Designation: D 5844 – 98

An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428

Standard Test Method for Evaluation of Automotive Engine Oils for Inhibition of Rusting (Sequence IID)[1]

This standard is issued under the fixed designation D 5844; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a laboratory engine test procedure, utilizing a 1977 350 in.^{3} displacement (5.7 L) Oldsmobile V-8 engine. The procedure, using leaded gasoline, evaluates the rust inhibition characteristics of engine oils. The test method was designed to relate particularly to short-trip service under typical winter conditions in the upper midwestern United States. The procedure has been correlated with vehicles, using leaded gasoline, in that type of service and prior to 1978,[2] particularly with regard to rusting. It is one of the test methods required to evaluate oils intended to satisfy the API SJ category.[3]

1.2 Information Letters are published occasionally by the ASTM Test Monitoring Center[4] (see Appendix X1) to update the test method. Copies of these letters can be obtained by writing the Center.

1.3 The method may not be applicable for the evaluation of engine oils if unleaded gasoline is used.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See Note 1, Note 2, Note 3, Note 6, Note 7, Note 8, Note 9, Note 10, Note 11, Note 14, and Note 15.

1.6 A Table of Contents follows:

[1] This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.B0.01 on Passenger Car Engine Oils.

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[2] Available from ASTM in Special Technical Publication (STP) 3151 (Part 1). Also available from the Society of Automotive Engineers (SAE) as Technical Paper No. 780931. The SAE address is 400 Commonwealth Drive, Warrendale, PA 15096.

[3] Information available from the American Petroleum Institute (API) in its publication API1509 Engine Oil Licensing and Certification System. The API address is 1220 L Street, NW, Washington, DC 20005.

[4] Until the next revision of this test method, the ASTM Test Monitoring Center will update changes in the test method by means of Information Letters; these can be obtained from the ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206-4489. Attention: Administrator. This edition incorporates revisions in all Information Letters through No. 97–1.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2982 Test Methods for Detecting Glycol-Base Antifreeze in Used Lubricating Oils[5]

D 4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants[5]

D 4863 Test Method for Determination of Lubricity of Two-Stroke-Cycle Gasoline Engine Lubricants[6]

D 5302 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation and Wear in a Spark-Ignition Internal Combustion Engine Fueled With Gasoline and Operated Under Low-Temperature, Light-Duty Conditions[6]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance With Specifications[7]

E 1119 Specification for Industrial Grade Ethylene Glycol[8]

G 40 Terminology Relating to Wear and Erosion[9]

2.2 *Coordinating Research Council:*

CRC Rust Rating Manual No. 7[10]

3. Terminology

3.1 *Definitions:*

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

3.1.1.1 *Discussion*—This is a coded reference oil which is submitted by a source independent from the test facility. **(Sub. B Glossary)[11]**

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

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

3.1.4 *clogging*, *n*—the restriction of a flow path due to the accumulation of material along the flow path boundaries. **(Sub. B Glossary)**

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

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

3.1.7 *nonstandard test*, *n*—a test that is not conducted in conformance with the requirements in the standard test method; such as running on an uncalibrated test stand, using different test equipment, applying different equipment assembly procedures, or using modified operating conditions. **(Sub. B Glossary)**

3.1.8 *operationally valid standard test*, *n—in automotive lubricant testing*, a standard test that meets operational validity requirements, where specified.

3.1.8.1 *Discussion*—Operational validity is determined after a test is completed. Requirements can include (*1*) mid-limit ranges for the average values of primary and secondary parameters that are narrower than the specified control ranges, (*2*) allowable deviations for primary and secondary parameters from the specified control ranges, (*3*) downtime limitations, and (*4*) special parameter limitations.

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

[6] *Annual Book of ASTM Standards*, Vol 05.03.

[7] *Annual Book of ASTM Standards*, Vol 14.02.

[8] *Annual Book of ASTM Standards*, Vol 15.05.

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

[10] Available from the Coordinating Research Council, Inc., Perimeter Center Pkwy., Atlanta, GA 30346.

[11] Available from the Secretary of the ASTM D02.B0 Subcommittee. The secretary is Mr. J. L. Newcombe, Exxon Chemical Co., 26777 Central Park Blvd., Ste. 300, Southfield, MI 48076-4172.

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

3.1.9.1 *Discussion*—Reference oils are used to calibrate testing facilities, to compare the performance of other oils, or to evaluate other materials (such as seals) that interact with oils. **(Sub. B Glossary)**

3.1.10 *rust*, *n*—*of ferrous alloys*, a corrosion product consisting primarily of hydrated iron oxides. **(Sub. B Glossary)**

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

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

3.1.13 *sludge*, *n*—*in internal combustion engines*, a deposit, principally composed of insoluble resins and oxidation products from fuel combustion and the lubricant, that does not drain from engine parts but can be removed by wiping with a cloth. **(Test Method D 5302)**

3.1.14 *standard test*, *n*—a test on a calibrated test stand, using the prescribed equipment that is assembled according to the requirements in the test method, and conducted according to the specified operating conditions. **(Sub. B Glossary)**

3.1.15 *stuck lifter*, *n*— *in internal combustion engines*, a lifter plunger that does not return to its original position by its own force upon removal from the engine.

3.1.16 *varnish*, *n*—*in internal combustion engines*, a hard, dry, generally lustrous deposit that can be removed by solvents but not by wiping with a cloth. **(Test Method D 5302)**

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

3.1.17.1 *Discussion*—Wear generally occurs between two surfaces moving relative to each other, and is the result of mechanical or chemical action or a combination of mechanical and chemical actions. **(Test Method D 5302)**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *test start*, *n*—the phrase denoting the installation of test oil into the engine.

4. Summary of Test Method

4.1 *Test Oil and Fuel Requirements*:

4.1.1 Approximately 2 gal (7.6 L) of test oil are required.

4.1.2 Approximately 120 gal (454 L) of test fuel are required.

4.2 *Test Stand Calibration*—Calibration is required and is achieved by the laboratory running reference oils supplied by the ASTM Test Monitoring Center (see Annex A1 for details).

4.3 *General Procedure*:

4.3.1 Prior to each test, the engine is completely disassembled, solvent cleaned, measured, and rebuilt in strict accordance with all furnished specifications.

4.3.2 Following this preparation, the engine is installed on a dynamometer test stand equipped with the appropriate accessories for controlling speed, load, and various other engine operating conditions.

4.3.3 The engine is operated continuously for 28 h under conditions of moderate engine speed, partially warmed-up jacket coolant temperature, and rich air-to-fuel ratio. The engine is then operated an additional 2 h at a slightly elevated jacket coolant temperature, with all other conditions unchanged.

4.3.4 After the 30 h of operation, the engine is shutdown for 25 min. During this period, spark plugs are changed, and adjustments made to the cooling system controls.

4.3.5 The engine is then operated for an additional 2 h under conditions of relatively high speed and jacket coolant temperature, and lean air-to-fuel ratio.

4.3.6 The engine is then disassembled, and specified parts visually rated to determine the extent of corrosion formed.

5. Significance and Use

5.1 Rust ratings from this test method indicate the tendency of an oil to permit the formation of corrosion products that can interfere with hydraulic valve lifter operation, or any other close tolerance engine parts, as well as contribute to general wear problems.

5.2 The test method is used in various engine oil specifications.

5.3 The test results are significant only when all details of the procedure are followed, and operationally valid criteria are documented.

6. Apparatus

6.1 The test engine is a 350-in.^{3} (5.7-L displacement) Oldsmobile V-8 engine with an 8.5:1 compression ratio and equipped with a two-barrel carburetor.[12]

6.2 The engine is mounted on a test stand and connected to a dynamometer capable of absorbing 100 hp (74.6 kW) at a speed of 3600 r/min.

6.3 An external cooling system is required for the engine, with a pumping system capable of delivering 60 gal/min (3.79 L/s) (see Annex A2 for details).

6.4 An external cooling system is required for the jacketed rocker cover, intake manifold crossover, and breather tubes. This system controls coolant flow, pressure, and temperature in these engine parts (see Annex A3 for details).

6.5 An external oil cooling system is required which includes a positive displacement pump and a heat exchanger (see Annex A4 for details).

6.6 Suitable air treatment equipment is required to maintain the carburetor intake air at constant moisture content and temperature (see 9.3).

6.7 A flushing tank is required to premix and circulate the cleaning agents (see Annex A5 for details).

6.8 A mixing tank is required to premix the glycol and water coolant (see Annex A6 for details).

6.9 A suitable pressurized fuel delivery system is required (see Annex A7 for details).

7. Reagents and Materials

7.1 *General Cleaning Agents*—The following have been found satisfactory:

7.1.1 Aliphatic naphtha with a 300 to 400°F (149 to 204°C) boiling point.

[12] Test engines and various other parts available from the Central Parts Distributor, Bowden Manufacturing Corp., 4590 Beidler, Willoughby, OH 44094.

NOTE 1—**Warning:** Combustible. Health hazard.

7.1.2 *Oakite 811*. [13]

NOTE 2—**Warning:** Combustible. Health hazard.

7.1.3 *Oakite 77*. [13]

7.1.4 *Oakite Rust Stripper—O.F*. [13]

NOTE 3—**Warning:** Health hazard.

NOTE 4—**Caution:** Some of the Oakite products listed in 7.1.2 to 7.1.4 are alkaline agents used to clean the engine coolant jacket and necessitate that all aluminum or galvanized materials be removed from contact with the cleaning agent.

7.2 *Organic Solvent*—Organic cleaning solution having a composition of:

ethyl acetate	37.5 % volume
denatured alcohol (No. 30)	27.5 % volume
butyl alcohol	5.0 % volume
tetrahydrofuran (THF)	30.0 % volume

7.2.1 The THF used shall meet the following specifications: 99.5 + % THF, inhibited with 0.025 % butylated hydroxy toluene (BHT), and less than 0.03 % water. Aldrich Chemical Co. THF,[14] catalog number 14722-2, has been found satisfactory. The BHT inhibitor limits the potential explosive hazard of THF upon drying.

NOTE 5—**Warning:** Flammable (alcohols). Denatured alcohol cannot be made nontoxic. Health hazard.

NOTE 6—**Warning:** Combustible (THF). Health hazard.

7.3 *Engine Coolant*—The engine coolant and the rocker cover and breather tube coolant (see Annex A9) consist of a mixture of 40 ± 1 % volume ethylene glycol meeting Specification E 1119 for industrial grade ethylene glycol,[15] and 60 ± 1 % volume distilled water, to which is added 0.25 pt/gal (31.25 mL/L) Pencool 2000 coolant additive.[16]

NOTE 7—**Warning:** Combustible (ethylene glycol). Health hazard.

7.3.1 Only the materials from the stated supply sources have been found satisfactory.

7.4 *Test Fuel*—The test fuel is certified GMR 995 gasoline.[17]

NOTE 8—**Warning:** Flammable. Health hazard.

7.4.1 Care shall be taken by purchasers of GMR 995 gasoline that all tanks used for transportation and storage are adequately cleaned before being filled with the test fuel.

7.5 *Sealing Compounds*:

7.5.1 *Perfect Seal No. 4 Sealing Compound*, [18] (Part No. 1050026).

7.5.2 No. 2 Non-Hardening Permatex.[19]

7.5.3 3M Super Weatherstrip Adhesive[20] (Part No. 051135-08001).

7.5.4 *Anti-Seizure Compound*, such as Fel-Pro C-100[21] or EM Lubricants Inc. CP-29 Spray or can.[22]

7.6 *Engine Assembly Oil*—Engine Test Assembly Fluid, EF 411[23] (Part No. 47503-8).

7.7 *Reference Oils*—Can be purchased from the ASTM Test Monitoring Center.[4] Send inquiries to the attention of the operations manager (see Annex A1).

7.8 *Rust Remover*—The composition of the rust remover is as follows:

Phosphoric acid (85 % concentrate)	20 % by volume
Denatured alcohol	40 % by volume
Distilled water	40 % by volume

NOTE 9—**Warning:** Corrosive (phosphoric acid). Health hazard.

8. Preparation of Apparatus

8.1 *Laboratory Ambient Condition*:

8.1.1 Air from fans or a ventilation system should not be permitted to blow directly on the test engine.

8.1.2 Do not use heat lamps or insulation for temperature control.

8.1.3 The ambient laboratory atmosphere should be relatively free of contaminants.

8.1.4 It is recommended that the atmosphere in the engine buildup areas be filtered and controlled for temperature and humidity to minimize accumulation of dirt or rust on engine parts.

8.1.4.1 Uniform temperature control also aids in measuring and selecting parts for assembly.

8.1.5 Engines assembled in a controlled environment area and moved to a non-controlled storage area, should be protected so moist air cannot enter the engine and promote pretest corrosion.

8.2 *Assembling the Test Engine*:

8.2.1 *General Information*:

8.2.1.1 Use standard General Motors service parts and buildup procedures as outlined in the 1977 Oldsmobile Parts Book and the Service Manual[23] unless special or modified parts or procedures are specified. Make pertinent measurements of the cylinders, pistons, journals, bearings, and valve train to ensure conformance to the test method's specifications.

[13] Oakite materials are available from Oakite Products, Inc., 50 Valley Rd., Berkeley Heights, NJ 07922. However, when ordering Oakite Rust Stripper, specify Oakite Rust Stripper O.F., and order from Wrico Corp., 4835 Whirlwind, San Antonio, TX 78217.

[14] THF is available from Aldrich Chemical Co., 1001 W. St. Paul Ave., Milwaukee, WI 53233.

[15] Available from Chemcentral, 1107 E. Southcross, San Antonio, TX 78223.

[16] The sole source of supply of Pencool 2000 known to the committee at this time is The Penray Companies, Inc., 1801 Estes Ave., Elk Grove, IL 60007. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[17] Direct purchase orders to Phillips 66 Oil Co., Philter Marketing Service, P.O. Box 968, Borger, TX 79008.

[18] Order part No. 1050026 (available in 40 oz, pt, or gal containers) from Allied Technology, Inc., P.O.B. Sealants Division, 11102 Kenwood Rd., Cincinnati, OH 45242.

[19] Available from local distributors of Permatex products. Contact Permatex Co., Inc., (Loctite Corp.), 18731-T Cranwood Pkwy., P.O. Box 7183, Cleveland, OH 44128, for distributor names in your locality.

[20] Order part No. 051135-08001 from Minnesota Mining and Manufacturing Co., AC & S Division, Dept. TR, 3M Center 223-6 N.E., St. Paul, MN 55101.

[21] Available from Fel-Pro, Inc., 7450 N. McCormick Blvd., Skokie, IL 60076. Also available from E/M Lubricants, Inc., 6940 Farmdale, N. Hollywood, CA 91605.

[22] Refer to Engine Test Assembly Fluid, EF 411 No. PN 47503-8 when ordering from Mobil Oil Corp., Illinois Order Board, P.O. Box 66940, AMF-O'Hare, IL 60666.

[23] Available from local General Motors Corp. dealers.

8.2.1.2 To avoid contamination of rated surfaces (hydraulic valve lifters, oil pump relief valve, and pushrods), handle these engine parts with gloved hands at all times, particularly during assembly as well as at the end of the test.

8.2.1.3 Sealing compound application information is detailed in Annex A9.

8.2.1.4 Fastener torque specifications and torquing procedures are detailed in Annex A10.

8.2.1.5 The classification of engine test parts is provided in A11.1.

8.2.1.6 Procurement and usage of engine test parts are discussed in A11.2.

8.2.1.7 New parts required for each test are shown in Annex A11.3 .

8.2.1.8 Parts replaced as necessary are shown in Annex A11.4 .

8.2.2 *Clean All Engine Parts*:

8.2.2.1 Before using a new block, physically remove all slag and sand deposits contained in the water jacket with a sharp-ended 0.25-in. (6.4-mm) diameter drill rod.

8.2.2.2 Tap the oil filler tube hole with a ¾-in. NPT tap.

8.2.2.3 Whether using a new or used block, remove the crankshaft, main bearings, camshaft bushings, and oil gallery plugs.

8.2.2.4 Clean block by applying Oakite 811 to cylinder walls, and other areas, with a paint brush. **Do not submerge the block in Oakite 811. Do not allow the Oakite 811 to enter the engine jacket cooling areas.**

8.2.2.5 Remove the Oakite 811 by spraying with aliphatic naphtha that has a boiling point between 300 to 400°F (149 to 204°C). Blow dry with air.

8.2.2.6 Care should be taken to prevent the attack of nonferrous materials when using Oakite 811.

8.2.2.7 An alternate method of cleaning the block is to immerse it in a heated chloroethane VG (inhibited 1,1,1, trichloroethane) bath. In this case, the cleaning solution can be circulated through the oil passages to ensure removal of deposits.

8.2.2.8 If a heated bath or approved pressure washing system is used, clean all parts afterwards using Oakite 811 and aliphatic naphtha. Allow block to cool before performing further assembly steps.

8.2.2.9 Degrease all other engine parts in either a heated bath; or brushing with Oakite 811, followed by spraying with aliphatic naphtha.

8.2.2.10 Immediately after cleaning, oil all parts except the block, using EF-411 fluid.

8.2.3 *Cylinder Block Preparation*:

8.2.3.1 Install a solid plug (Part No. 22527020) in the rear oil gallery. Some engines may already have this modification.

8.2.3.2 Replace the freeze plugs. A helpful tool for this purpose is shown in print RX-117622-B.

8.2.3.3 Prestress the block before honing:

(*a*) The honing adapter plate, shown in print RX-117520-D, is required. The RX prints are available through the TMC.

(*b*) Use new head gaskets (Part No. 12355889) with the adapter plate each time an engine block is honed. Since these same head gaskets are to be used for engine assembly, they should be marked *right* and *left* so that they can be installed in exactly the same way they were positioned during honing.

(*c*) Use special bolts (Part No. 9409054) in connection with washers, as shown in print RX-117636-A, to bolt the honing adapter plate to the engine block. Torque these bolts in the same sequence as indicated in the 1977 Oldsmobile Service Manual (Fig. 6A3-29). Torque the bolts three times: first, at 100 lbf·ft (136 N·m), second at 110 lbf·ft (149 N·m), and third a repeat at 110 lbf·ft (149 N·m).

8.2.3.4 Hone The Cylinder Walls:

(*a*) Sunnen CK-10 or Sunnen CV-616[24] honing machines have been found suitable.

(*b*) The appropriate machine setup is as follows:

	CK-10	CV-616
spindle speed	155 r/min	170 r/min
stroke rate	46 strokes/min	57 strokes/min
feed ratchet	3 or 30 tooth gear	2 or 3

(*c*) These speeds and stroke rates provide the required 30 to 40° maximum cross-hatch pattern. Equip the honing machine with a fiber mat, part CV-1100.

(*d*) The flow rate of the honing lubricant (Sunnen CK-50[24]) should be controlled at 2 gal/min (0.13 L/s).

(*e*) The honing fluid should not contain an excessive amount of honing debris. In addition, no solvents are to be introduced into the honing fluid or used to clean the honing stones or guides; clean honing stones or guides only with honing fluid.

(*f*) The cylinders should be honed without main bearings, but with all main bearing caps in place and torqued. Bearing caps Nos. 1 through 4 should be torqued to 80 lbf·ft (108 N·m), and No. 5 should be torqued to 100 lbf·ft (136 N·m).

(*g*) The following stones and resulting finish are recommended:

	Roughening	Finishing
stone	JHU 525[24]	JHU 820[24]
microfinish (AA)	0.51 to 0.76 µm (20 to 30 µin.)	0.23 to 0.28 µm (9 to 11 µin.)

NOTE 10—Once the meter readings have been established which will produce the above micro-inch finishes using a particular honing machine, it is recommended that those same meter readings be used with that machine for future honing jobs.

(*h*) Hone the cylinder walls so that no more than 0.0004 in. (0.010 mm) difference exists at any point of measurement in the piston ring travel area. Essentially zero taper should also exist in this area.

(*i*) *Do not bore cylinder blocks oversize*.

(*j*) After honing, clean the engine block again using Oakite 811 and aliphatic naphtha only.

8.2.4 *Install Main Bearings*:

8.2.4.1 Use production main bearings. Bearings can be reused.

8.2.4.2 Use Plastigage to check bearing clearances. Numbers 1 through 4 main bearing clearances should be 0.0005 to 0.0021 in. (0.0127 to 0.0533 mm), and the rear main bearing clearance should be 0.0015 to 0.0031 in. (0.0381 to 0.0787 mm). Undersize bearings in steps of 0.0005 in. (0.0127 mm) are available to obtain the specified clearances.

[24] Available from Sunnen Products Co., 7910 Manchester Ave., St. Louis, MO 63143.

8.2.4.3 Crankshaft end play should be between 0.004 and 0.008 in. (0.102 and 0.203 mm).

8.2.4.4 Torque bearings Nos. 1 through 4 to 80 lbf·ft (108 N·m), and bearing No. 5 to 100 lbf·ft (136 N·m).

8.2.5 *Piston Fitting and Numbering*:

8.2.5.1 Fit pistons to cylinders as described in the Oldsmobile Service Manual (page 6A3-24 (Fig. 6A3-53)).

8.2.5.2 The maximum permissible cylinder wall-to-piston clearance is defined as a fit resulting in a 3-lb (13.3-N) pull with a 0.005-in. (0.127-mm) gage.

8.2.5.3 Use only the specified pistons and piston ring set; Central Parts Distributor[12] (CPD) parts BX-214-1 and BX-215-1, respectively.

8.2.5.4 Number pistons with odd numbers in the left bank from front to rear and with even numbers in the right bank from front to rear (the same numbers appear on the intake manifold legs at the cylinders).

8.2.5.5 Take extreme care when installing the connecting rods on the piston wrist pins in order to avoid piston pin distortion, to ensure proper connecting rod to piston pin alignment, and to allow the rod to move freely.

8.2.6 *Adjust Piston Ring End Gaps*:

8.2.6.1 For a laboratory setting up this test for the first time, and using a new engine, it is recommended that a top and second end ring gap (suggest using ring gap feeler gage,[25] Part No. X467X) of 0.022 and 0.020 in. (0.56 and 0.51 mm) respectively. The compression ring gaps can be modified in subsequent tests to assist in controlling blowby rates.

8.2.6.2 A Sanford SG-48 Ring Grinder,[26] or a manufactured ring grinder (see prints RX-116728-C through 116733-A, 116933-E through 116949-A, 116951-A through 116957-A, and 117052-C, 117506-B, and 117507-B) is helpful in grinding the ring ends to obtain a square-edged gap.

8.2.6.3 To measure ring end gaps, position rings in the appropriate cylinder bore using a piston ring depth gage (print RX-117329-B). Remove any burrs from the rings with a fine stone prior to installation.

8.2.7 *Install Connecting Rod and Piston Assemblies in the Cylinders*:

8.2.7.1 Oil cylinder walls with EF 411 oil and wipe with a clean, soft cloth. Repeat process until there are no honing or grinding particles left on the cloth. Change cloths frequently. As the final step, re-oil the cylinder walls with EF 411.

8.2.7.2 Use a piston ring expander tool for installing the piston rings. A Perfect Circle 4.0625 ring expander tool[27] (Part No. P401-K) has been found satisfactory for this purpose.

8.2.7.3 Align piston rings as described on print RX-117372-C prior to installing the pistons in the cylinders.

8.2.7.4 Use a Snap-on ring compressor tool (RC-40C or equivalent) to compress the rings, and slide the connecting rod and piston assemblies carefully into the correct cylinders.

8.2.8 *Install Connecting Rod Bearings*:

8.2.8.1 Use connecting rod bearings, Part No. 18008494. Bearings can be reused.

8.2.8.2 The bearing clearance shall be between 0.0004 and 0.0033 in. (0.010 and 0.084 mm).

8.2.8.3 The side clearance shall be between 0.006 and 0.020 in. (0.152 and 0.508 mm).

8.2.8.4 Bolts on Nos. 5 and 6 connecting rods shall be no longer than 2.375 in. (60.33 mm).

8.2.9 *Install Camshaft*:

8.2.9.1 Modify the front camshaft bearing (Part No. 12339842) as shown in print RX-118211-C. The machined groove from the oil hole to the front edge of the bearing provides an oil feed to the thrust washer.

8.2.9.2 When camshaft bearings are replaced, a Burroughs cam bearing installation tool[28] (Part No. BT6409, or equivalent) is recommended.

8.2.9.3 Remove any nicks, burrs, or ridges on the thrust face of the camshaft (Part No. 562299) by light filing. *Do not machine the surface nor remove significant material, as this may alter the thrust face to lifter dimension*.

8.2.9.4 A thrust washer as shown on print RX-118213-A is required between the thrust surfaces of the camshaft and the block. A thrust washer can be used more than once, if in good condition; however, if reused, position the same side of the thrust washer toward the block as previously.

8.2.9.5 Replace the camshaft timing gear (Part No. 381263) at least every second test.

8.2.9.6 Modify the camshaft gear bolt as shown in print RX-117228-A.

8.2.9.7 A timing gear oil deflector and washer are required as shown on prints RX-118306-A and RX-117464-A.

8.2.10 *Install Harmonic Balancer and Oil Slinger*:

8.2.10.1 Deburr the harmonic balancer keyway slot and the slot on the crankshaft with a mill file, and modify as shown in print RX-118317-B. The inside diameter of the bore on the harmonic balancer can be reamed to 1.50 in. (38.1 mm) to facilitate installation and removal. The harmonic balancer should also be checked to ensure that no slippage has occurred between the hub and the outer flange.

8.2.10.2 The production oil slinger (Part No. 382572) may not provide sufficient clearance between the front cover and the harmonic balancer. An additional spacer washer as shown in print RX-117382-A can be used to shim the harmonic balancer out from the front cover.

8.2.11 *Install the Engine Front Cover and Seal*:

8.2.11.1 Replace the front cover and water pump assembly with the front cover shown in print RX-117224-D.

8.2.11.2 Use the production front seal (Part No. 552711), and this can be installed using a seal driver shown in print RX-117370-B.

8.2.11.3 Attach the front cover oil deflector, shown in print RX-117319-B, to the front cover.

8.2.11.4 Use the production front cover gasket (Part No. 22547856).

[25] Part No. X467X, with a range of 0.508 to 1.27 mm (0.020 to 0.050 in.) by 0.0259 mm (0.001 in.) increments, available from Sterling Supply Co., 1220 East Nine Mile Rd., Ferndale, MI 48220.

[26] Sanford SG-48 (with Oldsmobile 350 head) can be ordered from Sanford Manufacturing Co., P.O. Box 318, Roselle, NJ 07203.

[27] The following Perfect Circle tools and seals: 4.0625 in. ring expander tool (Part No. P401-K), valve stem seals (Part No. 55A397), and valve stem seal installation tool (Part No. 55A396) are available from Engine Products Division, Dana Corp., P.O. Box 1166, Richmond, IN 47374.

[28] Available from Burroughs Tool and Equipment Co., 2429 N. Burdick St., Kalamazoo, MI 49002.

8.2.12 *Timing Mark Indicator*:

8.2.12.1 Modify the timing mark indicator in accordance with print RX-118318-A.

8.2.12.2 Dowel the indicator to the front cover to ensure proper alignment.

8.2.13 *Install Oil Pump*:

8.2.13.1 Use a new oil pump for each test. Pumps are available (Part No. BX-211-1 or BX-211-2) through the Central Parts Distributor,[12] and are supplied with all necessary hardware, excluding the relief valve. *Use no abrasive materials during cleaning, and do not make modifications to any part of the assembly*.

8.2.13.2 The oil pump relief valve is available from the CPD (Part No. BX-201-1). *Use the valve as received with no modifications to the surface finish.*

8.2.13.3 Wash the valve with aliphatic naphtha and oil with EF 411 prior to installation.

8.2.13.4 The cleaned valve should have a numerical rating of 9.7 using the Coordinating Research Council (CRC) Rating Manual No. 7.

8.2.13.5 The oil pump relief valve spring can be stretched or trimmed to vary oil pressure. Up to three coils can extend beyond the housing with the relief valve seated.

8.2.14 *Install Dipstick Tube*:

8.2.14.1 Install a dipstick tube using a driver conforming to print RX-117348-B. Check the position of the tube with a gage shown in print RX-117326-B. Note position at cylinder head for manifold clearance.

8.2.14.2 No dipstick is used for the test. Use a dipstick tube cap, shown in print RX-117349-A, during the test.

8.2.15 *Oil Pan*—Modify the oil pan (Part No. 555137) as shown on print RX-118305-D.

8.2.15.1 Install the special oil pan baffle shown on print RX-118332-B.

8.2.16 *Cylinder Head Preparation*:

8.2.16.1 Deburr all mating surfaces of the cylinder heads to the block and manifolds with a 12-in. (30.5-cm) smooth file to ensure gasket seating.

8.2.16.2 Machine the outside diameter of all valve guides to 0.531 ± 0.007 in. (13.49 ± 0.18 mm) using a valve guide cutter.[29]

(*a*) Machine the guides until the cutter touches the top of the guides (approximately 0.38 in. [9.53 mm]). *Do not machine the top of the guide*.

(*b*) Be sure that the guides are machined all around (360°) and have no nicks or grooves.

(*c*) Use an 11⁄32-in. (8.73-mm) pilot with the cutting tool. *Check the pilot periodically for wear*. No excessive clearance should exist between the pilot and the valve bores.

8.2.16.3 Thoroughly clean cylinder heads with Oakite 811 solvent, followed by spraying with aliphatic naphtha, and air-blow dry.

8.2.16.4 Install the cup-type freeze plugs (Part No. 380254) on the cylinder heads. A driver that facilitates the installation is shown on print RX-117377-A.

8.2.16.5 All valves should be lightly lapped with fine grit lapping compound to improve seating (before seals are installed).

8.2.16.6 Use new valve stem seals (Part No. BX-216-1)[12] for 11⁄32-in. (8.73-mm) diameter valve stems on both intake and exhaust valves.

8.2.16.7 Install the seals using the plastic shields, to protect the seals from damage, and an installation tool (Part No. 53A396),[27] to ensure proper seating.

8.2.16.8 Use Part No. BX-213-1[12] valve springs. These springs are protected with red oxide primer by the manufacturer.

8.2.17 *Valve Lifters*:

8.2.17.1 Do not remove the oil in the hydraulic valve lifters[12] (Part No. BX-202-1).

8.2.17.2 Oil the lifter bodies with EF-411 oil prior to installation.

8.2.17.3 Number the left bank lifters with odd numbers from front to rear, and the right bank with even numbers from front to rear.

8.2.18 *Pushrods*:

8.2.18.1 Use the pushrods[12] (Part No. BX-210-1) as received from the CPD.

8.2.18.2 Clean the pushrods with aliphatic naphtha, air-dry, and oil with EF-411 oil prior to installation.

8.2.19 *Rocker Arm Pivots*:

8.2.19.1 Use rocker pivots (Part No. 391208) for cylinder numbers 1, 2, 7, and 8.

8.2.19.2 Use rocker pivots (Part No. BX-221-1) for cylinders 3, 4, 5, and 6.

8.2.20 *Rocker Cover Deflectors*:

8.2.20.1 Use four stud-type bolts (Part No. 556931) for mounting the rocker cover deflector stanchions shown on print RX-117288-A.

8.2.20.2 Attach the rocker cover deflectors shown on print RX-117289-B, (modified) to the stanchions using the specified bolts (Part No. 388708).

8.2.21 *Intake Manifold*:

8.2.21.1 Modify the intake manifold crossover, as shown on prints RX-118315-D, RX-117813-A and RX-118316-A, to permit the circulation of coolant per print RX-117928-C.

8.2.21.2 Plug the heater water outlet hole located at the right rear corner and the temperature sensor hole on the left front corner.

8.2.21.3 Remove the choke stove from the manifold, and install a plate conforming to print RX-117813-A using a gasket (Part No. 382709).

8.2.21.4 Deburr all mating surfaces of the intake manifolds to cylinder heads with a 12-in. (30.5-cm) smooth file to ensure gasket seating.

8.2.21.5 Use special intake manifold gaskets[12] (Part Nos. BX-204-1 [left] and BX-205-1 [right]).

8.2.22 *Rocker Cover, Spacers and Gaskets*:

8.2.22.1 Install rocker cover spacer-to-head gaskets[30] (Part No. 393573) on the cylinder heads using Perfect Seal No. 4 Sealing Compound.

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[29] TRW No. VP-503 for 11⁄32 in. can be ordered from TRW Valve Division, 8001 E. Pleasant Valley, Cleveland, OH 44131. Also available as Crane No. 97017 for 11⁄32 in. from Crane Cams, Inc., 100 N.W. 9th Terrance, Hallandale, FL 33009.

[30] These gaskets are manufactured semiannually (order cut-off dates are January 1 and July 1). Order from Crotty Corp., 848 W. Chicago, Quincy, MI 49082.

8.2.22.2 Attach rocker cover spacers conforming to print RX-118304-D to the head using 0.875 in. (22.2 mm) ¼ by 20 socket head cap screws coated with 3M Super Weatherstrip Adhesive.

8.2.22.3 Install the cork rocker cover gasket (Part No. 573396) on the rocker cover side of the spacer with 3M Super Weatherstrip Adhesive.

8.2.23 *Water Inlet Adapter*:

8.2.23.1 Use a water inlet adapter conforming to that shown on print RX-118315-D and in conjunction with a gasket (Part No. 382927).

8.2.23.2 Quick disconnect full-opening fittings[31] such as shown on prints RX-118137-C and RX-118136-A can also be used.

8.2.24 *Breather Tube*—Attach a breather tube (Part No. BX-212-1), available from the CPD, to the front cover using a gasket (Part No. 555765).

8.2.25 *Thermostat Housing*—Replace the thermostat housing with a coolant outlet adapter (fabricated from copper or black iron), using a gasket (Part No. 22547855), and with a suitable connection as on print RX-117261-A.

8.2.26 *Fuel Pump and Eccentric*:

8.2.26.1 Remove and replace the fuel pump with a plate conforming to print RX-117262-A, and use a gasket (Part No. 22505998).

8.2.26.2 Remove and replace the eccentric with a deflector and washer as on prints RX-118306-A and RX-117464-A, respectively.

8.2.27 *Oil Filter Housing*:

8.2.27.1 Separate the oil filter housing from the engine by an oil filter block conforming to print RX-117227-A.

8.2.27.2 Use gaskets (Part No. 382455, two required), and Perfect Seal No. 4 Sealing Compound.

8.2.28 *Oil Sample Line*—Remove the oil pressure sensing element located in the front-left corner of the cylinder block, and add suitable plumbing to permit the removal of oil samples. *The oil sample line length should be held to a minimum*.

8.2.29 *Ignition System*:

8.2.29.1 High energy ignition wire capable of withstanding moisture and high temperature is required. Delco part 378E, or equivalent, is satisfactory.

(*a*) Use an acceptable spark plug boot removal tool[32] (Part Nos. OTC 7078 or BT 7604) to remove the ignition wires from the spark plugs.

8.2.29.2 Check the distributor (Part No. 1103259) on a distributor tester before installing in the engine.

(*a*) Disable the mechanical advance mechanism by tack welding the advance weights so that no motion is possible.

8.2.29.3 Disconnect the vacuum advance unit by removing the vacuum hose and plugging the vacuum source at the carburetor, shown on print RX-118319-D.

8.2.29.4 Use AC spark plugs (Part No. R46SZ).

(*a*) Install new spark plugs prior to test startup and at the 30 h shutdown.

(*b*) Gap spark plugs with a wire gage to 0.060 in. (1.52 mm).

8.2.30 *Carburetor*—Use a duty cycle controlled carburetor (Part No. 17111526) to control air to fuel ratio.

8.2.30.1 Obtain a carburetor adapter plate (Part No. BX-260-1) and model 555 timer (Part No. BX-150-1) from the CPD.

8.2.30.2 Carburetor settings and build guidelines can be obtained from GM NAO Research and Development Center.[33]

8.2.30.3 Disassemble, clean and rebuild carburetors prior to each sixth test, or more often if air to fuel ratio control becomes a problem.

8.2.31 *Accessory Drive Units—Use no external drive units*, including alternators, generators, fuel pumps, power steering units, air pumps, etc.

8.2.32 *Exhaust Manifolds*:

8.2.32.1 Use the left exhaust manifold (Part No. BX-209-1) on both banks.

8.2.32.2 Deburr all mating surfaces of the exhaust manifolds to cylinder heads with a 12-in. (30.5-mm) smooth file to ensure gasket seating.

8.2.32.3 The recommended method for connecting the exhaust pipes to the manifolds is shown on print RX-117284-A.

8.2.32.4 Locate pressure taps for exhaust back pressure and exhaust gas analysis in each manifold as shown on print RX-117286-C.

8.2.32.5 Stainless steel bolts, ⅜ by 16 and 1.25-in. (31.8-mm) long, can be used to fasten the exhaust manifolds to the engine.

NOTE 11—**Caution:** Exhaust manifolds can warp during engine operation. The sealing surfaces may be reground flat several times to increase utilization of the manifolds.

8.2.33 *Engine Flywheel and Guards*:

8.2.33.1 Modify the flywheel (Part No. 399071) as shown on print RX-117225-C.

8.2.33.2 The engine flywheel guard shown on print RX-117167-E and the safety housing shown on print RX-117168-D, facilitate the installation and removal of the engine.

8.2.34 *Special Parts*—In Section 8 there have been references to several prints where part fabrication is described. These parts can be ordered from GM[33] or made by any machine shop capable of fabricating the parts exactly according to the prints.

8.2.35 *Pressure Checking the Engine Coolant System*:

8.2.35.1 It has been found advantageous to pressure check the coolant system before installing the assembled engine on the test stand.

8.2.35.2 Block and pressurize the coolant passages to 30 in. Hg (101 kPa) and monitor any change in pressure for 10 min.

(*a*) Changes in pressure of less than 1 in. Hg (3.4 kPa) in 10 min are considered satisfactory.

(*b*) Larger changes in pressure necessitate re-torquing or replacing the cylinder heads, or both; or replacing the intake manifold gaskets or seals, or both.

[31] Available from Aeroquip Corp., Industrial Division, 1225 W. Main St., Van Wert, OH 45891.

[32] Tool OTC 7078 is available from Owatonna Tool Co., 376 North St., Owatonna, MN 55060. Tool BT 7604 is available from Burroughs Tool and Equipment Co., 2429 N. Burdick St., Kalamazoo, MI 49007.

[33] Available from GM NAO Research and Development Center, Warren, MI 48090. Attention: Sequence Test Coordinator.

8.3 *Install Assembled Engine on Test Stand*:

8.3.1 *Lifting Engine*—Lift the assembled engine as described in the 1977 Oldsmobile Service Manual (Fig. 6A3-6). *Do not lift the engine by the manifold. Glycol coolant leaks may occur*.

8.3.2 *Engine Mounts*—In conjunction with prints RX-117379-D, RX-117529-D and RX-117990-B, the following engine mounts are recommended:

8.3.2.1 Rear right-hand (Part Nos. 568980 or 31-2138),

8.3.2.2 Rear left-hand (Part Nos. 568981 or 31-2139), and

8.3.2.3 Front (Part Nos. 572945 or 31-2137).

8.3.3 *Drive Shaft*—A flywheel to driveshaft coupling adapter shown on print RX-117157-B, can be used in conjunction with a Dana shaft[34] (Part No. 1601-1608), and a rubber joint set (part 206881-20).

8.4 *Engine-Dynamometer Installation*:

8.4.1 A typical engine-dynamometer installation is shown on print RX-117529-D.

8.4.2 Mount the engine on the test stand so that the carburetor mounting flange to intake manifold interface is horizontal.

9. Measurement and Control of Operating Conditions

9.1 *Temperature Measurements*:

9.1.1 *General Considerations*:

9.1.1.1 Accurate temperature measurement of several operating conditions is required. Temperature measurement is of extreme importance and assurance of temperature measurement accuracy is mandatory.

9.1.1.2 Suitable temperature readout instrumentation with premium type, sheathed, grounded thermocouples, and premium grade wire shall be used.

9.1.1.3 Check all thermocouples for accuracy at the temperature levels at which they are used.

(*a*) This is particularly important for the thermocouples used in the oil filter block and water jacket.

9.1.1.4 Iron-Constantan (Type J) thermocouples are recommended. Conax[35] part numbers are as follows:

(*a*) For the oil filter block and breather tube gas—Conax J-SS-12-G-PJ 1.5 in. (38 mm).

(*b*) For fuel, the coolant outlet and inlet, breather tube coolant outlet, carburetor air, and intake manifold—Conax J-SS-12-G-PJ 2 in. (51 mm).

(*c*) For the rocker cover coolant outlet, and intake manifold exhaust crossover—Conax J-SS-12-G-PJ 3 in. (76 mm).

(*d*) For the oil pan—Conax J-SS-G-PJ 4 in. (102 mm).

9.1.1.5 The recommended thermocouple packing gland for the above thermocouples is the Conax MPG-125-A-T[35] packing gland.

9.1.1.6 Accurate location of thermocouples is essential for acceptable test operation.

9.1.2 *Specific Thermocouple Locations*:

9.1.2.1 *Oil Filter Block*—Locate the thermocouple in the center of the stream of flow (see print RX-117227-A).

9.1.2.2 *Oil Pan (Sump)*—Locate the thermocouple in the right rear corner of the oil sump as shown on print RX-118305-D; it should extend 1.5 in. (38 mm) into the oil pan.

9.1.2.3 *Engine Coolant Out*—Locate the thermocouple in the thermostat housing within 3 in. (76 mm) of the intake manifold in the center of the stream of flow.

9.1.2.4 *Engine Coolant In*—Locate the thermocouple in the coolant inlet adapter 9 in. (22.9 cm) from the front cover to the inlet adapter interface, as shown on print RX-118135-D. The thermocouple should be located in the center of the stream of flow.

9.1.2.5 *Rocker Cover Coolant Out*—Locate the thermocouple within 3 in. (76 mm) of the fitting in the cover. The thermocouple should be located in the center of the stream of flow.

9.1.2.6 *Breather Tube Coolant Out*—Locate the thermocouple within 3 in. (76 mm) of the fitting in the breather tube. The thermocouple should be located in the center of the stream of flow.

9.1.2.7 *Blowby Gas*—Extend the thermocouple 0.5 in. (12.7 mm) into the stream from the wall, as shown on print RX-117729-C.

9.1.2.8 *Intake Manifold Exhaust Crossover Coolant Outlet*—Install the thermocouple in a tee fitting in the coolant outlet close to the intake manifold. The thermocouple should be located in the center of the stream of flow.

9.1.2.9 *Carburetor Air*—Locate the thermocouple in the intake air horn (Part No. BX-395-1). The thermocouple should be located in the center of the stream of flow.

9.1.2.10 *Intake Manifold Mixture*—Install the thermocouple in the threaded ¼in. NPT hole located to the front of the carburetor and in the center of the Nos. 1 and 4 cylinder legs of the intake manifold. Locate the thermocouple in the center of the intake mixture stream (approximately 0.75 in. (19.1 mm)).

9.1.2.11 *Fuel*—Install the thermocouple in a tee fitting in the fuel line within 2 in. (51 mm) of the carburetor fuel inlet. The thermocouple should be located in the center of the stream of flow.

9.2 *Air to Fuel Ratio (AFR) Measurement and Control*:

9.2.1 Determine engine AFR by Orsat analysis or by electronic gas analysis equipment of the exhaust gases, and comparing the analyzed values with theoretical values plotted on a chart of exhaust gas component volumes versus AFR (see Fig. 1).

9.2.2 Suitable electrical AFR indicating equipment may be used to provide continuous AFR indications, as long as it is properly calibrated using appropriate span gases.

9.2.3 The electronic fuel mixture control unit (BX-150-1) can be used to control air-to-fuel ratios.

9.2.4 The theoretical relationship between engine exhaust gas CO_2, CO, and O_2 contents and AFR is shown on Fig. 1 for fuel with an H to C ratio of 2:1.

9.2.4.1 Since the theoretical chart was constructed assuming complete combustion, it is necessary to correct exhaust gas analyses that contain either oxygen or carbon monoxide (indicating *rich* and *lean* combustion, respectively) before using the figure. The corrections can be made as follows:

[34] Available from Dana Corp., Spicer Universal Joint Division, P.O. Box 986, Toledo, OH 43696.

[35] Available from Conax Corp., 2302 Walden Ave., Buffalo, NY 14225. Attention: Sales Dept.

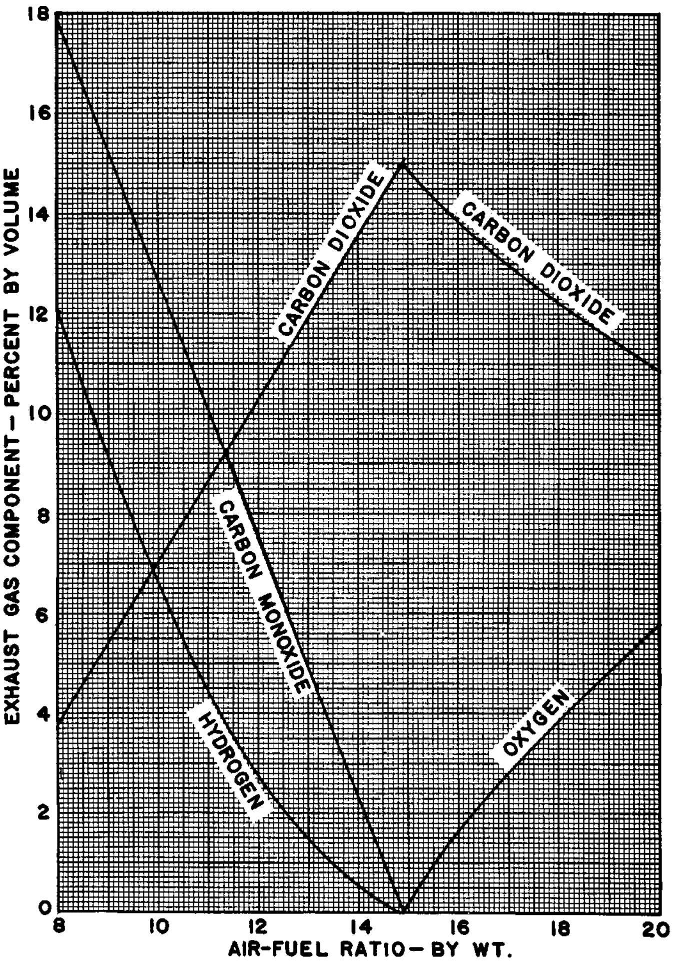


FIG. 1 Air-to-Fuel Ratio Chart

(*a*) *Rich Samples:*

$$\frac{\text{observed \% } CO_2 \times 100}{100 - 5\text{ (observed \% } O_2)} = \text{corrected } CO_2 \tag{1}$$

$$\frac{\text{observed \% } CO \times 100}{100 - 5\text{ (observed \% } O_2)} = \text{corrected } CO \tag{2}$$

(*b*) *Lean Samples:*

$$\text{observed \% } O_2 - 0.5\text{ (observed \% } CO) = \text{ corrected } O_2 \tag{3}$$

$$\text{observed \% } CO_2 + \text{observed \% } CO = \text{corrected } CO_2 \tag{4}$$

9.2.4.2 Air to fuel ratios obtained from Fig. 1 using the corrected CO, CO_2, and O_2 values shall agree within 0.5 ratio.

9.3 *Carburetor Air Supply Humidity Measurement and Control*:

9.3.1 An instrument such as the Alnor 7300 Dewpointer[36] can be used to determine the moisture content of the carburetor air.

9.3.2 Determination of the dew point should be made at the test stand.

9.3.3 Suitable equipment is needed to maintain the carburetor intake air at a moisture content of 80 ± 5 grains/lb of dry air (11.4± 0.7 g/kg of dry air), a dry bulb temperature of 80 ± 2°F (26.7 ± 1.1°C), and a static pressure of 0.1 to 0.3 in. water (24.9 to 74.6 Pa) measured at the carburetor inlet.

9.3.3.1 A system, such as shown in prints RX-179649-D through RX-179653-D, RX-117375-C and RX-117376-C, can be used to control the moisture content and temperature of the carburetor air.

9.3.4 Maintain the duct surface temperature above the dew point to prevent condensation (loss of humidity level).

9.3.5 A method of controlling the flow of air to the carburetor is shown on print RX-117162-C.

9.3.5.1 Use the intake air horn, Part No. BX-395-1; the carburetor intake air adapter shown on print RX-118616-E and corresponding gasket, Part No. BX-361-1; and the carburetor adapter plate, Part No. BX-260-1. Alternatively, the air intake horn can be fabricated from a print available from the CPD.

9.3.5.2 Position the adapter so that the air enters the adapter from the rear of the engine.

9.3.5.3 *Remove the carburetor intake air horn anytime the engine is not running and during the timing run.*

9.3.5.4 Carburetors shall be disassembled, cleaned, and rebuilt prior to each test, or more often if air-to-fuel ratio control becomes a problem.

9.4 *Exhaust and Exhaust Back Pressure Measurement and Control*:

9.4.1 The use of 4-in. (102-mm) stainless steel exhaust pipe, Part No. RT10E (Flexonic Corp.)[37] has proven satisfactory.

9.4.2 Do not add cooling water or spray directly into the exhaust streams or onto the exhaust pipes.

9.4.3 Do not use water-jacketed exhaust pipes on the sections of the exhaust pipes extending from the exhaust manifold to the test bed or floor level.

9.4.4 Jacketed exhaust pipes or external water spray can be used on the portions of the exhaust systems extending below the test bed or floor level.

9.4.5 Measure the exhaust back pressure at the exhaust sample line location as shown on print RX-117286-C.

9.4.6 The back pressure and exhaust sample lines from the exhaust manifold, their location shown on print RX-117286-C, shall run downhill from the manifolds to traps before the connection to manometers.

9.4.6.1 It is recommended that about 0.75 in (19 mm) of water (19 mm) be left in the traps to ascertain that a closed system exists.

9.4.7 Pressure taps are required in each manifold in order to permit reading the back pressure separately on each bank.

9.4.8 Do not connect the sample lines together, in order that separate samples can be taken from each bank for air-to-fuel ratio determinations.

9.4.9 The readout device for exhaust back pressure can be either a manometer or a suitable pressure gage with scale graduations of 0.1 in. of water (24.9 Pa), and a suggested range of zero to 36 in. of water (8.96 kPa).

9.4.10 The control system can be either a manual system for controlling the exhaust back pressure from each bank, or an automatic system such as shown on print RX-117462-C. A

[36] Available through local distributors, or Alnor Instrument Co., 97301 N. Caldwell Ave., Niles, IL 60648.

[37] Available from local distributors, or Flexonic Division UOP, Inc., 300 E. Devon Ave., Bartlett, IL 60123.

restriction in one side may be required to permit automatic differential pressure control.

9.5 *Blowby Measurement and Control*:

9.5.1 Measure blowby at the breather tube outlet with the crankcase oil filler tube and the dipstick guide tube plugged and while maintaining the crankcase pressure at 0.05 in. of water (0.0 ± 12.4 Pa).

9.5.1.1 Crankcase pressure should be stabilized in 6 min or less. If not, record the blowby rate obtained and include a note on the Supplemental Operational Data sheet that the crankcase pressure had not stabilized within the 6 min.

9.5.2 Use a sharp-edged orifice meter such as shown on print RX-116169-C[33] to measure engine blowby rates.

9.5.3 The blowby meter to breather tube connection shall exist only during the blowby rate determinations. At all other times, the blowby gas shall be emitted directly out of the breather tube top, as shown on print RX-117729-C, into the surrounding air.

9.5.4 This system includes the required surge tank shown on print RX-117431-C, means to measure blowby gas temperature, and means to maintain crankcase pressure at 0.00 ± 0.05 in. of water (0.00 ± 12.4 Pa).

9.5.5 A system, such as shown on prints RX-117726-C, RX-117727-C, RX-117294-A, RX-117730-C and RX-117731-C can be used as an aid in making blowby measurements.

9.5.6 Report observed data in cfm (L/min) after correcting for meter calibrations and adjusting these results to 100°F (37.8°C) and 29.7 in. Hg (100 kPa).

9.5.7 Refer to 8.2.6.1 for information about controlling blowby.

9.6 *Crankcase Pressure Measurement*:

9.6.1 Measure the pressure with a gage or manometer that has a range of − 0.5 to 0.5 in. of water (−124 to 124 Pa), in graduations of no greater than 0.02 in. of water (5.0 Pa).

9.6.2 For manual systems, Magnehelic Gage Model No. 2301[38] is suitable.

9.6.3 If a manometer is used in this application, a condensation trap shall be employed to eliminate the possibility of manometer fluid accidentally entering the crankcase.

9.6.4 For automated blowby systems, a Honeywell Controller 714P2B-31K1[39] shown on print RX-117727-C has been found satisfactory for measuring crankcase pressure. This controller can be used for pressure measurements up to 0.5 in. of water (124 Pa).

9.6.5 For either manual or automated systems, two additional indicators such as Magnehelic Model No. 2310 and Model No. 2020 (see print RX-117727-C for location) can be used for pressure measurements from 0.5 to 5.0 in. of water (0.124 to 1.24 kPa), and 0 to 20 in. of water (0 to 4.98 kPa), respectively.

9.6.5.1 The first indicator shall have a zero center scale and measure from−0.5 to + 5.0 in. of water (−1.24 to +1.24 kPa), with graduations no greater than 0.5 in. of water (0.124 kPa).

9.6.6 The accuracy of both the low range (0 ± 0.5 in. of water (0 ± 0.124 kPa)) and the mid range (0 ± 5.0 in. of water (0 ± 1.24 kPa)) pressure indicating devices used by a laboratory shall not be affected by pressure excursions of about 5.0 in. of water (1.24 kPa).

9.6.7 Pressures exceeding 5.0 in. of water (1.24 kPa) should be measured and recorded on the 0 to 20 in. of water (0 to 4.98 kPa) gage. Record pressures exceeding 20 in. of water (4.98 kPa) as + 20.0 in. of water (+ 4.98 kPa).

9.7 *Oil Pressure at the Oil Pump Outlet—Measurement and Control*:

9.7.1 Measure the oil pressure at the location shown on print RX-117227-A.

9.7.2 Measurement of the oil pressure at the oil pump outlet pressure requires the use of a pressure gage having a scale range of 0 to 100 psi (0 to 689 kPa), with scale graduations of 1 psi (6.9 kPa).

9.7.3 Refer to 8.2.13.5 for information about the control of oil pressure.

9.8 *Oil Pressure at the Engine Oil Filter—Measurement*—Measurement of the oil pressure at the engine oil filter requires the use of a gage having a scale range of 0 to 100 psi (0 to 689 kPa), with scale graduations of 1 psi (6.9 kPa).

9.9 *Carburetor Inlet Air Pressure Measurement and Control*:

9.9.1 Measure the air pressure at the carburetor intake air horn (BX-395-1).

9.9.2 The measurement of carburetor inlet air pressure can be made by either a manometer or a pressure gage. A range of 0 to 0.5 in. of water (0 to 124 Pa), and scale graduations of 0.02 in. of water (4.98 Pa) are required.

9.9.2.1 When using a manometer, a condensate trap should be installed between the manometer and the air horn to protect against the possibility of a momentary interruption of air flow or any other transient condition that might result in manometer fluid entering the engine intake system.

9.9.2.2 Measure the pressure at the location provided on the carburetor intake air horn, Part No. BX-395-1.

9.9.3 Refer to 9.3.5 for information about controlling the inlet air pressure.

9.10 *Intake Manifold Vacuum Measurement*:

9.10.1 Install a fitting for the measurement of intake manifold vacuum in the existing ¼in. NPT hole located in the center of the No. 6 and 7 cylinder leg of the intake manifold (to the rear of the carburetor).

9.10.2 Suitable readout instrumentation with a range of 0.0 to 20 in. Hg (0.0 to 68 kPa) and approximate scale graduations of 0.1 in. Hg (0.34 kPa) is required.

9.11 *Rocker Cover Coolant Pressure Measurement and Control*:

9.11.1 Measure the pressure at the top front fitting of each rocker cover as described on print RX-117928-C.

9.11.2 A pressure gage with scale graduations of approximately 1 psi (6.9 kPa) and a range of 0.0 to approximately 15 psi (103.5 kPa) is required.

9.11.3 Refer to Annex A3 for information about controlling the rocker cover coolant pressure.

9.12 *Breather Tube Coolant Pressure Measurement*:

[38] Available from Dwyer Instrument Co., P.O. Box 373-T, Michigan City, IN 46360.

[39] Available from Honeywell Inc., Industrial and Automation Div., 1100 Virginia Dr., Ft. Washington, PA 19034.

9.12.1 Measure the pressure at the coolant outlet fitting of the breather tube as shown on print RX-117731-C.

9.12.2 A pressure gage with scale graduations of approximately 1 psi (6.9 kPa) and a range of 0.0 to approximately (15 psi) (103.5 kPa) is required.

9.13 *Intake Manifold Crossover Coolant Outlet Pressure Measurement*:

9.13.1 Measure the pressure at the tee installed in the choke stove adapter plate as shown on print RX-117813-A.

9.13.2 A pressure gage with a range of 0 to 15 psi (0 to 6.9 kPa) and scale graduations 1 psi (6.9 kPa) is suggested.

9.14 *Engine Speed and Load Measurement and Control*:

9.14.1 Engine speed and load are important test parameters, and particular attention should be given to achieving and maintaining accurate calibration of the related instrument systems.

9.14.2 A typical closed loop control system maintains speed by dynamometer control, and load by engine throttle control.

10. Procedure (Start of the Test)

10.1 *External Cooling System Cleaning*:

10.1.1 Clean the external cooling system of a new test stand or new flushing tank assembly, or both, prior to flushing an engine the first time.

10.1.2 Remove all aluminum and galvanized materials from the system.

10.1.3 A solution of 5 oz/gal (37.4 g/L) of Oakite 77 in water heated to 160 ± 5°F (71.1 ± 2°C) and circulated at the maximum obtainable flow rate for 60 min will clean the external system satisfactorily. Follow this cleaning with a thorough water flush of all system components.

10.1.4 Recleaning of the external cooling system is periodically required.

10.2 *Engine Coolant Jacket and Intake Manifold Coolant Crossover Cleaning (Flushing)*:

10.2.1 After the engine has been installed on the test stand, chemically clean the engine coolant jacket and intake manifold coolant crossover simultaneously.

10.2.1.1 Make the connection of the cleaning flushing tank to the engine so that the cleaning solutions enter at the coolant outlet adapter and exit at the front of the block (reverse flow direction only for flushing) though the water inlet adapters shown on print RX-118135-D.

10.2.1.2 Attach the coolant crossover fitting for the dual rocker cover system (prints RX-117814-C or RX-117815-C) to the intake manifold coolant crossover as shown on the schematic.

10.2.1.3 Plumb the output of the intake manifold coolant crossover into the jacket flush return line at the front of the block.

10.2.1.4 Print RX-118138-B describes a charging adapter useful when charging the system with the specified coolant.

10.2.2 Care should be taken to reduce the elapsed time between each step of the cleaning procedure to minimize rusting of the water jacket.

10.2.3 Use new flushing agents for each test.

10.2.4 Use the following jacket cleaning procedure:

10.2.4.1 Pass 120 ± 5°F (48.9 ± 2.8°C) water once through the engine with block petcocks open for 2 min.

10.2.4.2 Remove the oil pan drain plug. If no water comes out, that indicates that there are no coolant leaks. Replace plug.

10.2.4.3 Add 120 ± 2°F (48.9 ± 1.1°C) water to the flushing tank to provide a total volume of 10 to 12 gal (37.8 to 45.4 L) in the tank and water jackets.

10.2.4.4 Close valves to isolate the engine block from the flushing tank. The engine should remain full of water.

10.2.4.5 Begin circulating the water in the tank and add sufficient Oakite 77 to provide a concentration of 5 oz/gal (37.4 g/L) in water.

10.2.4.6 Premix for 15 min at 160 ± 5°F (71.1± 2.8°C). The fifteen minute time period should start when the mixture reaches 160 ± 5°F (71.1 ± 2.8°C).

10.2.4.7 After the premixing period, open the valves to the engine and circulate the mixture for 30 min at 160 ± 5°F (71.1 ± 2.8°C) at a flow rate of 30 to 35 gal/min (1.89 to 2.21 L/s). Start timing when the mixture temperature (leaving the engine) reaches 160 ± 5°F (71.1 ± 2.8°C).

10.2.4.8 Drain the Oakite 77/water mixture from the flushing tank leaving the water jacket full.

10.2.4.9 Flush the engine with water for 2 to 3 min at 120± 5°F (48.9 ± 2.8°C) and at a flow rate of 20 to 25 gal/min (1.26 to 1.58 L/s). *Discard the flushing water after passing it through the engine once*. The pH of the flushing water should be neutral after about 2 min. The engine exit water shall be checked with litmus paper or other suitable pH measuring equipment.

10.2.4.10 Shut drain lines. Do not drain the engine water jacket.

10.2.4.11 Add 120 ± 5°F (48.9 ± 2.8°C) water to the flushing tank to provide a total volume of 10 to 12 gal (37.8 to 45.4 L) in the tank and water jacket. Close valves to isolate the engine block from the flushing tank. The engine should remain full of water.

10.2.4.12 Begin circulating the water in the tank and very slowly add sufficient Oakite Rust Stripper (RS) to provide a concentration of 1 lb/gal (119.8 g/L) in water. The rate of addition should be adjusted to keep mixture temperature below 165°F (73.8°C).

NOTE 12—**Precaution:** In addition to other precautions, face masks, dust breathers, and gloves should be worn when handling RS. Also, use extra care during the addition of RS to water since this causes an exothermic reaction.

10.2.4.13 Premix the rust stripper and water for about 2 min at 160 ± 5°F (71.1 ± 2.8°C). The 2-min premix time starts when the solution reaches 160 ± 5°F (71.1 ± 2.8°C). After premixing, open the valves to the engine and circulate the mixture for 1 h at 30 to 35 gal/min (1.89 to 2.21 L/s), and at 160± 5°F (71.1 ± 2.8°C). The 1 h time starts when the temperature of the mixture (leaving the engine) reaches 160 ± 5°F (71.1 ± 2.8°C).

10.2.4.14 Drain the rust stripper mixture from the tank and engine, and retain for proper disposal.

10.2.4.15 Flush the engine with water at 120 ± 5°F (48.9 ± 2.8°C), and at a flow rate of 20 to 25 gal/min (1.26 to 1.58 L/s) for 2 to 3 min with the petcocks open. *Discard the flushing water after one pass through the engine*. The pH of the engine exit water should be neutral after about 2 min when checked with litmus paper or other pH measuring device.

10.2.4.16 Remove one or more freeze plugs and immediately inspect the water jacket. The cylinder walls should be clean and free of deposit when wiped with a finger. *Inspection speed is essential so that the water jacket does not air dry and start to rust.*

10.2.4.17 Quickly install new freeze plugs (cup type) and connect the engine to the external engine cooling system.

10.2.4.18 The engine jacket, rocker cover, and breather tube cooling systems shall be immediately charged with coolant. (See 10.3 for details.)

10.3 *Coolant Charging*:

10.3.1 After cleaning the engine coolant passages, 22.5 ± 2.5 gal (85 ± 9 L) of inhibited coolant (see 7.3.1) should immediately be charged to the jacket, rocker cover, and breather tube coolant circulating systems.

10.3.2 Use a new glycol/water/additive mixture in both the engine and rocker cover cooling systems for each test.

10.3.3 Fill the engine water jacket with the inhibited coolant prior to filling the other associated piping and equipment. Charge the rocker cover and breather tube cooling system immediately after charging the engine cooling system.

10.3.4 Check the coolant glycol percentages in both cooling systems after charging and at the test times specified in Fig. 2.

10.3.4.1 See Annex A12 for details of making coolant calibration standards that are used for checking glycol percentages.

10.3.5 Intermittently operate the coolant circulating pump (on 15 s and off 45 s) for a 10-min period after adding the inhibited coolant. This aids in the removal of air and consequently decreases the time to coolant clarity. Any proportioning valves in the coolant systems should be operated during this 10-min period.

10.3.6 Circulate the inhibited coolant at 120 ± 5°F (48.9 ± 2.8°C) , and at a flow rate of 60 gal/min (3.78 L/s) until the test is started. *No more than 6 h can elapse between filling the cooling system and starting the test.*

10.3.7 Check the glycol concentration during this period (prior to the engine timing run).

10.3.8 Maintain the glycol concentration in the cooling systems at 40 ± 1 %.

10.3.9 Record the addition of any glycol or water or both to the coolants for concentration adjustments on the data sheets.

10.3.9.1 When an adjustment has been made, check the resulting new glycol percentage after the coolant has been circulated for approximately 1 h.

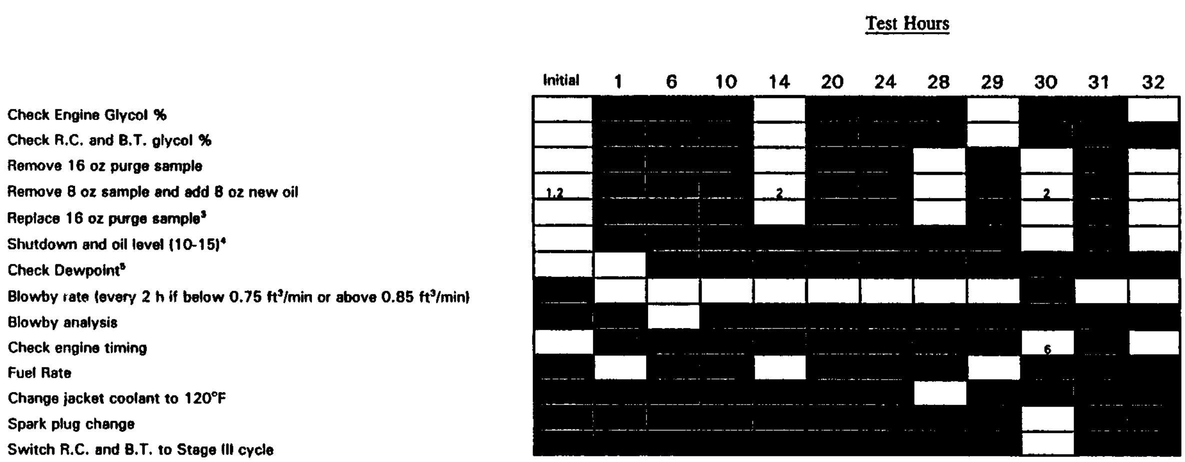
NOTE 13—**Precaution:** In addition to other precautions, the ethylene glycol type coolant used represents a special fire hazard. Coolant hoses and clamps should be selected and installed with special care to prevent leaks and spills since ethylene glycol may ignite when it contacts hot exhaust system components. A dry chemical fire extinguisher should be available at the test stand to extinguish any coolant fires. The use of water is not recommended for this type of fires.

10.4 *The following operations shall be performed in the order listed in 10.4.1 through 10.4.3.*

10.4.1 *Test Oil Charging*:

10.4.1.1 Air-dry the heat exchanger prior to charging the engine with test oil.

Laboratory:	EOT Date:
Test Number:	EOT Time:
Oil Code:	
Formulation/Stand Code:	



1 Do not replace oil sample.
2 Samples to be checked for glycol contamination.
3 At 32 h use 16 oz purge sample for engine oil leveling.
4 Pump on 10 min, off 15 min.
5 Alnor Dewpointer or other suitable apparatus shall be used.
6 Check timing at end of Stage II and start of Stage III cycles (30 test hours).

NOTE 1—Operator should sign open block after completing specified function.

FIG. 2 Operational Check List

10.4.1.2 Use a single, clean, well-calibrated and accurate container to install the initial filling of test oil.

(*a*) Add 5 qt, 28 oz (5.56 L) of test oil to the engine through the oil fill tube.

(*b*) Add 4 oz (118 mL) of test oil to the rocker arm pivots (approximately 2 oz (59 mL) per side).

10.4.2 *Installation of Rocker Covers*:

10.4.2.1 Use special rocker arm covers available from the CPD.

10.4.2.2 Install the rocker covers on the engine after pre-oiling the rocker arm pivots. (*Note that the coolant lines shall have been installed on the rocker covers prior to coolant charging.*)

10.4.3 *Timing Run*:

10.4.3.1 After the engine is filled with oil, start the external oil pump and start the engine (see 10.5) for a 10-min timing run. *The carburetor intake air horn is not to be connected during the timing run*.

10.4.3.2 Initially, establish the engine speed at 1500 r/min for 2 min and set the spark timing at 27° before top dead center (btdc).

10.4.3.3 For the remainder of the 10 min, operate the engine at 1500 r/min and 25 bhp (18.6 kW).

10.4.3.4 Control the oil sump temperature, and the coolant temperatures in the jacket, rocker covers, breather tube, and intake manifold crossover at 120 ± 5°F (48.9 ± 2.8°C)

10.4.3.5 Draw the initial oil sample at 10 min after starting, but prior to stopping the engine (see Fig. 3).

10.4.3.6 During the timing run, check that the ignition voltage is at least 13 V. *Be sure that the ignition voltage is at least 13 V throughout the test*.

10.4.3.7 At the end of the 10-min timing run, shutdown the engine (see 10.7.2).

10.4.3.8 Re-torque the exhaust manifold bolts after the timing run.

10.4.3.9 Fifteen minutes after the shutdown at the end of the timing run, switch the rocker covers and breather tube cooling system to chilled glycol at 60°F (15.6°C). See A4.1.

10.5 *Engine Startup Procedure*—Use the following procedure to start the engine where motor generator dynamometers are not used:

10.5.1 Back the idle screw off the lowest cam position.

10.5.2 Close throttle completely.

10.5.3 Crank engine for no more than 3 s.

10.5.4 During cranking, crack throttle at high intake manifold vacuum. This procedure normally provides sufficient fuel for starting. *Do not pour fuel directly into the carburetor or intake manifold*.

10.5.5 Repeat steps (*c*) and (*d*) if engine fails to start.

10.5.6 When engine has been started, bring to 1500 r/min and 25 bhp (18.6 kW) as soon as possible (*except for timing run*).

10.5.7 After 2 min of operation, set the specified speed and load conditions.

NOTE 14—**Precaution:** In addition to other precautions, guards should be installed around all moving parts. When the engine is operating at high speed, heavy duty guards should be placed on both sides of the engine and personnel should be cautioned against working alongside the engine and coupling shaft. All fuel lines, oil lines and electrical wiring should be properly routed, guarded, and kept in good condition. Safety masks or glasses should always be worn by personnel working on and around the engine, and no loose or flowing clothing should be worn near a running engine.

The external parts of the engine and the floor area around the engine should be kept free of oil or fuel spills. Do not allow containers of fuel or oil to accumulate in the testing area.

Personnel should be alert for leaking fuel or exhaust gas. Leaking fuel represents a fire hazard and exhaust gas fumes are noxious.

11. Procedure—During the Test

11.1 *Engine Shutdown Procedure*:

11.1.1 Use the following procedure in stopping the engine:

11.1.1.1 Reduce engine speed and load to 1500 r/min and 25 bhp (18.6 kW).

11.1.1.2 Disconnect the fuel line or shut off fuel.

Test Stand:____________ Test No:____________

Engine No:____________ Oil Code:____________

Date:____________

SEQUENCE IID OIL SAMPLE, LEVEL, AND CONSUMPTION RECORDS

Initial Oil Level[1]:____________ in[2]:____________ oz. Below Factory Stamped Dipstick Full Mark[3]

IID Test Hours

	Initial[1]	14	28	30	32
1. Remove 16 oz. Purge Sample					
2. Remove 8 oz. Analysis Sample					
3. Replace 16 oz. Purge Sample					
4. Add 8 oz. to Replace Sample					
5. Oil Level (in.) After Draindown					
6. Computer Oil Level[4] (oz.)					
7. Performed by (initials)					

NOTE 1—Oil consumption for test is calculated as follows:
[Initial oil level oz—oil level at 32 h (oz, Item 6)] ÷ 32 = qt.

[1] Initial oil level is to be determined at the end of the 10 min timing run and is used in all computations of oil consumption.

[2] Should be 5⁄16 to 9⁄16 in. below factory stamped full mark.

[3] Determined prior to startup of each test.

[4] Difference from initial oil level.[1]

FIG. 3 Oil Sampling, Leveling, and Consumption

11.1.1.3 Allow the engine to run out of fuel.

NOTE 15—**Precaution:** In addition to other precautions, the test installation should be equipped with a fuel shut-off valve which is designed to automatically cut off the fuel supply to the engine when the engine is not running. A remote station for cutting off fuel from the test stand is recommended. Suitable interlocks should be provided so that the engine is automatically shut down when any of the following events occur: engine or dynamometer loses field current, engine overspeeds, exhaust system fails, room ventilation fails, or the fire protection system is activated.

Consider installing an excessive vibration pickup interlock if the equipment operates unattended. Fixed fire protection equipment should be provided.

11.2 *Oil Sampling*:

11.2.1 *Take all oil samples with the engine running.*

11.2.1.1 First, remove a 16-oz (472-mL) purge sample, and then draw a 8-oz (236-mL) sample from the engine.

11.2.1.2 The initial 8-oz (236-mL) oil sample is taken at the end of the timing run (see section 10.8.5). Take the other oil samples at 14, 28, 30 and 32 h.

11.2.1.3 While the engine is operating, the tapped oil fill hole is plugged tightly with a ¾-in. NPT plug. Alternatively, a ¾-in. NPT pipe nipple, 3 to 4-in. long, with a ¾-in. to 1¼-in. NPT reducing coupling and a 1¼-in. NPT pipe plug can be used. This alternative nipple arrangement, which facilitates the addition of oil, shall be securely tightened.

11.2.1.4 After shutting down the engine, return the 16-oz (472-mL) purge sample to the engine after each sample is removed, and add 8 oz (236 mL) of new oil (*except at the initial oil sampling, where only the purge sample is returned and no new oil is added*).

11.2.1.5 The oil sampling checklist and suggested oil log format is shown in Fig. 3.

11.3 *Checking Oil Samples for Glycol Content*:

11.3.1 Check the initial, 14-h, and 30-h oil samples for glycol content using Test Method D 2982, Procedure A12.1.

11.3.1.1 If the glycol content determination of the initial sample is positive, check a sample of the new oil using the same test method.

11.3.1.2 If the glycol content determination of the sample of new oil is similar to that of the initial sample, no additional analyses are required and the test should be continued.

11.3.1.3 If the initial, 14-h, or 30-h oil samples show a consistently higher level of glycol than the new oil, then the test shall be invalidated and the engine completely rebuilt.

11.3.1.4 Include all glycol leak check results in the final report.

11.4 *Oil Leveling*:

11.4.1 After the 10-min timing run, at the 30-h shutdown, and at the end of the test (32 h), shut down the engine for 25 min to allow the oil to drain down.

11.4.2 During these 25-min shutdowns, conduct the following operations:

11.4.2.1 Run the external oil circulating pump for the first 10 min and then shut it off for 15 min. This procedure will maintain the oil sump at the required oil temperature of 120 ± 5°F (48.9± 2.8°C).

11.4.2.2 Maintain the jacket coolant temperature at 120 ± 5°F (48.9± 2.8°C).

11.4.2.3 Maintain the rocker cover and breather tube coolant temperatures at 120 ± 5°F (48.9 ± 2.8°C), except during the last 10 min after the timing run when they are reduced to 60 ± 2°F (15.6 ± 1.1°C).

11.4.2.4 Remove the dipstick guide tube cap (see print RX-117349-A), which is used during engine operation, and install the dipstick (see Annex A13 for the dipstick calibration procedure).

11.4.2.5 Determine the oil level by dipstick measurement 25 min after engine shutdown. (The oil leveling operational checklist is shown as Fig. 2, and the oil leveling log sheet is shown as Fig. 3.)

11.4.2.6 Remove the dipstick and reinstall the dipstick guide tube cap.

11.4.3 The initial oil level, which is determined after the 10-min timing run, is used in all computations of oil consumption.

11.5 *Test Periods*:

11.5.1 The engine test is operated for a total of 32 h under three sets of conditions; that is, 28 h in Stage I (low speed and cold temperatures), 2 h in Stage II (low speed and slightly warmer temperatures), and 2 h in Stage III (high speed and hot temperatures).

11.5.2 Count test time for Stage I and Stage III from the moment when all the specified test conditions are reached.

11.5.3 When changing from Stage I to Stage II, 3 min are allowed for the temperature change, and the 3 min are counted as test time for Stage II.

11.5.4 Between Stages II and III, there is a scheduled 25 min shutdown period that is not counted as test time during either stage.

11.6 *Non-Scheduled Shutdowns*—One non-scheduled shutdown is allowed, for a maximum of 20 min if it occurs during the cold cycle and 30 min if it occurs on the hot cycle.

11.7 *Data Recorded at Hourly Intervals*:

11.7.1 Engine speed, r/min,

11.7.2 Engine load, bhp (kW),

11.7.3 Oil temperature (sump), °F (°C),

11.7.4 Oil temperature (filter block), °F (°C),

11.7.5 Jacket coolant out temperature, °F (°C),

11.7.6 Jacket coolant inlet temperature, °F (°C),

11.7.7 Jacket coolant flow rate, gal/min (L/s),

11.7.8 Rocker covers (both left and right) and breather tube system coolant outlet temperatures, °F (°C),

11.7.9 Rocker covers and breather tube system coolant flow rates, gal/min (L/s),

11.7.10 Rocker cover system coolant outlet pressure, psi (kPa),

11.7.11 Crossover coolant outlet temperature, °F (°C),

11.7.12 Crossover coolant flow rate, gal/min (L/s),

11.7.13 Crossover coolant outlet pressure, psi (kPa),

11.7.14 Ambient air temperature, °F (°C),

11.7.15 Fuel temperature, °F (°C),

11.7.16 Intake manifold vacuum, in. Hg (kPa),

11.7.17 Exhaust back pressure (left and right), in. of water (kPa),

11.7.18 Exhaust back pressure differential, in. of water (Pa),

11.7.19 Carburetor air dew point or wet bulb temperature,° F (°C), 11.7.20 Carburetor air temperature, °F (°C),

11.7.21 Carburetor air pressure, in. of water (Pa),

11.7.22 Oil pump outlet pressure, psi (kPa),

11.7.23 Engine oil pressure, psi (kPa),

11.7.24 Crankcase pressure, in. water (Pa),

11.7.25 Breather tube blowby gas outlet temperature,° F (°C), and

11.7.26 Intake manifold mixture temperature, °F (°C).

11.8 *Data Recorded at Irregular Intervals*:

11.8.1 Make and record blowby rates, blowby analyses, glycol percentage checks, and dew point determinations at approximately the hours shown in Fig. 2.

11.8.1.1 Observe and record crankcase pressure readings prior to blowby determinations.

11.8.2 Make and record air-to-fuel ratio measurements at hours 1, 7, 14, 21, 28, and 30 for the cold cycle and at hours 31 and 32 for the hot cycle.

11.8.3 Suggested data log sheets are shown in Fig. 4 and Fig. 5.

11.9 *Engine Operating Conditions*:

11.9.1 Following the timing run (10.4.1) and the initial oil level check, operate the engine continuously for 28 h at the Stage I conditions shown in Table 1.

11.9.2 Following Stage I (28 h) operation, and without shutdown, operate the engine for an additional 2 h at Stage II conditions; these are under the same conditions as in Stage I, except for the changes noted in Table 2.

11.9.2.1 Make jacket coolant out temperature change from 110 to 120°F (43.3 to 48.9°C) within 3 min. The 3 min are counted as test time for Stage II.

11.9.3 Shut down the engine for 25 min at the end of Stage II operation (30 h).

11.9.3.1 Disconnect the air supply to the carburetor immediately after shutting down the engine.

11.9.3.2 Maintain the jacket coolant out temperature at 120 ± 5°F (48.9 ± 2.8°C).

11.9.3.3 Leave the external oil circulating pump *on* for 10 min, and then shut *off* for the final 15 min.

11.9.3.4 Maintain the oil temperature at 120 ± 5°F (48.9 ± 2.8°C).

11.9.3.5 Determine the oil level by dipstick measurement at the end of the 25 min shutdown period.

11.9.3.6 During this 25-min shutdown:

(*a*) Make the necessary adjustments to the rocker cover and breather tube cooling circuit for the Stage III (hot) conditions (see Fig. A1.60 [Print No. RX-117928-C]).

(*b*) Install new R46SZ spark plugs.

11.9.4 Immediately after the 25-min shutdown period, start the engine and connect the carburetor air supply. Operate the engine for 2 h under the Stage III high speed-hot temperature conditions shown in Table 3.

11.9.4.1 Count test time from the moment when all of the conditions in Table 3 are obtained (15 to 30 min are permitted for stabilization).

11.9.5 After the two hours at Stage III conditions (32 h of engine operation total), reduce speed and load to 1500 r/min and 25 bhp (18.6 kW), respectively, and operate for 2 to 4 min prior to shutdown.

11.9.5.1 Reduce both the jacket coolant and oil sump temperatures to 120 ± 5°F (48.9 ± 2.8°C) during the 2 to 4 min of operation.

12. Procedure—at the End of the Test

12.1 Shut down the engine and determine the oil level using a 25-min draindown time (as described in 11.4).

12.2 The glycol coolant should be circulated through the block, rocker covers, and intake manifold exhaust crossover at the flow rates specified (in Stage I or III) and 120 ± 5°F (48.9 ± 2.8°C) for 30 min (time starts as soon as the engine is stopped).

12.2.1 Immediately drain the glycol mixture following the 30 min of circulation.

12.2.2 The external water system should be immediately flushed until the flush water is clear.

12.2.3 Remove the freeze plugs and inspect the water jacket. Record cleanliness condition.

12.3 The breather tube cooling system should be drained immediately following the inspection of the water jacket.

12.4 Flush the external oil cooling system (see A3.2) within 15 min of the determination of the final oil level (see 12.1).

13. Interpretation of Results

13.1 *Engine Disassembly and Elapsed Time—General*:

13.1.1 On completion of the test, completely disassemble the engine for inspection and rating. A maximum of 2 h is allowed between test completion and removal of parts to be rated (time starts as soon as the final oil level is completed).

13.1.1.1 Disassemble and immediately clean all parts to be rated.

13.1.1.2 Handle all parts to be rated with gloved hands during the disassembly process.

13.2 *Disassembly and Preparation of Parts for Rating*:

13.2.1 Prior to disassembling the hydraulic valve lifters, perform the following visual inspection of each lifter:

13.2.1.1 Position lifter so that the foot faces downward.

13.2.1.2 Use a soft cloth, such as a Teri Towel,[40] to remove any oil from the top surface of the pushrod seat.

13.2.1.3 Observe the orientation of the top of the pushrod seat in relation to the bottom of the lifter body retaining clip.

(*a*) If any portion of the top of the pushrod seat touches any portion of the retaining clip, rate the plunger as being *free*.

(*b*) Rate the plunger as *stuck*, if the top of the pushrod seat does not touch any portion of the retaining clip.

13.2.1.4 Report the total number of lifter assemblies rated as *stuck* on the test results page of the report.

13.2.2 Completely disassemble the hydraulic valve lifters, and remove the oil pump relief valve and the pushrods. These are the parts to be rated and special care is required in handling the parts.

13.2.2.1 To facilitate the disassembly of lifters, a lifter plunger remover, such as shown on prints RX-117257-C through RX-117260-A, is recommended.

13.2.2.2 After disassembly and prior to rating, clean the parts listed in 13.2.2 according to the following procedure:

[40] Available from local suppliers of Kimberly Clark products.

Test No:________ Oil:________ Oil Level (in.):________ Fuel:________ Dyn. Const.:________ Sheet:________

Test Type:________ Sample:________ Oil Level (oz.):________ Tank:________ Engine No:________ Cover No:________ Manifold No:________ Head No:________

Project No:________ Container:________ Viscosity:________ Line:________ Observer:________

						Temperature °F								Carb.		ΔP	Pressure						Rocker Cover System											
Date	Time		Engine			Oil		Coolant		Air			Fuel	Air		Jacket Flow	Man.	Exh. Back		Oil		C.	Temperature					FL	IID-X.Ov. PSI		Deg.		Observer's Initials	Comments
	Start	Stop	Hrs	RPM	Beam	Block	Sump	In	Out	Man	Carb	Room	Carb	DP	CP		Vac	Lft	Rt	Ftr	Eng	C	Rt	Lft	Cond	B.T	X.Ov	%	R	L	FL	PSI	btdc	

FIG. 4 Daily Log of Operating Conditions

Test Cell:______________ Test No:____________

Engine No:_____________ Oil Code:____________

Date:________________

SEQUENCE IID SUPPLEMENTAL DAILY LOG

BLOWBY (at 0 psi crankcase pressure)

Test Hours								
RPM								
HP or load (lbs)								
Orifice Diameter or #								
ΔP (in of H_2O)								
Temperature (°F)								
Barometer								
Observed Flow (cfm)								
Correction Factor								
Corrected Flow (cfm)								

ORSAT ANALYSES [Exhaust (E) or Blowby (B)]

Test Hours (E or B)								
Bank (R or L)								
% CO_2								
% O_2								
% CO								
AFR (CO_2)								
AFR (CO or O_2)								
AFR Average								

FUEL RATE

Test Hours								
Rate (lb/hr)								
Temperature (°F)								
Volume (ml)								
Time (min)								

DEW POINT

Test Hours								
Alnor Dew Point (°F)								

GLYCOL PERCENT

Engine (E) or Rocker Cover (RC)								
Test Hours								
Specific Gravity								
Temperature (°F)								
Glycol Percent								
Adjustments								

FIG. 5 Supplemental Daily Log

(*a*) Remove the test oil film using an aliphatic naphtha wash.

(*b*) Soak the parts in new, clean organic solvent (see 7.2) for about 10 min to remove hardened organic deposits.

(*c*) Wash the parts a second time using new, clean, aliphatic naphtha.

(*d*) Wipe each part using a Teri Towel; be sure that all solvent film is removed from the rating surfaces prior to rating.

13.2.2.3 Immediately after the test parts are cleaned, either rate the parts or store them in a desiccator (be sure that the desiccant is in satisfactory condition) until time of rating.

13.3 *Rust Rating*:

13.3.1 *Environment*—Use a lamp with two 15 W *cool white* fluorescent bulbs[41] which produce 350 to 500 candlepower against a white background rating area.

13.3.2 *Parts Layout*—A rust rating board similar to that shown in print RX-117552-D is recommended.

13.3.3 *Method*:

13.3.3.1 Rate all valve lifter bodies, plungers and balls, pushrods and the relief valve for rust or corrosion deposits, or both, using the methods detailed in CRC Manual No. 7.

(*a*) In Manual No. 7, the protective plastic covers are standards themselves and these shall be periodically inspected

[41] Available from Dazor Manufacturing Corp., 4455 Duncan Ave., St. Louis, MO 63110.

TABLE 1 Engine Operating Conditions for Stage I (28 h)

Parameter	Specification	
Engine speed	1500 ± 20 r/min	...
Engine load	25 ± 2 bhp	(18.6± 1.5 kW)
Oil temperature (filter block)	120 ± 2°F	(48.9 ± 1.1°C)
Oil pump outlet pressure	50 ± 10 psi	(345 ± 69 kPa)
Jacket coolant out temperature	110 ± 1°F	(43.3 ± 0.6°C)
Jacket coolant in temperature	106 ± 1°F	(41.1 ± 0.6°C)
Jacket coolant flow rate	60 ± 1 gal/min	(3.78 ± 0.06 L/s)
Crossover coolant outlet temperature	109 ± 2°F	(42.8 ± 1.1°C)
Crossover coolant flow rate	3.0 ± 0.5 gal/min	(0.19 ± 0.03 L/s)
Crossover coolant outlet pressure	2.5 ± 0.5 psi	(17.2± 3.4 kPa)
Breather tube system coolant outlet temperature	60± 2°F	(15.6 ± 1.1°C)
Breather tube system coolant flow rate	3.0 ± 0.5 gal/min	(0.19 ± 0.03 L/s)
Rocker covers' coolant outlet temperatures	60 ± 2°F	(15.6 ± 1.1°C)
Rocker covers' flow rates (per cover)	1.5 ± 0.5 gal/min	(0.09 ± 0.03 L/s)
Rocker cover system coolant outlet pressure	5.0 ± 0.5 psi	(34.5 ± 3.4 kPa)
Air-to-fuel ratio	13.0 ± 0.5	...
Carburetor air temperature	80 ± 2°F	(26.7 ± 1.1°C)
Carburetor air humidity	80 ± 5 grains/lb of dry air	(11.4 ± 0.7 g/kg of dry air)
Carburetor air pressure	0.1 to 0.3 in. H_2O	(24.9 to 74.6 Pa
Blowby rate at 100°F and 29.7 in. Hg (at 37.8°C and 100 kPa)	0.8 ± 0.1 ft^3/min	(0.38 ± 0.05 L/s)
Intake manifold vacuum	16 ± 1.5 in. Hg	(54.4 ± 5.1 kPa)
Exhaust back pressure	4 ± 1 in. H_2O	(1.0 ± 0.25 kPa)
Exhaust back press. differential, max	0.2 in. H_2O	(49.8 Pa)
Crankcase oil fill tube	tightly plugged	

TABLE 2 Engine Operating Conditions for Stage II[A] (2h)

Parameter	Specification	
Jacket coolant out temperature	120 ± 1°F	(48.9 ± 0.6°C)
Jacket coolant inlet temperature	116± 1°F	(46.7 ± 0.6°C)
Crossover coolant outlet temperature	119 ± 2°F	(48.3 ± 1.1°C)

[A]All conditions the same as in Stage I except for the changes noted in the table.

and replaced if any detectable deterioration has occurred.

(*b*) Use a CRC Rust Rating Scale shown in print RX-117364-B. This scale is also a standard and it shall be periodically inspected and replaced if detectable deterioration has occurred.

13.3.3.2 Use the rust remover (see 7.8) as an aid in identifying rust. Apply with a soft cloth.

13.3.3.3 The 15 % of the lifter body surface that is not polished during operation of the engine should be upgraded 0.5 rating numbers when rated for deposits.

13.3.3.4 The area of the lifter body between the groove and the pushrod end is 38 % of the total lifter body area.

13.3.3.5 The area of the lifter plunger between the groove and pushrod end is 35 % of the total lifter plunger area.

13.3.3.6 A suggested rust rating work sheet is shown in Fig. 6.

13.3.3.7 Note and record the general appearance of the test parts (surface condition, finish, and color).

13.3.3.8 After rating, store parts in a desiccator until they are photographed.

13.4 *Photographs of Test Parts*:

13.4.1 Colored photographs of the test parts shall show two representative lifter bodies, plungers and balls, as well as the oil pump relief valve on one print, and at least two representative pushrods on another.

13.4.1.1 Both photographs can be placed on one page; however, the photographs shall be of sufficient size to detect

TABLE 3 Engine Operating Conditions for Stage III (2 h)

Paramete	Specification	
Engine speed	3600 ± 20 r/min	...
Engine load	100 ± 2 bhp	(74.6± 1.5 kW)
Oil temperature (filter block)	260 ± 2°F	(126.7 ± 1.1°C)
Jacket coolant out temperature	200 ± 2°F	(93.3 ± 1.1°C)
Jacket coolant in temperature	190 ± 2°F	(87.8 ± 1.1°C)
Jacket coolant flow rate	60 ± 1 gal/min	(3.78 ± 0.06 L/s)
Crossover coolant outlet temperature	197 ± 2°F	(91.7 ± 1.1°C)
Breather tube system coolant outlet temperature	199 ± 2°F	(92.8 ± 1.1°C)
Breather tube system coolant flow rate	3.0 ± 0.5 gal/min	(0.19 ± 0.03 L/s)
Rocker covers' coolant outlet temperatures	198 ± 2°F	(92.2 ± 1.1°C)
Rocker covers' flow rate (per cover)	1.5 ± 0.5 gal/min	(0.09 ± 0.03 L/s)
Rocker cover system coolant outlet pressure	5.0 ± 0.5 psi	(34.5 ± 3.4 kPa)
Air-to-fuel ratio	16.5 ± 0.5	...
Carburetor air temperature	80 ± 2°F	(26.7 ± 1.1°C)
Carburetor air humidity	80 ± 5 grains/lb of dry air	(11.4 ± 0.7 g/kg of dry air)
Carburetor air pressure	0.1 to 0.3 in. H_2O	(24.9 to 74.6 Pa)
Blowby rate at 100°F and 29.7 in. Hg (at 37.8°C and 100 kPa)	1.35 ± 0.35 ft^3/min	(0.64 ± 0.16 L/s)
Intake manifold vacuum	8.5 ± 2.0 in. Hg	(28.7 ± 6.8 kPa)
Exhaust back pressure	30 ± 2.0 in. H_2O	(7.5 ± 0.5 kPa)
Exhaust back press. differential, max	0.5 in. H_2O	(124.4 Pa)
Crankcase oil fill tube	tightly plugged	(tightly plugged)

the presence of any deposits (lifter body no smaller than 2 in. (51 mm) in length, and pushrod no smaller than 6 in. (152 mm) in length).

13.4.2 The lifter bodies and plungers should be numbered so that the photographs, parts, and ratings can be compared.

13.5 *Permanent Storage of Test Parts*— Special care is required if parts are stored for any period of time, since rusted parts can continue to rust at a rapid rate under some conditions. Two general methods have been found satisfactory:

13.5.1 *Desiccator Storage*—Following cleaning and rating, the parts can be placed in a desiccator for storage. Parts can be stored this way indefinitely providing the desiccant is in satisfactory condition.

13.5.2 *Strippable Coatings*—Strippable coatings also provide effective long-term storage of rusted parts. (Detailed information about these types of coatings is found in a military handbook entitled "Plastic Coating Compounds, Hot and Cold Dip" MIL-HDBK 696, 30 March, 1965). When these coatings are used, it is necessary to ensure that the parts are dry before being coated, and that any attached strings or wires do not provide access for moisture through the coating to the part. The following procedure has been found to provide effective protection:

13.5.2.1 Wash parts in the organic cleaning solution.

13.5.2.2 Dry for a maximum of 5 min.

13.5.2.3 Warm in an oven at 300 °F (148.9°C) for 90 min.

13.5.2.4 Dip hot, as according to 13.2.1.5, or place in a desiccator to cool to room temperature.

13.5.2.5 Coat part by dipping in an MIL-P-149A9 Type 11 coating compound, or equivalent coating[42] (JAN-C-149 [Type 11 HR-5] and MIL-P-149A [HR 65] materials have also been found satisfactory).

[42] Available from Western Coating Manufacturers (formerly "Seal-Peel"), 611 E. Elmwood, Troy, MI 48084.

14. Report

14.1 *Report the Following Information*:

14.1.1 Test oil results (Annex A16),

14.1.2 Reference oil results,

14.1.3 Operational summary,

14.1.3.1 For additional operational details, see Fig. A16.7.

14.1.3.2 All specified values are judged and reported by the Absolute Method.

14.1.4 Test validity confirmation (Fig. A16.7),

14.1.5 Reference oil test telefax to the TMC,

14.1.6 Hardware identification, and

14.1.7 Operational deviations (Fig. A16.6).

14.2 *Calculation of Rust Results*—Report rust results to two significant places, using the method described in Practice E 29. Use the Rating Worksheet. The engine rust rating is the average of the five parts listed in 14.2.1 to 14.2.5.

14.2.1 Valve lifter bodies,

14.2.2 Valve lifter plungers,

14.2.3 Valve lifter balls,

14.2.4 Oil pump relief valve, and

14.2.5 Pushrods.

14.3 *Lifter Plunger Sticking*—Report the number of lifter plungers *stuck* (see 13.2 for the definition of a *stuck* lifter).

14.4 *Oil Pump Relief Valve Sticking*— If the oil pump relief valve sticks, excessive oil pressure generally is observed during Stage III and should be noted.

14.5 *Oil Consumption Computation*—Compute oil consumption as total oil charged to the engine less samples and discards drained. Maximum oil consumption allowed is 24 oz or 0.75 qt (708 mL).

14.6 *Operational Deviations*:

14.6.1 A number of operational parameters are not included in the summary sheet. Some examples are glycol coolant concentrations, warm-up times, unscheduled shutdowns, shutdown procedures, and oil level information.

14.6.2 Report *all* observed deviations from the specified limits (not only hourly readings but also during the hour) by recording these on the daily log sheet and on a supplemental report page.

14.6.2.1 Report the test hour, magnitude, and duration of the deviation for both these special, as well as the normally summarized, parameters.

14.6.3 Report, on a supplemental report page, if no operating deviations occurred.

14.7 *Additional Operational Details*:

14.7.1 Record maximum, minimum, and average crankcase pressures on the summary sheet. Use the value of 4.98 for calculating crankcase pressure average when pressures are +4.98 kPa.

14.7.2 In the event of any oil pressure deviation from prescribed limits, include a plot of oil pressure versus test hours in the test report.

14.7.3 Include plots of blowby rate and crankcase pressure versus test hours in the test report. The maximum scale value for the plot of crankcase pressure should be 1 in. of water (unless higher values are recorded). Use Practice E 29 for rounding off data.

15. Precision and Bias

15.1 *Precision*:

15.1.1 *Non-reference Oils*—To aid the potential user of this test method to assess the variability that can be expected between test results when the test method is used in one or more reasonably competent laboratories, the precision information in Table 4 has been developed.

15.1.1.1 The non-reference oil precision for this test method is determined by the statistical analysis of sets of data submitted by users of the test method. Each set of data consists of two or more engine test results, on the same oil formulation. Each data set can be from tests run in the same laboratory or different laboratories, and with any approved fuel batch. The data are collected and analyzed by industry volunteers working within the Sequence IID Test Method Surveillance Panel, and are reported semiannually to the ASTM D02.B0 Subcommittee.

15.1.1.2 The statistical criteria summarized in Table 4 represent the estimate of reproducibility, based on 24 sets of data and 51 total tests. These data were obtained over the period of October 1, 1993 through March 31, 1994. (If a potential user has a desire to know what the most recent precision data are for non-reference oils, the TMC can provide the information by consulting the appropriate Surveillance Panel report.)

15.1.1.3 *Reproducibility (R)*—The difference between two single and independent results obtained on the same oil by different operators working in different laboratories and 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.

15.1.1.4 No similar estimate of non-reference oil repeatability is available with this test method, since the number of non-reference oil tests repeated in the same engine, test stand, and laboratory by the same operator are essentially nonexistent.

15.1.1.5 An estimate of reference oil repeatability and reproducibility is contained in the reference oil data base maintained by the TMC. Reference oil precision data for the period January 1, 1992 through June 30, 1994 are shown in Table 5. The repeatability precision data were based on 97 degrees of freedom, and the reproducibility precision data were based on 101 degrees of freedom. Updated reference oil precision data are available upon request from the TMC.

15.1.2 *Bias*—Bias is determined by applying an accepted statistical technique to reference oil test results and when a significant bias is determined, a severity adjustment is permitted for non-reference oil test results (see Annex A14).

16. Keywords

16.1 engine oil; engine oil testing; engine rusting; Sequence IID

TABLE 4 Test Precision—Non-reference Oils

Parameter	Standard Deviation	Reproducibility, *R*
Average engine rust	0.22	0.62

TABLE 5 Test Precision—Reference Oils

Parameter	Repeatability		Reproducibility	
	s_r	r	s_R	R
Average engine rust	0.115	0.323	0.116	0.325

ANNEXES

(Mandatory Information)

A1. ENGINE TEST STAND CALIBRATION

A1.1 *Standard Sequence IID tests shall be conducted only in calibrated engine test stands.*

A1.1.1 Engine test stand calibration is accomplished by a laboratory conducting the Sequence IID test method with reference oils furnished by the ASTM Test Monitoring Center (TMC) and stored at the laboratory.

A1.1.1.1 The laboratory has responsibility to keep the on-site blind reference oil inventory at or above the minimum level specified by the TMC.

A1.1.2 These reference oils are normally supplied under code numbers (blind reference oils) to ensure that the testing laboratory will not be influenced by preconceived opinions in assessing the test results.

A1.1.3 It is the test laboratory's responsibility to maintain calibration of its test stands in accordance with the guidelines furnished by the TMC.

A1.1.3.1 When laboratory personnel decide that a reference oil test should be run, they request a blind oil code from the TMC.

A1.1.3.2 Upon completion of the blind reference oil test, a summary of the data is sent to the TMC by telephone facsimile transmission, or some other method acceptable to the TMC.

A1.1.3.3 The TMC will review the data and contact the laboratory to report the laboratory's calibration status.

A1.1.3.4 All reference oil tests, whether aborted, invalidated, or successfully completed shall be reported to the TMC.

A1.1.4 No more than 18 test starts nor 90 days shall elapse on a calibrated stand without running an acceptable blind reference oil test.

A1.1.5 To ensure that a laboratory's test severity stays within acceptable guidelines, no more than 36 total test starts are allowed, on all of the calibrated stands in a laboratory, between reference oil tests in the laboratory.

A1.1.6 The TMC may schedule more frequent or less frequent reference oil tests, at its discretion, depending on special circumstances.

A1.1.6.1 Non-reference oil tests conducted during a special extended period between reference oil tests shall be annotated in the test note section of the report.

A1.1.7 Failure of a reference oil test to meet the established statistical guidelines (the TMC can provide details), can be indicative of a false alarm, test stand, testing laboratory, or industry-related problem.

A1.1.7.1 The TMC has the ultimate responsibility for deciding whether an unacceptable blind reference oil test is isolated to one particular stand or related to other stands. The TMC will seek industry expertise, as necessary, to help in making this decision.

A1.1.7.2 If the problem is determined to be a false alarm or involving only one test stand, there is no impact on non-reference oil tests running in other test stands within the laboratory.

A1.1.7.3 If it is determined that the problem is laboratory-related, non-reference oil tests during the problem period shall be considered nonstandard tests, unless there is specific evidence to the contrary for each individual test.

A1.1.7.4 The laboratory, in conjunction with the TMC, shall attempt to determine the problem source.

A1.1.7.5 Until the problem is identified, corrected and an acceptable reference oil test completed in the involved stand, or one of the involved stands (when the problem is related to other stands), standard testing of non-reference oils cannot be conducted in the stand(s) in question.

A1.1.7.6 Industry problems shall be resolved by the Sequence IID Test Method Surveillance Panel that reports to Subcommittee B in ASTM Committee D-2, Petroleum Products and Lubricants.

A1.1.8 If a nonstandard test is conducted on a calibrated test stand, the test stand has to be recalibrated prior to again running standard tests.

A1.2 *Each test shall be numbered to identify the test (IID), the stand number, the stand test number (0 to 18), and a sequential laboratory test number based on the starting date of the test.*

A1.2.1 For example, IID 58-0-401 defines a test on stand 58 as a reference test which is numbered as the 401st IID test in the laboratory.

A1.2.1.1 The only exception to this format is that the sequential laboratory test number shall be followed by the letter A for the first rerun, B for the second rerun, and so forth, of invalid or unacceptable reference oil tests.

A1.3 *Each laboratory that is monitored by the TMC shall run at least one donated test per year on a poor reference oil supplied through the normal blind reference oil system.*

A1.3.1 The purpose of such tests is to verify that each laboratory discriminates *good* oils from *poor* oils.

A2. EXTERNAL ENGINE COOLING SYSTEM

A2.1 An external cooling system such as shown on print RX-116681-D is required to maintain the specified jacket cooling temperature during the operating and shutdown portions of the test. The system has the following features:

A2.1.1 It shall not be pressurized.

A2.1.2 The pumping system shall be capable of delivering 60 ± 1 gal/min (3.79 L/s).

A2.1.3 It shall have a total capacity of 22.5 ± 2.5 gal (85 ± 9 L).

A2.1.4 A sharp-edge orifice meter[33] such as shown on prints RX-116645-D through RX-116650-D shall be used for the measurement of coolant flow rates.

A2.1.5 A system to control the coolant flow rate such as shown on print RX-117161-C is required.

A2.1.6 The system shall have provisions (for example, low point drains) for draining all of the flushing water prior to installing a new glycol mixture.

A3. EXTERNAL JACKETED ROCKER COVER, INTAKE MANIFOLD CROSSOVER AND BREATHER TUBE COOLING SYSTEMS

A3.1 Description of the System

A3.1.1 An external cooling system for the rocker covers, intake manifold exhaust crossover, and breather tube, incorporating pumps, flowmeters, plumbing connections, and heat exchangers, such as shown on prints RX-117731-C and RX-117814-C or RX-117815-C, is required to maintain the specified operating temperatures in these engine parts.

A3.1.2 The system shall have the following features:

A3.1.2.1 A pump and flowmeter capable of supplying engine coolant to the rocker covers and intake manifold crossover at 3 ± 1 gal/min (0.19± 0.06 L/s); that is, 1.5 ± 0.5 gal/min (0.09 ± 0.06 L/s) per each rocker cover.

A3.1.2.2 Maintain the rocker cover coolant outlet pressure at 5.0 ± 0.5 psi (34.5 ± 3.4 kPa).

A3.1.2.3 Maintain the intake manifold exhaust crossover coolant outlet pressure at 2.5 ± 0.5 psi (17.2 ± 3.4 kPa).

A3.1.2.4 Use a second coolant system, having a pump and flowmeter capable of supplying coolant at 60°F (15.5°C) and 3 gal/min (0.19 L/s), to control the temperature of the rocker arm and breather tube assembly. This system can be drained upon completion of test.

A3.1.3 Equip the system with low point drains to allow for removal of all coolant.

A3.2 Cleaning the System's Jacketed Rocker Cover

A3.2.1 Either with new rocker covers or after each test, flush the stainless steel rocker covers (see print RX-117470-D) clean with aliphatic naphtha in order to ensure proper heat transfer rates.

A3.2.2 Polish the engine side of the rocker covers lightly with 400 grit 3M cloth (3M Elek-tro Cut Cloth 400J[43]), or equivalent, before each test.

A3.2.3 Clean the coolant side of the rocker covers after every tenth test, or sooner if a film is present, with concentrated nitric acid.

A3.2.3.1 A 1-min exposure to the nitric acid followed by thorough rinsing with water is satisfactory.

A3.2.4 Pressure check the rocker covers for leaks at a pressure of 10 psig (69 kPa) after cleaning. *Pressures in excess of 10 psig (69 kPa) are likely to balloon the covers*.

A3.3 Cleaning the System's Breather Tube

A3.3.1 Remove the stainless steel breather tube (see print RX-117729-C) immediately after each test and soak in Oakite 811.

A3.3.2 After soaking, clean the inside of the tube with Oakite 811 and a non-cuprous brush (a 0.25 caliber rifle cleaning rod with a non-cuprous brush has been found satisfactory).

A3.3.3 Following the cleaning procedures described above, rinse the breather tube with clean aliphatic naphtha.

A3.3.4 Breather tube heat exchanger gaskets can be readily made, or ordered as American Standard Part 2G-3A, 901.[44]

A3.3.5 Clean the coolant side of the breather tube after every tenth test, or sooner if a film is present, with concentrated nitric acid.

A3.3.5.1 A 1-min exposure to the nitric acid followed by thorough rinsing with water is satisfactory.

A3.3.6 Flush the glycol side of the breather tube with aliphatic naphtha after each test.

A3.3.6.1 Pressure check the glycol side of the breather tube for leaks after cleaning at a pressure of 10 psig (69 kPa).

A3.4 Cleaning the System's Intake Manifold

A3.4.1 Wire brush the side exposed to the lifter valley and thoroughly wash with Oakite 811. Follow by rinsing with aliphatic naphtha.

A3.4.2 Minimize the exposure of the exhaust crossover passage to the Oakite 811 cleaning agent.

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[43] Available through local suppliers. Order 400 grit 3H cloth or 3M Elek-tro-Cut Cloth 400J, or equivalent.

[44] Available from American Standard, Industrial Products Division, P.O. Box 76, Dearborn, MI 48121.

A4. EXTERNAL OIL COOLING SYSTEM, CLEANING AND CALIBRATION

A4.1 Oil Cooling System

A4.1.1 An external oil cooling system such as shown on print RX-116680-C is required to maintain the specified oil temperatures.

A4.1.1.1 A positive displacement pump, Viking Oil Pump, Model 4125[45] is mandatory. This pump delivers 5.75 ± 0.25 gal/min (0.363 ± 0.016 L/s) at 1150 r/min.

A4.1.1.2 There is no relief valve in the system.

A4.1.1.3 A heat exchanger assembly, Part BX-250-1,[12] is mandatory. This cooler has a capacity of 1 pt (473 mL).

A4.1.2 Pillow blocks should be used to support the drive shaft and ensure longer pump life.

A4.1.3 Suitable fittings, as shown on print RX-118305-D, shall be provided in the engine oil pan to accommodate the oil lines. *Do not use cuprous lines or fittings in the cooling system. Do not use magnetic plugs anywhere in the engine or in the cooling system*.

A4.1.4 The length of the oil lines to the heat exchanger and valves should be minimized. The total oil volume in the external oil cooling system, including the volume of the lines, heat exchanger, valves, pump, and sensing elements shall be 32 ± 2 oz (946 ± 59 mL) of oil.

A4.1.5 Number 8 Aeroquip hose, inside diameter 0.417 in. (10.59 mm), type T Teflon 2807[33] and fittings are recommended.

A4.1.6 If quick disconnect type fittings are used, only the straight-through type, such as shown on print RX-116680-C, shall be used.

A4.2 Cleaning the Oil Cooling System

A4.2.1 Either with a new cooling system or within 15 min of completing the final oil level in this test method, flush the external oil cooling system, including lines, pump, heat exchanger, and valve with a 100 % by volume solution of Oakite 811 until clean.

A4.2.2 Periodically, the heat exchanger should be removed and cleaned separately as discussed in the following:

A4.2.2.1 Details of an oil heat exchanger flushing apparatus are shown in print RX-117374-R.

A4.2.2.2 Use Section A of unit for flushing water side of the heat exchanger, and Section B for flushing the oil side of the exchanger. *Do not flush more than two exchangers at one time*.

(*a*) Flush the water side of the exchanger for ½ h, using oxalicacid proportionate concentration. Preheat the solution to 140± 5°F (60 ± 2.8°C) and pump at approximately 4 gal/min (0.25 L/s).

(*b*) After ½ h flush on the water side of the exchanger, rinse (*one pass*) with water preheated to 120°F (48.9°C). Do this until the rinse water has a neutral pH.

(*c*) Flush the oil side of the exchanger for ½ h, using 100 % Oakite 811. Preheat the cleaning agent to 140 ± 5°F (60 ± 2.8°C) and pump at approximately 2.5 gal/min (0.16 L/s).

(*d*) After ½ h flush on the oil side of the exchanger, rinse with Solvasol No. 5 (*one pass*) until solvent is clear; and then, air dry.

(*e*) Both sides of the exchanger can be flushed at the same time.

A4.2.2.3 After a cleaned heat exchanger has been installed in the external oil cooling system, flush clean the pump, lines, exchanger, and proportioning valve using aliphatic naphtha with a 300 to 400°F (149 to 204°C) boiling point, and air dry the system before each test.

(*a*) Rotate the external oil pump shaft by hand while air blowing to ensure that all solvent is removed from the system.

A4.3 Calibrating the External Oil Cooling System Flow Rate

A4.3.1 Perform the following procedure to verify that the external oil system flow rate meets the specification before each reference oil test and after any system component (for example, pump, control valve, heat exchanger) is replaced:

A4.3.1.1 After cleaning (see Annex A5.2), connect the oil lines to a calibration oil pan firmly mounted at engine height.

A4.3.1.2 Insert a calibrated flow meter in the oil return line. Use a flow meter with minimum pressure drop and restriction to flow (a suitable flow meter is the Cox Model AN10 Turbine Meter).

(*a*) Calibrate the flow meter using EF 411 oil heated to 85°F (29.4°C).

(*b*) Observe typical 10 times diameter straight pipe rule before and after meter to reduce flow disturbance.

A4.3.1.3 Add 5680 mL of EF 411 to oil pan.

A4.3.1.4 Operate the oil pump while cycling the 3-way control valve to purge air from the system (*excessive air in the oil will cause erroneous flow measurement, particularly with turbine meters*).

A4.3.1.5 With the 3-way control valve set at 50 %, record flow rate when the reading has stabilized and the oil temperature measures 84 to 85°F (28.9 to 30.0°C) by the sump thermocouple.

A4.3.1.6 Determine if the system meets the specified flow rate of 5.75 ± 0.25 gal/min (21.8 ± 0.95 L/min).

(*a*) If the flow rate doesn't meet the specification, adjust the pump clearance or replace the pump, then recheck the flow rate using the above procedure.

A4.4 Calibrating the Volume of the Oil Cooling System

A4.4.1 Perform the following procedure to verify that the external oil cooling system volume meets the specification before every reference oil test, and after any system component (for example, line length, pump, valve) is changed.

A4.4.1.1 After cleaning (see Annex A5.2), connect the oil lines to a calibrated oil pan firmly mounted at engine height.

(*a*) Install a 0.375-in. (9.5-mm) diameter drain valve in place of the oil drain plug or at the lowest point of the pan.

(*b*) Plug the pan outlet fitting with a rubber stopper, or modify the outlet by threading with a ½-in. NPT thread so that

[45] Available from local Viking distributors, or Viking Pump Division, Houdaille Industries, Inc., George and Wyeth Sts., Cedar Falls, IA 50613. Alternatively, a Viking Model G4125 pump, 0.38 ± 0.03 L/s (6 ± 0.5 gpm) at 1150 rpm and no relief valve, is satisfactory.

a ½-in. NPT plug can be screwed in.

A4.4.2 Weigh, at room temperature, 5680 mL of solvent (aliphatic naphtha) with a boiling point greater than 300 °F (149°C) to determine the weight per volume of solvent (g/mL).

A4.4.3 Carefully add the weighed solvent to the oil pan.

A4.4.4 Operate the oil pump alternately 1 min on and 1 min off while cycling the 3-way control valve.

A4.4.4.1 Repeat cycling of the pump several times to purge all air from the system.

A4.4.5 Turn off the oil pump, and firmly insert rubber stopper or screw in a ½-in. NPT plug in the pan outlet fitting to keep oil lines filled with solvent when the pan is drained.

A4.4.6 Drain solvent remaining in the pan using the pan drain valve. Manually scrape any residual solvent into the drain using a plastic scraper.

A4.4.7 Measure the weight of the removed solvent and subtract from the initial solvent weight.

A4.4.8 Repeat the above process until the weight measurement repeats within 4 % (equivalent to 1 fluid oz (30 mL) volume of solvent).

A4.4.9 Determine if the external oil system meets the volume specification of 25 ± 2 fluid oz (739 ± 59 mL).

(*a*) If the measured volume doesn't meet the specification, adjust the length of the oil lines or fitting size to obtain the required volume. Recheck the system volume using the above procedure. *Note that the system flow rate shall be rechecked when any component, except the oil heat exchanger or oil heat exchanger core, is replaced.*

A5. EXTERNAL FLUSHING TANK

A5.1 A flushing tank, such as shown on prints RX-116924-C, RX-117230-E and RX-117231-C, is required to premix and circulate the cleaning agents.

A6. EXTERNAL COOLANT MIXING TANK

A6.1 A mixing tank such as shown on print RX-117350-D can be used to premix the glycol/water coolant.

A7. EXTERNAL FUEL SYSTEM

A7.1 A suitable pressurized fuel system is required to provide 2 to 6 psi (14 to 42 kPa) fuel pressure at the carburetor.

A7.2 A Fisher Governor Company regulator[46] (Part No. 95L-34) has been found satisfactory for controlling the fuel pressure.

A7.3 Additional shutoff valves should be incorporated in the system so that no fuel pressure is present at the carburetor during engine shutdowns.

A7.3.1 A suitable shutoff valve is available from Skinner Precision Industries[47] (Part No. XSD30280).

[46] Available from Fisher Governor Co., 1900 Fisher Building, Marshalltown, IA 50158.

[47] Skinner Electric Valve Division, Skinner Precision Industries, Inc., 100 Edgewood Ave., New Britain, CT 06050.

A8. ENGINE COOLANT PREPARATION

A8.1 Measure the appropriate amount of additive, proportionate to the total coolant volume mixed, into a clean container prior to coolant mixing.

A8.2 Premix the glycol and water combination and the additive concentrate in a container (see Annex A7) prior to adding the finished coolant to the engine, rocker cover, and breathing tube cooling systems.

A8.3 Approximately 25.1 gal (95 L) of coolant should be prepared. The specified quantity to be charged to the various cooling systems is 22.5 ± 2.5 gal (85 ± 9 L). See 7.3.1 for the percentages of glycol and water required.

A8.4 The premixing should not be done more than 2 h prior to filling these systems.

A8.5 *Do not heat the coolant during the premixing step.*

A8.6 Prior to adding the additive concentrate to the glycol and water mixture, withdraw a small portion of the glycol and water mix to use as a rinsing agent for the container that holds the additive concentrate.

A8.6.1 Add the concentrate and thoroughly rinse the container.

A9. SEALING COMPOUND APPLICATIONS

A9.1 Adequate amounts of sealing compound, Perfect Circle No. 4 Sealing Compound, should be used on

A9.1.1 Both sides of the head gaskets,

A9.1.2 Both sides of each rocker cover spacer-to-head gasket,

A9.1.3 The intake manifold gasket areas adjacent to the intake ports, and

A9.1.4 The front and rear oil pan seals.

A9.2 It is convenient to apply the Perfect Seal compound to the head gaskets with a small mohair paint roller (1⅞ in. outside diameter and 3 in. wide (48 mm outside diameter and 76 mm wide)).

A9.3 The Perfect Seal compound being used from the 1 gal (4 L) container and the roller can be stored in a small desiccator such as Sargent-Welch No. S-25140..[48]

[48] Available from Sargent-Welch Scientific Co., 7300 N. Linder Ave., P. O. Box 1026, Skokie, IL 60077.

A9.4 Either ethyl alcohol (minimum 180 proof) or commercially pure isopropyl alcohol can be used as a solent in removing the Perfect Seal compound from metal surfaces.

A9.5 No. 2 non-hardening Permatex should be applied:

A9.5.1 To the ends of the intake manifold gasket adjacent to water ports and at the exhaust crossover ports.

A9.5.2 To the tapered ends of the front and rear elastomeric intake manifold seals which are adjacent to the cylinder heads, and

A9.5.3 On the mating surfaces of the rear main oil seal.

A9.6 Use 3M Super Weatherstrip Adhesive to cement the cork rocker over gasket to the rocker cover spacer.

A9.6.1 *Use no compound on the rocker cover side of the cork gasket.*

A9.7 The use of anti-seizure compound, such as Fel-Pro C-100 or E/M Lubricants, Inc. CP-29 spray or can is recommended on the exhaust manifold and pipe bolts.

A10. FASTENER TORQUE SPECIFICATIONS AND TORQUING PROCEDURES

A10.1 *Cylinder Head Bolts:*

A10.1.1 Install cylinder heads using thoroughly cleaned bolts oiled with EF-411.

A10.1.2 After the bolts are finger-tight, torque them in the sequence shown in the 1977 Oldsmobile Service Manual (Fig. 6A3-29).

A10.1.3 Torque the bolts three times:

(*a*) First, torque them at 100 lbf·ft (136 N·m),

(*b*) Second, torque them at 110 lbf·ft (139 N·m), and

(*c*) Third, repeat torquing at 110 lbf·ft (139 N·m).

A10.2 *Intake Manifold Bolts:*

A10.2.1 Install intake manifolds using thorougly cleaned bolts oiled with EF-411.

A10.2.2 After the bolts are finger-tight, torque them in the sequence shown in the 1977 Oldsmobile Service Manual (Fig. 6A3-15).

A10.2.3 Torque the bolts four times:

A10.2.3.1 First, torque them at 15 lbf·ft (20 N·m),

A10.2.3.2 Second, torque them at 35 lbf·ft (47 N·m),

A10.2.3.3 Third and fourth, repeat the 35 lbf·ft (47 N·m) torquing.

A10.3 *Other Torque Specifications Are Presented in the Following Text Table:*

Part	lbf·ft	(N·m)
Bolts for main bearing caps Nos. 1, 2, 3 and 4	80	(108)
Bolts for main bearing cap No. 5	100	(136)
Flywheel bolts	70	(95)
Connecting rod nuts	42	(57)
Timing gear-to-camshaft bolt	65	(88)
Front cover-to-block bolt (⅜in.)	35	(47)
Front cover-to-block bolt (5⁄16in.)	25	(34)
Crankshaft balance bolt	160	(217)
Rocker arm pivot bolts	25	(34)
Rocker arm cover bolts	7	(9)
Condenser-to-front cover bolts	25	(34)
Oil pump-to-bearing cap bolts	35	(47)
Oil pan bolts	10	(14)
Choke stove plate bolts	15	(20)
Water outlet adapter bolts	20	(27)
Carburetor-to-intake manifold bolts	10	(14)

A11. ENGINE TEST PARTS

A11.1 Engine Test Parts Classification

A11.1.1 *Critical Parts* —These are engine parts that are known to affect test severity. They will be identified with a serial number or a batch lot control number as supplied by the Central Parts Distributor.[12] In the following listing of engine parts (Table A11.1), those in this category will have the letters *CP* noted after the description of the part.

A11.1.2 *Non-production Parts*—These are engine parts no longer available except through the Central Parts Distributor, by special order through General Motors,[33] or by fabrication from prints. In the following listing of engine parts, those in this category will have the letters *NP* noted after the description of the part.

A11.1.3 *Service Parts Operations (SPO) Parts*—These are most of the remaining engine parts, and some are available from the CPD while most are available through local General Motors' dealer networks. In the following listing of engine parts, those in this category will have the letters *SPO* noted after the description of the part.

A11.1.3.1 The engine parts supplied through General Motors' Service Parts Operations are designated by numbers containing five-to-eight digits.

A11.1.4 *CPD Special Test Parts*—These are parts which do not meet all the definitions of Critical Parts, Non-production Parts, or SPO parts, and are obtained only from the Central Parts Distributor (CPD). In the following listing of engine parts, those in this category will have the letters *STP* noted after the description of the part.

A11.1.5 The engine parts supplied by the Central Parts Distributor are designated by numbers with a *BX* prefix.

A11.1.6 There are a few other engine parts that are available from sources identified by footnotes in the following listing.

A11.2 *Parts Procurement and Usage Guidelines:*

A11.2.1 Use all parts on a first-in first-out basis.

A11.2.2 The maximum order quantity of Critical Parts from the Central Parts Distributor is limited to a sixty-day supply for any given laboratory.

A11.2.3 Order quantities for Non-Production Parts and SPO Parts are also encouraged to be as low as feasible to ensure a timely inventory turnover.

A11.2.4 The maximum inventory for all test parts at any given laboratory is a six-months supply.

A11.2.5 Use all parts as received unless specific modifications are prescribed in the test method.

A11.2.6 All Critical Parts shipped from the Central Parts Distributor will be accompanied by a Critical Parts Accountability Form (see Fig. A11.1). If any of these parts are rejected by a test laboratory, the reason for rejection shall be stated on the form and a copy immediately faxed to the Test Monitoring Center, CPD and Test Developer. All rejected Critical Parts shall be saved for return shipment to the Central Parts Distributor semiannually on April 15 and October 15, or earlier as directed by the TMC.

A11.2.6.1 New valve lifters from the Central Parts Distributor are required for each test. These valve lifters are designated as Special Test Parts, but any lifters that are rejected by a test laboratory shall be treated in the same manner as rejected Critical Parts.

A11.2.7 Any part number deviations from the current SPO Parts List are not allowed except for depletion of old stock. Deviations shall be recorded in the supplementary test notes. The current SPO Parts List may differ from that in this test method, and the TMC should be contacted for the latest version of this list.

CRITICAL PARTS ACCOUNTABILITY FORM

CUSTOMER		
PACKING LIST		
DATE SHIPPED		
PART NUMBER		
DESCRIPTION		
QUANTITY SHIPPED		
P.O.		

SERIAL NO. / BATCH CODE	TEST NUMBER	REJECTION / COMMENTS

FIG. A11.1 Critical Parts Accountability Form

TABLE A11.1 Parts Required for Each Test

New Parts	Part Number
Camshaft (SPO)	562299
Seals, intake manifold, front and rear (SPO)	22509595 (front) or BX-206-1 22509596 (rear) or BX-207-1
Gaskets, intake manifold, stainless steel (NP)	4861-OEM (left) or BX-204-1 4860-OEM (right) or BX-205-1
Piston rings, 0.127 mm (0.005 in.) oversize set (CP)	BX-215-1
Head gasket (SPO)	555201
Piston, Code D (CP)	BX-214-1
Cylinder heads (CP)	BX-208-1
Valve lifters (STP)	BX-202-1
Valves, intake (SPO)	553396
Valves, exhaust (SPO)	555456
Seals, intake and exhaust valve stem (CP)	55A397[27] or BX-216-1
Chain, engine timing (SPO)	401584
Oil pump (CP)	BX-211-1 or BX-211-2
Oil pump relief valve (CP)	BX-201-1
Oil pump relief valve spring (SPO)	401366
Rocker arms, non-lubricated (SPO)	401384
Pivot bolts (SPO)	9423842
Pivots, cylinder nos. 1, 2, 7, and 8 (SPO)	391208
Pivots, cylinder nos. 3, 4, 5, and 6 (CPO)	BX-221-1
Oil filter, PF-24 (CP)	BX-217-1
Spark plugs, 2 sets per test	R46SZ
Gasket, exhaust manifold	X4434, or S-4679-OTH[31]
Seal, front cover, crankcase (SPO)	552711
Gasket, rocker cover spacer-to-head	393573[32]
Seal, crankshaft, rear main (SPO)	BX-309-1
Pushrods (CP)	BX-210-1
Rocker cover gasket, cork (SPO)	573396
Parts Replaced as Necessary	
Part	Part Number
Engine bare block (STP)	BX-203-1
Dipstick, guide tube (SPO)	417090
Dipstick indicator (SPO)	419242
Valve springs (CP)	BX-213-1
Valve rotators (SPO)	406996
Keys, valve spring cap (SPO)	3947770
Baffle, oil fill (SPO)	383379
Connecting rod bearings (SPO)	18008494
Camshaft bearings, front (SPO)	12339842
Camshaft bearings, front intermediate (SPO)	390300
Camshaft bearings, center (SPO)	390301
Camshaft bearings, rear intermediate (SPO)	12351407
Camshaft bearings, rear (SPO)	390303
Crankshaft (NP)	BX-219-1
Gear, engine crankshaft (SPO)	382880
Flywheel bolts (SPO)	558805
Bolts, intake manifold (⅜–16 by 2 in.) (SPO)	179847
Bolts, intake manifold (⅜–16 by 1¼ in.) (SPO)	9420462
Main bearing, position 1 (SPO)	5466211
Main bearings, positions 2 and 4 (SPO)	5466089
Main bearing, position 3 (SPO)	12329430
Main bearing, position 5 (SPO)	12329996
Gasket, carburetor-to-manifold (SPO)	22508038
Camshaft, thrust washer (NP)	RX-118213-A
Connecting rods (SPO)	554976
Plug, oil passage (r.r. inner) (SPO)	404199
Plug, oil passage (r.r. outer) (SPO)	557319
Plug, oil passage (l. front) (SPO)	22527020
Plug, oil passage (r. front) (SPO)	22527021
Special Test Parts	
Part	Part Number
Electronic fuel mixture control w/555 timer	BX-150-1
Breather tube	BX-212-1
Oil heat exchanger assembly	BX-250-1
Non-production Parts	
Part	Part Number

TABLE A11.1 *Continued*

New Parts	Part Number
Exhaust manifold	BX-209-1
Crankshaft, casting	BX-219-1
Intake manifold, remanufactured	BX-220-1
Gear, distributor	BX-218-1
Carburetor adapter plate	BX-260-1
Packing rear main rope (pkg/100)	BX-309-1
Rocker cover assembly (avail. from CPD)	RX-117470-D
Indicator, timing	BX-270-1
Non-production Parts (can be ordered from GM or fabricated by a machine shop)	
Part	Print Number
Rocker cover spacers	RX-118304-D
Rocker cover deflectors, stainless steel	RX-117289-B
Rocker cover deflector stanchions	RX-117288-A
Front cover	RX-117224-D
Front cover deflector, stainless steel	RX-117319-B
Timing gear deflector, stainless steel (thin)	RX-119306-A
Blowby meter	RX-116169-C
Sharp edge orifice water flowmeter	RX-116650-D
Sharp edge orifice plate	RX-116649-A
Oil pan baffle	RX-118332-B
Service Part Operations Parts	
Part	Part Number
Bolt, balancer crankshaft	271630
Bolt, connecting rod	382570
Bolt, crankshaft main cap	392190
Bolt, crankshaft main cap	398659
Bolt, cylinder head	22510579
Bolt, cylinder head	22510580
Bolt, cylinder head stud	22510585
Bolt, intake manifold	9423490
Bolt, oil pan	9440033
Bolt, oil pan corner	9442184
Bolt, oil pump mount	9442339
Cap, distributor	1974408
Capacitor	12332666
Clamp, distributor	3835505
Coil	1985473
Coil, complete field assembly (replaces 1877306)	10470770
Coil, distributor pick-up	1876210
Collar	1927849
Filter, oil base	25010469
Flywheel	398071
Frame	1974157
Gasket, carburetor air horn	25511809
Gasket, EGR valve	22547852
Gasket, front cover	22547856
Gasket, fuel pump	22505998
Gasket, oil filter mount	22527229
Gasket, oil pan package	22519181
Gasket, oil pump cover	382160
Gasket, water outlet	22547855
Gear, camshaft	381263
Holder	1940477
Holder	1988414
Housing	1876207
Key, crankshaft sprocket	588526
Lockring	1927848
Module, distributor ignition	1875990
Motor, starter	1109022
Nut, engine connecting rod	395921
Pan, engine oil	555137
Pin	455862
Pin	585927
Pivot, rocker arm	22527956
Plug, cup cylinder head	380254
Plug, oil pan drain	380919
Rotators, valve	406996
Slinger, crankshaft	382572
Spring, (replaces 1926622)	10498866
Stud	333959
Support	1928015

TABLE A11.1 *Continued*

New Parts	Part Number
Washer, intake manifold bolt	3899696
Weights, distributor shaft	1893888

A12. COOLANT CALIBRATION STANDARDS

A12.1 Prepare coolant calibration standards containing 35, 40, and 45 % by volume glycol in distilled water plus the specified additive concentrations (see 7.3.1).

A12.1.1 Control temperature during preparation at 80 ± 1°F (26.7 ± 0.6°C).

A12.2 Generate calibration curves by determining the specific gravity of the three standards at various temperatures.

A12.3 Use an ASTM Hydrometer, Model 112-H, with a 1.050 to 1.100 range, to determine the specific gravity of both the calibration standards and the actual engine coolant mixtures. This can be obtained from the H-B Instrument Co.[49]

[49] Available from H-B Instrument Co., 4303 N. American St., Philadelphia, PA 19140.

A13. DIPSTICK CALIBRATION

A13.1 Use a graduated dipstick method to determine the oil level.

A13.1.1 Develop a curve of dipstick measurement versus oil level at 120 ± 5°F (48.9 ± 2.8°C).

A13.1.1.1 The oil level should first be adjusted to be at the indicated full mark on the dipstick in an engine mounted as described in 8.4.2.

A13.1.1.2 Withdraw the oil in increments of 2 or 4 fluid oz (59 or 118 mL), and record the resulting dipstick measurements. Develop a curve of dipstick measurements versus oil volume removed from these data.

A13.2 Although not linear, 1⁄32 in. (0.79 mm) on the dipstick is equivalent to about 1 oz (29.5 mL) of oil.

A14. CALCULATION OF SEVERITY ADJUSTMENTS

A14.1 There is an accepted method for determining if a severity adjustment (SA) should be applied to non-reference oil test results.

A14.1.1 An exponentially weighted moving average (EWMA) of reference oil test results is the basis for such a determination.

A14.1.2 If the EWMA for a valid standard reference test exceeds a statistically derived control limit, then an SA will be in effect and shall be applied to ensuing non-reference oil test results until the next valid standard reference test.

A14.2 The following example illustrates the computation of the EWMA and SA values, and the application of the SA value:

A14.2.1 Assume that a valid standard reference oil test has just been completed on Reference Oil A. Assume that the control limit is 0.600 (this is in standard deviation units).

A14.2.2 The mean average rust value for previous tests with Reference Oil A test is 8.256, and the standard deviation for that oil is 0.159. The actual average rust test result for the test just completed with Reference Oil A was 8.99.

A14.2.3 First, a standardized test result (in standard deviation units) is calculated for the test just completed by dividing the difference between the actual test result and the mean value by the standard deviation; that is, $(8.99 - 8.526)/0.159 = 2.918$.

A14.2.4 The EWMA prior to this latest standardized test result is 0.791, and experience has shown that the prior EWMA value should receive more weight (80 %) than the newest result (20 %) when calculating the new EWMA value.

A14.2.5 Thus, the calculated new EWMA value is $0.8(0.791) + 0.2(2.918) = 1.216$.

A14.2.6 Since 1.216 exceeds the control limit of 0.600, it is necessary to calculate and apply an SA on ensuing non-reference oil tests.

A14.2.7 Converting the 1.216 EWMA value from standard deviation units to average rust units, requires multiplying the 1.216 value by 0.12 (the pooled standard deviation for the reference oils used in the test method); that is, $0.12 \times 1.216 = 0.1459$.

A14.2.8 Since the new EWMA is on the *mild* side of the control limit, it is necessary to correct ensuing non-reference oil test results by subtracting the SA. Thus, multiply the SA by − 1 and round to two places after the decimal point; that is, $-1 \times 0.1459 = -0.15$.

A14.3 Enter this SA value on the Test Result Summary page (Fig. 7) of the test report, and add the Average Rust value to obtain the Adjusted Rust value.

A14.4 The above is just an example. Contact the TMC for the necessary factors needed to make an actual calculation of severity adjustment.

A15. OPERATIONAL VALIDITY CRITERIA

A15.1 The test laboratory is responsible for determining and documenting the operational validity of every standard test.

A15.2 *Mid-limit Operation for Primary and Secondary Parameters* —The intent of this test method is to run the standard test at the mid point of all control parameters. A test is invalid if the average of the operating data for a controlled primary or secondary parameter deviates from the target mean by more than the mid-limit range specifications in Table A15.1. All averages of operating parameters shall be reported to the nearest tenth of a unit using the method described in Practice E 29.

A15.3 *Deviation Percentage Criteria*—In order for a standard test to be operationally valid, the deviation percentage criteria defined below shall be met:

$$DP = \sum_{i=1}^{n} \left[\frac{M_i}{0.5\,R} \times \frac{T_i}{D} \right] \times 100 \quad \text{(A15.1)}$$

TABLE A15.1 Mid-limit Operation Range Specifications (in.-lb units only)

NOTE 1—The boldfaced numbers in the table are the mid-limit range specifications.

Primary Parameters	Specification	Specification Range	Mid-limit Range	
Engine oil filter block temperature (°F)	120.0	±2.0	±0.5	**0.5**
Coolant temperature (jacket out) (°F)	110.0	±1.0	±0.25	**0.3**
Coolant flow rate (gal/min)	60.0	±1.0	±0.25	**0.3**
Breather tube temperature (°F)	60.0	±2.0	±0.5	**0.5**
Breather tube flow rate (gal/min)	3.0	±0.5	±0.125	**0.2**
Secondary Parameters				
Coolant pressure (crossover out) (psi)	2.5	±0.5	±0.25	**0.3**
Coolant flow rate (crossover out) (gal/min)	3.0	±0.5	±0.25	**0.3**
Carburetor pressure (in. H_2O)	0.2	±0.1	±0.05	**0.1**
Exhaust back pressure (right and left) (in. H_2O)	4.0	±1.0	±0.5	**0.5**

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,

NOTE A15.1—T_i is assumed to be no less than the recorded data-acquisition frequency unless supplemental readings are documented.

where:
n = number of times that a test parameter deviated from the test limits, and
D = test or test-phase duration in same time units as T_i.

A15.3.1 Any test exceeding the following deviation percentages is invalid:

Primary test parameter	2.5 %
Secondary test parameter	5.0 %

A15.3.2 *Primary Test Parameters*:

	D Factor
Engine oil filter block temperature (to engine after filter)	32
Coolant temperature (jacket out)	32
Coolant flow rate	32
Coolant temperature and flow rate at breather tube	32
Engine power	32

A15.3.3 *Secondary Test Parameters*:

Engine speed	30
Oil pump pressure	30
Coolant temperature (jacket in)	30
Coolant temperature/flow rate (crossover out)	30
Carburetor pressure	30
Intake manifold vacuum	30
Exhaust back pressure, right and left	30

A15.3.4 *Special Test Parameters*.

A15.3.4.1 *Air-Fuel Ratio (AFR)*— A test is invalid if the deviation percentages of either the left or right AFRs are greater than 2.5 %. The time weighting factor used results from a linear interpolation of the individual left and right AFR data points.

A15.3.4.2 *Blowby*—A test is invalid if more than 4 h of the readings for test hours 0 to 30 are out of limits by a linear interpolation of the blowby plot.

A15.3.4.3 *Crankcase Pressure*—A test is valid but the results are not representative of oil performance if:

(*a*) Average cold cycle crankcase pressure is greater than 1.3 in. H_2O, and

(*b*) Maximum cold cycle crankcase pressure is greater than 3.0 in. H_2O.

A15.3.4.4 *Downtime*—If a maximum of 20 min off-test conditions on the cold cycle or 30 min off-test conditions on the hot cycle is exceeded, the test is invalid.

A15.3.4.5 *Ignition Timing*—A test is invalid if any reading is greater than 1° from the required initial set point.

A16. REPORTING TEST METHOD D 5844 RESULTS

A16.1 Use the standardized report form package detailed in A16.2 to report all Test Method D 5844 non-reference oil and reference oil results.

A16.2 *Test Report Forms with Data Dictionary Variable Mneumonics* —The following report forms contain field names for all reported variables. These variables are for use in data communication as being developed by the Data Communication Task Force. See Figs. A16.1-A16.11.

A16.3 *Test Report Variable Data Dictionary*—The following is a complete data dictionary of the field names used in A16.2. See Fig. A16.12.

A16.4 *Reporting Reference Oil Test Results:*

A16.4.1 *Reporting Preliminary Reference Oil Test Results*—Report preliminary reference oil test results to the TMC by way of telecopier facsimile using forms shown in Fig. A16.1, Figs. A16.5-A16.9, and Fig. A16.11.

A16.4.2 *Final Reference Oil Test Report*—A final reference oil test report shall include all forms, with Fig. A16.3 omitted, in the standardized report form package. See Fig. A16.1, Fig. A16.2, and Figs. A16.4-A16.11.

A16.5 *Reporting Non-reference Oil Test Results*—A final non-reference oil test report shall include all forms, with Fig. A16.2 omitted, in the standardized report form package. See Fig. A16.1, and Figs. A16.3-A16.11.

REPORT ON
SEQUENCE IID EVALUATION

VERSION *19960206*

CONDUCTED FOR

TSTSPON1

TSTSPON2

LABVALID	V =VALID
	I = INVALID
	N =RESULTS CAN NOT BE INTERPRETED AS REPRESENTATIVE OF OIL PERFORMANCE (NON-REFERENCE OIL) AND SHALL NOT BE USED FOR MULTIPLE TEST ACCEPTANCE CRITERIA

Test Number		
Test Stand: *STAND*	Stand Test Number: *STRUN*	Lab Test Number: *LABRUN*
EOT Time: *EOTTIME*	EOT Date: *DTCOMP*	
Oil Code[A]: *CMIR/OILCODE*		
Formulation/Stand Code: *FORM*		
Alternate Codes: *ALTCODE1*	*ALTCODE2*	*ALTCODE3*

In my opinion this test *OPVALID* been conducted in a valid manner in accordance with the ASTM STP 315I Part I and the appropriate amendments through the information letter system. The remarks included in the report describe the anomalies associated with this test.

The test stand and laboratory have been calibrated in accordance with the requirements specified in ASTM STP 315I Part I and the appropriate amendments through the information letter system.

[A]CMIR or Non-Reference Oil Code

SUBMITTED BY:

SUBLAB
Testing Laboratory

SUBSIGIM
Signature

SUBNAME
Typed Name

SUBTITLE
Title

FIG. A16.1 Validity Statement

SEQUENCE IID REFERENCE TEST RESULTS

LAB *LAB*	OIL CODE *CMIR*	
TEST STAND NO. *STAND*	TEST NO. *STAND* - *STRUN* - *LABRUN*	
SAE VISCOSITY *SAEVISC*	EOT DATE *DTCOMP*	EOT TIME *EOTTIME*
FUEL BATCH *FUELBTID*	START DATE *DTSTRT*	START TIME *STRTTIME*
INTERNAL OIL CODE *LABOCODE*		ENGINE NO. *ENGINENO*
TEST LENGTH *TESTLEN*		

Rust:	Lifter Bodies	*LFTBDY*
	Lifter Plungers	*PLUNG*
	Lifter Balls	*BALLS*
	Relief Valve Plunger	*RVPLUN*
	Pushrods	*PUSHRD*
	Average Rust*	*AER*
	Final Average Rust	*AERFNL*
Stuck Lifters (number)		*LFTSTK*
Stuck Relief Valve		*RVSTK*
Oil Consumption (qt)		*OILCON*

Industry Oil Code: *IND*

*The Industry Average Rust Rating is: *IAVGRST*

(Note: Obtain from ASTM Test Monitoring Center)

FIG. A16.2 Reference Test Results

SEQUENCE IID TEST RESULTS

LAB *LAB*	OIL CODE *OILCODE*	
TEST STAND NO. *STAND*	TEST NO. *STAND* - *STRUN* - *LABRUN*	
SAE VISCOSITY *SAEVISC*	EOT DATE *DTCOMP*	EOT TIME *EOTTIME*
FUEL BATCH *FUELBTID*	START DATE *DTSTRT*	START TIME *STRTTIME*
INTERNAL OIL CODE *LABOCODE*		ENGINE NO. *ENGINENO*
FORMULATION/STAND CODE: *FORM*		
TEST LENGTH *TESTLEN*	VISCOSITY @ 40°C, cSt *VNEW*	

Rust: Lifter Bodies *LFTBDY*

Lifter Plungers *PLUNG*

Lifter Balls *BALLS*

Relief Valve Plunger *RVPLUN*

Pushrods *PUSHRD*

Average Rust *AER* Corrected Average Rust *AERCOR*

Severity Adjustment *AER_SA* Adjusted Rust *AERFNL*

Stuck Lifters (number): *LFTSTK*

Stuck Relief Valve: *RVSTK*

Oil Consumption (qt): *OILCON*

FIG. A16.3 Test Results

SEQUENCE IID
DOWNTIME & OUTLIER REPORT FORM

Unscheduled Downtime & Maintenance Summary

Laboratory: *LAB*	EOT Date: *DTCOMP*
Test Number: *STAND - STRUN - LABRUN*	EOT Time: *EOTTIME*
Oil Code: *CMIR/OILCODE*	
Formulation/Stand Code: *FORM*	

Number of Downtime Occurrences			DWNOCR
Test Hours	Date	Downtime	Reasons
DOWNH001	DDATH001	DTIMH001	DREAH001
		TOTLDOWN	Total Downtime

Other Comments	
Number of Comment Lines	TOTCOM
OCOMH001	

FIG. A16.4 Downtime and Outlier Report

SEQUENCE IID HARDWARE INFORMATION

Laboratory: *LAB*	EOT Date: *DTCOMP*
Test Number: *STAND - STRUN - LABRUN*	EOT Time: *EOTTIME*
Oil Code: *CMIR/OILCODE*	
Formulation/Stand Code: *FORM*	

	Serial Number		Batch Code
Engine Number:	*ENGSN*	Valve Springs:	*VALSPBAT*
Breather Tube ID:	*BRTHSN*	Valve Seals:	*INVSLBAT*
Cylinder Head:		Lifters:	*LFTCODE*
Left Head ID	*LHEADSN*	Oil Filter:	*OILFIBAT*
Right Head ID:	*RHEADSN*	Pistons:	*PISTBAT*
Oil Pump Assembly ID:	*OILPSN*	Pushrods:	*PUSHBAT*
Relief Valve Plunger ID:	*RVPSN*	Rings:	*RINGBAT*

FIG. A16.5 Hardware Information

SEQUENCE IID DEVIATION PERCENTAGE & MID LIMIT OPERATION REPORT FORM

Laboratory: *LAB*	EOT Date: *DTCOMP*
Test Number: *STAND - STRUN - LABRUN*	EOT Time: *EOTTIME*
Oil Code: *CMIR/OILCODE*	
Formulation/Stand Code: *FORM*	

Primary Parameter	Maximum Permitted Deviation Percentage	Calculated Deviation Percentage	Mid Limit Operation Range	Test Average Value	Test Stage
Engine Power	2.5%	*PWRDP*			
Breather Tube Coolant Temperature	2.5%	*BTOTDP*	60.0 ± 0.5 °F	*ABTOT12*	I, II
Breather Tube Coolant Flow Rate	2.5%	*BTFLODP*	3.0 ± 0.2 gpm	*ABTFLO12*	I, II
Oil Filter Block Temperature	2.5%	*OILFBDP*	120.0 ± 0.5 °F	*AOILTM12*	I, II
Jacket Coolant Out Temperature	2.5%	*COLOUTDP*	110.0 ± 0.3 °F	*ACOLOUT1*	I
Jacket Coolant Flow Rate	2.5%	*COLFLODP*	60.0 ± 0.3 gpm	*ACOLFLO*	I, II, III
Secondary Parameters					
Engine Speed	5%	*RPMDP*			
Coolant In Temperature	5%	*COLINDP*			
Oil Pump Pressure	5%	*OILPPDP*			
Intake Manifold Vacuum	5%	*INMVACDP*			
Carburetor Pressure	5%	*CARBDP*	0.2 ± 0.1 in. H_2O	*ACARBP*	I, II, III
Coolant Flow Rate (Crossover Out)	5%	*RCFLODP*	3.0 ± 0.3gal/min	*ACCFLO12*	I, II
Coolant Temperature (Crossover Out)	5%	*COLTPXDP*			
Coolant Pressure (Crossover Out)	5%	*COLPRXDP*	2.5 ± 0.3 psi	*ACPREO12*	I, II
Exhaust Back Pressure, Left	5%	*LEXPDP*	4.0 ± 0.5 in. H_2O	*ALEXP12*	I, II
Exhaust Back Pressure, Right	5%	*REXPDP*	4.0 ± 0.5 in. H_2O	*AREXP12*	I, II
Special Parameters					
Air-to-Fuel Ratio, Left	2.5%	*LATFDP*			
Air-to-Fuel Ratio, Right	2.5%	*RATFDP*			

FIG. A16.6 Deviation Percentage & Mid-limit Operation Report

SEQUENCE IID OPERATIONAL SUMMARY

Laboratory:	*LAB*	EOT Date:	*DTCOMP*
Test Number:	*STAND - STRUN - LABRUN*	EOT Time:	*EOTTIME*
Oil Code:	*CMIR/OILCODE*		
Formulation/Stand Code:	*FORM*		

	STAGES I & II (IID Cold Cycle)			STAGE III (IID Hot Cycle)		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Speed (rpm)	XRPM12	IRPM12	ARPM12	XRPM3	IRPM3	ARPM3
Load (bhp)	XPWR12	IPWR12	APWR12	XPWR3	IPWR3	APWR3
Oil, Filter Block Temperature (°F)	XOILTM12	IOILTM12	AOILTM12	XOILTM3	IOILTM3	AOILTM3
Oil Pan Temperature (°F)	XSUMPT12	ISUMPT12	ASUMPT12	XSUMPT3	ISUMPT3	ASUMPT3
Pressure, Pump Outlet (psi)	XOPMPP12	IOPMPP12	AOPMPP12	XOPMPP3	IOPMPP3	AOPMPP3
Pressure, Filter Block (psi)	XENOPR12	IENOPR12	AENOPR12	XENOPR3	IENOPR3	AENOPR3
Coolant, Jacket Flow (gpm)	XCOLFL12	ICOLFL12	ACOLFL12	XCOLFL3	ICOLFL3	ACOLFL3
Breather Tube Out Temperature (°F)	XBTOT12	IBTOT12	ABTOT12	XBTOT3	IBTOT3	ABTOT3
Left Cover Out Temperature (°F)	XLCOUT12	ILCOUT12	ALCOUT12	XLCOUT3	ILCOUT3	ALCOUT3
Right Cover Out Temperature (°F)	XRCOUT12	IRCOUT12	ARCOUT12	XRCOUT3	IRCOUT3	ARCOUT3
Right Cover Flow (gpm)	XRCFLO12	IRCFLO12	ARCFLO12	XRCFLO3	IRCFLO3	ARCFLO3
Left Cover Flow (gpm)	XLCFLO12	ILCFLO12	ALCFLO12	XLCFLO3	ILCFLO3	ALCFLO3
Breather Tube Flow (gpm)	XBTFLO12	IBTFLO12	ABTFLO12	XBTFLO3	IBTFLO3	ABTFLO3
Crossover Flow (gpm)	XCCFLO12	ICCFLO12	ACCFLO12			
Crossover Pressure Out (psi)	XCPREO12	ICPREO12	ACPREO12			
Air to Fuel Ratio	XAFR12	IAFR12	AAFR12	XAFR3	IAFR3	AAFR3
Fuel, Inlet Temperature (°F)	XFINL12	IFINL12	AFINL12	XFINL3	IFINL3	AFINL3
Carburetor, Air Temperature (°F)	XAIRTP12	IAIRTP12	AAIRTP12	XAIRTP3	IAIRTP3	AAIRTP3
Air Humidity (gr/lb)	XAIRHM12	IAIRHM12	AAIRHM12	XAIRHM3	IAIRHM3	AAIRHM3
Pressure (in. of H2O)	XINAP12	IINAP12	AINAP12	XINAP3	IINAP3	AINAP3
Ambient Air Temperature (°F)	XAMBAT12	IAMBAT12	AAMBAT12	XAMBAT3	IAMBAT3	AAMBAT3
Blowby Gas Outlet Temperature (°F)	XBGAST12	IBGAST12	ABGAST12	XBGAST3	IBGAST3	ABGAST3
Blowby (cfm at 100° F, 29.7 in. of Hg)	XCBLRT12	ICBLRT12	ACBLRT12	XCBLRT3	ICBLRT3	ACBLRT3
Right Exhaust Pressure (in. of H2O)	XREXP12	IREXP12	AREXP12	XREXP3	IREXP3	AREXP3
Left Exhaust Pressure (in. of H2O)	XLEXP12	ILEXP12	ALEXP12	XLEXP3	ILEXP3	ALEXP3
Differential Exhaust Pressure (in. of H2O)	XDFEXP12	IDFEXP12	ADFEXP12	XDFEXP3	IDFEXP3	ADFEXP3
Intake Vacuum (in. of Hg)	XINTV12	IINTV12	AINTV12	XINTV3	IINTV3	AINTV3
Intake Mixture Temperature (°F)	XINTMX12	IINTMX12	AINTMX12	XINTMX3	IINTMX3	AINTMX3
Crankcase Pressure (in. of H2O)	XCCASP12	ICCASP12	ACCASP12	XCCASP3	ICCASP3	ACCASP3
Percent Glycol Concentration	XPGLYC12	IPGLYC12	APGLYC12			

	STAGE I			STAGE II			STAGE III		
Jacket Out temperature (°F)	XCOLOUT1	ICOLOUT1	ACOLOUT1	XCOLOUT2	ICOLOUT2	ACOLOUT2	XCOLOUT3	ICOLOUT3	ACOLOUT3
Jacket In temperature (°F)	XCOLIN1	ICOLIN1	ACOLIN1	XCOLIN2	ICOLIN2	ACOLIN2	XCOLIN3	ICOLIN3	ACOLIN3
Crossover out temperature (°F)	XCOVTMP1	ICOVTMP1	ACOVTMP1	XCOVTMP2	ICOVTMP2	ACOVTMP2	XCOVTMP3	ICOVTMP3	ACOVTMP3

Glycol Contamination Data

Hours	0	14	30
Positive or Negative	GLYCH000	GLYCH014	GLYCH030

FIG. A16.7 Operational Summary

BLOWBY PLOT

Laboratory: *LAB*		EOT Date:	*DTCOMP*
Test Number: *STAND - STRUN - LABRUN*		EOT Time:	*EOTTIME*
Oil Code: *CMIR/OILCODE*			
Formulation/Stand Code: *FORM*			

Blowby Plot

BLOWBYIM

Test Hours / Blowby, cfm	Total Number of Blowby Readings: *TOTBLWBH*								
TESTH001									
BLWBH001									

Cold Cycle Blowby Average (0 - 30 hrs):	*ACBLRT12*	Hot Cycle Blowby Average (31 - 32 hrs):	*ACBLRT3*

FIG. A16.8 Blowby Plot

CRANKCASE PRESSURE PLOT FORM

Laboratory:	*LAB*	EOT Date:	*DTCOMP*
Test Number:	*STAND - STRUN - LABRUN*	EOT Time:	*EOTTIME*
Oil Code:	*CMIR/OILCODE*		
Formulation/Stand Code:	*FORM*		

Crankcase Pressure Plot

CCPRESIM

Test Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CCP	*CCP_H001*	*CCP_H002*	*CCP_H003*	*CCP_H004*	*CCP_H005*	*CCP_H006*	*CCP_H007*	*CCP_H008*	*CCP_H009*	*CCP_H010*	*CCP_H011*	*CCP_H012*	*CCP_H013*	*CCP_H014*	*CCP_H015*	*CCP_H016*
Test Hours	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
CCP	*CCP_H017*	*CCP_H018*	*CCP_H019*	*CCP_H020*	*CCP_H021*	*CCP_H022*	*CCP_H023*	*CCP_H024*	*CCP_H025*	*CCP_H026*	*CCP_H027*	*CCP_H028*	*CCP_H029*	*CCP_H030*	*CCP_H031*	*CCP_H032*

Cold Cycle CCP Average: *ACCASP12*	Cold Cycle CCP Maximum: *XCCASP12*

FIG. A16.9 Crankcase Pressure Plot

SEQUENCE IID RUST RATING WORKSHEET

Laboratory: *LAB*	EOT Date: *DTCOMP*
Test Number: *STAND - STRUN - LABRUN*	EOT Time: *EOTTIME*
Oil Code: *CMIR/OILCODE*	
Formulation/Stand Code: *FORM*	

Rated by: *RINIT*

No.[B]	Body	Plunger	Ball Check	Push Rod
1	*RBODR001*	*RPLGR001*	*RBCKR001*	*RPSHR001*
2	*RBODR002*	*RPLGR002*	*RBCKR002*	*RPSHR002*
3	*RBODR003*	*RPLGR003*	*RBCKR003*	*RPSHR003*
4	*RBODR004*	*RPLGR004*	*RBCKR004*	*RPSHR004*
5	*RBODR005*	*RPLGR005*	*RBCKR005*	*RPSHR005*
6	*RBODR006*	*RPLGR006*	*RBCKR006*	*RPSHR006*
7	*RBODR007*	*RPLGR007*	*RBCKR007*	*RPSHR007*
8	*RBODR008*	*RPLGR008*	*RBCKR008*	*RPSHR008*
9	*RBODR009*	*RPLGR009*	*RBCKR009*	*RPSHR009*
10	*RBODR010*	*RPLGR010*	*RBCKR010*	*RPSHR010*
11	*RBODR011*	*RPLGR011*	*RBCKR011*	*RPSHR011*
12	*RBODR012*	*RPLGR012*	*RBCKR012*	*RPSHR012*
13	*RBODR013*	*RPLGR013*	*RBCKR013*	*RPSHR013*
14	*RBODR014*	*RPLGR014*	*RBCKR014*	*RPSHR014*
15	*RBODR015*	*RPLGR015*	*RBCKR015*	*RPSHR015*
16	*RBODR016*	*RPLGR016*	*RBCKR016*	*RPSHR016*
Total	*TRBODR*	*TRPLGR*	*TRBCKR*	*TRPSHR*
Avg.	*LFTBDY*	*PLUNG*	*BALLS*	*PUSHRD*
Relief Valve	*RVPLUN*			

AVERAGE ENGINE RUST: *AER*

REMARKS *RUSTREM*

[B] This number should correspond to position in the engine for all parts (1 to 16 numbered from front to rear).

FIG. A16.10 Rust Rating Worksheet

SEQUENCE IID
CHARACTERISTICS OF THE DATA ACQUISITION SYSTEM

Laboratory: *LAB*	EOT Date: *DTCOMP*
Test Number: *STAND - STRUN - LABRUN*	EOT Time: *EOTTIME*
Oil Code: *CMIR/OILCODE*	
Formulation/Stand Code: *FORM*	

PARAMETER (1)	SENSING DEVICE (2)	CALIBRATION FREQUENCY (3)	RECORD DEVICE (4)	OBSERVATION FREQUENCY (5)	RECORD FREQUENCY (6)	LOG FREQUENCY (7)	SYSTEM RESPONSE (8)
Temperature							
Oil Filter Block	OFILSENS	OFILCALF	OFILRECD	OFILOBSF	OFILRECF	OFILLOGF	OFILSYSR
Fuel	FTEMSENS	FTEMCALF	FTEMRECD	FTEMOBSF	FTEMRECF	FTEMLOGF	FTEMSYSR
Breather Tube Gas Outlet	BGASSENS	BGASCALF	BGASRECD	BGASOBSF	BGASRECF	BGASLOGF	BGASSYSR
Breather Tube Coolant Outlet	BTCTSENS	BTCTCALF	BTCTRECD	BTCTOBSF	BTCTRECF	BTCTLOGF	BTCTSYSR
Coolant Outlet	COTSENS	COTCALF	COTRECD	COTOBSF	COTRECF	COTLOGF	COTSYSR
Coolant Intlet	CITSENS	CITCALF	CITRECD	CITOBSF	CITRECF	CITLOGF	CITSYSR
Carb Air	CARBSENS	CARBCALF	CARBRECD	CARBOBSF	CARBRECF	CARBLOGF	CARBSYSR
Intake Manifold Mixture	IMANSENS	IMANCALF	IMANRECD	IMANOBSF	IMANRECF	IMANLOGF	IMANSYSR
Rocker Cover Coolant Outlet	RCCTSENS	RCCTCALF	RCCTRECD	RCCTOBSF	RCCTRECF	RCCTLOGF	RCCTSYSR
Intake Manifold Coolant Crossover Outlet	IMCTSENS	IMCTCALF	IMCTRECD	IMCTOBSF	IMCTRECF	IMCTLOGF	IMCTSYSR
Pressure							
Crankcase	CRNKSENS	CRNKCALF	CRNKRECD	CRNKOBSF	CRNKRECF	CRNKLOGF	CRNKSYSR
Oil Pump Outlet	OPMPSENS	OPMPCALF	OPMPRECD	OPMPOBSF	OPMPRECF	OPMPLOGF	OPMPSYSR
Engine Filter Block	EOILSENS	EOILCALF	EOILRECD	EOILOBSF	EOILRECF	EOILLOGF	EOILSYSR
Carb Inlet Air	CRBISENS	CRBICALF	CRBIRECD	CRBIOBSF	CRBIRECF	CRBILOGF	CRBISYSR
Exhaust Back Pressure	EXPRSENS	EXPRCALF	EXPRRECD	EXPROBSF	EXPRRECF	EXPRLOGF	EXPRSYSR
Intake Vacuum	INTVSENS	INTVCALF	INTVRECD	INTVOBSF	INTVRECF	INTVLOGF	INTVSYSR
Rocker Cover Coolant Outlet	RCCPSENS	RCCPCALF	RCCPRECD	RCCPOBSF	RCCPRECF	RCCPLOGF	RCCPSYSR
Breather Tube Coolant Outlet	BTCPSENS	BTCPCALF	BTCPRECD	BTCPOBSF	BTCPRECF	BTCPLOGF	BTCPSYSR
Intake Manifold Exhaust Crossover	IMCPSENS	IMCPCALF	IMCPRECD	IMCPOBSF	IMCPRECF	IMCPLOGF	IMCPSYSR
Other							
AFR Measurement	AFRSENS	AFRCALF	AFRRECD	AFROBSF	AFRRECF	AFRLOGF	AFRSYSR
Blowby Gas	BLWGSENS	BLWGCALF	BLWGRECD	BLWGOBSF	BLWGRECF	BLWGLOGF	BLWGSYSR
Intake Air Humidity	IAHMSENS	IAHMCALF	IAHMRECD	IAHMOBSF	IAHMRECF	IAHMLOGF	IAHMSYSR
Load	LOADSENS	LOADCALF	LOADRECD	LOADOBSF	LOADRECF	LOADLOGF	LOADSYSR

LEGEND:
(1) OPERATING PARAMETER
(2) THE TYPE OF DEVICE USED TO MEASURE TEMPERATURE, PRESSURE OR FLOW
(3) FREQUENCY AT WHICH THE MEASUREMENT SYSTEM IS CALIBRATED
(4) THE TYPE OF DEVICE WHERE DATA IS RECORDED:
- LG - HANDLOG SHEET
- DL - AUTOMATIC DATA LOGGER
- SC - STRIP CHART RECORDER
- C/M - COMPUTER, USING MANUAL DATA ENTRY
- C/D - COMPUTER, USING DIRECT I/O ENTRY

(5) DATA ARE OBSERVED BUT ONLY RECORDED IF OFF SPEC.
(6) DATA ARE RECORDED BUT ARE NOT RETAINED AT EOT
(7) DATA ARE LOGGED AS PERMANENT RECORD, NOT SPECIFY IF:
- SS - SNAPSHOT TAKEN AT SPECIFIED FREQUENCY
- AG/X AVERAGE OF X DATA POINTS AT SPECIFIED FREQUENCY

(8) TIME FOR THE OUTPUT TO REACH 63.2% OF FINAL VALUE FOR STEP CHANGE AT INPUT

FIG. A16.11 Characteristics of the Data Acquisition System

6-feb-1996

Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
10	1	IID	VERSION	8	0	C	YYYYMMDD	IID VERSION 19960206
20	1	IID	TSTSPON1	40	0	C		TEST SPONSOR, FIRST LINE
30	1	IID	TSTSPON2	40	0	C		TEST SPONSOR, SECOND LINE
40	1	IID	LABVALID	1	0	C	V, I OR N	TEST LAB VALIDATION (V, I OR N)
50	1	IID	STAND	5	0	C		STAND
60	1	IID	STRUN	4	0	C		STAND RUN
70	1	IID	LABRUN	5	0	C		LAB RUN NUMBER
80	1	IID	DTCOMP	8	0	C	YYYYMMDD	COMPLETED DATE(YYYYMMDD)
90	1	IID	EOTTIME	5	0	C	HH:MM	COMPLETED TIME (HH:MM)
100	1	IID	OILCODE	38	0	C		NON-REFERENCE OIL CODE
110	1	IID	CMIR	6	0	C		CMIR
120	1	IID	FORM	38	0	C		FORMULATION/STAND CODE
130	1	IID	ALTCODE1	10	0	C		ALTERNATE OIL CODE 1
140	1	IID	ALTCODE2	10	0	C		ALTERNATE OIL CODE 2
150	1	IID	ALTCODE3	10	0	C		ALTERNATE OIL CODE 3
160	1	IID	OPVALID	8	0	C		OPERATIONAL VALIDITY - HAS/HAS NOT
170	1	IID	SUBLAB	40	0	C		SUBMITTED BY: TESTING LABORATORY
180	1	IID	SUBSIGIM	70	0	C		SUBMITTED BY: SIGNATURE IMAGE
190	1	IID	SUBNAME	40	0	C		SUBMITTED BY: SIGNATURE TYPED NAME
200	1	IID	SUBTITLE	40	0	C		SUBMITTED BY: TITLE
210	2	IID	LAB	2	0	C		LAB CODE
220	2	IID	SAEVISC	7	0	C		SAE VISCOSITY GRADE
230	2	IID	TESTLEN	3	0	Z	HOURS	TEST LENGTH(HOURS)
240	2	IID	FUELBTID	16	0	C		FUEL BATCH IDENTIFIER
250	2	IID	DTSTRT	8	0	C	YYYYMMDD	START DATE (YYYYMMDD)
260	2	IID	STRTTIME	5	0	C	HH:MM	START TIME (HH:MM)
270	2	IID	LABOCODE	12	0	C		LABORATORY INTERNAL OIL CODE
280	2	IID	ENGINENO	15	0	C		ENGINE NUMBER
290	2	IID	LFTBDY	6	2	N	MERITS	AVERAGE LIFTER BODY RUST (MERITS)
300	2	IID	PLUNG	6	2	N	MERITS	AVG LIFTER PLUNGER RUST (MERITS)
310	2	IID	BALLS	6	2	N	MERITS	AVG LIFTER BALLS RUST (MERITS)
320	2	IID	RVPLUN	6	2	N	MERITS	AVG RELIEF VALVE PLUNGER RUST (MERITS)
330	2	IID	PUSHRD	6	2	N	MERITS	AVG PUSHROD RUST (MERITS)
340	2	IID	AER	6	2	N	MERITS	AVG RUST RATING (MERITS)
350	2	IID	AERFNL	6	2	N	MERITS	FINAL AVG RUST RATING (MERITS)
360	2	IID	LFTSTK	2	0	N	#	NUMBER OF STUCK LIFTERS (#)
370	2	IID	RVSTK	5	0	C	STUCK/FREE	STUCK RELIEF VALVE (STUCK/FREE)
380	2	IID	OILCON	5	2	N	QT	OIL CONSUMPTION (QT)
390	2	IID	IND	6	0	C		TMC OIL CODE
400	2	IID	IAVGRST	7	3	N	MERITS	INDUSTRY AVG RUST RATING (MERITS)
410	3	IID	VNEW	8	2	N	CST	VISCOSITY OF NEW OIL (CST)
420	3	IID	AERCOR	6	2	N	MERITS	CORRECTED AVG RUST RATING (MERITS)
430	3	IID	AER_SA	6	2	N	MERITS	SEVERITY ADJUSTMENT AVG RUST RATING (MERITS)
440	4	IID	DWNOCR	2	0	Z		NUMBER OF DOWNTIME OCCURRENCES
450	4	IID	DOWNHxxx	5	0	C	HH:MM	DOWNTIME TEST HOURS (HH:MM)
460	4	IID	DDATHxxx	8	0	C	YYYYMMDD	DOWNTIME DATE (YYYYMMDD)
470	4	IID	DTIMHxxx	5	0	C	HH:MM	DOWNTIME TIME (HH:MM)
480	4	IID	DREAHxxx	60	0	C		DOWNTIME REASON
490	4	IID	TOTLDOWN	6	0	C	HHH:MM	DOWNTIME TIME TOTAL (HHH:MM)
500	4	IID	TOTCOM	3	0	Z		TOTAL LINES OF COMMENTS & OUTLIERS
510	4	IID	OCOMHxxx	70	0	C		OTHER DOWNTIME COMMENT XXX
520	5	IID	ENGSN	11	0	C		ENGINE NUMBER SERIAL NUMBER
530	5	IID	VALSPBAT	5	0	C		VALVE SPRINGS BATCH CODE

FIG. A16.12 Data Dictionary

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
540	5	IID	BRTHSN	11	0	C		BREATHER TUBE ID SERIAL NUMBER
550	5	IID	INVSLBAT	5	0	C		INTAKE VALVE SEALS BATCH CODE
560	5	IID	LFTCODE	5	0	C		LIFTER BATCH CODE
570	5	IID	LHEADSN	11	0	C		LEFT HEAD SERIAL NUMBER
580	5	IID	OILFIBAT	5	0	C		OIL FILTER BATCH CODE
590	5	IID	RHEADSN	11	0	C		RIGHT HEAD SERIAL NUMBER
600	5	IID	PISTBAT	5	0	C		PISTON BATCH CODE
610	5	IID	OILPSN	11	0	C		OIL PUMP ASSEMBLY ID SERIAL NUMBER
620	5	IID	PUSHBAT	5	0	C		PUSHROD BATCH CODE
630	5	IID	RVPSN	11	0	C		RELEIF VALVE PLUNGER ID SERIAL NUMBER
640	5	IID	RINGBAT	5	0	C		RING BATCH CODE
650	6	IID	PWRDP	5	1	N	%	ENGINE POWER CALCULATED DEVIATION % (%)
660	6	IID	BTOTDP	5	1	N	%	BREATHER TUBE COOLANT OUT TEMP CALC DEVIATION % (%)
670	6	IID	BTFLODP	5	1	N	%	BREATHER TUBE FLOW RATE CALCULATED DEVIATION % (%)
680	6	IID	ABTFLO12	5	1	N	GPM	AVERAGE BREATHER TUBE COOLANT FLOW STAGE I & II
690	6	IID	OILFBDP	5	1	N	%	OIL FILTER BLOCK TEMP CALCULATED DEVIATION % (%)
700	6	IID	COLOUTDP	5	1	N	%	COOLANT OUT TEMP CALCULATED DEVIATION % (%)
710	6	IID	COLFLODP	5	1	N	%	COOLANT FLOW RATE CALCULATED DEVIATION % (%)
720	6	IID	ACOLFLO	6	1	N		AVG ENGINE COOLANT FLOW RATE
730	6	IID	RPMDP	5	1	N	%	ENGINE SPEED CALCULATED DEVIATION % (%)
740	6	IID	COLINDP	5	1	N	%	COOLANT IN TEMP CALCULATED DEVIATION % (%)
750	6	IID	OILPPDP	5	1	N	%	OIL PUMP PRESSURE CALCULATED DEVIATION % (%)
760	6	IID	INMVACDP	5	1	N	%	INTAKE MANIFOLD VACUUM CALCULATED DEVIATION % (%)
770	6	IID	CARBDP	5	1	N	%	CARBURATOR PRESSURE CALCULATED DEVIATION % (%)
780	6	IID	ACARBP	5	2	N		AVG CARBURETOR PRESSURE
790	6	IID	RCFLODP	5	1	N	%	ROCKER COVER/CROSSOVER COOLANT FLOW RATE DEVIATION % (%)
800	6	IID	COLTPXDP	5	1	N	%	COOLANT TEMP.-CROSSOVER OUT CALCULATED DEVIATION PERCENT,(%)
810	6	IID	COLPRXDP	5	1	N	%	COOLANT PRESSURE-CROSSOVER OUT CALCULATED DEVIATION %, (%)
820	6	IID	LEXPDP	5	1	N	%	LEFT EXHAUST BACK PRESSURE CALCULATED DEVIATION % (%)
830	6	IID	REXPDP	5	1	N	%	RIGHT EXHAUST BACK PRESSURE CALCULATED DEVIATION % (%)
840	6	IID	LATFDP	5	1	N	%	LEFT AIR TO FUEL RATIO CALCULATED DEVIATION % (%)
850	6	IID	RATFDP	5	1	N	%	RIGHT AIR TO FUEL RATIO CALCULATED DEVIATION % (%)
860	7	IID	XRPM12	4	0	N	R/MIN	MAX ENGINE SPEED STAGE I & II (R/MIN)
870	7	IID	IRPM12	4	0	N	R/MIN	MIN ENGINE SPEED STAGE I & II (R/MIN)
880	7	IID	ARPM12	4	0	N	R/MIN	AVG ENGINE SPEED STAGE I & II (R/MIN)
890	7	IID	XRPM3	4	0	N	R/MIN	MAX ENGINE SPEED STAGE III (R/MIN)
900	7	IID	IRPM3	4	0	N	R/MIN	MIN ENGINE SPEED STAGE III (R/MIN)
910	7	IID	ARPM3	4	0	N	R/MIN	AVG ENGINE SPEED STAGE III (R/MIN)
920	7	IID	XPWR12	5	1	N	BHP	MAX ENGINE POWER STAGE I & II (BHP)
930	7	IID	IPWR12	5	1	N	BHP	MIN ENGINE POWER STAGE I & II(BHP)
940	7	IID	APWR12	5	1	N	BHP	AVG ENGINE POWER STAGE I & II(BHP)
950	7	IID	XPWR3	5	1	N	BHP	MAX ENGINE POWER STAGE III (BHP)
960	7	IID	IPWR3	5	1	N	BHP	MIN ENGINE POWER STAGE III (BHP)
970	7	IID	APWR3	5	1	N	BHP	AVG ENGINE POWER STAGE III (BHP)
980	7	IID	XOILTM12	6	1	N	°F	MAX FILTER BLOCK OIL TEMP STAGE 1 & II(°F)
990	7	IID	IOILTM12	6	1	N	°F	MIN FILTER BLOCK OIL TEMP STAGE 1 & II (°F)
1000	7	IID	AOILTM12	6	1	N	°F	AVG FILTER BLOCK OIL TEMP STAGE 1 & II(°F)
1010	7	IID	XOILTM3	6	1	N	°F	MAX FILTER BLOCK OIL TEMP STAGE III (°F)
1020	7	IID	IOILTM3	6	1	N	°F	MIN FILTER BLOCK OIL TEMP STAGE III (°F)
1030	7	IID	AOILTM3	6	1	N	°F	AVG FILTER BLOCK OIL TEMP STAGE III (°F)
1040	7	IID	XSUMPT12	6	1	N	°F	MAX SUMP OIL TEMP STAGE 1 & II(°F)
1050	7	IID	ISUMPT12	6	1	N	°F	MIN SUMP OIL TEMP STAGE 1 & II (°F)
1060	7	IID	ASUMPT12	6	1	N	°F	AVG SUMP OIL TEMP STAGE 1 & II (°F)
1070	7	IID	XSUMPT3	6	1	N	°F	MAX SUMP OIL TEMP STAGE III (°F)

FIG. A16.12 *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
1080	7	IID	ISUMPT3	6	1	N	°F	MIN SUMP OIL TEMP STAGE III (°F)
1090	7	IID	ASUMPT3	6	1	N	°F	AVG SUMP OIL TEMP STAGE III (°F)
1100	7	IID	XOPMPP12	5	1	N	PSIG	MAX PUMP OIL PRESSURE STAGE I & II (PSIG)
1110	7	IID	IOPMPP12	5	1	N	PSIG	MIN PUMP OIL PRESSURE STAGE I & II(PSIG)
1120	7	IID	AOPMPP12	5	1	N	PSIG	AVG PUMP OIL PRESSURE STAGE I & II (PSIG)
1130	7	IID	XOPMPP3	5	1	N	PSIG	MAX PUMP OIL PRESSURE STAGE III (PSIG)
1140	7	IID	IOPMPP3	5	1	N	PSIG	MIN PUMP OIL PRESSURE STAGE III (PSIG)
1150	7	IID	AOPMPP3	5	1	N	PSIG	AVG PUMP OIL PRESSURE STAGE III (PSIG)
1160	7	IID	XENOPR12	5	1	N	PSIG	MAX ENGINE OIL PRESSURE STAGE I & II (PSIG)
1170	7	IID	IENOPR12	5	1	N	PSIG	MIN ENGINE OIL PRESSURE STAGE I & II (PSIG)
1180	7	IID	AENOPR12	5	1	N	PSIG	AVG ENGINE OIL PRESSURE STAGE I & II (PSIG)
1190	7	IID	XENOPR3	5	1	N	PSIG	MAX ENGINE OIL PRESSURE STAGE III (PSIG)
1200	7	IID	IENOPR3	5	1	N	PSIG	MIN ENGINE OIL PRESSURE STAGE III (PSIG)
1210	7	IID	AENOPR3	5	1	N	PSIG	AVG ENGINE OIL PRESSURE STAGE III (PSIG)
1220	7	IID	XCOLFL12	5	1	N	GPM	MAX ENGINE COOLANT FLOW RATE STAGE I & II (GPM)
1230	7	IID	ICOLFL12	5	1	N	GPM	MIN ENGINE COOLANT FLOW RATE STAGE I & II (GPM)
1240	7	IID	ACOLFL12	5	1	N	GPM	AVG ENGINE COOLANT FLOW RATE STAGE I & II (GPM)
1250	7	IID	XCOLFL3	5	1	N	GPM	MAX ENGINE COOLANT FLOW RATE STAGE III (GPM)
1260	7	IID	ICOLFL3	5	1	N	GPM	MIN ENGINE COOLANT FLOW RATE STAGE III (GPM)
1270	7	IID	ACOLFL3	5	1	N	GPM	AVG ENGINE COOLANT FLOW RATE STAGE III (GPM)
1280	7	IID	XBTOT12	5	1	N	°F	MAX BREATHER TUBE OUT TEMP STAGE 1 & II (°F)
1290	7	IID	IBTOT12	5	1	N	°F	MIN BREATHER TUBE OUT TEMP STAGE 1 & II (°F)
1300	7	IID	ABTOT12	5	1	N	°F	AVG BREATHER TUBE OUT TEMP STAGE 1 & II (°F)
1310	7	IID	XBTOT3	5	1	N	°F	MAX BREATHER TUBE OUT TEMP STAGE III (°F)
1320	7	IID	IBTOT3	5	1	N	°F	MIN BREATHER TUBE OUT TEMP STAGE III (°F)
1330	7	IID	ABTOT3	5	1	N	°F	AVG BREATHER TUBE OUT TEMP STAGE III (°F)
1340	7	IID	XLCOUT12	6	1	N	°F	MAX LEFT ROCKER COVER COOLANT OUT TEMP STAGE I & II (°F)
1350	7	IID	ILCOUT12	6	1	N	°F	MIN LEFT ROCKER COVER COOLANT OUT TEMP STAGE I & II (°F)
1360	7	IID	ALCOUT12	6	1	N	°F	AVG LEFT ROCKER COVER COOLANT OUT TEMP STAGE I & II (°F)
1370	7	IID	XLCOUT3	6	1	N	°F	MAX LEFT ROCKER COVER COOLANT OUT TEMP STAGE III (°F)
1380	7	IID	ILCOUT3	6	1	N	°F	MIN LEFT ROCKER COVER COOLANT OUT TEMP STAGE III (°F)
1390	7	IID	ALCOUT3	6	1	N	°F	AVG LEFT ROCKER COVER COOLANT OUT TEMP STAGE III (°F)
1400	7	IID	XRCOUT12	6	1	N	°F	MAX RIGHT ROCKER COVER COOLANT OUT TEMP STAGE I & II (°F)
1410	7	IID	IRCOUT12	6	1	N	°F	MIN RIGHT ROCKER COVER COOLANT OUT TEMP STAGE I & II (°F)
1420	7	IID	ARCOUT12	6	1	N	°F	AVG RIGHT ROCKER COVER COOLANT OUT TEMP STAGE I & II (°F)
1430	7	IID	XRCOUT3	6	1	N	°F	MAX RIGHT ROCKER COVER COOLANT OUT TEMP STAGE III (°F)
1440	7	IID	IRCOUT3	6	1	N	°F	MIN RIGHT ROCKER COVER COOLANT OUT TEMP STAGE III (°F)
1450	7	IID	ARCOUT3	6	1	N	°F	AVG RIGHT ROCKER COVER COOLANT OUT TEMP STAGE III (°F)
1460	7	IID	XRCFLO12	5	1	N	GPM	MAXIMUM RIGHT COVER FLOW
1470	7	IID	IRCFLO12	5	1	N	GPM	MINIMUM RIGHT COVER COOLANT FLOW
1480	7	IID	ARCFLO12	5	1	N	GPM	AVERAGE RIGHT COVER COOLANT FLOW
1490	7	IID	XRCFLO3	5	1	N	GPM	AVERAGE RIGHT COVER COOLANT FLOW STAGE III
1500	7	IID	IRCFLO3	5	1	N	GPM	MINIMUM RIGHT COVER COOLANT FLOW STAGE III
1510	7	IID	ARCFLO3	5	1	N	GPM	AVERAGE RIGHT COVER COOLANT FLOW STAGE III
1520	7	IID	XLCFLO12	5	1	N	GPM	MAXIMUM LEFT COVER COOLANT FLOW STAGE I & II
1530	7	IID	ILCFLO12	5	1	N	GPM	MINIMUM LEFT COVER COOLANT FLOW STAGE I & II
1540	7	IID	ALCFLO12	5	1	N	GPM	AVERAGE LEFT COVER COOLANT FLOW STAGE I & II
1550	7	IID	XLCFLO3	5	1	N	GPM	MAXIMUM LEFT COVER COOLANT FLOW STAGE III
1560	7	IID	ILCFLO3	5	1	N	GPM	MINIMUM LEFT COVER COOLANT FLOW STAGE III
1570	7	IID	ALCFLO3	5	1	N	GPM	AVERAGE LEFT COVER COOLANT FLOW STAGE III
1580	7	IID	XBTFLO12	5	1	N	GPM	MAXIMUM BREATHER TUBE COOLANT FLOW STAGE I & II
1590	7	IID	IBTFLO12	5	1	N	GPM	MINIMUM BREATHER TUBE COOLANT FLOW STAGE I & II
1600	7	IID	XBTFLO3	5	1	N	GPM	MAXIMUM BREATHER TUBE COOLANT FLOW STAGE III
1610	7	IID	IBTFLO3	5	1	N	GPM	MINIMUM BREATHER TUBE COOLANT FLOW STAGE III

FIG. A16.12 *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
1620	7	IID	ABTFLO3	5	1	N	GPM	AVERAGE BREATHER TUBE COOLANT FLOW STAGE III
1630	7	IID	XCCFLO12	5	1	N	GPM	MAX COOLANT CROSSOVER FLOW RATE STAGE I & II (GPM)
1640	7	IID	ICCFLO12	5	1	N	GPM	MIN COOLANT CROSSOVER FLOW RATE STAGE I & II (GPM)
1650	7	IID	ACCFLO12	5	1	N	GPM	AVG COOLANT CROSSOVER FLOW RATE STAGE I & II (GPM)
1660	7	IID	XCPREO12	5	1	N	PSI	MAXIMUM COOLANT CROSSOVER PRESSURE OUT STAGE I & II(PSI)
1670	7	IID	ICPREO12	5	1	N	PSI	MINIMUM COOLANT CROSSOVER PRESSURE OUT STAGE I & II(PSI)
1680	7	IID	ACPREO12	5	1	N	PSI	AVERAGE COOLANT CROSSOVER PRESSURE OUT STAGE I & II(PSI)
1690	7	IID	XAFR12	5	1	N		MAX AIR TO FUEL RATIO STAGE I & II
1700	7	IID	IAFR12	5	1	N		MIN AIR TO FUEL RATIO STAGE I & II
1710	7	IID	AAFR12	5	1	N		AVG AIR TO FUEL RATIO STAGE I & II
1720	7	IID	XAFR3	5	1	N		MAX AIR TO FUEL RATIO STAGE III
1730	7	IID	IAFR3	5	1	N		MIN AIR TO FUEL RATIO STAGE III
1740	7	IID	AAFR3	5	1	N		AVG AIR TO FUEL RATIO STAGE III
1750	7	IID	XFINL12	5	1	N	°F	MAX FUEL INLET TEMPERATURE STAGE I & II (°F)
1760	7	IID	IFINL12	5	1	N	°F	MIN FUEL INLET TEMPERATURE STAGE I & II (°F)
1770	7	IID	AFINL12	5	1	N	°F	AVG FUEL INLET TEMPERATURE STAGE I & II (°F)
1780	7	IID	XFINL3	5	1	N	°F	MAX FUEL INLET TEMPERATURE STAGE III (°F)
1790	7	IID	IFINL3	5	1	N	°F	MIN FUEL INLET TEMPERATURE STAGE III (°F)
1800	7	IID	AFINL3	5	1	N	°F	AVG FUEL INLET TEMPERATURE STAGE III (°F)
1810	7	IID	XAIRTP12	5	1	N	°F	MAX CARB AIR TEMP STAGE I & II (°F)
1820	7	IID	IAIRTP12	5	1	N	°F	MIN CARB AIR TEMP STAGE I & II (°F)
1830	7	IID	AAIRTP12	5	1	N	°F	AVG CARB AIR TEMP STAGE I & II(°F)
1840	7	IID	XAIRTP3	5	1	N	°F	MAX CARB AIR TEMP STAGE III (°F)
1850	7	IID	IAIRTP3	5	1	N	°F	MIN CARB AIR TEMP STAGE III (°F)
1860	7	IID	AAIRTP3	5	1	N	°F	AVG CARB AIR TEMP STAGE III (°F)
1870	7	IID	XAIRHM12	5	1	N	GRAINS/LB	MAX CARB AIR SPECIFIC HUMIDITY STAGE I & II (GRAINS/LB)
1880	7	IID	IAIRHM12	5	1	N	GRAINS/LB	MIN CARB AIR SPECIFIC HUMIDITY STAGE I & II (GRAINS/LB)
1890	7	IID	AAIRHM12	5	1	N	GRAINS/LB	AVG CARB AIR SPECIFIC HUMIDITY STAGE I & II (GRAINS/LB)
1900	7	IID	XAIRHM3	5	1	N	GRAINS/LB	MAX CARB AIR SPECIFIC HUMIDITY STAGE III (GRAINS/LB)
1910	7	IID	IAIRHM3	5	1	N	GRAINS/LB	MIN CARB AIR SPECIFIC HUMIDITY STAGE III (GRAINS/LB)
1920	7	IID	AAIRHM3	5	1	N	GRAINS/LB	AVG CARB AIR SPECIFIC HUMIDITY STAGE III (GRAINS/LB)
1930	7	IID	XINAP12	5	2	N	in. H2O GAGE	MAX CARB AIR PRESSURE STAGE I & II (in. H2O GAGE)
1940	7	IID	IINAP12	5	2	N	in. H2O GAGE	MIN CARB AIR PRESSURE STAGE I & II (in. H2O GAGE)
1950	7	IID	AINAP12	5	2	N	in. H2O GAGE	AVG CARB AIR PRESSURE STAGE I & II (in. H2O GAGE)
1960	7	IID	XINAP3	5	2	N	in. H2O GAGE	MAX CARB AIR PRESSURE STAGE III (in. H2O GAGE)
1970	7	IID	IINAP3	5	2	N	in. H2O GAGE	MIN CARB AIR PRESSURE STAGE III (in. H2O GAGE)
1980	7	IID	AINAP3	5	2	N	in. H2O GAGE	AVG CARB AIR PRESSURE STAGE III (in. H2O GAGE)
1990	7	IID	XAMBAT12	5	1	N	°F	MAX AMBIENT AIR TEMP STAGE I & II (°F)
2000	7	IID	IAMBAT12	5	1	N	°F	MIN AMBIENT AIR TEMP STAGE I & II (°F)
2010	7	IID	AAMBAT12	5	1	N	°F	AVG AMBIENT AIR TEMP STAGE I & II (°F)
2020	7	IID	XAMBAT3	5	1	N	°F	MAX AMBIENT AIR TEMP STAGE III (°F)
2030	7	IID	IAMBAT3	5	1	N	°F	MIN AMBIENT AIR TEMP STAGE III (°F)
2040	7	IID	AAMBAT3	5	1	N	°F	AVG AMBIENT AIR TEMP STAGE III (°F)
2050	7	IID	XBGAST12	5	1	N	°F	MAX BLOWBY GAS TEMP STAGE I & II (°F)
2060	7	IID	IBGAST12	5	1	N	°F	MIN BLOWBY GAS TEMP STAGE I & II (°F)
2070	7	IID	ABGAST12	5	1	N	°F	AVG BLOWBY GAS TEMP STAGE I & II(°F)
2080	7	IID	XBGAST3	5	1	N	°F	MAX BLOWBY GAS TEMP STAGE III (°F)
2090	7	IID	IBGAST3	5	1	N	°F	MIN BLOWBY GAS TEMP STAGE III (°F)
2100	7	IID	ABGAST3	5	1	N	°F	AVG BLOWBY GAS TEMP STAGE III (°F)
2110	7	IID	XCBLRT12	5	2	N	CFM	MAX CORRECTED BLOWBY FLOW RATE STAGE I & II (CFM)
2120	7	IID	ICBLRT12	5	2	N	CFM	MIN CORRECTED BLOWBY FLOW RATE STAGE I & II (CFM)
2130	7	IID	ACBLRT12	5	2	N	CFM	AVG CORRECTED BLOWBY FLOW RATE STAGE I & II (CFM)
2140	7	IID	XCBLRT3	5	2	N	CFM	MAX CORRECTED BLOWBY FLOW RATE STAGE III (CFM)
2150	7	IID	ICBLRT3	5	2	N	CFM	MIN CORRECTED BLOWBY FLOW RATE STAGE III (CFM)

FIG. A16.12 *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
2160	7	IID	ACBLRT3	5	2	N	CFM	AVG CORRECTED BLOWBY FLOW RATE STAGE III (CFM)
2170	7	IID	XREXP12	5	2	N	IN. H2O	MAX RIGHT EXHAUST PRESSURE STAGE I & II(IN. H2O)
2180	7	IID	IREXP12	5	2	N	IN. H2O	MIN RIGHT EXHAUST PRESSURE STAGE I & II (IN. H2O)
2190	7	IID	AREXP12	5	2	N	IN. H2O	AVG RIGHT EXHAUST PRESSURE STAGE I & II (IN. H2O)
2200	7	IID	XREXP3	5	2	N	IN. H2O	MAX RIGHT EXHAUST PRESSURE STAGE III (IN. H2O)
2210	7	IID	IREXP3	5	2	N	IN. H2O	MIN RIGHT EXHAUST PRESSURE STAGE III (IN. H2O)
2220	7	IID	AREXP3	5	2	N	IN. H2O	AVG RIGHT EXHAUST PRESSURE STAGE III (IN. H2O)
2230	7	IID	XLEXP12	5	2	N	IN. H2O	MAX LEFT EXHAUST PRESSURE STAGE I & II (IN. H2O)
2240	7	IID	ILEXP12	5	2	N	IN. H2O	MIN LEFT EXHAUST PRESSURE STAGE I & II (IN. H2O)
2250	7	IID	ALEXP12	5	2	N	IN. H2O	AVG LEFT EXHAUST PRESSURE STAGE I & II (IN. H2O)
2260	7	IID	XLEXP3	5	2	N	IN. H2O	MAX LEFT EXHAUST PRESSURE STAGE III (IN. H2O)
2270	7	IID	ILEXP3	5	2	N	IN. H2O	MIN LEFT EXHAUST PRESSURE STAGE III (IN. H2O)
2280	7	IID	ALEXP3	5	2	N	IN. H2O	AVG LEFT EXHAUST PRESSURE STAGE III (IN. H2O)
2290	7	IID	XDFEXP12	5	2	N	IN. H2O	MAX DIFFERENTIAL EXHAUST PRESSURE STAGE I & II (IN. H2O)
2300	7	IID	IDFEXP12	5	2	N	IN. H2O	MIN DIFFERENTIAL EXHAUST PRESSURE STAGE I & II (IN. H2O)
2310	7	IID	ADFEXP12	5	2	N	IN. H2O	AVG DIFFERENTIAL EXHAUST PRESSURE STAGE I & II (IN. H2O)
2320	7	IID	XDFEXP3	5	2	N	IN. H2O	MAX DIFFERENTIAL EXHAUST PRESSURE STAGE III (IN. H2O)
2330	7	IID	IDFEXP3	5	2	N	IN. H2O	MIN DIFFERENTIAL EXHAUST PRESSURE STAGE III (IN. H2O)
2340	7	IID	ADFEXP3	5	2	N	IN. H2O	AVG DIFFERENTIAL EXHAUST PRESSURE STAGE III (IN. H2O)
2350	7	IID	XINTV12	5	1	N	in. Hg gage	MAX INTAKE MANIFOLD VACUUM STAGE I & II(in. Hg gage)
2360	7	IID	IINTV12	5	1	N	in. Hg gage	MIN INTAKE MANIFOLD VACUUM STAGE I & II (in. Hg gage)
2370	7	IID	AINTV12	5	1	N	in. Hg gage	AVG INTAKE MANIFOLD VACUUM STAGE I & II(in. Hg gage)
2380	7	IID	XINTV3	5	1	N	in. Hg gage	MAX INTAKE MANIFOLD VACUUM STAGE III (in. Hg gage)
2390	7	IID	IINTV3	5	1	N	in. Hg gage	MIN INTAKE MANIFOLD VACUUM STAGE III (in. Hg gage)
2400	7	IID	AINTV3	5	1	N	in. Hg gage	AVG INTAKE MANIFOLD VACUUM STAGE III (in. Hg gage)
2410	7	IID	XINTMX12	5	1	N	°F	MAX INTAKE MIXTURE TEMP. STAGE I & II (°F)
2420	7	IID	IINTMX12	5	1	N	°F	MIN INTAKE MIXTURE TEMP. STAGE I & II (°F)
2430	7	IID	AINTMX12	5	1	N	°F	AVG INTAKE MIXTURE TEMP. STAGE I & II (°F)
2440	7	IID	XINTMX3	5	1	N	°F	MAX INTAKE MIXTURE TEMP. STAGE 3 (°F)
2450	7	IID	IINTMX3	5	1	N	°F	MIN INTAKE MIXTURE TEMP. STAGE 3 (°F)
2460	7	IID	AINTMX3	5	1	N	°F	AVG INTAKE MIXTURE TEMP. STAGE 3 (°F)
2470	7	IID	XCCASP12	6	2	N	in. H2O GAGE	MAX CRANKCASE PRESSURE STAGE I & II (in. H2O GAGE)
2480	7	IID	ICCASP12	6	2	N	in. H2O GAGE	MIN CRANKCASE PRESSURE STAGE I & II (in. H2O GAGE)
2490	7	IID	ACCASP12	6	2	N	in. H2O GAGE	AVG CRANKCASE PRESSURE STAGE I & II (in. H2O GAGE)
2500	7	IID	XCCASP3	6	2	N	in. H2O GAGE	MAX CRANKCASE PRESSURE STAGE III (in. H2O GAGE)
2510	7	IID	ICCASP3	6	2	N	in. H2O GAGE	MIN CRANKCASE PRESSURE STAGE III (in. H2O GAGE)
2520	7	IID	ACCASP3	6	2	N	in. H2O GAGE	AVG CRANKCASE PRESSURE STAGE III (in. H2O GAGE)
2530	7	IID	XPGLYC12	6	2	N	PERCENT	MAXIMUM GLYCOL CONCENTRATION STAGE I & II (PERCENT)
2540	7	IID	IPGLYC12	6	2	N	PERCENT	MINIMUM GLYCOL CONCENTRATION STAGE I & II (PERCENT)
2550	7	IID	APGLYC12	6	2	N	PERCENT	AVERAGE GLYCOL CONCENTRATION STAGE I & II (PERCENT)
2560	7	IID	XCOLOUT1	5	1	N	°F	MAX ENGINE COOLANT OUT TEMP STAGE I (°F)
2570	7	IID	ICOLOUT1	5	1	N	°F	MIN ENGINE COOLANT OUT TEMP STAGE I (°F)
2580	7	IID	ACOLOUT1	5	1	N	°F	AVG ENGINE COOLANT OUT TEMP STAGE I (°F)
2590	7	IID	XCOLOUT2	5	1	N	°F	MAX ENGINE COOLANT OUT TEMP STAGE II (°F)
2600	7	IID	ICOLOUT2	5	1	N	°F	MIN ENGINE COOLANT OUT TEMP STAGE II (°F)
2610	7	IID	ACOLOUT2	5	1	N	°F	AVG ENGINE COOLANT OUT TEMP STAGE II (°F)
2620	7	IID	XCOLOUT3	5	1	N	°F	MAX ENGINE COOLANT OUT TEMP STAGE III (°F)
2630	7	IID	ICOLOUT3	5	1	N	°F	MIN ENGINE COOLANT OUT TEMP STAGE III (°F)
2640	7	IID	ACOLOUT3	5	1	N	°F	AVG ENGINE COOLANT OUT TEMP STAGE III (°F)
2650	7	IID	XCOLIN1	6	1	N	°F	MAX ENGINE COOLANT IN TEMP STAGE I (°F)
2660	7	IID	ICOLIN1	6	1	N	°F	MIN ENGINE COOLANT IN TEMP STAGE I (°F)
2670	7	IID	ACOLIN1	6	1	N	°F	AVG ENGINE COOLANT IN TEMPERATURE STAGE I (°F)
2680	7	IID	XCOLIN2	6	1	N	°F	MAX ENGINE COOLANT IN TEMP STAGE II (°F)
2690	7	IID	ICOLIN2	6	1	N	°F	MIN ENGINE COOLANT IN TEMP STAGE II (°F)

FIG. A16.12 *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
2700	7	IID	ACOLIN2	6	1	N	°F	AVG ENGINE COOLANT IN TEMPERATURE STAGE II (°F)
2710	7	IID	XCOLIN3	6	1	N	°F	AVG ENGINE COOLANT IN TEMPERATURE STAGE III (°F)
2720	7	IID	ICOLIN3	6	1	N	°F	AVG ENGINE COOLANT IN TEMPERATURE STAGE III (°F)
2730	7	IID	ACOLIN3	6	1	N	°F	AVG ENGINE COOLANT IN TEMPERATURE STAGE III (°F)
2740	7	IID	XCOVTMP1	5	1	N	°F	MAX COOLANT CROSSOVER OUT TEMP STAGE I (°F)
2750	7	IID	ICOVTMP1	5	1	N	°F	MIN COOLANT CROSSOVER OUT TEMP STAGE I (°F)
2760	7	IID	ACOVTMP1	5	1	N	°F	AVG COOLANT CROSSOVER OUT TEMP STAGE I (°F)
2770	7	IID	XCOVTMP2	5	1	N	°F	MAX COOLANT CROSSOVER OUT TEMP STAGE II (°F)
2780	7	IID	ICOVTMP2	5	1	N	°F	MIN COOLANT CROSSOVER OUT TEMP STAGE II (°F)
2790	7	IID	ACOVTMP2	5	1	N	°F	AVG COOLANT CROSSOVER OUT TEMP STAGE II (°F)
2800	7	IID	XCOVTMP3	5	1	N	°F	MAX COOLANT CROSSOVER OUT TEMP STAGE III (°F)
2810	7	IID	ICOVTMP3	5	1	N	°F	MIN COOLANT CROSSOVER OUT TEMP STAGE III (°F)
2820	7	IID	ACOVTMP3	5	1	N	°F	AVG COOLANT CROSSOVER OUT TEMP STAGE III (°F)
2830	7	IID	GLYCHxxx	8	0	C		GLYCOL CONTAMINATION HOURS POSITIVE/NEGATIVE
2840	8	IID	BLOWBYIM	70	0	C		BLOWBY PLOT IMAGE
2850	8	IID	TOTBLWBH	2	0	N		TOTAL NUMBER OF BLOWBY READINGS
2860	8	IID	TESTHxxx	5	1	N	HOURS	TEST HOURS XXX FOR BLOWBY(HOURS)
2870	8	IID	BLWBHxxx	5	2	N	CFM	TEST BLOWBY AT HOURS XXX (CFM)
2880	9	IID	CCPRESIM	70	0	C		CRANKCASE PRESSURE PLOT IMAGE
2890	9	IID	CCP_Hxxx	6	2	N	IN. H2O	TEST CRANKCASE PRESSURE AT HOURS XXX (IN. H2O)
2900	10	IID	RINIT	3	0	C		RATERS INITIALS
2910	10	IID	RBODRxxx	6	2	N		RUST RATING BODY NO. XXX
2920	10	IID	RPLGRxxx	6	2	N		RUST RATING PLUNGER NO. XXX
2930	10	IID	RBCKRxxx	6	2	N		RUST RATING BALL CHECK NO. XXX
2940	10	IID	RPSHRxxx	6	2	N		RUST RATING PUSHROD NO. XXX
2950	10	IID	TRBODR	7	2	N		TOTAL RUST RATING BODY
2960	10	IID	TRPLGR	7	2	N		TOTAL RUST RATING PLUNGER
2970	10	IID	TRBCKR	7	2	N		TOTAL RUST RATING BALL CHECK
2980	10	IID	TRPSHR	7	2	N		TOTAL RUST RATING PUSHROD
2990	10	IID	RUSTREM	70	0	C		RUST RATING REMARKS/COMMENTS
3000	11	IID	OFILSENS	10	0	C		OIL FILTER BLOCK TEMPERATURE SENSING DEVICE
3010	11	IID	OFILCALF	10	0	C		OIL FILTER BLOCK TEMPERATURE CALIBRATION FREQUENCY
3020	11	IID	OFILRECD	3	0	C		OIL FILTER BLOCK TEMPERATURE RECORD DEVICE
3030	11	IID	OFILOBSF	10	0	C		OIL FILTER BLOCK TEMPERATURE OBSERVATION FREQUENCY
3040	11	IID	OFILRECF	10	0	C		OIL FILTER BLOCK TEMPERATURE RECORD FREQUENCY
3050	11	IID	OFILLOGF	9	0	C		OIL FILTER BLOCK TEMPERATURE LOG FREQUENCY
3060	11	IID	OFILSYSR	8	0	C		OIL FILTER BLOCK TEMPERATURE SYSTEM RESPONCE
3070	11	IID	FTEMSENS	10	0	C		FUEL TEMPERATURE SENSING DEVICE
3080	11	IID	FTEMCALF	10	0	C		FUEL TEMPERATURE CALIBRATION FREQUENCY
3090	11	IID	FTEMRECD	3	0	C		FUEL TEMPERATURE RECORD DEVICE
3100	11	IID	FTEMOBSF	10	0	C		FUEL TEMPERATURE OBSERVATION FREQUENCY
3110	11	IID	FTEMRECF	10	0	C		FUEL TEMPERATURE RECORD FREQUENCY
3120	11	IID	FTEMLOGF	9	0	C		FUEL TEMPERATURE LOG FREQUENCY
3130	11	IID	FTEMSYSR	8	0	C		FUEL TEMPERATURE SYSTEM RESPONCE
3140	11	IID	BGASSENS	10	0	C		BREATHER TUBE GAS OUTLET SENSING DEVICE
3150	11	IID	BGASCALF	10	0	C		BREATHER TUBE GAS OUTLET CALIBRATION FREQUENCY
3160	11	IID	BGASRECD	3	0	C		BREATHER TUBE GAS OUTLET RECORD DEVICE
3170	11	IID	BGASOBSF	10	0	C		BREATHER TUBE GAS OUTLET OBSERVATION FREQUENCY
3180	11	IID	BGASRECF	10	0	C		BREATHER TUBE GAS OUTLET RECORD FREQUENCY
3190	11	IID	BGASLOGF	9	0	C		BREATHER TUBE GAS OUTLET LOG FREQUENCY
3200	11	IID	BGASSYSR	8	0	C		BREATHER TUBE GAS OUTLET SYSTEM RESPONCE
3210	11	IID	BTCTSENS	10	0	C		BREATHER TUBE COOLANT OUTLET SENSING DEVICE
3220	11	IID	BTCTCALF	10	0	C		BREATHER TUBE COOLANT OUTLET CALIBRATION FREQUENCY
3230	11	IID	BTCTRECD	3	0	C		BREATHER TUBE COOLANT OUTLET RECORD DEVICE

FIG. A16.12 *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
3240	11	IID	BTCTOBSF	10	0	C		BREATHER TUBE COOLANT OUTLET OBSERVATION FREQUENCY
3250	11	IID	BTCTRECF	10	0	C		BREATHER TUBE COOLANT OUTLET RECORD FREQUENCY
3260	11	IID	BTCTLOGF	9	0	C		BREATHER TUBE COOLANT OUTLET LOG FREQUENCY
3270	11	IID	BTCTSYSR	8	0	C		BREATHER TUBE COOLANT OUTLET SYSTEM RESPONCE
3280	11	IID	COTSENS	10	0	C		COOLANT OUT TEMPERATURE SENSING DEVICE
3290	11	IID	COTCALF	10	0	C		COOLANT OUT TEMPERATURE CALIBRATION FREQUENCY
3300	11	IID	COTRECD	3	0	C		COOLANT OUT TEMPERATURE RECORD DEVICE
3310	11	IID	COTOBSF	10	0	C		COOLANT OUT TEMPERATURE OBSERVATION FREQUENCY
3320	11	IID	COTRECF	10	0	C		COOLANT OUT TEMPERTURE RECORD FREQUENCY
3330	11	IID	COTLOGF	9	0	C		COOLANT OUT TEMPERATURE LOG FREQUENCY
3340	11	IID	COTSYSR	8	0	C		COOLANT OUT TEMPERATURE SYSTEM RESPONCE
3350	11	IID	CITSENS	10	0	C		COOLANT IN TEMPERATURE SENSING DEVICE
3360	11	IID	CITCALF	10	0	C		COOLANT IN TEMPERATURE CALIBRATION FREQUENCY
3370	11	IID	CITRECD	3	0	C		COOLANT IN TEMPERATURE RECORD DEVICE
3380	11	IID	CITOBSF	10	0	C		COOLANT IN TEMPERATURE OBSERVATION FREQUENCY
3390	11	IID	CITRECF	10	0	C		COOLANT IN TEMPERATURE RECORD FREQUENCY
3400	11	IID	CITLOGF	9	0	C		COOLANT IN TEMPERATURE LOG FREQUENCY
3410	11	IID	CITSYSR	8	0	C		COOLANT IN TEMPERATURE SYSTEM RESPONCE
3420	11	IID	CARBSENS	10	0	C		CARB AIR SENSING DEVICE
3430	11	IID	CARBCALF	10	0	C		CARB AIR CALIBRATION FREQUENCY
3440	11	IID	CARBRECD	3	0	C		CARB AIR RECORD DEVICE
3450	11	IID	CARBOBSF	10	0	C		CARB AIR OBSERVATION FREQUENCY
3460	11	IID	CARBRECF	10	0	C		CARB AIR RECORD FREQUENCY
3470	11	IID	CARBLOGF	9	0	C		CARB AIR LOG FREQUENCY
3480	11	IID	CARBSYSR	8	0	C		CARB AIR SYSTEM RESPONCE
3490	11	IID	IMANSENS	10	0	C		INTAKE MANIFOLD TEMPERATURE SENSING DEVICE
3500	11	IID	IMANCALF	10	0	C		INTAKE MANIFOLD TEMPERATURE CALIBRATION FREQUENCY
3510	11	IID	IMANRECD	3	0	C		INTAKE MANIFOLD TEMPERATURE RECORD DEVICE
3520	11	IID	IMANOBSF	10	0	C		INTAKE MANIFOLD TEMPERATURE OBSERVATION FREQUENCY
3530	11	IID	IMANRECF	10	0	C		INTAKE MANIFOLD TEMPERATURE RECORD FREQUENCY
3540	11	IID	IMANLOGF	9	0	C		INTAKE MANIFOLD TEMPERATURE LOG FREQUENCY
3550	11	IID	IMANSYSR	8	0	C		INTAKE MANIFOLD TEMPERATURE SYSTEM RESPONCE
3560	11	IID	RCCTSENS	10	0	C		ROCKER COVER COOLANT OUTLET SENSING DEVICE
3570	11	IID	RCCTCALF	10	0	C		ROCKER COVER COOLANT OUTLET CALIBRATION FREQUENCY
3580	11	IID	RCCTRECD	3	0	C		ROCKER COVER COOLANT OUTLET RECORD DEVICE
3590	11	IID	RCCTOBSF	10	0	C		ROCKER COVER COOLANT OUTLET OBSERVATION FREQUENCY
3600	11	IID	RCCTRECF	10	0	C		ROCKER COVER COOLANT OUTLET RECORD FREQUENCY
3610	11	IID	RCCTLOGF	9	0	C		ROCKER COVER COOLANT OUTLET LOG FREQUENCY
3620	11	IID	RCCTSYSR	8	0	C		ROCKER COVER COOLANT OUTLET SYSTEM RESPONCE
3630	11	IID	IMCTSENS	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET SENSING DEVICE
3640	11	IID	IMCTCALF	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET CAL. FREQUENCY
3650	11	IID	IMCTRECD	3	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET RECORD DEVICE
3660	11	IID	IMCTOBSF	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET OBS. FREQUENCY
3670	11	IID	IMCTRECF	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET REC. FREQUENCY
3680	11	IID	IMCTLOGF	9	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET LOG FREQUENCY
3690	11	IID	IMCTSYSR	8	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET SYS. RESPONCE
3700	11	IID	CRNKSENS	10	0	C		CRANKCASE SENSING DEVICE
3710	11	IID	CRNKCALF	10	0	C		CRANKCASE CALIBRATION FREQUENCY
3720	11	IID	CRNKRECD	3	0	C		CRANKCASE RECORD DEVICE
3730	11	IID	CRNKOBSF	10	0	C		CRANKCASE OBSERVATION FREQUENCY
3740	11	IID	CRNKRECF	10	0	C		CRANKCASE RECORD FREQUENCY
3750	11	IID	CRNKLOGF	9	0	C		CRANKCASE LOG FREQUENCY
3760	11	IID	CRNKSYSR	8	0	C		CRANKCASE SYSTEM RESPONSE
3770	11	IID	OPMPSENS	10	0	C		OIL PUMP OUTLET SENSING DEVICE

FIG. A16.12 *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
3780	11	IID	OPMPCALF	10	0	C		OIL PUMP OUTLET CALIBRATION FREQUENCY
3790	11	IID	OPMPRECD	3	0	C		OIL PUMP OUTLET RECORD DEVICE
3800	11	IID	OPMPOBSF	10	0	C		OIL PUMP OUTLET OBSERVATION FREQUENCY
3810	11	IID	OPMPRECF	10	0	C		OIL PUMP OUTLET RECORD FREQUENCY
3820	11	IID	OPMPLOGF	9	0	C		OIL PUMP OUTLET LOG FREQUENCY
3830	11	IID	OPMPSYSR	8	0	C		OIL PUMP OUTLET SYSTEM RESPONSE
3840	11	IID	EOILSENS	10	0	C		ENGINE OIL PRESSURE SENSING DEVICE
3850	11	IID	EOILCALF	10	0	C		ENGINE OIL PRESSURE CALIBRATION FREQUENCY
3860	11	IID	EOILRECD	3	0	C		ENGINE OIL PRESSURE RECORD DEVICE
3870	11	IID	EOILOBSF	10	0	C		ENGINE OIL PRESSURE OBSERVATION FREQUENCY
3880	11	IID	EOILRECF	10	0	C		ENGINE OIL PRESSURE RECORD FREQUENCY
3890	11	IID	EOILLOGF	9	0	C		ENGINE OIL PRESSURE LOG FREQUENCY
3900	11	IID	EOILSYSR	8	0	C		ENGINE OIL PRESSURE SYSTEM RESPONSE
3910	11	IID	CRBISENS	10	0	C		CARB INLET AIR SENSING DEVICE
3920	11	IID	CRBICALF	10	0	C		CARB INLET AIR CALIBRATION FREQUENCY
3930	11	IID	CRBIRECD	3	0	C		CARB INLET AIR RECORD DEVICE
3940	11	IID	CRBIOBSF	10	0	C		CARB INLET AIR OBSERVATION FREQUENCY
3950	11	IID	CRBIRECF	10	0	C		CARB INLET AIR RECORD FREQUENCY
3960	11	IID	CRBILOGF	9	0	C		CARB INLET AIR LOG FREQUENCY
3970	11	IID	CRBISYSR	8	0	C		CARB INLET AIR SYSTEM RESPONSE
3980	11	IID	EXPRSENS	10	0	C		EXHAUST PRESSURE SENSING DEVICE
3990	11	IID	EXPRCALF	10	0	C		EXHAUST PRESSURE CALIBRATION FREQUENCY
4000	11	IID	EXPRRECD	3	0	C		EXHAUST PRESSURE RECORD DEVICE
4010	11	IID	EXPROBSF	10	0	C		EXHAUST PRESSURE OBSERVATION FREQUENCY
4020	11	IID	EXPRRECF	10	0	C		EXHAUST PRESSURE RECORD FREQUENCY
4030	11	IID	EXPRLOGF	9	0	C		EXHAUST PRESSURE LOG FREQUENCY
4040	11	IID	EXPRSYSR	8	0	C		EXHAUST PRESSURE SYSTEM RESPONSE
4050	11	IID	INTVSENS	10	0	C		INTAKE VACUUM SENSING DEVICE
4060	11	IID	INTVCALF	10	0	C		INTAKE VACUUM CALIBRATION FREQUENCY
4070	11	IID	INTVRECD	3	0	C		INTAKE VACUUM RECORD DEVICE
4080	11	IID	INTVOBSF	10	0	C		INTAKE VACUUM OBSERVATION FREQUENCY
4090	11	IID	INTVRECF	10	0	C		INTAKE VACUUM RECORD FREQUENCY
4100	11	IID	INTVLOGF	9	0	C		INTAKE VACUUM LOG FREQUENCY
4110	11	IID	INTVSYSR	8	0	C		INTAKE VACUUM SYSTEM RESPONSE
4120	11	IID	RCCPSENS	10	0	C		ROCKER COVER COOLANT OUTLET SENSING DEVICE
4130	11	IID	RCCPCALF	10	0	C		ROCKER COVER COOLANT OUTLET CALIBRATION FREQUENCY
4140	11	IID	RCCPRECD	3	0	C		ROCKER COVER COOLANT OUTLET RECORD DEVICE
4150	11	IID	RCCPOBSF	10	0	C		ROCKER COVER COOLANT OUTLET OBSERVATION FREQUENCY
4160	11	IID	RCCPRECF	10	0	C		ROCKER COVER COOLANT OUTLET RECORD FREQUENCY
4170	11	IID	RCCPLOGF	9	0	C		ROCKER COVER COOLANT OUTLET LOG FREQUENCY
4180	11	IID	RCCPSYSR	8	0	C		ROCKER COVER COOLANT OUTLET SYSTEM RESPONSE
4190	11	IID	BTCPSENS	10	0	C		BREATHER TUBE COOLANT OUTLET SENSING DEVICE
4200	11	IID	BTCPCALF	10	0	C		BREATHER TUBE COOLANT OUTLET CAL. FREQUENCY
4210	11	IID	BTCPRECD	3	0	C		BREATHER TUBE COOLANT OUTLET RECORD DEVICE
4220	11	IID	BTCPOBSF	10	0	C		BREATHER TUBE COOLANT OUTLET OBS. FREQUENCY
4230	11	IID	BTCPRECF	10	0	C		BREATHER TUBE COOLANT OUTLET REC. FREQUENCY
4240	11	IID	BTCPLOGF	9	0	C		BREATHER TUBE COOLANT OUTLET LOG FREQUENCY
4250	11	IID	BTCPSYSR	8	0	C		BREATHER TUBE COOLANT OUTLET SYS. RESPONCE
4260	11	IID	IMCPSENS	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET SENSING DEVICE
4270	11	IID	IMCPCALF	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET CAL. FREQUENCY
4280	11	IID	IMCPRECD	3	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET RECORD DEVICE
4290	11	IID	IMCPOBSF	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET OBS. FREQUENCY
4300	11	IID	IMCPRECF	10	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET REC. FREQUENCY
4310	11	IID	IMCPLOGF	9	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET LOG FREQUENCY

FIG. A16.12 *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Unit Of Measure	Description
4320	11	IID	IMCPSYSR	8	0	C		INTAKE MANIFOLD COOLANT CROSSOVER OUTLET SYS. RESPONCE
4330	11	IID	AFRSENS	10	0	C		AFR MEASUREMENT SENSING DEVICE
4340	11	IID	AFRCALF	10	0	C		AFR MEASUREMENT CALIBRATION FREQUENCY
4350	11	IID	AFRRECD	3	0	C		AFR MEASUREMENT RECORD DEVICE
4360	11	IID	AFROBSF	10	0	C		AFR MEASUREMENT OBSERVATION FREQUENCY
4370	11	IID	AFRRECF	10	0	C		AFR MEASUREMENT RECORD FREQUENCY
4380	11	IID	AFRLOGF	9	0	C		AFR MEASUREMENT LOG FREQUENCY
4390	11	IID	AFRSYSR	8	0	C		AFR MEASUREMENT SYSTEM RESPONSE
4400	11	IID	BLWGSENS	10	0	C		BLOWBY GAS SENSING DEVICE
4410	11	IID	BLWGCALF	10	0	C		BLOWBY GAS CALIBRATION FREQUENCY
4420	11	IID	BLWGRECD	3	0	C		BLOWBY GAS RECORD DEVICE
4430	11	IID	BLWGOBSF	10	0	C		BLOWBY GAS OBSERVATION FREQUENCY
4440	11	IID	BLWGRECF	10	0	C		BLOWBY GAS RECORD FREQUENCY
4450	11	IID	BLWGLOGF	9	0	C		BLOWBY GAS LOG FREQUENCY
4460	11	IID	BLWGSYSR	8	0	C		BLOWBY GAS SYSTEM RESPONSE
4470	11	IID	IAHMSENS	10	0	C		AIR HUMIDITY SENSING DEVICE
4480	11	IID	IAHMCALF	10	0	C		AIR HUMIDITY CALIBRATION FREQUENCY
4490	11	IID	IAHMRECD	3	0	C		AIR HUMIDITY RECORD DEVICE
4500	11	IID	IAHMOBSF	10	0	C		AIR HUMIDITY OBSERVATION FREQUENCY
4510	11	IID	IAHMRECF	10	0	C		AIR HUMIDITY RECORD FREQUENCY
4520	11	IID	IAHMLOGF	9	0	C		AIR HUMIDITY LOG FREQUENCY
4530	11	IID	IAHMSYSR	8	0	C		AIR HUMIDITY SYSTEM RESPONSE
4540	11	IID	LOADSENS	10	0	C		LOAD SENSING DEVICE
4550	11	IID	LOADCALF	10	0	C		LOAD CALIBRATION FREQUENCY
4560	11	IID	LOADRECD	3	0	C		LOAD RECORD DEVICE
4570	11	IID	LOADOBSF	10	0	C		LOAD OBSERVATION FREQUENCY
4580	11	IID	LOADRECF	10	0	C		LOAD RECORD FREQUENCY
4590	11	IID	LOADLOGF	9	0	C		LOAD LOG FREQUENCY
4600	11	IID	LOADSYSR	8	0	C		LOAD SYSTEM RESPONSE

FIG. A16.12 *(continued)*

APPENDIX

(Nonmandatory Information)

X1. TEST MONITORING CENTER INFORMATION LETTERS

X1.1 Occasionally, it is necessary to revise the test method, and notify the industry of the revision, prior to obtaining normal ASTM consensus. In such a case, the Test Monitoring Center immediately issues an Information Letter to the industry. Subsequently, the Information Letter is balloted by Subcommittee D02.B (generally, just prior to each semiannual Committee D-2 meeting), followed by a ballot of the Main Committee members. By this means, the Society due process procedures are applied to an Information Letter.

X1.2 The Test Monitoring Center receives assistance in the issue of an Information Letter, particularly from the test method's Surveillance Panel and the test developer (the representative of the engine manufacturer, whose engine is used in the test method).

X1.3 Authority for the issuance of Information Letters was given by the ASTM Committee on Technical Committee Operations in 1984, as follows:
"COTCO recognizes that D-2 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 should be moved to such consensus as rapidly as possible."