure*—Measure the oil pressure with an appropriate sensor having an accuracy of ±2 % and a resolution of 7 kPa, connected to the point shown in Fig. 5.

6.3.5 *Temperature Measurement*—The test requires the accurate measurement of oil and coolant temperature. Exercise care to ensure temperature measurement accuracy. Follow the guidelines of Research Report RR:D02-1218.[23]

6.3.5.1 Check all temperature devices for accuracy at the temperature levels at which they are to be used. Iron-Constantin (Type J) thermocouples are specified for temperature measurement.

6.3.5.2 All thermocouples shall be premium grade, sheathed types with premium wire. Use thermocouples of 3.2 mm diameter. Thermocouple lengths are not specified but shall not have greater than 50 mm of thermocouple sheath exposed to ambient laboratory temperature.

6.3.5.3 Some sources of thermocouples that have been found suitable for this application are, Leeds and Northrup, Conax, Omega, Revere, and Thermo Sensor.

6.3.5.4 System quality shall be adequate to permit calibration to ±0.56 °C for individual thermocouples.

6.3.6 *Thermocouple Location and Length*—All thermocouple tips shall be located in the center of the stream of the medium being measured unless otherwise specified.

6.3.6.1 *Coolant Temperatures*—Locate the thermocouples used to measure the coolant inlet and outlet temperatures within 100 mm of the inlet and outlet bosses on the power section.

6.3.6.2 *Air Inlet Temperature*—Measure the air inlet temperature with an exposed thermocouple or thermometer located at the center of the air tube, 38 mm above the carburetor air horn.

6.3.6.3 *Oil Gallery Temperature*—Measure oil gallery temperature at the front main bearing passage (see Fig. 5). The immersion length for these thermocouples is 35 mm.

6.3.6.4 *Crankcase Off–Gas Temperature Measurement*—Measure the off-gas temperature at the outlet side of the crankcase breather assembly. Fig. 3 shows a recommended system.

6.4 *Procurement of Parts*—Obtain information on the CLR Oil Test Engine (see 6.1.1) and parts for it from TEI. Users of this test method shall comply with CLR Oil Test Engine Shop Manual[5] and the latest supplements (Information Letters and Memoranda) available from the TMC.

7. Reagents and Materials

7.1 *Reagents:*

7.1.1 A 1:3 mixture of hydrochloric acid and deionized water. (**Warning—**The laboratory shall establish proper safety procedures for handling and disposal of this reagent.)

7.1.2 A 1:8 mixture of baking soda and water. (**Warning—**The laboratory shall establish proper safety procedures for handling and disposal of this reagent.)

7.2 *Cleaning Materials:*

7.2.1 *Abrasive Paper,*[24]400 grit, 600 grit, 800 grit, wet or dry.

7.2.2 *Crocus Cloth.*[24]

7.2.3 *Mylar Tape.*[24]

7.2.4 *Organic Solvent-Penmul L460*[25,8](**Warning—**Combustible. Health hazard.).

7.2.5 *Pentane (Solvent),* ≥99 %, high-performance liquid chromatography grade (**Warning—**Flammable. Health hazard).

7.2.6 *Solvent*—Use only mineral spirits meeting the requirements of Specification D235, Type II, Class C for Aromatic Content 0 % volume to 2 % volume, Flash Point (61 °C, min) and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale). (**Warning—**Combustible. Health hazard.) Obtain a Certificate of Analysis for each batch of solvent from the supplier.

7.2.7 *Tap Water,* heated to between 66 °C and 82 °C.

7.3 *Expendable Power Section-Related Items:*

7.3.1 *Sealing Compounds*—Approved sealing compounds, including pipe thread compound and gasket cement are:

7.3.1.1 *Perfect Seal Sealant No. 4*,[26]

7.3.1.2 *Permatex Ultra Blue 77B*,[26] identified and packaged as any of the following:

(1) 81724 95 g carded tube
(2) 85519 269 g PowerBead (Trademarked) can
(3) 81725 369 g cartridge
(4) 82170 95 g tube

7.3.1.3 *Permatex 3H, Permatex High Tack 99 MA*,[26]

7.3.1.4 *Dow Corning High Vacuum Grease*,[26]

7.3.1.5 *Dow Corning RTV Gray 3154*, and[26]

7.3.1.6 *Petroleum Jelly*.[26]

7.3.2 *Power Section Build-Up Oil.*[27]

7.4 *Power Section Coolant*—Use deionized or distilled water for the power section coolant, plus a suitable inhibitor such as Pencool 2000[28,8] used at 31 mL/L of water. Such water purchased from a commercial source is suitable.

7.5 *Reference Oils*—Conduct test periodically on reference oils supplied by the TMC, to document the test severity of a given power section and test stand, and the overall operation of the test. Use 8 L of reference oil for each test.

7.6 *Test Fuel*—Use Haltermann Products KA24E Test Fuel.[29,8] See Annex A17 for the specification for KA24E Test Fuel. (**Warning—**Flammable. Health hazard.)

[23] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1218.

[24] The sand paper and Mylar tape may be obtained from many commercial sources.

[25] The sole source of supply of Penmul L460, a registered trademark, known to the committee at this time is Penetone Corp., 7400 Hudson Ave., Tenafly, NJ 07670.

[26] These may be obtained from many commercial sources.

[27] Noncompounded oil ISO VG 46 (SAE 20) (see Classification D2422) is available through lubricant marketers. One supplier is Exxon-Mobil Oil Corp. The Exxon-Mobil product is designated EF-411, and is available from Exxon-Mobil Oil Corp., P.O. Box 66940, AMF O'Hare, IL 60666, Attn: Illinois Order Board.

[28] The sole source of supply of Pencool 2000 known to the committee at this time is The Penray Co, Inc., 1801 Estes Ave., Elk Grove, IL 60007.

[29] The sole source of supply of Haltermann Products KA24E Test Fuel known to the committee at this time is Haltermann Products, Ten Lamar, Ste 1800, Houston, TX 77002.

7.6.1 *Fuel Batch Approval*—New batches of KA24E Test Fuel are approved for use by the Subcommittee D02.B0.01 Sequence IVA Surveillance Panel.[30]

7.6.2 *Fuel Batch Analysis*—Details are available from Subcommittee D02.B0.01 Sequence IVA Surveillance Panel.

7.6.3 *Laboratory Storage Tank Fuel Analysis*—Details are available from Subcommittee D02.B0.01 Sequence IVA Surveillance Panel.

7.6.4 *Fuel Batch Shipment and Storage*—Details are available from Subcommittee D02.B0.01 Sequence IVA Surveillance Panel.

8. Test Oil Sample Requirements

8.1 *Selection*—The sample of test oil shall be representative of the lubricant formulation being evaluated and shall be uncontaminated.

8.2 *Inspection*—New oil sample baseline inspection requirements are described in 12.1.1.

8.3 *Quantity*—The fresh oil required to complete the test is approximately 7 L. It is recommended that a test laboratory have on hand approximately 8 L when starting a test to allow for inadvertent losses.

9. Preparation of Apparatus

9.1 *Test Stand Preparation:*

9.1.1 *Instrumentation Calibration* —Check the calibration of temperature sensors, flowmeters, pressure sensors, and dynamometer load indicator as required by the type of instrumentation being used. Details on calibration, of both power section and test stand, and of instrumentation, are given in 10.2.

9.1.2 *Preventive Maintenance*—Refer to and comply with "instructions for Assembly and Disassembly of the CLR Oil Test Engine" regarding details pertaining to care and maintenance of the accessory case.

9.2 *Conditioning Test Run on Power Section*—A new power section cannot be calibrated, nor is it suitable for test purposes, until a full-length, conditioning test run has been conducted on the power section. The conditioning test run is required to prepare the cast iron parts of such a power section, and the oil used for the run is a reference oil designated by the TMC. Upon completion of the conditioning run, recondition the power section as described in 9.4 before conducting a test. (A conditioning run on a reference oil shall not qualify as a reference test. Testing can commence only after a conditioning run and a reconditioning.)

9.3 *General Power Section Rebuild Instructions*—Assemble the power section according to the detailed instructions found in the assembly manual. Compliance with all provisions of the assembly manual is mandatory. However, in cases of disparity, the explicit instructions contained in this test method take precedence over the service manual. Information letters and memoranda issued by the TMC shall supersede this manual. Failure to follow the instructions provided in this document and related TMC information letters or memoranda, or both, may cause incorrect test results.

9.4 *Reconditioning of Power Section After Each Test*—Recondition a previously used power section before the start of a new test. Decontaminate power sections previously used with leaded fuel using the procedure shown in Annex A13 before use. Follow the parts replacement and cleaning procedures described in the following sections.

9.4.1 *New Parts*—Use the following new parts:

9.4.1.1 Piston and piston ring assembly,

NOTE 2—A used piston may be reused if it meets the requirements of 6.1.4.1 and the original piston pin is retained.

9.4.1.2 H-24 alloy connecting rod test bearing,

9.4.1.3 All gaskets, seals, O-rings, and

9.4.1.4 All parts that are excessively worn or that do not permit maintenance of the operating clearances specified in this method or in "Instructions for Assembly and Disassembly of the CLR Oil Test Engine."

9.4.2 *Documented Parts*—The parts supplier provides records, stating source codes and additional information such as batch code, lot number, and so forth. It is the responsibility of the laboratory to maintain records documenting these parts by proper identification numbers. The parts that require documentation are: (*1*) crankshafts, (*2*) camshafts, (*3*) connecting rod bearings, (*4*) crankshaft main bearings, (*5*) camshaft bearings, (*6*) piston rings, (*7*) connecting rods, (*8*) pistons, and (*9*) cylinder sleeves.

9.4.2.1 *Critical Parts*—The crankshaft and connecting rod are considered critical parts and are to be used as received from the supplier(s). If either is replaced during a reference period, the calibration status of the stand/power section is voided. A reference oil test meeting the calibration requirements of Section 10 is required before continuing non-reference oil testing.

9.4.3 *Parts Cleaning Procedures:*

9.4.3.1 *Oil Pump, Oil Pressure Regulator, Distributor, and Crankcase Breather*—Remove the distributor and crankcase breather. Remove the oil pump and oil pressure regulator with the oil gallery side cover plate. Clean this cover plate thoroughly using Penmul[25,8] (**Warning—**Combustible. Health hazard.) and a fiber brush or swab, then rinse the cover plate with tap water heated to 65 °C to 82 °C, and rinse it again with mineral spirits[31] (**Warning—**Combustible. Health hazard.). Carefully spray the oil pump, oil pressure regulator, and distributor with mineral spirits to remove deposits. Disassemble, inspect, and clean the crankcase breather with mineral spirits.

9.4.3.2 *Power Section*—Dismantle the power section completely before each test and thoroughly clean the parts by soaking them in Penmul for a minimum of 4 h. Remove remaining deposits on the crankshaft using fine or very fine 3M Scotch Brite pads.[32,8] After the minimal soak and cleaning period of 4 h, rinse the parts in hot tap water, (65 °C to 82 °C) to remove all traces of Penmul, and then rinse them with

[30] Contact the TMC for address information for the D02.B0.01 Sequence IVA Surveillance Panel.

[31] Mineral spirits meeting the limited Specification D235, Type II, Class C requirements are available from petroleum solvent suppliers.

[32] Trademark of 3M.

mineral spirits.[31] (**Warning—**Insufficient rinsing may allow Penmul carryover to the test oil causing increased severity in H-24 alloy bearing weight loss.)

9.4.3.3 *Alternative Methods*—The above-noted parts may be cleaned using a heated bath or temperature controlled automated parts washer. Allow the parts to cool before assembly or measurement. Protect parts cleaned by either method in accordance with 9.4.3.4.

9.4.3.4 *Protection of Parts*—Immediately after cleaning, protect all parts against moisture and contamination by the use of build-up oil, vapor-proof plastic bag, or both. Give special attention to cleaning the following: (*1*) sludge trap, (*2*) oil passages in crankshaft, in cylinder block, in crankcase and to valve lifters, (*3*) oil passage to rocker assembly, and (*4*) oil passage to timing gear oil jet.

9.4.3.5 *Oil Heater Cleaning*—Prior to each reference oil test, clean the oil heater case and inner cartridge with Penmul to remove all residues, deposits, and foreign material. Use a wire brush or emery cloth as needed to completely remove residues and deposits, then rinse with hot tap water and spray the case and cartridge with mineral spirits[31] and air dry. Prior to every test between references, the oil heater can be cleaned by circulating mineral spirits through it for 15 min and then air drying.

9.4.3.6 *H-24 Alloy Test Bearing*—Mark the bearing before using it in a test with the letters T (top) and B (bottom) on the backs of the bearing tangs, using a vibrating engraver. Make no other marks on the bearing until after the final weighing. Prior to initial weighing and prior to weighing at the end of a test, clean the bearing halves according to the procedure given in Annex A9. (Use fresh, clean mineral spirits[31] and pentane for cleaning.) (**Warning—**Flammable. Health hazard.)

9.4.4 *Cylinder Liner Finishing*—To minimize the effect of changes in oil consumption, finish a new TEI cylinder liner according to the honing procedure in Annex A6. The method for finishing a used liner is at the laboratory's judgment.

9.4.4.1 *Cleaning Procedure and Rust Prevention*—After the desired finish is achieved, spray the liner with mineral spirits, and air dry it. Apply build-up oil to the liner surface. Wipe the liner interior with a cloth or paper towel wetted with build-up oil until the wiping material appears clean after wiping. Coat the liner with build-up oil.

9.4.5 *Piston-to-Sleeve*—Determine the piston-to-sleeve clearance in accordance with the procedure given in Annex A4.

9.4.6 *Crankshaft Rear Seal Surface Conditioning*—Control of oil and air leakage at the crankshaft rear seal may be improved if the crankshaft rear seal surface is conditioned prior to each test in accordance with the recommendations of Annex A15.

9.4.7 *Crankshaft Journal Conditioning:*

9.4.7.1 Use crankshafts with all journals having out-of-round measurements of 0.025 mm or less.

9.4.7.2 Since the test method is primarily designed to measure bearing weight loss, maintain the crankshaft rod bearing journal such that weight loss due to abnormal mechanical wear is minimized. Exercise care when handling the crankshaft to prevent nicking the journal surfaces. Should nicks be observed, lightly dress the journal with a dressing stone. Remove as little metal as possible. Observe bearing wear pattern for the test following this process to confirm that mechanical wear is at a practical minimum.

9.4.7.3 Polish the connecting rod bearing journal according to the following guidelines. Mount the crankshaft on centers or position the main bearing journals in V-blocks. Prepare strips of polishing medium (only a wet/dry, silicon carbide, 400, 600 and 800 grit abrasive paper, standard crocus cloth, or Mylar 3M[33,8] tape is approved for use) with widths of 13 mm and lengths of 900 mm to 1200 mm. It is necessary to wet the strip of crocus cloth or abrasive paper with build-up oil or the Mylar tape with mineral spirits.[31] Wrap the strip 1½ times around the journal to provide a minimum of 360° contact between the cloth and journal. The Mylar tape[33] will not slide over itself so only wrap it 180°. Stroke the journal with the cloth or abrasive paper by alternately pulling on the two ends of the strip while maintaining a light tension on the strip, and while traversing across the journal. Do not dwell in the center of the journal. Rotate the crankshaft 90° between each traverse. Repeat four times. If abrasive paper is used, complete the fourth and final polishing process using crocus cloth or Mylar tape.

9.4.7.4 Alternatively, rotate the crankshaft (for example, with a metal turning lathe) during the polishing process at about 120 r/min. Polishing for approximately 20 s to 30 s, while traversing the cloth across the journal, has been found to be effective for this process. Do not dwell in the center of the journal. No other method of polishing process is permitted.

9.4.7.5 Repeat the polishing procedure with dry crocus cloth or Mylar tape.

9.4.7.6 To confirm the trueness of the journal, visually check the journal with a straight edge 30.12 mm long; this length equals the width of the connecting rod bearing. Place a bright light source near the crankshaft on the side opposite your eyes. Hold the straight edge axially against the journal and inspect for light leakage between the straight edge and the journal surface, at 30° increments around the journal. If light leakage is observed, measure the journal diameters at the large and small-diameter points, determine the axial distance between the two measurement points, and calculate the taper (using half of the diametrical difference) of the journal between the points. Discard any crankshafts having a connecting rod journal taper larger than 0.013 mm per 25.4 mm. (Experience has shown that mechanical bearing wear with such crankshafts is unacceptably high.) The use of technology, such as surface profile measuring equipment is acceptable if approved by the TMC.

9.4.7.7 Resizing (refinishing) of the connecting rod journal is allowed only as stated in 6.1.3.2.

9.4.7.8 Determine the connecting rod bearing clearance and journal taper according to the procedure given in Annex A1, or an equivalent method approved by the TMC, prior to the initial weighing of the bearing halves. Perform the connecting rod clearances prior to the initial weighing of the bearing halves.

9.4.7.9 Determine the main bearing clearance according to the procedure given in Annex A2 or an equivalent method

[33] Trademark of 3M.

approved by the TMC. Perform the connecting rod clearance measurements prior to the initial weighing of the bearing halves.

9.4.7.10 After preparing the crankshaft according to 9.4.7.1 – 9.4.7.9, clean it thoroughly. Either pressure spray it with mineral spirits[31] or brush it with mineral spirits,[31] and air dry.

9.4.8 *Camshaft Journal Conditioning*—The camshaft journal-to-bearing clearance shall be within the range of 0.030 mm to 0.132 mm. (However, to maintain good oil pressure control when using low-viscosity oils, it may be necessary to reduce this clearance to 0.030 mm to 0.081 mm.) A suggested method for salvaging out-of-limit camshaft bearing journals or for decreasing the camshaft journal clearance is provided in Appendix X2.

9.4.9 *Power Section Valve Clearances*—Make the appropriate adjustments during power section reassembly to obtain the clearances shown in the "Instructions for Assembly and Disassembly of the CLR Test Engine." If specifications do not include an inch tolerance, the intent is to meet this value.

9.4.10 *Power Section Assembly Torque Specifications*—During power section assembly, use the torque specifications shown in the "Instructions for Assembly and Disassembly of the CLR Test Engine."

9.4.11 *Connecting Rod Reconditioning*—Connecting rods can only be reconditioned by the supplier; this includes piston pin bushings, rod bolts, and resizing of the big end. Reconditioned connecting rods will be identified by the supplier by adding an alphabet suffix to the serial number; for example, A for first reconditioning, B for second, and so forth.

10. Calibration

NOTE 3—The ASTM Test Monitoring Center Calibration Program (Annex A3) dictates specific procedures which involve coordination with the TMC in order to obtain calibration status of a test power section and a test stand. The information given in the following sections provides a summary of the calibration process required.

10.1 *Power Section and Test Stand Calibration*—Calibrate power sections in combination with test stands by running tests on reference oils (see 10.1.3 for frequency). The purpose is twofold: *(1)* to verify standardized engine operation, and *(2)* to document a laboratory's severity level for given combinations of power sections and test stands. (Conduct a test of a non-reference oil only on a given combination of power section, test stand, and bearing batch lot that has been previously calibrated.) Conduct all non-reference oil and reference oil tests in the same manner.

10.1.1 *Reference Oils*—Obtain reference oils for calibration use from the TMC. Oils are available representing various levels of performance. See 14.1 for performance data.

10.1.2 *Test Numbering*—Calibration of power sections and test stands is closely related to test numbering; that is, the test number assigned to a test is a function of the calibration test recently conducted. Number each Sequence VIII Engine Oil Test by assigning it a test number that identifies the test stand number, the power section number, the number of tests conducted on the power section since the last successful reference oil test on that power section, and the total number of runs on the power section. The only exception to this format is to follow the sequential total number of runs on the power section by the letter A for the first rerun, B for the second, and so forth, for an invalid or unacceptable reference oil test.

10.1.3 *Reference Oil Test Frequency:*

10.1.3.1 Using blind reference oils supplied by the TMC, calibrate each power section/test stand combination following each 15 test starts or upon the expiration of the power section/test stand time period of 6 months, whichever occurs first. When a Sequence VIII oil test is terminated after the first interval of 10 h to determine the stripped viscosity of a multiviscosity-graded oil, on a calibrated Sequence VIII power section/test stand, the test is counted as one of 15 test starts allowed per reference period. Also, count any tests exceeding intervals of 40 h as more than one test each time it exceeds 40 h. For example, 0 h to 40 h equals one test; 41 h to 80 h equals two tests; 81 h to 120 h equals three tests, and so forth.

10.1.3.2 When circumstances develop that are beyond a laboratory's control, such as fuel or parts shortages, calibration periods and the number of test starts between calibrations may be adjusted. The TMC and the Sequence VIII Surveillance Panel approve adjustments to calibration periods and the number of test starts between calibrations before additional test starts are conducted. Make a note on the form shown in the final test report, stating that the test was conducted on a power section/test stand in which calibration requirements were adjusted and, also, the reason for the adjustment.

10.1.3.3 Laboratories running non-standard Sequence VIII tests shall contact the TMC before resuming calibrated Sequence VIII testing with the test stand or power section (or both) involved. Depending upon the modifications to the power section or test stand (or both) and the time period of non-standard testing, test stand checks or reference oil tests, or both, may be required before resumption of calibrated testing.

10.1.4 *Reference Oil Test Acceptance and Severity Monitoring:*

10.1.4.1 The TMC maintains records of reference oil test activity, analyzes severity trends, gives reports at ASTM meetings, and assists laboratories in the technical conduct of tests. (See Appendix X1 for a more detailed presentation of the TMC role.)

10.1.4.2 Submit all reference oil test reports to the TMC for review and acceptance. (See LTMS for reference oil test acceptance criteria[34]). The Test Results sheet for test reports on engine oils other than reference oils shall include the test number and completion date of the power section reference oil test(s) used to calibrate the power section/test stand used for the test.

10.1.4.3 Failure of a reference oil test to meet LTMS control charts limits can be indicative of a false alarm, or a power section/test stand, laboratory or industry problem. When this occurs, the laboratory, in conjunction with the TMC, shall attempt to determine the problem source. Input from industry expertise (ASTM Technical Guidance Committee, the Sequence VIII Surveillance Panel, Registration Systems, Inc., and so forth) may be solicited to help determine the cause and extent of the problem.

[34] The document, "Lubricant Test Monitoring System," is available from the TMC.

(1) In the event of a failed reference oil test, first review the calibration status of the power section or test stand, or both, before subsequent tests are conducted. If the TMC determines the problem is a false alarm, then there is no impact on non-reference tests running in the laboratory. If it is determined that the problem is related to the power section or test stand, review non-reference tests run during the problem period in that power section or test stand, or both, for validity taking into account the related new information.

(2) If it is determined that the problem is related to the laboratory, review all non-reference oil tests run in the laboratory during the problem period for validity taking into account the related new information.

(3) If it is determined that the problem appears to be industry-wide, request the ASTM Sequence VIII Surveillance Panel to develop a resolution.

10.2 *Instrumentation Calibration*—Calibrate the following instrumentation, immediately prior to each reference oil test, with the exception of a test stand where reference oil tests are conducted with multiple power sections. For a test stand using multiple power sections, the test stand instrument calibration may be extended by 14 days. For example, a reference oil test can be conducted in the same test stand with a second power section without calibrating the test stand instrumentation if the reference oil test is started within 14 days of the previous test stand instrument calibration. Unless otherwise specified in this test method, follow the instructions provided by the manufacturers of the instruments regarding the method of calibration. In calibrating each instrument, use certified reference standards having known values covering the range of measurements to be encountered in using this test method, and having tolerances less than those of the measurement tolerances specified in this test method. Retain the calibrations records for a minimum of 24 months.

10.2.1 Engine power measurement system,

10.2.2 Engine speed indicator,

10.2.3 Fuel flowmeter or weighing scale,

10.2.4 Temperature sensors and measurement system,

10.2.5 Electrical wattmeter (only if used),

10.2.6 Pressure gages,

10.2.7 Crankcase off-gas flowmeter,

10.2.8 Crankcase ventilation air flowmeter, and

10.2.9 Rocker cover air flowmeter.

10.3 *Calibration of AFR measurement Equipment:*

10.3.1 *Lambda Meters,* prior to each reference oil test.

10.3.2 *Exhaust Gas Analysis Meters,* prior to each reading zero and span.

10.4 Calibrate torque wrenches every 6 months.

11. Engine Operating Procedure

11.1 *Run-In and Flush*—At the beginning of each test, perform the following 4 h run-in and 0.5 h flush:

11.1.1 Install the Racor oil filter bypassing the oil heater (see Fig. 6). Use a new/clean filter screen (28 µm) for each new test run-in.

11.1.2 Charge the power section with 2840 mL of fresh test oil. Record the date and time that the oil is poured into the engine. These are considered the test start date/time. Prior to starting the engine and any restarts during the 4 h run-in, perform the oil priming procedure in Annex A7.

11.1.3 Operate the power section according to the schedule in Table 1 for 4 h. Maintain the oil gallery temperature no higher than 107.0 °C, the oil gallery pressure at 280 kPa ± 10 kPa, and the jacket outlet temperature no higher than 93.5 °C. Record data at least hourly using a form of the type shown in Fig. X3.1.

11.1.4 Shut down the power section after four running hours. Immediately move the piston to top dead center (TDC) on the compression stroke, and drain the crankcase for 10 min. Remove the crankcase breather tube to vent the power section to atmosphere during drain periods.

11.1.5 After the 4 h run-in, add the oil heater (Fig. 7). The oil heater remains in the oil circuit for the flush and steady-state portions of the test procedure. The external oil outlet shall pass through the heater, then the Racor filter before returning to the engine.

11.1.6 Charge the power section with 1660 mL of fresh test oil. Prior to starting the engine and any restarts during the 0.5 h flush, perform the oil priming procedure in Annex A7.

11.1.7 Flush the power section under the following operating conditions for 0.5 h: 3150 r/min ± 25 r/min, 3.73 kW ± 0.15 kW, spark advance 35° ± 1° before top dead center (BTDC), maximum oil gallery temperature 107.0 °C, maximum water jacket outlet temperature 93.5 °C, and oil gallery pressure 280 kPa ± 10 kPa. Do not energize the oil heater during this period. Record the operational data prior to shutdown using forms of the type shown in Figs. X3.1 and X3.2.

11.1.7.1 *Downtime Limits, Run-in and Flush*—During the run-in interval and the flush interval (11.1.3) no more than 4 h of off-test time are allowed. No more than one emergency shutdown is allowed. No more than two total shutdowns are allowed.

11.1.7.2 During the shutdown between the 4 h run-in and 0.5 h flush, consider any time in excess of 85 min as off-test time counted against the 4 h limit listed in 11.1.7.1.

11.1.7.3 During the shutdown after the 0.5 h flush, consider any time in excess of 145 min as off-test time counted against the 4 h limit listed in 11.1.7.1.

11.1.8 Shut down the power section; immediately move the piston to TDC on the compression stroke, and drain the crankcase and oil heater for 10 min. Replace or clean the filter

TABLE 3 Power Section Warm-up Schedule

Time, min	Total time, min[A]	Heat Flow Rate, W[B]	Temperature Set Point[B]
15	15	1000	101.7 °C
10	25	1300	112.8 °C
10	35	1600	123.9 °C
10	45	1900	132.8 °C
15	60	2200, if needed	(135.0 or 143.3) °C[C]

[A] Steady-state test time does not include warm-up time; rather, it begins only when the specified oil gallery temperature is reached.
[B] Either heat flow rate or temperature set point control may be used for warm-up operation.
[C] As appropriate from test oil viscosity grade. See Table 2.

screen in the Racor filter. An alternate method of having two Racor filters is allowable, one used for run-in and flush and another for test.

11.2 *Test Operating Conditions*—Throughout the remainder of the test, operate the power section under the conditions shown in Table 2.

11.2.1 *Downtime During the Test Conditions for 40 h*—The maximum allowable off-test time is 9 h; also, no more than two emergency shutdowns are allowed and no more than four total shutdowns are allowed.

11.2.2 *Warm-up Schedule*—Charge the power section with 1660 mL of fresh test oil. Prior to starting the engine and any restart during the test of 40 h, perform the oil priming procedure in Annex A7. Start the engine and bring engine speed up to 3150 r/min. Follow the schedule in Table 3. When restarting the power section after any unscheduled or emergency shut downs, start the warm-up at the oil gallery temperature recorded when the engine is restarted and adjust the heater wattage or temperature set point, in accordance with Table 3. For example, if the oil gallery temperature when the engine is restarted is 123.9 °C, set the warm-up condition at 1900 W or 132.2 °C for 10 min as shown in Table 3. The warm-up shall proceed from this point and continue with the required steps in Table 3.

11.3 *Air-Fuel Ratio and Spark Advance*—Record and adjust, if necessary, the air-fuel ratio and spark advance at 1 h, 10 h, 20 h, and 30 h. This is the minimum requirement. Additional readings are permitted. When determining the air-fuel ratio using the exhaust gas analysis measured by the calibrated electronic method, utilize Table A12.1.

11.4 *Rocker Cover Air, Off-gas, and Blowby Measurement:*

11.4.1 Adjust the rocker cover air control valve, as needed, to achieve an off-gas measurement in litres per hour that is then corrected to a standard litres per hour (SLH) value of 850 L/h ± 28 L/h. After the gas flow measurement has been corrected to an SLH value of 250 L/h ± 28 L/h, measure the rocker cover air flow in litres per hour, then correct to an SLH value of 850 L/h ± 28 L/h and record that value. Convert the observation to standard conditions 101.3 kPa and 21 °C) as follows:

$$SLH = ALH \times \left[\left((BARO + GAS)/101.32\ \text{kPa} \right) \times \left(294.26°\text{K}/TEMP \right) \right] \tag{1}$$

where:

SLH	=	off-gas, standard L/h,
ALH	=	actual measured off-gas, L/h,
BARO	=	barometer reading, kPa,
GAS	=	gage pressure at inlet of the off-gas measuring device, kPa, and
TEMP	=	temperature at the inlet of the off-gas measuring device, °K.

11.4.1.1 Adjust the rocker cover air control valve as needed to achieve off-gas flow 850 SLH ± 28 SLH.

11.4.1.2 Observe and record the rocker cover air flow reading in SLH after the off-gas flow has been adjusted to 850 SLH ± 28 SLH.

11.4.2 Blowby is the difference between the standardized off-gas flow measurement and the standardized rocker cover airflow measurement.

11.5 *Unscheduled Shutdowns*—There are no scheduled shutdowns during the 40 h at test conditions. Whenever unscheduled shutdowns become necessary, if possible, follow 11.5.1. If unable to follow 11.5.1, consider the shutdown an emergency shutdown.

11.5.1 Turn off the oil heater and idle the power section at 1500 r/min for 10 min. (This action prevents overheating of the oil in the heater.) Allow the rocker cover fresh air input to remain on. Turn off the ignition to stop the engine. It is also acceptable to disconnect the fuel supply and allow the engine to idle to a stop before turning off the ignition. Move the piston to TDC on the compression stroke.

11.6 *Oil Sampling and Oil Addition*—After 10 h, 20 h, and 30 h at test conditions, take oil purge, take oil samples and make additions as directed in the following sections.

11.6.1 Purge 60.0 mL of the engine oil into a beaker.

11.6.2 Take a sample of 180.0 mL (same location as purge).

11.6.3 Add 240.0 mL of new oil into the engine along with the original purge (60.0 mL).

11.7 *Periodic Measurements:*

11.7.1 Record, using the data log sheet shown in Fig. X3.2, the following data hourly:

11.7.1.1 Engine speed, r/min,

11.7.1.2 Engine power, kW,

11.7.1.3 Fuel flow, kg/h,

11.7.1.4 Oil gallery temperature, °C,

11.7.1.5 Oil heater input, W, (only if used to control temperature),

11.7.1.6 Jacket inlet coolant temperature, °C,

11.7.1.7 Jacket outlet coolant temperature, °C,

11.7.1.8 Oil pressure, kPa,

11.7.1.9 Crankcase vacuum, kPa,

11.7.1.10 Exhaust back pressure, kPa,

11.7.1.11 Intake air temperature, °C,

11.7.1.12 Intake manifold vacuum, kPa,

11.7.1.13 Crankcase off-gas, L/h, corrected to SLH,

11.7.1.14 Rocker cover fresh air flow, m^3/s, and,

11.7.1.15 Blowby, L/h.

11.7.2 Record the following data at test hours 1, 10, 20 and 30:

11.7.2.1 Air-fuel ratio, and,

11.7.2.2 Spark advance.

11.8 *Final Drain and Oil Consumption Computation*—At the completion of the 40th test hour, shut down the engine (see 11.5). Immediately move the piston to TDC on the compression stroke, and drain crankcase, Racor filter and oil heater. Leave the rocker cover air supply on and remove the breather tube to ensure a proper drain. Measure and record the amount of oil drained. The maximum allowable oil consumption is 778 mL.

11.9 *Operational Validity Criteria*—The test laboratory is responsible for determining and documenting the operational validity of every engine test. In order for a test to be operationally valid, the deviation percentage criteria defined in

11.9.1 shall be met. In addition, the test stand, test operation, and test build-up shall conform with the published procedure/ standard.

11.9.1 *Deviation Percentage*—Calculate the deviation percentage using the equation:

$$DP = \sum_{i=1}^{i=n} \left[\frac{M_i}{0.5R} \times \frac{T_i}{D} \right] \times 100 \qquad (2)$$

where:

DP = deviation percentage,
M_i = magnitude of test-parameter deviation from specification limit at occurrence i,
R = test parameter specification range,
T_i = length of time that test parameter was outside of specification range at occurrence i,
n = number of times that a test parameter deviated from test specifications limits, and
D = test or test-phase duration in same units as T_i.

NOTE 4—T_i is assumed to be no less than the recorded-data-acquisition frequency unless supplemental readings are documented.

11.9.1.1 Invalidate any tests exceeding the following deviation percentages:

(*a*) *Primary Test Parameters (2.5 %)*:
(1) Fuel flow,
(2) Crankcase off gas,
(3) Oil gallery temperature,
(4) Coolant out temperature,
(5) Coolant delta temperature, and
(6) Oil pressure.

(*b*) *Secondary Test Parameters (5.0 %)*:
(1) Speed,
(2) AFR,
(3) Spark advance,
(4) Exhaust pressure, and
(5) Crankcase vacuum.

11.10 *Test Completion*—Defined the end of test (EOT) time as 25 min after the 40th test hour.

12. Determination of Test Results

12.1 *Oil Sample Analysis:*

12.1.1 Determine the kinematic viscosity of the new oil and a sample taken at 10 h at 40 °C and 100 °C.

12.1.2 Determine the viscosity stability of a multiviscosity-graded oil by measuring the stripped viscosity of a sample of used oil taken at 10 h. See Annex A14 for the specified measurement method.

12.2 *Test Bearing Weight Loss Determination*—Record, in milligrams, the weights of the top and bottom connecting rod test bearing halves within 4 h of conclusion of the test. If this determination is delayed longer than 4 h, the test is invalid. Clean each test bearing half, as described in Annex A9, before weighing. Determine the weight loss of the bearing to the nearest 0.1 mg by subtracting from the initial weights recorded prior to power section run-in.

12.2.1 If applicable adjust the total bearing weight loss, according to the procedure in Annex A5. Record the severity adjustments (SA) in the test report (see Annex A16).

TABLE 4 Reference Oil Test Precision Limits

Variable	$S_{i.p.}$	i.p.	S_R	R
Bearing weight loss, mg	4.15	9.99	4.16	11.65
Stripped viscosity, mm²/s at 100 °C	0.11	0.31	0.12	0.34

Legend:
$S_{i.p.}$ = intermediate precision standard deviation
i.p. = intermediate precision
S_R = reproducibility standard deviation
R = reproducibility

13. Report

13.1 For referenced oil tests, the standardized report form set and data dictionary for reporting test results and for summarizing the operational data are required.

13.2 Use Forms 1, 2, 4, 5, 6, 7, and 8 (see Annex A16) for initial transmission of reference oil test results to the TMC.

13.3 Report results on all reference oil tests run to completion, regardless of validity.

14. Precision and Bias

14.1 *Precision*—Test precision (intermediate precision and reproducibility) is established on the basis of operationally-valid reference oil tests monitored by the TMC. The limits, including standard deviations, are given in Table 4. They were computed from test results obtained on TMC reference oils 704-1, 1006, 1006–2, and 1009 and are current as of May 31, 2015. Precision limits were obtained by multiplying respective standard deviations by 2.8.

14.1.1 *Intermediate Precision (formerly called repeatability) Conditions*—Conditions where test results are obtained with the same test method using the same test oil, with changing conditions such as operators, measuring equipment, test stands, test engines, and time.

14.1.1.1 *Intermediate Precision Limit* (i.p.)—The difference between two results obtained under intermediate precision conditions that would in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 4 in only one case in twenty.

14.1.2 *Reproducibility Condition*—Conditions where test results are obtained with the same test method using the same test oil in different laboratories with different operators using different equipment.

14.1.2.1 *Reproducibility Limit* (R)—The difference between two results obtained under reproducibility conditions that would, in the long run, in the normal and correct conduct of the test method, exceed the values in Table 4 in only one case in twenty.

14.2 *Bias*—Bias is determined by applying an acceptable statistical technique to reference oil test results. When a significant bias is obtained, a severity adjustment is permitted for non-reference oil test results. Contact the TMC for TMC Memo 94-200 (Lubricant Test Monitoring System Document).

15. Use of ASTM Rounding

15.1 Follow Practice E29 (6.4–6.5) guidelines for rounding of test results, operational parameters, and engine build-up measurements.

16. Keywords

16.1 bearing weight loss; CLR oil test engine; copper-lead bearings; engine oil; oil consumption; Sequence VIII test; shear stability

ANNEXES

(Mandatory Information)

A1. MEASUREMENT OF CONNECTING ROD BEARING CLEARANCE AND JOURNAL TAPER

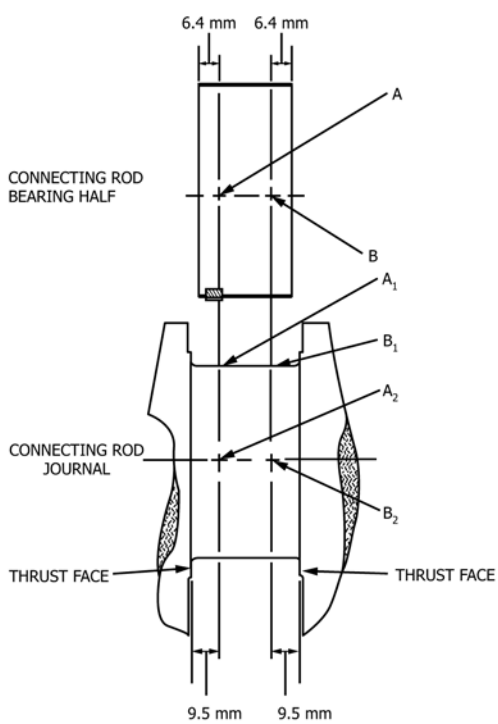


FIG. A1.1 Clearance Measuring Points for Connecting Rod Bearings

A1.1 Conduct the connecting rod bearing clearance measurements with the crankshaft, bearing sets, and measuring tools at room temperature.

A1.2 Use measuring tools having an accuracy of at least 0.003 mm.

A1.3 Thoroughly clean the connecting rod bore with mineral spirits[31] and air dry. Use caution not to affect the original surface. Clean the connecting rod bearings according to A9.1. Install the rod bearing halves that are to be used in the test into the proper location (top and bottom as marked). Place the connecting rod into a holding device clamping as close as possible to the large end of the connecting rod to prevent the rod from being twisted during the torquing procedure. Install lower bearing cap and apply 61 N·m torque to the bearing cap bolts.

TABLE A1.1 Connecting Rod Bearing Clearance[A]

A________	B________
A_1________	B_1________
A_2________	B_2________
$A–A_1$ = ________	$B–B_1$ = ________
$A–A_2$ = ________	$B–B_2$ = ________
min________	max________

[A] Diameters A_1 and B_1 are measured at points 90° from A_2 and B_2, respectively.

A1.4 Measure the connecting rod bearing vertical diameter at the two points A and B indicated in Fig. A1.1. Each of the points is located 6.4 mm from each bearing edge. Record the measurements in the appropriate spaces in a table such as Table A1.1. Immediately return the connecting rod bearings to the original container filled with build-up oil after measurements are performed.

A1.5 Mount the crankshaft on a workbench with the axis horizontal and with the connecting rod bearing journal vertically upward, simulating the top-dead-center position in the engine.

A1.6 Measure the diameter of the connecting rod bearing journal of the crankshaft at the points A_1, B_1, A_2, and B_2 indicated in Fig. A1.1. The measuring points are located 9.5 mm from each thrust face. Record the measurements in the appropriate spaces in a table such as Table A1.1.

A1.7 Subtract the diameters to obtain the clearances, as directed in Table A1.1. From the four clearance values thereby determined, select the minimum and maximum values, and enter them in the spaces provided in the table.

A1.8 The minimum and maximum connecting rod bearing clearances determined in A1.7 shall be within the range of 0.061 mm to 0.076 mm. If they fall outside of this range, select and measure a different crankshaft.

A1.9 Determine the taper of the connecting rod bearing journal by completing Table A1.2. Consider the maximum quotient obtained in Table A1.2 as the journal taper. Discard any crankshafts having a connecting rod journal taper larger than 0.0005 mm/mm.

TABLE A1.2 Taper of Connecting Rod Bearing Journal[A]

Use measurements from Table A1.1.
(A_1 – B_1 = ________)/34.85 mm = ________
(A_2 – B_2 = ________)/34.85 mm = ________

[A] Bearing width = 30.12 mm. Distance between the measuring points A_1 and B_1 (or A_2 and B_2) is 30.12 mm – 2 [6.4 mm] = 30.12 mm – 12.7 mm = 17.4 mm. Taper = (A_1 – B_1) (or A_2 – B_2) divided by 2 divided by 17.4 mm, or (A_1 – B_1) (or A_2 – B_2)/34.85 mm. (Division by 2 is required to obtain the desired difference in shaft radius between the measuring points.)

A2. MEASUREMENT OF MAIN BEARING CLEARANCE

A2.1 Conduct the main bearing clearance measurements with the crankcase, crankshaft, bearing sets, and measuring tools at room temperature.

A2.2 Use measuring tools having an accuracy of at least 0.003 mm.

A2.3 Install two bearing sets in the crankcase, but do not install the crankshaft. Use either two standard main bearing halves, one standard main bearing half (TEI Part No. 8252) and one undersize main bearing half (TEI Part No. 8252-0.0012 in. U.S.), or two undersize bearing halves. For consistency, when using one standard and one undersize bearing half together, install the standard half in the bearing cap. Torque the bearing block bolts to 81 N·m.

A2.4 Measure the front main bearing vertical diameter at the two points A and B indicated in Fig. A2.1. Each of the points is located in the middle of the respective non-relieved bearing surface. Record the measurements in the appropriate spaces in a table such as Table A2.1.

A2.5 Mount the crankshaft on a workbench with the axis horizontal and with the connecting rod bearing journal vertically upward, simulating the top-dead-center position in the engine.

A2.6 Measure the diameter of the front main journal of the crankshaft at the points A_1, B_1, A_2, and B_2 indicated in Fig. A2.1. Record the measurements in the appropriate spaces in a table such as Table A2.1.

A2.7 Measure the diameters of the rear main bearing and the rear main journal at the points described in A2.4 and A2.6. Record the measurements in Table A2.1.

A2.8 Subtract the diameters to obtain the clearances, as directed in Table A2.1. From the four clearance values thereby determined for each main journal and bearing combination, select the minimum and maximum values, and enter them in the spaces provided in the table.

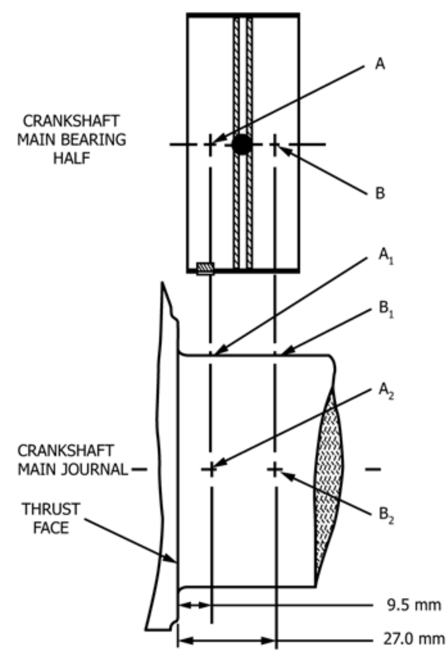


FIG. A2.1 Clearance Measuring Points for Crankshaft Main Bearings

A2.9 The minimum and maximum main bearing clearances determined in A2.8 shall be within the range of 0.051 mm to 0.076 mm. If they fall outside of this range, either install different bearings, or a different crankshaft, and remeasure the clearances.

TABLE A2.1 Crankshaft Main Bearing Clearance

Front Main Bearing[A]		Rear Main Bearing[A]	
A______	B______	A______	B______
A_1______	B_1______	A_1______	B_1______
A_2______	B_2______	A_2______	B_2______
$A - A_1$ = ______	$B - B_1$ = ______	$A - A_1$ = ______	$B - B_1$ = ______
$A - A_2$ = ______	$B - B_2$ = ______	$A - A_2$ = ______	$B - B_2$ = ______
min______	max______	min______	max______

[A] Diameters A_1 and B_1 are measured at points 90° from A_2 and B_2, respectively.

A3. THE ASTM TEST MONITORING CENTER CALIBRATION PROGRAM

A3.1 *Conducting a Reference Oil Test:*

A3.1.1 For those laboratories which choose to utilize the services of the TMC in maintaining calibration of power sections and test stands, full-scale calibration testing shall be conducted at regular intervals. These full-scale tests are conducted using blind, coded reference oils supplied by the TMC. It is a laboratory's responsibility to maintain the calibration in accordance with the test procedure. It is also a laboratory's responsibility to keep the on-site blind reference oil inventory at or above the minimum level specified by the TMC test engineers.

A3.1.2 When laboratory personnel decide to run a reference calibration run, they shall request a blind oil code from the cognizant TMC engineer. Upon completion of the reference oil test using the blind reference oil, the data shall be sent in summary form (use TMC forms) to the TMC by telephone facsimile transmission, or by some other method acceptable to the TMC. The TMC reviews the data and contacts the laboratory engineer to report the laboratory's calibration status. Report all reference oil tests, whether aborted, invalidated, or successfully completed, to the TMC. Subsequent to sending the data in summary form to the TMC, the laboratory is required to submit to the TMC the written test report specified in the test procedure.

A3.2 *New Laboratories*—Laboratories wishing to become a part of the ASTM Test Monitoring System will be requested to generate both blind and non-blind tests to ensure that the laboratory is using the proper testing techniques. Information concerning fees, laboratory inspection, reagents, testing practices, appropriate committee membership, and rater training can be obtained by contacting the TMC Administrator.[2]

A3.3 *Introducing New Sequence VIII Reference Oils*—The calibrating reference oils produce various copper-lead bearing weight loss and deposit characteristics. When new reference oils are selected, the TMC requests member laboratories to conduct their share of tests to enable the TMC to establish the proper industry average and test acceptance limits. The ASTM D02.B0.01 Sequence VIII Surveillance Panel requires a minimum of four tests to be conducted prior to establishing the industry average and test acceptance targets for new reference oils. The TMC estimates that laboratories will be requested to run an average of one contributing test per year for each eight test power sections operated throughout the year.

A3.4 *TMC Information Letters*:

A3.4.1 Occasionally, it is necessary to change the procedure, and notify the test laboratories of the change, prior to consideration of the change by either Subcommittee D02.B on Automotive Lubricants or Committee D02 on Petroleum Products and Lubricants. In such a case, the TMC issues an Information Letter. Subsequently, prior to each semiannual Committee D02 meeting, the accumulated Information Letters are balloted by Subcommittee D02.B0. The ballot is reviewed at the Subcommittee D02.B0 meeting, and the actions taken are considered at the following meeting of Committee D02. By this means, the Society due process procedures are applied to these Information Letters.

A3.4.2 Several methods and levels of review are conducted prior to issuing an Information Letter. In the case of an Information Letter concerning a part number change which does not affect test results, the TMC is authorized to issue such a letter. Long-term studies by the Surveillance Panel to improve the test procedure through improved operation and hardware control may result in a recommendation to issue an Information Letter. If obvious procedural items affecting test results need immediate attention, the test sponsor and the TMC issue an Information Letter and present the background and data to the Surveillance Panel for approval prior to the semiannual Subcommittee D02.B meeting.

A3.4.3 Authority for the issuance of Information Letters was given by the Committee on Technical Committee Operations in 1984, as follows:

"COTCO recognizes that D02 has a unique and complex situation. The use of Information Letters is approved providing each letter contains a disclaimer to the effect that such has not obtained ASTM consensus. These Information Letters shall be moved to such consensus as rapidly as possible."

A4. MEASUREMENT OF PISTON-TO-SLEEVE CLEARANCE

A4.1 Conduct the piston-to-sleeve clearance measurements with the sleeve, barrel assembly, cylinder head, piston, and measuring tools at room temperature.

A4.2 Use measuring tools having an accuracy of at least 0.003 mm.

A4.3 Install the sleeve into the barrel assembly and torque the cylinder head into place.

A4.4 Measure the sleeve diameter in the transverse (between the valves) direction at the top, middle, and bottom of the sleeve using a bore gage and the bore measurement ladder (Fig. A4.1). Record the measurements in the appropriate spaces in a table such as Table A4.1. Repeat the preceding for the longitudinal (across the valves) direction.

A4.5 Heat the piston so that the piston pin can be installed without using any force. Do not exceed 65.5 °C piston temperature. Allow the piston to return to room temperature before measuring. Measure the piston skirt at the middle and bottom of the skirt as indicated in Fig. A4.2. Record the measurements in the appropriate spaces in a table such as Table A4.1.

A4.6 Calculate the sleeve bore diameter to be used for the piston-to-sleeve clearance using the middle and bottom transverse measurements according to Table A4.1.

A4.7 Calculate the sleeve taper according to Table A4.1.

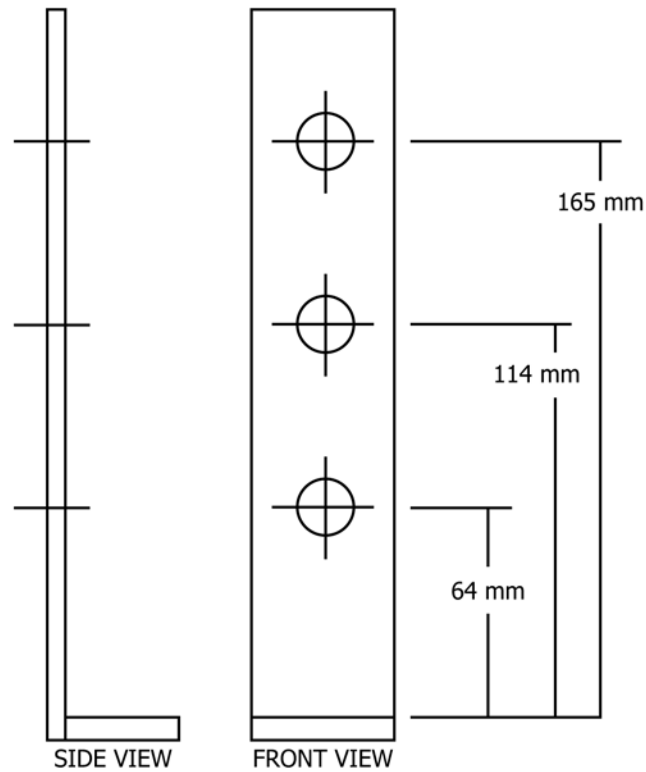
A4.8 Calculate the sleeve out-of-round according to Table A4.1.

A4.9 Calculate the piston diameter to be used for the piston-to-sleeve clearance using the middle and bottom measurements according to Table A4.1.

A4.10 Calculate the piston taper according to Table A4.1.

A4.11 Calculate the piston-to-sleeve clearance according to Table A4.1.

A4.12 The piston-to-sleeve clearance as determined in Table A4.1 shall be within the range of 0.030 mm to 0.063 mm. If the clearance falls outside of this range, replace the liner, the piston, or both, depending on their relative size.



NOTE 1—Overall dimensions are not critical.

NOTE 2—Make the ladder of brass or aluminum to prevent liner scratching.

NOTE 3—Holes should be sized as dictated by the bore measurement device which will be used.

FIG. A4.1 Sequence VIII Bore Measurement Ladder

TABLE A4.1 Piston-to-Sleeve Clearance

	Sleeve Diameters, mm			Taper
	TOP	MIDDLE	BOTTOM	mm
Transverse	a	b	c	g
Longitudinal	d	e	f	h
Out-of-Round	i	j	k	

g = (Largest of a, b or c)—(smallest of a, b, or c)
h = (Largest of d, e or f)—(smallest of d, e, or f)
i = (Largest of a or d)—(smallest of a or d)
j = (Largest of b or e)—(smallest of b or e)
k = (Largest of c or f)—(smallest of c or f)

Piston Skirt Diameters	
Middle	m
Bottom	n
Taper	p
Average	q

p = (Largest of m or n)—(smallest of m or n)
q = (m + n)/2
Piston-to-Sleeve Clearance ((b + c)/2) − q)

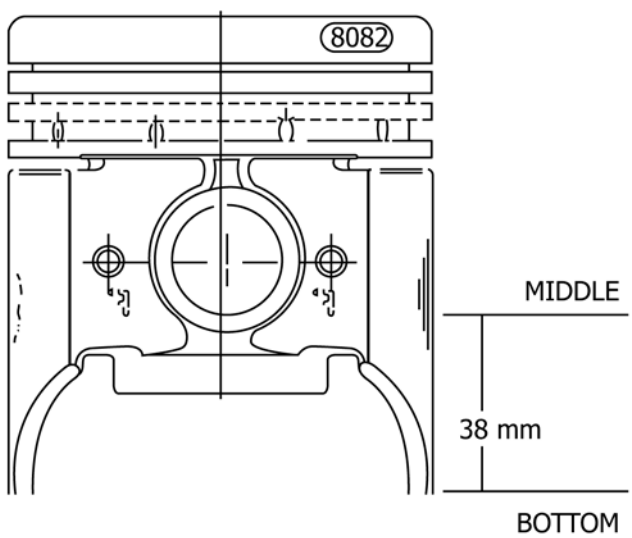


FIG. A4.2 Measurement Points for Sequence VIII Piston

A5. CONTROL CHART TECHNIQUE FOR A LABORATORY'S SEVERITY ADJUSTMENT (SA)

A5.1 Complete information on the control chart technique is presented in the Lubricant Test Monitoring System, available from the ASTM Test Monitoring Center.

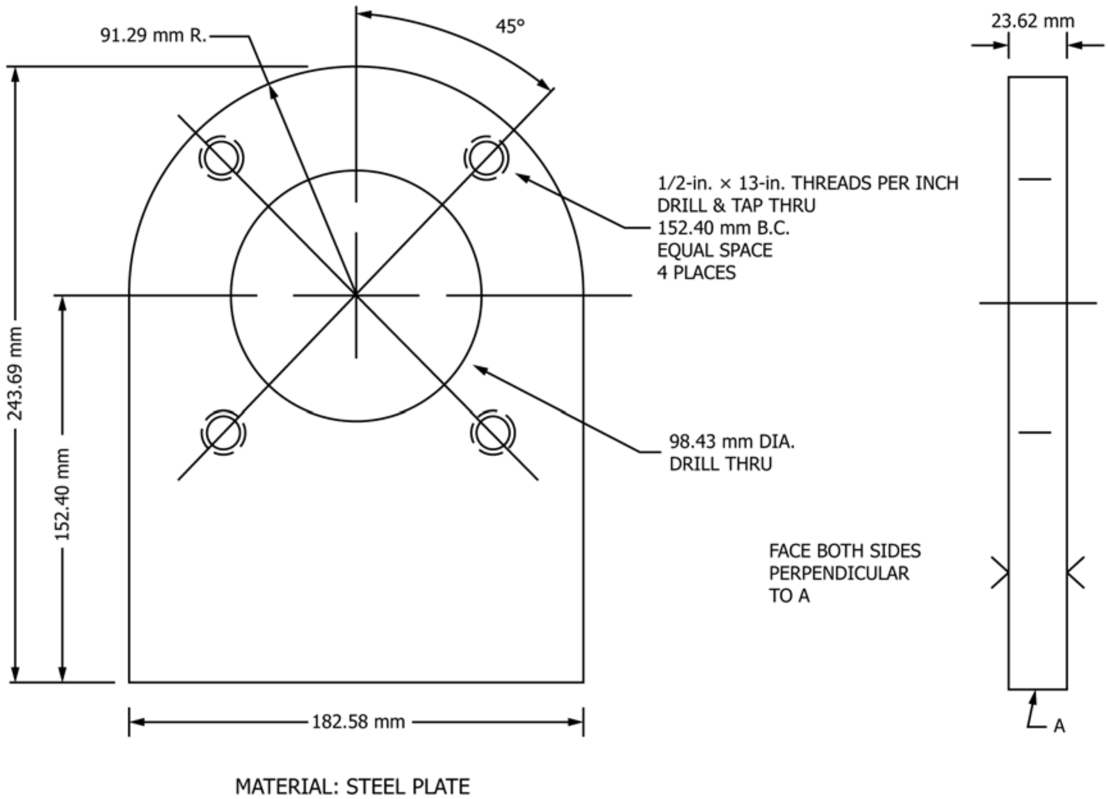


FIG. A6.1 Stress Plate

A6. NEW LINER HONING PROCEDURE

A6.1 Remove new liner from box and clean protective coating from the liner.

A6.2 Install fret ring and liner into cylinder barrel. Install head gasket and stress plate, torque to specified setting. Fig. A6.1 shows a recommended stress plate.

A6.3 Set cylinder barrel fixture and cylinder barrel into Sunnen CK-10 or CV-616 honing machine[35,8] and secure. Fig. A6.2 shows a recommended cylinder barrel fixture. The appropriate honing machine setups and honing stone selections are in Table A6.1.

A6.4 Coarse hone liner to within 0.025 mm of determined finish diameter. During coarse honing, rotate and clean stones after every 30 strokes and measure liner between stone rotations for correct taper.

A6.5 After reaching the desired coarse honed liner diameter, allow liner to cool to room temperature and coarse hone to within 0.013 mm of the desired diameter before beginning the finish honing.

A6.6 Complete honing with finishing stone to desired liner diameter and surface finish. The approximate number of strokes will depend on the finishing stone selected.

A6.7 Make the final liner measurements in the actual cylinder barrel of the power section to be used.

A6.8 Use this procedure only for initial new liner honing. For used liners, see 9.4.4.

[35] The sole source of supply of the honing machine known to the committee at this time is Sunnen Products Co., 7910 Manchester Road, St. Louis, MO 63143.

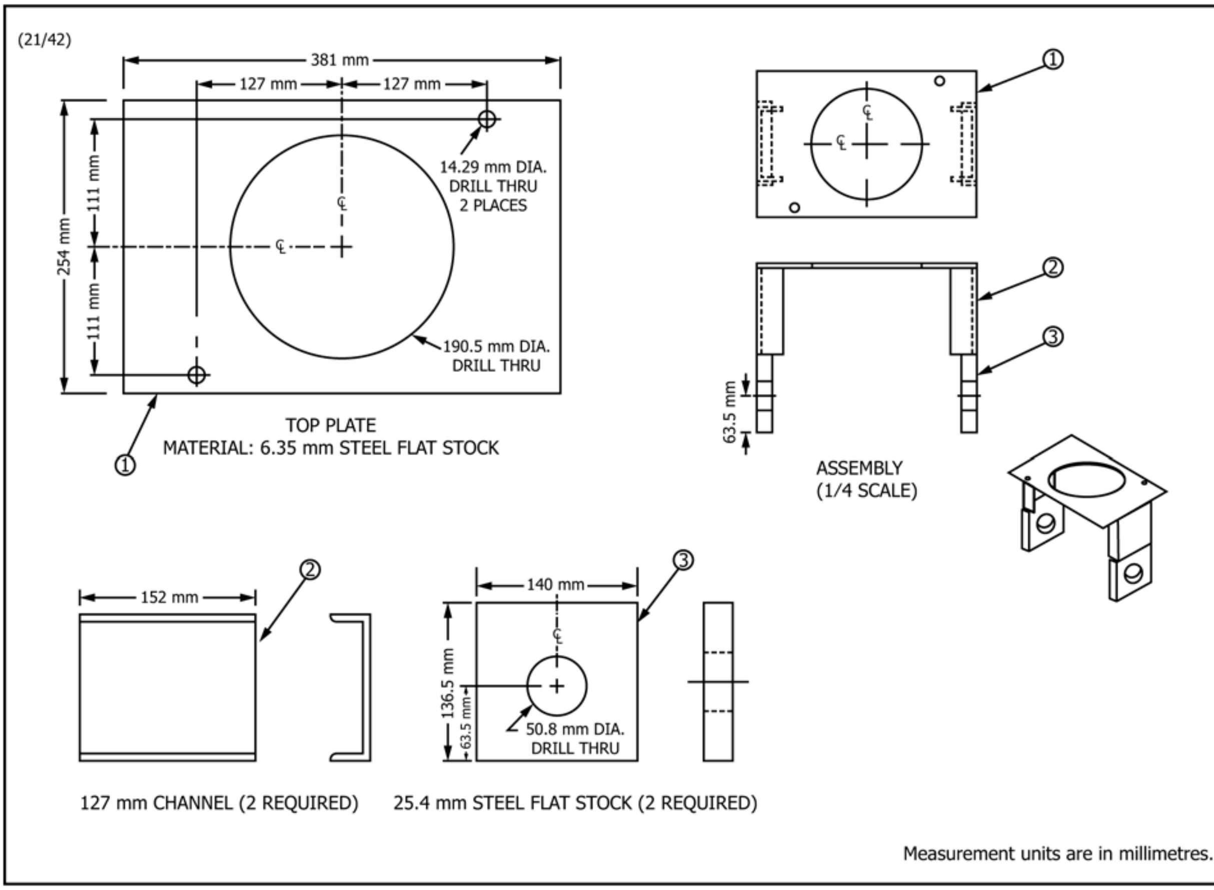


FIG. A6.2 Cylinder Barrel Fixture

TABLE A6.1 Honing Machine Setups and Honing Stone Selection

Honing Machine Setup		
Parameter	Honing Machine Model No.	
	CK-10	CV-616
Honing oil flow, L/s	0.13	0.13
Spindle speed, r/min	155	170
Stroke rate, spm	46	57
Stroke length, mm	180 to 185	180 to 185
Over-stroke, mm	9.53	9.53
Honing Stones		
Desired Hone	Honing Stone Selection	No. of Strokes (approximate)
Coarse hone	EHU 525	—
Finished hone	JHU 625	10
Finished hone	JHU 820	4

A7. SEQUENCE VIII OIL PRIMING PROCEDURE

A7.1 Prior to engine starts, confirm that the crankcase has been filled with test oil to the required level.

A7.2 Disconnect the fuel supply.

A7.3 Remove the spark plug.

A7.4 Motor the engine, using the starter, until the oil pressure gage shows a pressure increase.

A7.5 Cease motoring and reinstall the spark plug.

A7.6 Start the engine.

A8. ALTERNATIVE CRANKCASE BREATHER CONFIGURATION

A8.1 See Fig. A8.1 for Sequence VIII crankcase breather detail.

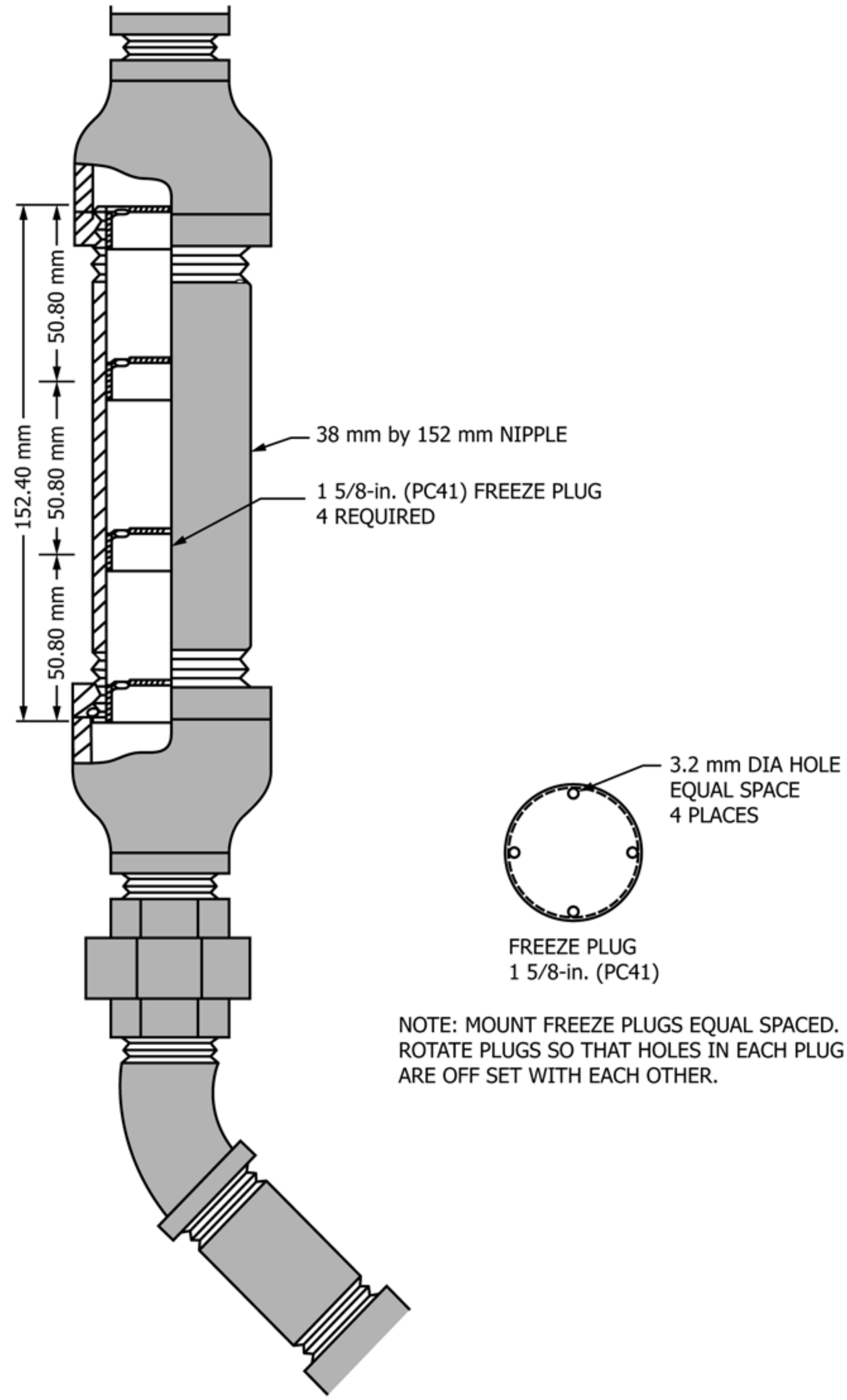


FIG. A8.1 Sequence VIII Crankcase Breather Freeze Plug Detail

A9. CONNECTING ROD BEARING CLEANING PROCEDURE

Initial Cleaning

A9.1 Soak bearings halves in a container of mineral spirits[31] to remove all traces of oil from both the front and back of the bearing for a minimum of 5 min. During the soak period move the bearing halves back and forth in solvent using protective tongs. Exercise care when handling the bearings to prevent nicking or scratching the bearing surface. (Always use latex gloves and protective tongs when handling bearings.)

A9.2 Dip the bearing halves in pentane and allow to dry; do not place in vacuum desiccator.

A9.3 Wipe bearings with soft paper towel soaked in pentane.

A9.4 Weigh and record the initial mass of the whole test bearing and the separate masses of the top and bottom halves to the nearest 0.1 mg.

A9.5 Repeat steps A9.3 and A9.4 until no change in mass is noted.

A9.6 Place bearing halves into a vacuum desiccator for a maximum of 5 min.

A9.7 Coat the bearing halves with build-up oil.

A9.8 Store the bearing halves in a vacuum desiccator until ready for installation into the engine. Start the test break-in within 8 h of removal of the bearing halves from the vacuum desiccator. If the limit of 8 h is exceeded, install a new set of bearings, repeating steps A9.1 – A9.8.

End of Test Cleaning

A9.9 Soak bearing halves in a container of mineral spirits[31]to remove all traces of oil from both the front and back of the bearing for a minimum of 5 min. During the soak period, move the bearing halves back and forth in solvent using protective tongs. Exercise care when handling the bearings to prevent nicking or scratching the bearing surface. (Always use latex gloves and protective tongs when handling bearings.)

A9.10 Dip the bearing halves in pentane and allow to dry.

A9.11 Place bearing halves into a vacuum desiccator for a maximum of 5 min.

A9.12 Remove bearing halves from the vacuum desiccator and inspect for traces of residue. Repeat A9.10 and A9.11 if any residue is evident.

A9.13 Weigh and record the final mass of the whole test bearing and the separate masses of the top and bottom halves to the nearest 0.1 mg.

A10. SEQUENCE VIII ELECTRONIC IGNITION CONVERSION PROCEDURE

A10.1 The following parts are needed for the Ford distributor assembly modification:

A10.1.1 Ford distributor assembly,[36] Part No. D7EE-12127DA.

A10.1.2 Ford wiring harness,[36] Part No. D7JL-12A200A.

A10.1.3 Ford module,[36] Part No. D9VZ-12A199A.

A10.1.4 Ford stator assembly,[36] Part No. D5TZ-12A122A.

A10.1.5 Ford ignition coil,[36] Part No. D5AZ-12029-A.

A10.1.6 GM flat washer,[37] Part No. 1984361.

A10.1.7 Nylon flat washer, Part No. 98160-0.62.[38,8]

A10.1.8 Fabricated distributor shaft.[39,8]

A10.1.9 Fabricated hold down assembly.[39,8]

A10.2 Disassemble the Ford distributor assembly, Part No. D7EE-12127DA. Save all parts as most will be needed for the modification.

A10.3 Remove the vacuum advance mounting assembly from the Ford distributor housing as shown in Fig. A10.1.

[36] This apparatus may be purchased from any Ford dealership.

[37] This apparatus may be purchased from any General Motors dealership.

[38] The sole source of supply of the flat washer known to the committee at this time is Accurate Screw Machine Co., 19 Baltimore St., Nutley, NJ 07110.

[39] The sole source of supply of the apparatus known to the committee at this time is Texas Tool Makers, Inc., San Antonio, TX 78216.

A10.4 Modify the lower section of the Ford distributor housing as shown in Fig. A10.2.

A10.5 Remove three of the four existing poles from the armature of the Ford distributor assembly as shown in Fig. A10.3. Reference the grooves for the roll pin to remove the correct poles.

A10.6 Remove the fibre seat from the lower plate assembly of the Ford distributor and enlarge the hole to 4.76 mm as shown in Fig. A10.4.

A10.7 Remove the vacuum advance bracket from the upper stator assembly plate of the Ford distributor shown in Fig. A10.5.

A10.8 Center and mount the upper stator assembly plate onto the lower plate. Drill a hole with a diameter of 4.76 mm through the upper plate aligning that hole with hole with a diameter of 4.76 mm in the lower plate as shown in Fig. A10.5.

A10.9 Attach the upper and lower plates using a 4.76 mm rivet as shown in Fig. A10.5. Use a spacer of approximately 2.16 mm between the two plates.

A10.10 Cut the drive gear from the upper collar of the Ford distributor assembly. Fig. A10.6 shows the dimensions of the collar after the drive gear has been removed.

A10.11 Fabricate the distributor shaft as shown in Fig. A10.7. The shaft may also be purchased from Texas Tool Makers, Inc.[39,8]

A10.12 Fabricate the hold down assembly as shown in Figs. A10.8 and A10.9. The hold down assembly may also be purchased from Texas Tool Makers, Inc.

A10.13 Assemble the modified distributor as shown in Fig. A10.10.

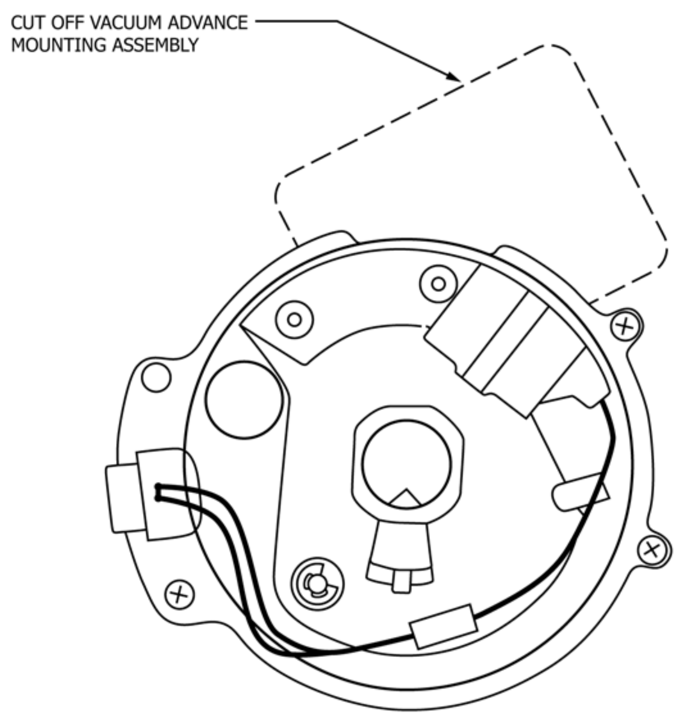
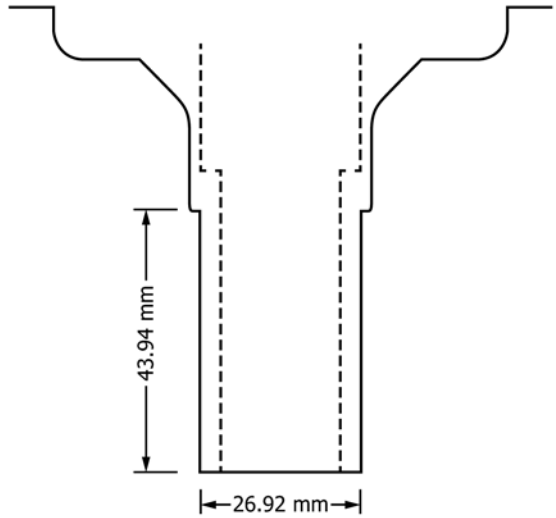


FIG. A10.1 Modified Ford Distributor Housing



MODIFY TO SPECIFICATION SHOWN

FIG. A10.2 Modified Ford Distributor Housing

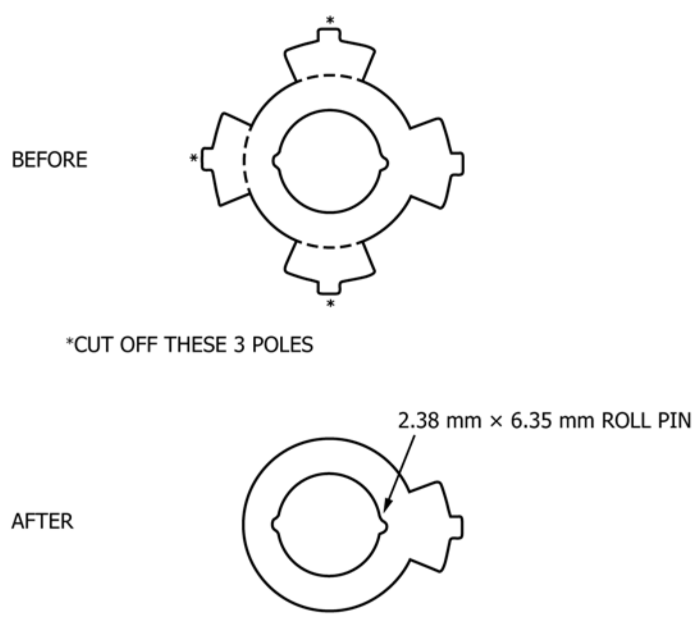


FIG. A10.3 Modified Ford Distributor-Armature

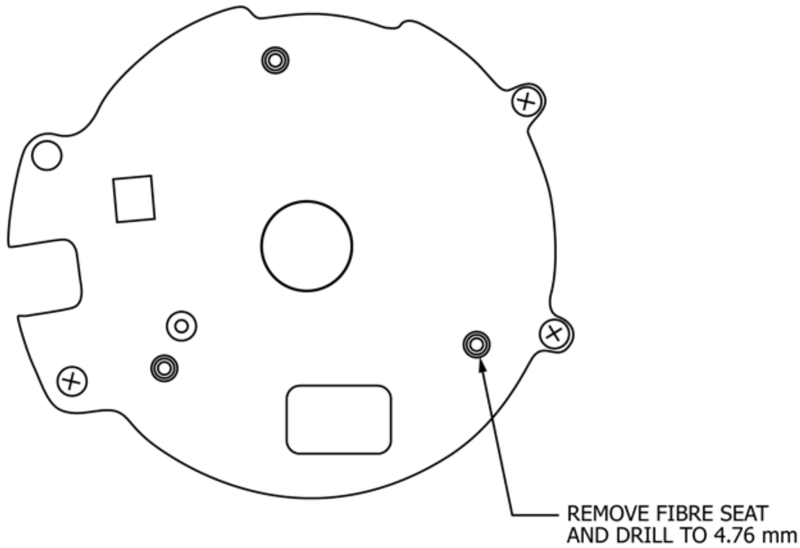


FIG. A10.4 Modified Ford Distributor-Lower Plate Assembly

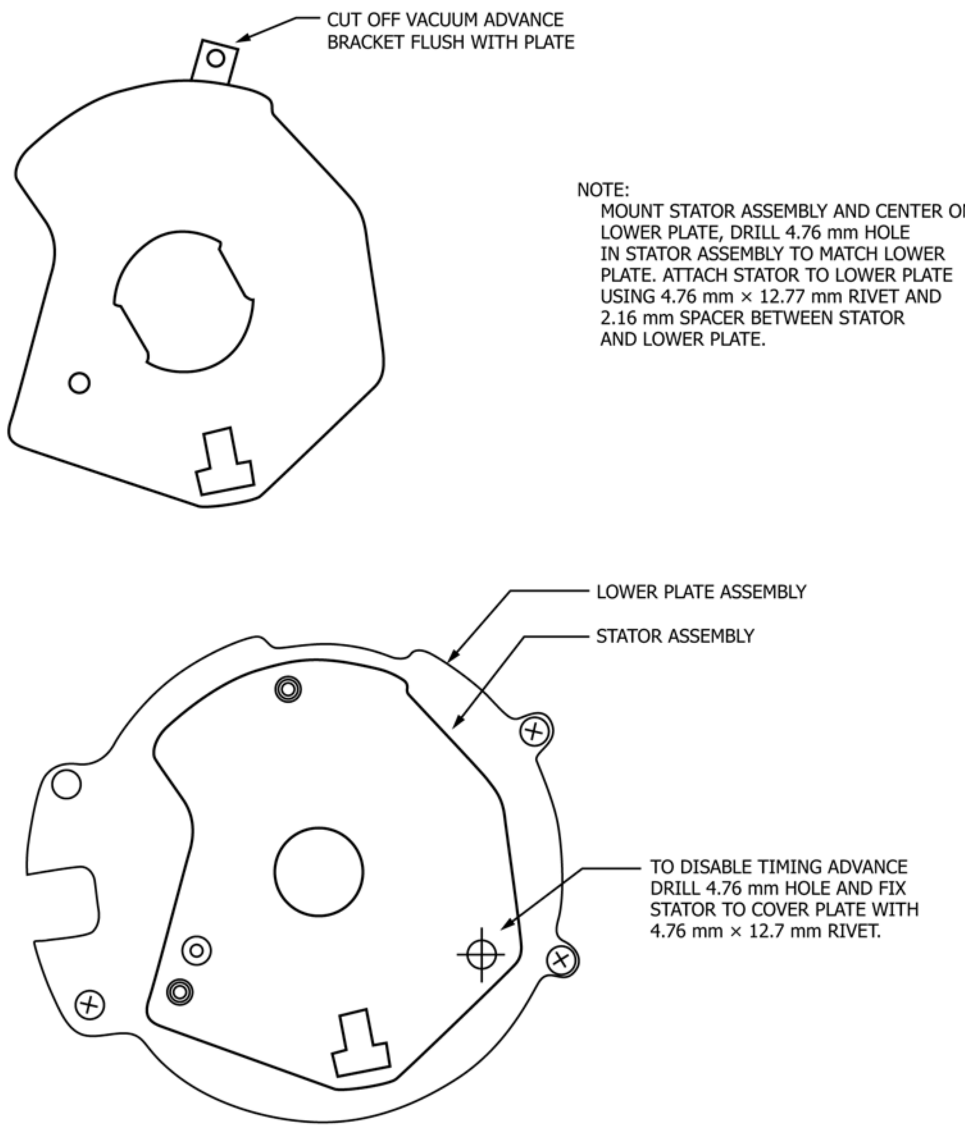


FIG. A10.5 Modified Ford Distributor-Stator Assembly

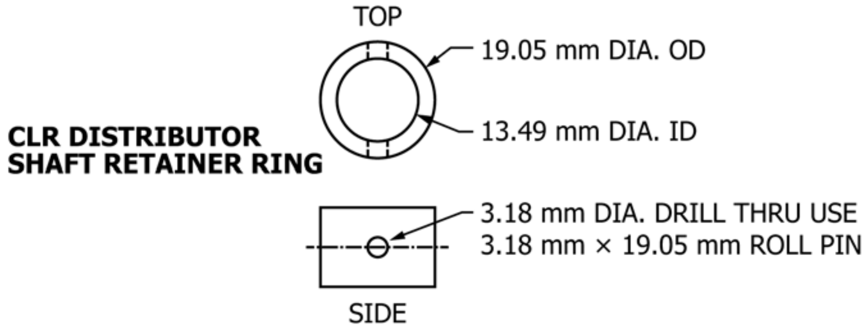


FIG. A10.6 Modified Ford Distributor-Upper Collar

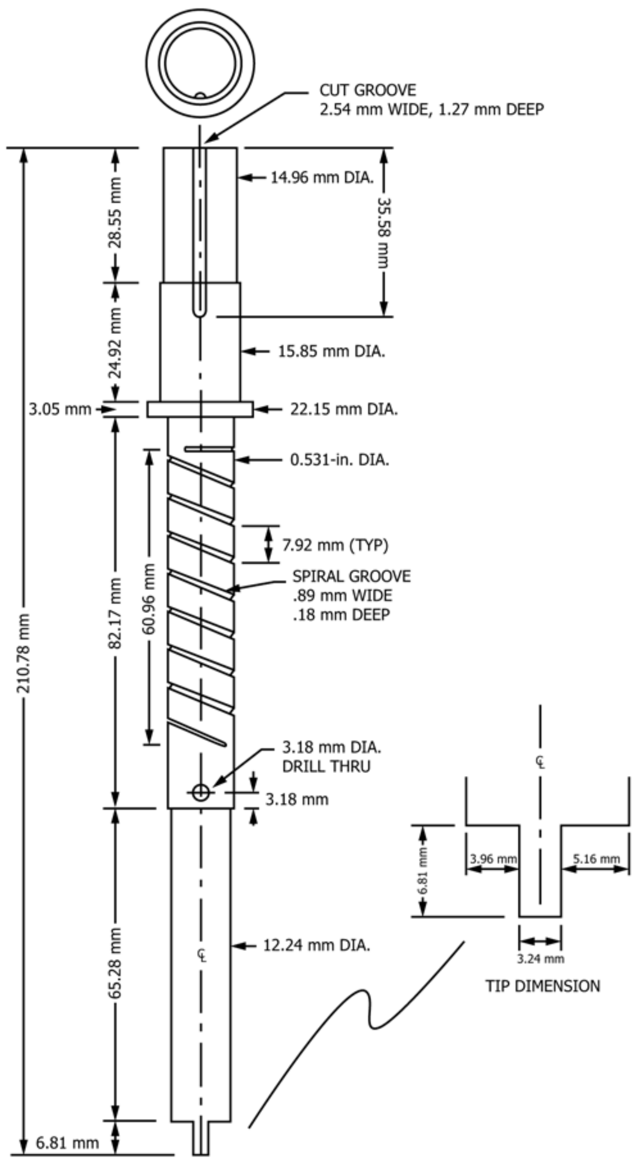
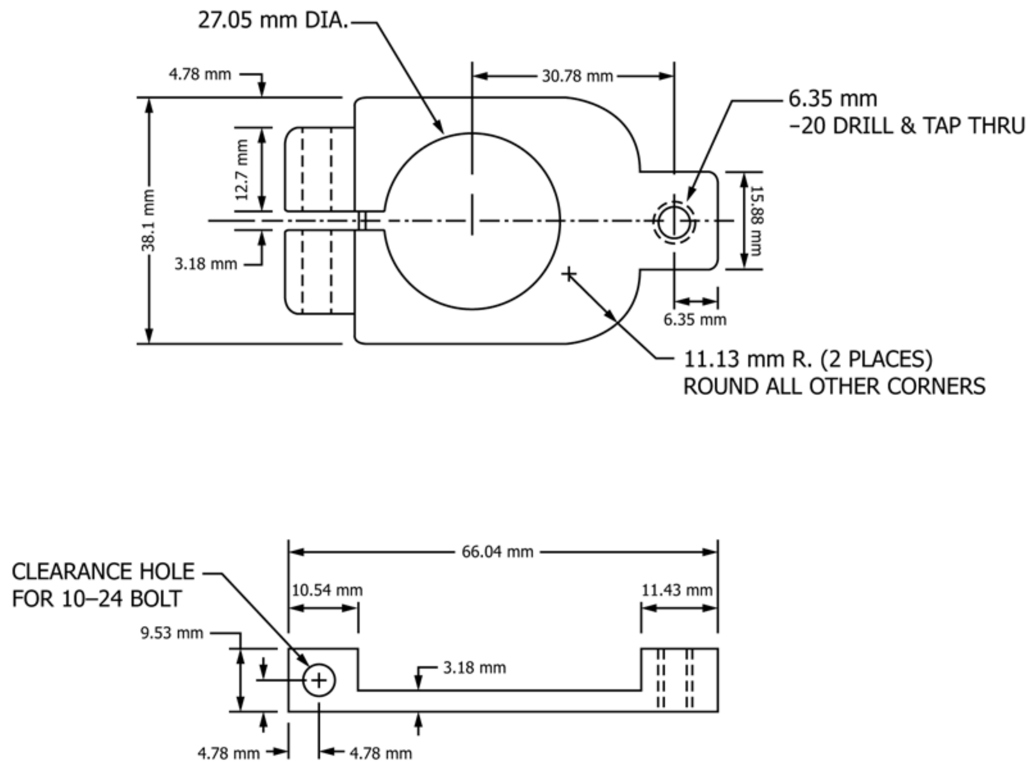
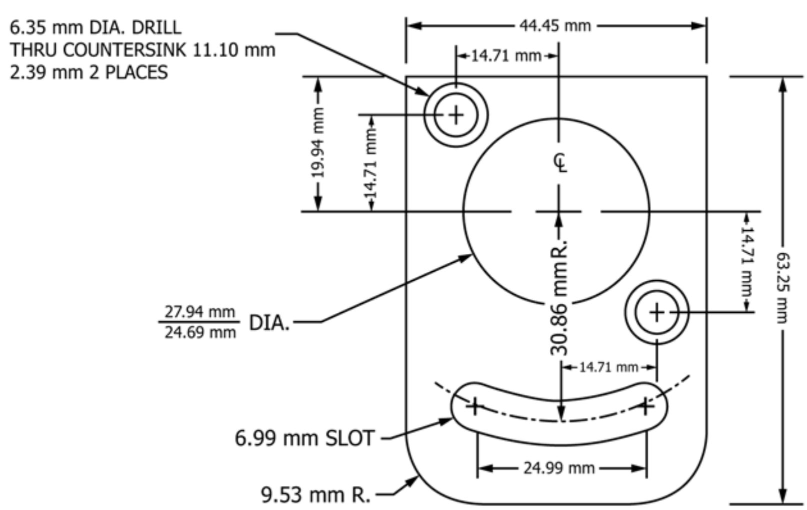


FIG. A10.7 Fabricated Distributor Shaft



NOTE 1—Material: steel plate with thickness of 9.53 mm, and with the following dimensions, 38.1 mm by 66.68 mm.

FIG. A10.8 Fabricated Hold Down Clamp



NOTE 1—Material: 3.18 mm plate.

FIG. A10.9 Fabricated Hold Down Clamp

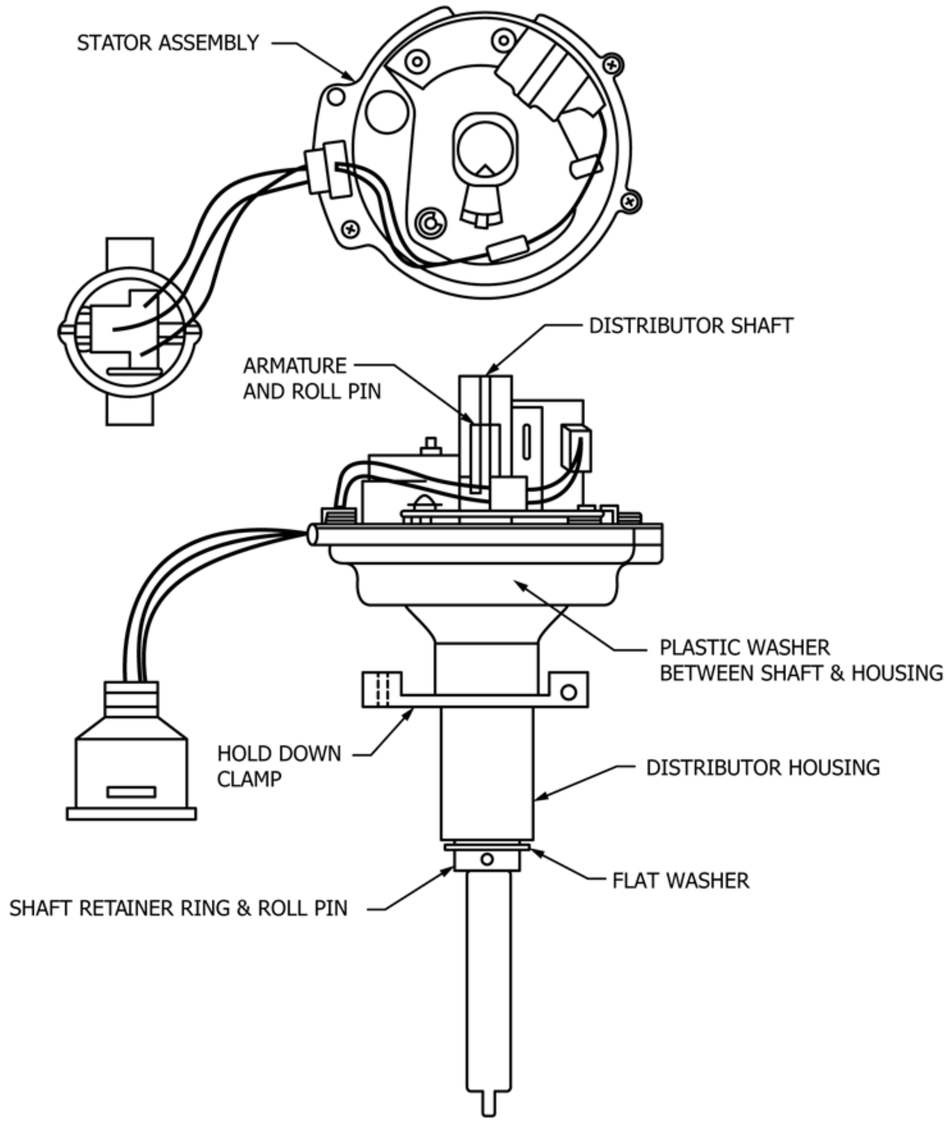


FIG. A10.10 Modified Ford Distributor Assembly

A11. SYSTEM RESPONSE PROCEDURE

A11.1 *Temperatures*—Remove the thermocouples from the engine locations as specified in 6.3.5. Allow the thermocouples to stabilize at ambient conditions, then insert them into a bucket of ice water. Record the time it takes the thermocouple to reach 63 % of its final value.

A11.2 *Pressures and Vacuums*—First perform a leak-down on the measurement system to ensure there are no air leaks by following the test below:

A11.2.1 Disconnect the sensor lines at the engine locations as specified in 6.3.4. Connect an air line to the sensor line and pressurize the line slightly above the specified range required (test specification). Isolate the air pressure in the sensor line and remove the source from the sensor line. If the system leaks down, repair the leak before proceeding.

A11.2.2 After completion of the leak down step, determine the system response. Connect an air line to the sensor line and pressurize the system to the specified mean range. Let the system stabilize, then quickly release pressure, record the time to reach 63 % of its final value.

A11.2.3 For vacuums, follow the above procedure replacing air pressure with vacuum.

A11.3 *Fuel Flow:*

A11.3.1 *Flow Meters*—Establish a steady flow at the normal test specified mean range. Let the system stabilize. Shut off the flow and record the time required to reach 63 % of the final value.

A11.3.2 *Fuel Weight Scales*—Follow the normal procedure for measuring fuel usage. This value shall represent the total time it takes to measure the fuel flow (from the time the engine begins to run from the beaker until the scales trips).

A11.4 *Speed*—Using a frequency counter, inject a frequency so that the system readout stabilizes at the test specified mean value. Use a frequency device to determine the engine speed. Disconnect the frequency device, measure and record the time required to reach 63 % of the final value.

A11.5 *Power*—Place a mass on a measurement device and let the reading stabilize. Quickly remove the mass, and measure and record the time required to reach 63 % of the final value. Masses used shall represent the normal readout value. For manual measurements, a stopwatch is required with increments of 0.1 s.

A12. AIR-FUEL RATIO MEASUREMENT

A12.1 Correct carbon monoxide (CO) or carbon dioxide (CO_2) measurements to an oxygen-free basis, using formulae Eq A12.1 and A12.2 prior to determining air-fuel ratio. Use the corrected CO or CO_2 value and Table A12.1 to determine air-fuel ratio.

$$\frac{\text{Observed Percent CO} \times 100}{100 - 5\left(\text{Observed \% } O_2\right)} = \text{Corrected CO} \quad (A12.1)$$

$$\frac{\text{Observed Percent } CO_2 \times 100}{100 - 5\left(\text{Observed \% } O_2\right)} = \text{Corrected } CO_2 \quad (A12.2)$$

TABLE A12.1 Air-Fuel Ratio Versus (O_2, CO and CO_2)

NOTE 1—Theoretical Combustion, KA24E Green Fuel Batch 9910652.

Air-Fuel Ratio	O_2	CO	CO_2	Air-Fuel Ratio	O_2	CO	CO_2
7.298	0	19.793	2.97	14.595	0	0	15.215
7.59	0	19.008	3.383	14.887	0.44	0	14.896
7.881	0	18.218	3.807	15.179	0.862	0	14.589
8.173	0	17.424	4.241	15.471	1.266	0	14.295
8.465	0	16.626	4.686	15.763	1.655	0	14.013
8.757	0	15.823	5.142	16.055	2.029	0	13.741
9.049	0	15.017	5.607	16.347	2.388	0	13.48
9.341	0	14.206	6.081	16.639	2.735	0	13.229
9.633	0	13.393	6.564	16.931	3.068	0	12.987
9.925	0	12.577	7.055	17.223	3.389	0	12.753
10.217	0	11.76	7.553	17.514	3.7	0	12.528
10.509	0	10.943	8.058	17.806	3.999	0	12.31
10.801	0	10.126	8.567	18.096	4.288	0	12.1
11.092	0	9.31	9.081	18.39	4.567	0	11.898
11.384	0	8.497	9.598	18.682	4.838	0	11.701
11.676	0	7.687	10.116	18.974	5.099	0	11.511
11.968	0	6.883	10.636	19.266	5.352	0.	11.328
12.26	0	6.084	11.156	19.558	5.597	0	11.149
12.552	0	5.291	11.675	19.85	5.835	0	10.977
12.844	0	4.507	12.193	20.142	6.065	0	10.81
13.136	0	3.731	12.707	20.433	6.288	0	10.647
13.428	0	2.964	13.218	20.725	6.505	0	10.49
13.72	0	2.207	13.725	21.017	6.716	0	10.337
14.012	0	1.46	14.227	21.309	6.92	0	10.189
14.303	0	0.724	14.724	21.601	7.119	0	10.044
				21.893	7.312	0	9.904

A13. LEAD DECONTAMINATION PARTS/PROCEDURE

A13.1 Use the following procedure for lead decontamination of CLR test engine that previously ran using a lead base fuel.

A13.1.1 *Parts to be Cleaned:*

A13.1.1.1 Inside of crankcase.

A13.1.1.2 Bottom of cylinder jug assembly.

A13.1.1.3 Cylinder head assembly.
A13.1.1.4 Inside of intake manifold.
A13.1.1.5 All crankcase cover plates (front and both sides).
A13.1.1.6 Oil pan.
A13.1.1.7 Rocker cover.
A13.1.1.8 Oil heater and canister.
A13.1.1.9 Blowby tube assembly.
A13.1.1.10 Camshaft and gear.
A13.1.1.11 Crankshaft and gear.
A13.1.1.12 Oil pump assembly.
A13.1.1.13 Any other parts that may have come in contact with lead.

A13.2 *Cleaning Procedure:*

A13.2.1 Prior to acid cleaning of all parts, remove all sludge and varnish deposits.

A13.2.2 Using a lint free towel or parts washing brush apply the 1:3 mixture of hydrochloric acid and deionized water to all parts.

A13.2.3 Apply a 1:8 mixture of baking soda and water after approximately 60 s.

A13.2.4 Repeat A13.2.2 and A13.2.3.

A13.2.5 Apply build-up oil to ensure that rust does not form.

A13.2.6 Clean engine parts according to either procedure in 9.4.3.

A13.3 *Future Cleaning after Lead Decontamination:*

A13.3.1 Once the engine parts have been decontaminated, handle them only in a lead-free environment. If the parts come into contact with a lead contaminated cleaning material or are used in an engine running on a fuel containing 0.003 g/L of lead they shall lose their status as cleaned parts. They shall only regain their clean status by undergoing another lead decontamination cleaning (A13.2.1 through A13.2.6).

A14. STAY-IN-GRADE OIL ANALYSIS PROCEDURE

A14.1 Determine the ability of the test oil (multiviscosity oils only) to stay in grade by measuring the shear stability using the following method.

A14.1.1 Weigh 25 g of the test oil sample taken at 10 h into a 50 mL three-necked round-bottom flask equipped with a thermometer, gas inlet tube, and distillation side arm.

A14.1.2 Heat the sample at 120 °C ± 5 °C in a vacuum of 13.33 kPa with a nitrogen sparge for 1 h. Do not consider warm-up time to meet the specified temperature as part of the 1 h.

A14.1.2.1 Place the gas inlet tube beneath the surface of the oil sample in the flask so that the nitrogen sparge stirs the sample during the heating operation.

A14.1.2.2 Begin the time clock for 1 h when the oil sample reaches 115 °C.

A14.1.3 Filter the stripped sample through a 0.5 µm filter pad.

A14.1.4 Determine the kinematic viscosity at 100 °C of the filtered sample using Test Method D445.

A15. CRANKSHAFT REAR SEAL CONDITIONING PROCEDURE

A15.1 *Procedure for Preparation of Rear Oil Seal Crankshaft Surface:*

NOTE A15.1—This procedure aids in preventing rear seal related oil leaks.

A15.1.1 Prepare a 25.4 mm wide and 600 mm long section of 120 grit abrasive paper.

A15.1.2 Looking from the back of the crankshaft forward, move the paper across the seal surface in a counter-clockwise direction with a front to back motion using a spiraling motion that produces scratches with an approximate 5 to 10° helix angle. Between 5 to 10 strokes shall produce the proper surface finish.

A15.1.3 Clean the crankshaft (see 9.4.7.10) to ensure that no abrasive remains on it.

A16. REPORT FORMS AND DATA DICTIONARY

A16.1 Download the actual report forms and data dictionary separately from the ASTM Test Monitoring Center web page at ftp://ftp.astmtmc.cmu.edu/datadict/viii/; or obtain them in hardcopy fomat from the TMC.[2]

Title/Validity Declaration Page	Form 1
Table of Contents	Form 2
Summary of Test Method	Form 3
Test Results	Form 4
Operational Summary	Form 5
Parts Measurement and Critical Parts Listing	Form 6
Downtime Occurences and Other Comments	Form 7
Operational Outliers Occurrences	Form 8
Deviations of Operational Parameters	Form 9
Data Acquisition System Details	Form 10

A17. TEST FUEL SPECIFICATION

A17.1 The Test Fuel Specification is shown in Table A17.1.

TABLE A17.1 KA24E Test Fuel Specification

ASTM D6709 Sequence VIII Test Fuel Specification Halterman Products KA24E Test Fuel Product Code: HF008					
Test	ASTM Test Method	Units	Specifications		
			Min	Target	Max
Distillation – IBP	D86	°C	24		35
5 %		°C			
10 %		°C	49		57
20 %		°C			
30 %		°C			
40 %		°C			
50 %		°C	93		110
60 %		°C			
70 %		°C			
80 %		°C			
90 %		°C	149		163
95 %		°C			
Distillation – EP		°C	196		213
Recovery		vol %		Report	
Residue		vol %		Report	
Loss		vol %		Report	
Gravity	D4052	°API	58.7		61.2
Density	D4052	kg/L	0.734		0.744
Reid Vapor Pressure	D323	kPa	60.7		63.4
Carbon	E191	mass fraction	0.8580		0.8667
Carbon	D3343	mass fraction		Report	
Sulfur	D4294	mass %	0.01		0.04
Lead	D3237	g/L			0.013
Phosphorous	D3231	g/L			0.0013
Oxygen	D4815	mass %			0.05
Composition, aromatics	D1319	vol %			35.0
Composition, olefins	D1319	vol %	5.0		10.0
Composition, saturates	D1319	vol %		Report	
Oxidation Stability	D525	minutes	1440		
Copper Corrosion	D130				1
Gum content, washed	D381	mg/100 mL			5
Research Octane Number	D2699		96.0		97.5
Motor Octane Number	D2700			Report	
R+M/2	D2699/ D2700			Report	
Sensitivity	D2699/ D2700		7.5		
Net Heat of Combustion	D240	J/kg		Report	
Color	Visual			Green	

APPENDIXES

(Nonmandatory Information)

X1. ROLE OF THE ASTM TEST MONITORING CENTER AND THE CALIBRATION PROGRAM

X1.1 The TMC, a nonprofit organization located in Pittsburgh, Pennsylvania, is staffed to administer engineering studies; conduct engineering laboratory visits; conduct statistical analysis of reference data; store, blend, and ship reference oils; and provide the associated administrative functions to maintain the referencing calibration program for various tests as directed by Subcommittee D02.B0 and the Test Monitoring Board. The TMC maintains close communication with the test sponsors, the test developers, the surveillance panels, and the testing laboratories.

X1.2 The TMC operates in accordance with the ASTM Charter, the ASTM Bylaws, the Regulations Governing ASTM Technical Committees, the Bylaws Governing ASTM Committee D02, and the Rules and Regulations governing the ASTM Test Monitoring System. The management of the system is vested in the Test Monitoring Board elected by Subcommittee D02.B0.

X1.3 The TMC operating income is obtained from fees for each reference oil test conducted and each reference oil issued. Fee schedules are reviewed and established by Subcommittee D02.B0.

X2. SUGGESTED METHOD FOR SALVAGING CAMSHAFT BEARING JOURNALS

X2.1 The following method is suggested for salvaging out-of-limit camshaft journals, or for decreasing the camshaft journal clearance.

X2.1.1 Build up material on the journals by flame spraying. The following material has proven successful:

Met-Caloy No. 2[40,8] (mass %)
Carbon, 0.32 %
Silicon, 0.50 %
Magnesium, 0.50 %
Phosphorus, 0.02 %
Sulfur, 0.02 %
Chromium, 13.5 %
Iron, balance

X2.1.1.1 Apply a layer of Met-Caloy No. 2, 0.25 mm maximum thickness, directly to the worn surface. Grind the journal to the desired size.

X2.1.1.2 If a build-up of more than 0.25 mm thickness is required, first grind the surface undersize and apply a spray of bond material to within 0.05 mm undersize of the final diameter. Cover the remaining surface with Met-Caloy No. 2 and grind to the desired size.

[40] The sole source of supply of the apparatus known to the committee at this time is Met-Caloy No. 2 can be obtained from Metco, Inc., 1101 Prospect Ave., Westbury, NY 11590.

X3. DATA LOG SHEETS

X3.1 Examples of suitable log sheets are shown in Figs. X3.1 and X3.2.

Page Number ______________

"LABORATORY NAME"
SEQUENCE VIII TEST DATA LOG SHEET

RUN NUMBER ______________________
(Stand-Engine-Runs Since Reference-Total Runs)

ENGINE NUMBER ________________ STAND NUMBER ________________ OIL CODE ______________

		RUN-IN				FLUSH
HEADER	OBSERVER					
	DATE					
	TIME					
	TOTAL HOURS ON "RUN-IN" OR "FLUSH"	1	2	3	4	1/2
	TEST PARAMETER					
ENGINE	ENGINE SPEED (Specified, ± 25 r/min)	1500	2000	2500	3150	3150
	ENGINE SPEED (Actual, r/min)					
	ENGINE POWER (Specified, ± 150 W)	1500	3000	3700	3700	3730
	ENGINE POWER (Actual, W)					
TEMPERATURES	OIL GALLERY (107.0 °C MAX)					
	COOLANT OUTLET (93.5 °C MAX)					
	**COOLANT INLET (Record, °C)					
	**COOLANT DIFFERENTIAL ((5.6 ± 1) °C)					
	**CARBURETOR INTAKE AIR (Record, °C)					
	**EXHAUST (Record, °C)					
PRESSURES	OIL GALLERY ((280 ± 10) kPa)					
	**CRANKCASE VACUUM ((.500 ± .120) kPa)					
	**EXHAUST BACK PRESSURE ((0 to 3.4) kPa)					
	**INTAKE VACUUM (Record, kPa)					
FLOWS	**FUEL ((2.15 ± 0.11) kg/h @ 3150 r/min)					
	**CARBURETOR AIR (Record, kg/h)					
	**AIR FUEL RATIO (13.43 ± 0.5)					
	**CRANKCASE OFF-GAS ((850 ± 28) SLH)					
	**ROCKER AIR (Record, SLH)					
	**BLOWBY (approx. (280 ± 60) SLH)					
MISC	IGNITION ADVANCE (Specified, ± 1° Before Top Dead Center, BTDC)	25	25	35	35	35
	IGNITION ADVANCE (Actual, BTDC)					
	OIL HEATER-HEAT FLOW RATE (W)	Oil Heater not in Oil Circuit.				OFF

**Recommended but Not Required.

Required Oil Charge and Sample Volumes	
Run-in Oil Charge:	2840 mL
Flush Oil Charge:	1660 mL
Test Oil Charge:	1660 mL
Purge Sample:	60 mL
Oil Sample:	180 mL
New Oil Additions	240 mL

FIG. X3.1 Run-in and Flush Data Log Sheet

Page Number ________

"LABORATORY NAME"
SEQUENCE VIII TEST DATA LOG SHEET

RUN NUMBER ________________
(Stand-Engine-Runs Since Reference-Total Runs)

ENGINE NUMBER ____________ STAND NUMBER ____________ OIL CODE ________

	Column No. ------>	1	2	3	4	5	6	7	8	9	10
HEADER	OBSERVER										
	DATE										
	TIME										
	TOTAL HOURS ON STEADY-STATE TEST										
TEST PARAMETER											
ENG	ENGINE SPEED ((3150 ± 25) r/min)										
	ENGINE POWER (Record, W)										
TEMPERATURES	OIL GALLERY ((135 ± 1) °C: SAE 0W, 5W, 10W oils) ((143.5 ± 1) °C: SAE 20, 30, 40, 50, & multivis-grade oils)										
	COOLANT OUTLET ((93.5 ± 1) °C)										
	COOLANT INLET (Record, °C)										
	COOLANT DIFFERENTIAL ((5.6 ± 1) °C)										
	CARBURETOR INTAKE AIR (Record, °C)										
PRESSURES	OIL GALLERY ((280 ± 10) kPa)										
	CRANKCASE VACUUM ((.500 ± .120) Pa)										
	EXHAUST BACK PRESSURE ((0 to 3.4) kPa)										
	INTAKE VACUUM (Record, kPa)										
FLOWS	FUEL ((2.15 ± 0.11) kg/h)										
	*CARBURETOR AIR (approx. 30.2 kg/h)										
	*AIR FUEL RATIO (13.43 ± 0.5)										
	CRANKCASE OFF-GAS ((850 ± 28) SLH)										
	ROCKER AIR (Record, SLH)										
	BLOWBY (approx. (280 ± 60) SLH)										
MISC	*IGNITION ADVANCE ((35 ± 1) ° Before Top Dead Center, BTDC)										
	OIL HEATER-HEAT FLOW RATE (Optional, record if used for for oil temp control, W)										

*Required during Hours: 1, 10, 20 and 30.

FIG. X3.2 Test Data Log Sheet

SUMMARY OF CHANGES

Subcommittee D02.B0 has identified the location of selected changes to this standard since the last issue (D6709 – 15) that may impact the use of this standard. (Approved Oct. 1, 2015.)

(1) Subsection 7.3.1.2 updated, identifying three additional package forms of Permatex.

(2) Subsection 14.1 (Table 4), precision data updated.

Subcommittee D02.B0 has identified the location of selected changes to this standard since the last issue (D6709 – 14a) that may impact the use of this standard. (Approved April 1, 2015.)

(1) Subsections 11.1.7.2 and 11.1.7.3, typographical errors corrected, and time limit of 4 h clarified.

Subcommittee D02.B0 has identified the location of selected changes to this standard since the last issue (D6709 – 14) that may impact the use of this standard. (Approved Dec. 1, 2014.)

(1) Added subsection 1.3.1.1 exception language in units statement.

Subcommittee D02.B0 has identified the location of selected changes to this standard since the last issue (D6709 – 13) that may impact the use of this standard. (Approved May 1, 2014.)

(1) Subsection 6.1.5 revised to include the use of an alternative Hastings piston ring assembly.

(2) Subsection 6.1.6 added as an alternative source for remanufactured camshafts.