Designation: D 6681 – 01

An American National Standard

Standard Test Method for Evaluation of Engine Oils in a High Speed, Single-Cylinder Diesel Engine—Caterpillar 1P Test Procedure[1]

This standard is issued under the fixed designation D 6681; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Any properly equipped laboratory without outside assistance can use the test method described in this standard. However, the ASTM Test Monitoring Center (TMC)[2] provides calibration oils and an assessment of the test results obtained on those oils by the laboratory. By this means the laboratory will know whether their use of the test method gives results statistically similar to those obtained by other laboratories. Furthermore, various agencies require that a laboratory utilize the TMC services in seeking qualification of oils against specifications. For example, the U.S. Army has such a requirement in some of its engine oil specifications. Accordingly, this test method is written for those laboratories that use the TMC services. Laboratories that choose not to use these services should ignore those portions of the test method that refer to the TMC. Information Letters issued periodically by the TMC may modify this method.[3] In addition, the TMC may issue supplementary memoranda related to the test method.

1. Scope

1.1 This test method is required to evaluate the performance of engine oils intended to satisfy certain American Petroleum Institute (API) C service categories (included in Specification D 4485). It is performed in a laboratory using a standardized high-speed, single-cylinder diesel engine.[4] Piston and ring groove deposit-forming tendency and oil consumption is measured. The piston, the rings, and the liner are also examined for distress and the rings for mobility.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 *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.* Being an engine test method, this standard does have definite hazards that require safe practices (see Appendix X2 on Safety).

1.4 The following is the Table of Contents:

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.B0.02 on Heavy Duty Engine Oils.

Current edition approved June 10, 2001. Published October 2001.

[2] ASTM Test Monitoring Ctr., 6555 Penn Ave., Pittsburgh, PA 15206–4489.

[3] This edition incorporates revisions contained in all information letters through 99-1. Users of this test method shall contact the ASTM Test Monitoring Center to obtain the most recent information letters.

[4] Available from Caterpillar Inc., Engine System Technology Development, P.O. Box 610, Mossville, IL 61552-0610.

2. Referenced Documents

2.1 *ASTM Standards:*

D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure[5]

D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester[5]

D 97 Test Method for Pour Point of Petroleum Products[5]

D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[5]

D 235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)[6]

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)[5]

D 482 Test Method for Ash from Petroleum Products[5]

D 524 Test Method for Ramsbottom Carbon Residue of Petroleum Products[5]

D 613 Test Method for Cetane Number of Diesel Fuel Oil[7]

D 664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration[5]

D 1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption[5]

D 2274 Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)[5]

D 2425 Test Method for Hydrocarbon Types in Middle Distillates by Mass Spectrometry[5]

D 2500 Test Method for Cloud Point of Petroleum Products[5]

D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry[5]

D 2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge[5]

D 3227 Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)[5]

D 3524 Test Method for Diesel Fuel Diluent in Used Diesel Engine Oils by Gas Chromatography[8]

D 4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants[8]

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[8]

D 4485 Specification for Performance of Engine Oils[8]

D 4739 Test Method for Base Number Determination by Potentiometric Titration[8]

D 4863 Test Method for Determination of Lubricity of Two-Stroke-Cycle Gasoline Engine Lubricants[8]

D 5185 Test Method for Determination of Additive Elements, Wear Metals and Contaminants in Used Lubricating Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)[8]

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[8]

D 5844 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Rusting (Sequence IID)[9]

D 5862 Test Method for Evaluation of Engine Oils in the

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

[6] *Annual Book of ASTM Standards*, Vol 06.04.

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

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

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

Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine[9]

D 6202 Test Method for Automotive Engine Oils on the Fuel Economy of Passenger Cars and Light-Duty Trucks in the Sequence VIA Spark-Ignition Engine[9]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[10]

E 344 Terminology Relating to Thermometry and Hydrometry[11]

G 40 Terminology Relating to Wear and Erosion[12]

2.2 *SAE Standard:*

SAE J183 Engine Oil Performance and Engine Service Classification[13]

2.3 *API Standard:*

API 1509 Engine Service Classification and Guide to Crankcase Oil Selection[14]

3. Terminology

3.1 *Definitions:*

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

3.1.2 *automotive*, *adj*—descriptive of equipment associated with self-propelled machinery, usually vehicles driven by internal combustion engines. **D 4485**

3.1.3 *blind reference oil*, *n*—- a reference oil, the identity of which is unknown by the test facility. **D 5844**

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

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

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

3.1.6 *calibrated test stand*, *n*—a test stand on which the testing of reference material(s), conducted as specified in the standard, provided acceptable test results. **Sub. B Glossary**[15]

3.1.6.1 *Discussion*—In several automotive lubricant standard test methods, the ASTM Test Monitoring Center provides testing guidance and determines acceptability.

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

3.1.7.1 *Discussion*—These oils are mainly submitted for testing as *candidates* to satisfy a specified performance; hence the designation of the term.

3.1.8 *debris*, *n—in internal combustion engines*, solid contaminant materials unintentionally introduced into the engine or resulting from wear. **D 5862**

3.1.9 *disperant*, *n—in engine oil*, an additive that reduces deposits on oil-wetted surfaces primarily through suspension of particles. **D 4175**

3.1.10 *engine oil*, *n*—a liquid that reduces friction or wear, or both, between the moving parts within an engine; removes heat, particularly from the underside of pistons; and serves as a combustion gas sealant for the piston rings. **D 5862**

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

3.1.11 *heavy-duty*, *adj—in internal combustion engine operation*, characterized by average speeds, power output, and internal temperatures that are close to the potential maximums. **D 4485**

3.1.12 *lubricant*, *n*—any material interposed between two surfaces that reduces the friction or wear, or both, between them. **D 5862**

3.1.13 *lubricating oil*, *n*—a liquid lubricant, usually comprising several ingredients, including a major portion of base oil and minor portions of various additives. **Sub. B Glossary**[15]

3.1.14 *oxidation*, *n—of engine oil*, the reaction of the oil with an electron acceptor, generally oxygen, that can produce deleterious acidic or resinous materials often manifested as sludge formation, varnish formation, viscosity increase, or corrosion, or a combination thereof. **Sub. B Glossary**[15]

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

3.1.16 *purchaser*, *n—of an ASTM test*, person or organization that pays for the conduct of an ASTM test method on a specified product. **D 6202**

3.1.17 *reference oil*, *n*—an oil of known performance characteristics, used as a basis for comparison. **D 5844**

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

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

3.1.19 *scuff, scuffing*, *n—in lubrication*, damage caused by instantaneous localized welding between surfaces in relative motion that does not result in immobilization of the parts. **D 4863**

3.1.20 *sponsor*, *n—of an ASTM test method*, an organization that is responsible for ensuring supply of the apparatus used in the test procedure portion of the test method. **Sub. B Glossary**[15]

3.1.20.1 *Discussion*—In some instances, such as a test method for chemical analysis, an ASTM working group can be the sponsor of the test method. In other instances, a company with a self-interest may or may not be the developer of the test procedure used within the method, but is the sponsor of the test method.

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

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

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

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

[13] Available from the Society of Automotive Engineers Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

[14] Available from the American Petroleum Institute, 1220 L Street NW, Washington D.C., 20005.

[15] Available from the Test Monitoring Center (TMC), 6555 Penn Avenue, Pittsburgh, PA 15206–4489.

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

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

3.1.23.1 *Discussion*—Wear generally occurs between two surfaces moving relative to each other, and is the result of mechanical or chemical action, or by a combination of mechanical and chemical actions.

4. Summary of Test Method

4.1 Prior to each test, the power section of the engine is disassembled, solvent-cleaned, measured, and rebuilt in strict accordance with the specifications. A new piston, ring assembly, and cylinder liner are measured and installed for each test. The engine crankcase is solvent-cleaned and worn or defective parts are replaced. The test stand is equipped with feedback control systems for fuel rate, engine speed, and other engine operating conditions. A suitable system for filtering, compressing, humidifying, and heating the inlet air shall be provided along with a system for controlling the engine exhaust pressure. Test operations involve the control of the single-cylinder diesel test engine for a total of 360 h at specified speeds and fuel rate input using the test oil as a lubricant. A defined break-in precedes each test and is also used when restarting an engine. At the end of the test, the piston deposits are rated, the piston, rings and liners are photographed, inspected and measured, oil consumption is calculated and the oil is analyzed to determine the test results. Critical engine conditions are statistically analyzed to determine if the test was precisely operated. Test acceptability parameters for each calibration test are also statistically analyzed to determine if the engine/test stand produce the specified results.

5. Significance and Use

5.1 This is an accelerated engine oil test, performed in a standardized, calibrated, stationary single-cylinder diesel engine that gives a measure of (*1*) piston and ring groove deposit forming tendency, (*2*) piston, ring and liner scuffing and (*3*) oil consumption. The test is used in the establishment of diesel engine oil specification requirements as cited in Specification D 4485 for appropriate API Performance Category C oils (API 1509). The test method can also be used in diesel engine oil development.

6. Apparatus and Installation

6.1 The test engine is an electronically controlled, direct injection, in-head camshaft, single-cylinder diesel engine with a four-valve arrangement. The engine has a 137.2 mm bore and a 165.1 mm stroke resulting in a displacement of 2.4 L.

6.1.1 The electronic control module (ECM) defines the desired engine fuel timing, monitors and limits maximum engine speed, maximum engine power, minimum oil pressure, and, optionally, maximum engine crankcase pressure. The ECM also controls the fuel injection duration that defines the engine fuel rate based on set conditions from the test cell feedback control systems. The oil pressure is also set by the ECM with signals to the 1Y3867 engine air pressure controller (Mamac) to modulate the facility air supply to the 1Y3898 Johnson Controls relief valve.

6.1.2 The 1Y3700 engine arrangement also consists of inlet air piping and hoses from the cylinder head to the air barrel and exhaust piping and bellows from the cylinder head to the exhaust barrel that are specifically designed for oil testing.[16]

6.2 Equip the engine test stand with the following accessories or equipment:

6.2.1 *Intake Air System*—The intake air system components from the cylinder head to the air barrel are a part of the basic 1Y3700 engine arrangement. These components consisting of an adapter, elbow, hose, clamps, and flanged tube can be found in the 1Y3700 Parts Book.[17]

6.2.1.1 The 1Y3978 intake air barrel (which is almost identical to the exhaust barrel except for the top cover) has been specifically designed and shall be purchased from one of the three approved manufacturers.[18] Install the intake air barrel at the location shown in Annex A7. Do not add insulation to the barrel.

6.2.1.2 Paint the inside of the intake air piping with Caterpillar yellow primer or red Glyptal prior to installation.[19]

6.2.1.3 Install the air heater elements in the intake air barrel as specified in Annex A7 (even if they will not be supplied with electricity).[20]

6.2.1.4 Use an air filter capable of 10 µ (or smaller) filtration.

6.2.1.5 Use a Sierra Model 780 airflow meter with Feature 1 = F6, Feature 2 = CG and calibration temperature = 60°C to measure intake airflow for each calibration test.[21] Annex A4 shows the piping requirements for the installation of the Sierra Model 780 airflow meter.

6.2.1.6 Measure the inlet air temperature at the location shown in Annex A2. Measure the inlet air pressure at the air barrel as shown in Annex A7. The location of the 1Y3977 humidity probe is shown in Annex A8. The sample line may require insulation to prevent dropping below dew point temperature and shall not be hygroscopic. Drain taps may be installed at the low points of the combustion air system.

6.2.1.7 Use feedback-equipped controls to maintain filtered, compressed, and humidified inlet air at the conditions specified in Annex A12.

6.2.2 *Exhaust System*—The exhaust system components from the cylinder head to the exhaust barrel are part of the basic 1Y3700 engine arrangement. These components consisting of an adapter, elbow, bellows, flange, and clamps can be found in the 1Y3700 Parts Book.

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[16] See the Caterpillar Service Manual. Available from Caterpillar Inc., Engine System Technology Development, P.O. Box 610, Mossville, IL 61552-0610.

[17] Available from Caterpillar Inc., Engine System Technology Development, P.O. Box 610, Mossville, IL 61552-0610.

[18] Cimino Machinery Corp., 5958 South Central Ave., Chicago, IL 60638; Gaspar Inc., 4106 Mahoning Rd. N.E., Canton, OH 44705; M.L. Wyrick Welding, 2301 Zanderson Highway 16 N, Jourdanton, TX 78026.

[19] Crankcase Paint Primer: BASF Coating and Colorant Div., P.O. Box 1297, Morganton, NC 28655. (Primer No.A123590 and BASF Part No.U27YD005, Yellow CAT Primer Part No.IE2083A.)

[20] Watlow Air Heaters, Chicago, IL 708-490-3900.

[21] Sierra Instruments, Inc., 5 Harris Ct., Monterey, CA 93940.

6.2.2.1 The 1Y3976 exhaust barrel (which is almost identical to the intake barrel except for the top cover) has been specifically designed and shall be purchased from one of the three approved manufacturers.[11] Install the exhaust barrel at the location shown in Annex A7. Do not add insulation to the barrel.

6.2.2.2 Install a restriction valve downstream from the exhaust barrel. The distance between the valve and barrel is not specified. The location of the exhaust thermocouple is shown in Annex A2. Measure the exhaust pressure at the exhaust barrel shown in Annex A7.

6.2.2.3 Use feedback-equipped controls to maintain the exhaust gases at the pressure specified in Annex A12.

6.2.3 *Fuel System*—The fuel system schematic is shown in Annex A5. Desired fuel injection timing is controlled by the engine computer at 13° BTC. Measure the fuel rate using micro motion device with a 90 kg/h maximum range scaled to the 1P operation range specified in Annex A12.[22] Use the day tank specified in Annex A5. Measure fuel temperature at the fuel filter base as shown in Annex A2 and control it using the cell facility feedback system. Use the required fuel heat exchanger(s) and arrange them as specified in Annex A5. Use the Fisher regulator specified in Annex A5.

6.2.4 *Oil Consumption System*—Use an oil scale system to accurately measure oil consumption (see Figs. A6.2 and A6.3). The oil scale system shall have a resolution as listed in Annex A2. Use flexible hoses similar to Aeroquip flexible hose, FC352-08, to-and-from the oil scale reservoir to eliminate measurement errors.[23] Use No.5 TFE-fluorocarbon, steel-braided hoses to and from the oil scale pumps. The hose length to-and-from the oil scale cart shall not exceed 2.7 m. Use the special oil pan adapter described in Fig. A6.4. The flow rates for the oil consumption oil scale pumps shall be 23.6-24.9 kg/h for the oil being pumped from the oil pan to the oil scale, and 16.3-17.7 kg/h for the oil being pumped from the oil scale to the oil pan. See Annex A6 for the procedure to verify these flow rates.

6.2.5 *Engine Oil System*—A schematic of the oil system is shown in Fig. A6.1. Measure oil pressure at the engine oil manifold (see Annex A2). An engine oil pressure sensor transmits a signal to the ECM that maintains oil pressure at 415 kPa. The ECM transmits a signal to an engine-mounted Mamac air pressure controller. The Mamac modulates the facility air pressure of 280 kPa to levels that vary between 0 to 140 kPa and directs it to the normally closed Johnson Controls relief valve. Because the engine oil pressure sensor calibration may vary from the cell data acquisition transducer, vary the oil pressure adjust signal to the ECM to maintain the oil pressure at the test specifications. See the Electronic Installation and Operation manual for additional information. The ECM maintains the oil pressure regardless of engine speed. Measure the oil temperatures at locations shown in Annex A2.

6.2.5.1 *Oil Heating System*—Use an external oil heating system provided by the test facility to maintain the engine oil manifold temperature specified in Annex A12. An example system is shown in Appendix X1. A special 1Y3908 oil cooler bonnet has been designed to allow separate fluids to the engine coolant tower arrangement (see Fig. A6.9). Plug the 1Y3660 oil cooler adapter and 1Y3908 heat exchanger bonnet as shown in Annex A6. Use Paratherm NF for the heating fluid.[24] The temperature of the Paratherm NF is measured by the thermocouple shown in Annex A2.

6.2.5.2 *Oil Sample Valve*—Refer to Annex A2 for the installation location and component makeup of the oil sample valve. Use of alternate equivalent components for the sample valve is permitted.

6.2.6 *Engine Coolant System*—The coolant system schematic is shown in Annex A3. Control the coolant temperature out of the engine using a cell facility feedback system. Use a 1Y3898 Johnson Controls valve or equivalent fail-open valve to regulate the coolant temperature out of the engine as shown by the schematic in Annex A3. If the 1Y3898 Johnson valve is used, supply facility air pressure at 280 kPa to the controller that regulates air pressure to the valve at 0-140 kPa. Install a feedback-equipped control system to pneumatically adjust the valve. Remove the 1Y3832 hose originally supplied with the engine and install a sight glass using the components shown in Annex A3.

6.2.7 *Engine Instrumentation*—Use feedback-equipped systems to control the engine operating temperatures, pressures, and flow rates. Measure the engine operating conditions at the locations shown in Annex A2. For temperature measurements, use thermocouples 1Y468 (intake air), 1Y467 (engine exhaust) and 1Y466 (fluids-water, oil, and fuel) or equivalent thermocouples as specified in Annex A2. Instrument measurement and reporting resolutions are shown in Annex A2.

6.2.8 A dynamometer with feedback control to maintain engine load and speed. Use a starting system capable of at least 136 Nm breakaway and 102 Nm sustained torque at 200 r/min.

6.2.9 Compressed air at 35 kPa to the top of the coolant tower as specified in Annex A3 to ensure water does not boil out of the antifreeze mixture and result in less heat rejection from the engine.

6.2.10 Measure engine blowby down stream of the engine breather housing by measuring the delta pressure across an orifice or an equivalent device.

6.2.11 The crankcase pressure is above atmospheric pressure with this engine arrangement. Measure it at the location shown in Annex A2.

6.3 Obtain information concerning the test engine, engine electronics system, new engine parts, replacement parts, and permissible substitution or replacement parts from Caterpillar, Inc.

6.4 Engine and parts warranty information can be found in Annex A1. Use the form listed in Annex A9 for returning defective parts.

7. Reagents and Materials

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on

[22] Micro Motion, Inc. 7070 Winchester Circle, Boulder, CO 80301.

[23] Aeroquip Industrial Div, 1225 W. Main Street, Van Wert, OH 45891.

[24] Paratherm NF Oil, Conshohocken, PA 19428.

Analytical Reagents of the American Chemical Society where such specifications are available.[25] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Diesel Piston Rating Booth*, as described by CRC Manual 18.[26]

7.3 *Diesel Piston Rating Lamp*, as described by CRC Manual 18.

7.4 *Dispersant Engine Cleaner.*[27]

7.5 *Engine Coolant*—Use a mixture of 50 % mineral-free water and 50 % Caterpillar brand coolant (P/N 8C684 for 1 gal or 8C3686 for 55 gal drum) for engine coolant. Mineral-free water is defined as water having a mineral content no higher than 34.2 ppm total dissolved solids. The coolant mixture may be reused for up to 1600 h. Keep the mixture at a 50:50 ratio as determined by using either Caterpillar testers 5P3514 or 5PO957 or an equivalent tester. Keep the coolant mixture contamination free. Total solids shall remain below 5000 ppm. Keep the additive level correct using Caterpillar test kit P/N 8T5296.

7.6 *Lead Shot*, commercial grade, approximately 5 mm in diameter.

7.7 *Light Grease*.

7.8 *Mobil EF-411*, as supplied by Mobil for engine assembly and calibration of the oil scale pump flow rates.[28]

7.9 *Paratherm NF*, as supplied by Paratherm and used as the fluid to heat the engine oil.[24]

7.10 *Pentane (Solvent)*, 99 + %, high-performance, liquid chromatography grade.

7.11 *Reference Oil*, as supplied by the TMC for calibration of the test stand.

7.12 *REO 217*, as supplied by the CRC and used when any copper components are changed.

7.13 *Sodium Bisulfate ($NaHSO_4$)*, commercial grade.

7.14 *Stoddard Solvent*, Specification D 235, Part 1.

7.15 *Test Fuel*—The specified test fuel is Specified Fuels & Chemicals LSRD-4 diesel test fuel. The specifications are shown in Annex A14.

7.16 *Test Oil*—The total amount of oil needed for each lubricant test is approximately 42 L.

7.17 *Trisodium Phosphate (Na_3PO_4)*, commercial grade.

7.18 *5.4000 in. Ring Bore Standard Class Z Master.*[29]

8. Oil Samples

8.1 Take a 250 mL purge sample at 48, 72, 120, 144, 168, 192, 216, 264, 312 and 336 h. Following removal of the purge sample, remove a 30 mL sample, then add 317 ± 10 g of new oil. It is not necessary to perform analysis on these 30 mL samples. Use the purge sample to return to the full mark. At 0 (new), 24, 96, 240, 288 and 360 h, take a 250 mL purge sample. Following removal of the purge sample, remove a 90 mL sample and add 370 ± 10 g of new oil. Analyze all 90 mL samples for 100 and 40 °C viscosity by Test Method D 445, TBN by Test Method D 4739, TAN by Test Method D 664, and the wear metals Al, Cr, Cu, Fe, Pb, Si by Test Method D 5185. Analyze the 24, 240, and 360 hour samples for fuel dilution by Test Method D 3524. See Figs. A6.7 and A6.8 for two graphical examples and a sample worksheet.

9. Preparation of Apparatus

9.1 *General Engine Assembly Practices*—As a part of good laboratory practice, inspect all components and assemblies that are exposed when the engine is disassembled and record the information for future reference. Inspect valve train components, bearings, journals, housings, seals and gaskets, and so forth and replace as needed. Assemble the engine with components and bolt torques as specified in the 1Y3700 engine Service Manual (see Annex A10 for a partial list). It is the intent of this procedure for all engine assemblies and adjustments to be targeted to the mean of the specified values. Clean and lubricate the components in keeping with good assembly practices. Keep airborne dirt and debris to a minimum in the assembly area. Maintain standard engine assembly techniques and practices (such as staggering piston ring gap positions, and so forth).

9.2 *Complete Engine Inspection*—Perform a complete engine inspection at intervals of 13 000 h. Ensure that wearing surfaces such as main bearings and journals, rod bearings and journals, camshaft bearings, valve train components, fuel system components, and so forth all are within manufacturer's specifications. Refer to the 1Y3700 Service Manual for disassembly, assembly, inspections, and specifications. Paint crankcases as necessary with either Caterpillar yellow primer or red Glyptal.[19]

9.3 *Copper Components*—Anytime a copper part is replaced, run an engine test using REO 217 until two consecutive 12-h periods show a stable copper level.

9.4 *Engine Lubricant System Flush*—Flush the engine of used oil before every test. Annex A11 shows the engine flush procedure and apparatus. A flushing instruction sheet shown in Annex A11 gives the step-by-step process required for flushing. The 1Y3700 engine arrangement includes five flushing nozzles in the crankcase and front cover (see Annex A11). These nozzles are piped in parallel with the 1Y3935 filter flushing adapter (or equivalent) from a laboratory provided manifold that pressurizes fluids supplied by a flush cart (see Appendix X1). Seal the gear train housing during flush with a 1Y3917 round plug with a 117-8801 o-ring as shown in Annex A11. Seal the crankcase using a 1Y3979 block flush cover with an internal bleed passage for the cam oil supply. Bolt a 1Y3980 plastic jet aiming fixture to the flush cover that is also used for flushing (see Annex A11). If the test oil is not available at engine assembly, Mobil EF411 oil may be substituted.

9.5 *Engine Piston Cooling Jets*—The piston cooling jets are flow-checked at the supplier and serialized to ensure proper

[25] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

[26] Available from the Coordinating Research Council Inc., 3650 Mansell Road Suite 140, Atlanta, GA 30022-8246.

[27] Available from The Lubrizol Corp., 29400 Lakeland Blvd., Cleveland, OH 44092

[28] Mobil EF-411 may be purchased from Golden West Oil Co., 3010 Aniol St., San Antonio, TX 78219.

[29] Available from Morse-Hemco, 457 Douglas Ave., Holland, MI 49423.

performance, but the rod clearances are minimal which may result in jet movement during assembly. Verify proper jet flow positioning using EF-411 before each test with the 1Y3980 plastic jet aiming fixture and 415 kPa oil pressure to the manifold. Record the cooling jet serial number.

9.6 *Engine Measurements and Inspections*—Measure and inspect the engine components prior to each test (see Table A10.2 for partial specification list). Refer to the 1Y3700 Service Manual for information concerning component reusability and assembly not found in this procedure. The part numbers of components that need replacing are found in the 1Y3700 Parts Manual. Record the crankshaft angles at the specified maximum injector lift, exhaust, and intake maximum lift before each test using the reference listed in Fig. A10.7. Record component part numbers and serial numbers and other required measurements as shown in the test report. Inspect and reuse the rocker arm roller followers and camshaft lobe surfaces based on Caterpillar Service Publication SEBF8256.[17]

9.7 *Cylinder Head*—A reconditioned head is required for each test. Measurements after reconditioning shall be within specifications as shown in the 1Y3700 Service Manual. Do not swap the cylinder head/jug assembly from test stand-to-test stand. Use the head/jug assembly used to calibrate the stand for all non-reference oil testing in that stand. Fig. A10.1 shows the cylinder head nut torque sequence.

9.8 *Valve Guide Bushings*—Clean the valve guide bushings with a solvent and bristle brush prior to assembly. Lubricate the bushings and valve stems with Mobil EF-411 prior to assembly. See the 1Y3700 Service Manual for guide reusability specifications. Install new valve guide seals for each test.

9.9 *Fuel Injector*—Remove the fuel injector from the cylinder head before reconditioning commences. Refer to the 1Y3700 Service Manual for removal and assembly. Return defective fuel injectors to Caterpillar for warranty and failure-mode testing using the form listed in Annex A9.

9.10 *Piston and Rings*—Use a new piston (1Y3400 iron crown, 1Y3659 aluminum skirt) and new rings (1Y3802, 1Y3803, 1Y3804) for each test. Clean all three rings with pentane and a lint-free 100% cotton towel. Measure the ring side clearances and ring end gaps for all three rings (see Fig. A10.1 and Table A10.1). Keystone ring side clearance measurements require the ring to be confined in a dedicated slotted liner (see Appendix X1) or a 137.16 mm ring gage.[21] Measure the side clearances using four feeler gages of equal width and 0.01 mm thickness at 90° intervals around the piston. Measure the rectangular ring side clearance this way as well. Measure the minimum side clearance as specified in CRC Manual 18. Record the measurements for these parts before and after each test. Compare the measurements before the test and after the test to determine the amount of wear. Assemble the piston with the part number toward the camshaft.

9.11 *Cylinder Liner*—Use a new 1Y3805 cylinder liner for each test. After removing the protective oil/grease with Stoddard solvent, clean the liner bore with a hot tap water and heavy-duty clothes washing detergent solution, then rinse with hot tap water. Measure and record the liner surface finish. Oil the liner bore with only Mobil EF-411. Assemble the cylinder liner, block and head with the torque specification shown in the 1Y3700 Service Manual or Fig. A10.1. Measure the liner with a dial bore gage to ensure that the out-of-round and taper conditions are within specified tolerances measured at seven intervals as shown in Fig. A10.3. Measure the cylinder liner projection using the modified indicator shown in Fig. A10.4. Torque the cylinder liner support ring using the procedure shown in Fig. A10.5.

9.12 *Compression Ratio*—Before starting each test, measure the piston-to-head clearance to ensure the proper compression ratio is used. Determine this dimension by using approximately 3.5 mm diameter lead balls. Locate four lead balls on the top of the piston at 90° intervals on the major and minor piston diameters. Hold them in place with light grease. With the piston near the top of the stroke, install the head and block assembly and torque to specifications. Turn the engine over top center by hand to compress the lead balls then remove the head and block assembly and measure the thickness of the lead balls to obtain the average piston-to-head clearance. The piston-to-head clearance specification is 1.62 mm ± 0.07 mm. Use multiple 1Y3817 block gaskets to adjust the clearance. If the piston-to-head measurement exceeds the tolerance specification, check the crankshaft main and rod journals, connecting rod and main bearings, and piston pin and rod bushing for excessive wear. The specified compression ratio for the 1Y3700 engine is 16.2 to 1.

9.13 *Engine Timing*—The engine ECM sets desired fuel injection timing to 13° BTC. Record this timing using the engine technician service tool. Mechanically time the actual engine components as shown in Annex A10. Install the electronic sensors as shown in the Electronic Installation and Operation manual. Both the mechanical and electrical systems shall be correctly assembled to produce the desired fuel timing.

9.14 *Engine Coolant System Cleaning Procedure*—Clean the coolant system when visual inspections show the presence of any oil, grease, mineral deposits, or rust following the procedure listed in Annex A3.

9.15 After the engine components have been prepared and assembled, perform the following:

9.15.1 Fill the crankcase with 5800 ± 50 g of test oil.

9.15.2 Install a new 1R0713 oil filter.

9.15.3 Fill the coolant system with coolant specified in Section 7.

9.15.4 Ensure the facility coolant to the engine heat exchanger is operational.

9.15.5 Pressurize the fuel system to remove air, then return the system to a non-pressurized state before starting engine.

9.15.6 Ensure all other systems and facilities are operational before starting the engine break-in.

10. Calibration and Standardization

10.1 *Test Cell Instrumentation*—Calibrate all facility readout instrumentation used for the test immediately prior to subsequent stand calibration. Instrumentation calibration prior to subsequent stand calibration tests (that is, those that follow a failed or invalid first attempt) are at the discretion of the test laboratory. Refer to Annex A2 for calibration tolerances and allowable *system* time constants.

10.2 *Instrumentation Standards*—Calibrate all temperature, pressure, flow, and speed measurement *standards* on a yearly basis. The calibration of all standards shall be traceable to a national bureau of standards. Maintain all calibration records for a minimum of two years.

10.3 *Coolant Flow*—Calibrate the coolant flow rate as follows: (*1*) calibrate the differential pressure transducer as outlined in 10.1 and 10.2 and, (*2*) replace the Barco venturi every two years.[30] Use the following relationships as conversion factors from the differential pressure across the Barco venturi to L/min: 3.0 in. H_2O = 24.3 L/min, 7.1 in. H_2O = 37.8 L/min and 28 in. H_2O = 75.7 L/min or use Eq 1 where ΔP is measured in in. H_2O.

$$L/min = \sqrt{\Delta P}\, 14.44 - 0.69 \quad (1)$$

10.4 *Re-calibration Requirements*—Re-calibration due to parts replacement is not required unless the engine crankcase or crankshaft, or both, require replacing or regrinding, or the crankshaft is removed for any other purpose besides bearing replacement, or the head/jug suffer a failure for any reason during the calibration period.

10.5 *Fuel Injectors*—The fuel injectors are calibrated during the manufacturing process. These fuel injectors can not be re-calibrated in the usual manner and require special test equipment to ensure proper flow, timing response, and spray patterns. Therefore, replace the fuel injector at the start of every calibration test (unless that test is the second of two required tests for a new stand or is a re-run of a previous calibration attempt). If the fuel injector is replaced on a calibrated stand, re-calibration is not required.

10.6 *Air Flow*—Install the Sierra Model 780 airflow meter to measure intake airflow. This meter should be calibrated yearly at a temperature of 60 °C. Measure the intake airflow during the break-in of every calibration test. Record the last value recorded during step five of the break-in as shown in Annex A12.

10.7 *Intake Air Barrel*—Prior to each stand calibration test, inspect the intake air barrel for rust or debris. This may be done through either of the pipe flanges using a borescope or some other optical means.

10.8 *Fuel Filter*—Change the fuel filter before every calibration test.

10.9 *Oil Scale Flow Rates*—Verify the oil scale flow rates before the start of every calibration test using the procedure listed in Annex A6.

10.10 *Calibration of Test Stands*—A stand calibration test is required every nine months with the test results falling within the required values before non-reference oils are run. Use a blind calibration oil from the TMC to calibrate the engine stand every nine months. The nine-month calibration period begins at the start of the last acceptable calibration test. Actual test completion dates may differ from scheduled completion dates because of unexpected downtime. Accordingly, if the last non-reference test before a new calibration is interrupted because of unscheduled shutdowns, stand calibration will continue through the completion of this non-reference test. The intention is that the non-reference test be started in time to finish within the nine-month period, had the unscheduled shutdowns not occurred. A test stand is considered calibrated when the test results are within the acceptability limits as published by TMC and the test is operationally acceptable. The TMC may request stand checks on calibration tests that fail because of statistical reasons. Laboratory and referee rate piston deposits for all operationally valid calibration tests. Use the laboratory rating results to determine test acceptability and use the referee rating as a secondary measurement. For calibration tests, electronically send the test data to the TMC within seven days from end-of-test (EOT) in order for the test to be considered valid. The TMC will issue to the testing laboratory a control chart analysis for each calibration test (see Annex A14). The test stand is not considered calibrated for invalid or non-interpretable calibration tests.

10.11 *Extending Test Stand Calibration Period*—There may be occasions when laboratories conduct a large portion of calibration tests in a short period of time. This may result in an unacceptably large time frame when very few calibration tests are conducted. To ensure proper severity and precision monitoring, calibration tests shall be conducted throughout the year. The TMC is permitted to move up or extend calibration tests to enhance calibration test program design and test severity monitoring. An extensive test stand check will be required for any engines having extended test stand calibration periods.

10.12 *Test Run Numbering*—Number each test to identify the test stand number and the test run number. Number all runs sequentially. Append repeat calibration runs with a letter that is also sequential (that is, number the first re-run of test 45 as 46A, the second as 47B, and so forth). Maintain the letter suffix sequencing for each calibration test until the calibration has been accepted. Increment the run number for any test start.

10.13 *Humidity Calibration Requirements*—The accuracy of the laboratory's primary humidity measurement system shall be within ± 0.6 g of the humidity measuring chilled mirror dew point hygrometer. Calibrate the primary laboratory humidity measurement system during the first 24 h of each calibration test at each stand using a chilled mirror dew point hygrometer with an accuracy of at least ± 0.55°C at a 24°C dew point. The calibration consists of a series of paired comparison measurements between the primary system and the chilled mirror dew point hygrometer. The comparison period lasts from 20 min to 2 h with measurements taken at 1 min to 6 min intervals, for a total of 20 paired measurements. The measurement interval should be appropriate for the time constant of the humidity measuring instruments. Ensure that the flow rate is within the equipment manufacturer's specification. Take all measurements made with the dew point hygrometer at atmospheric pressure and correct them to standard pressure conditions (101.12 kPa). Compute the difference between each pair of measurements and calculate the mean and standard deviation of the differences. The absolute value of the mean difference shall not exceed 0.6 g and the standard deviation shall be less than or equal to 0.3 g. The primary humidity measurement system is deemed calibrated only if both of these requirements are met. If either of these requirements is not met, investigate the cause, make repairs, and recalibrate. Maintain the calibration data for a minimum of two years.

[30] Available from Hyspan Precision Products, Inc., 1685 Brandywine Avenue, Chula Vista, CA 91911.

10.14 *Calibration of Piston Deposit Raters*—The piston deposit raters shall be trained by the CRC Rating Task Force and maintain rating expertise by attending the rating seminars. Each calendar year, each facility shall send at least one Heavy Duty Diesel Piston Rater to either the Task Force meeting held every Spring or the expanded Heavy Duty Piston Rating Workshop held every Fall. Each rater shall rate a minimum of six diesel pistons. If this schedule is not suitable to a particular rater or test laboratory, then make alternative arrangements as soon as possible to have the rater calibrated.

11. Procedure

11.1 *Engine Break-in Procedure*—Open any drain taps at the low points of the combustion air system (if they are installed) during the start of the break-in and warm-ups, and following any shutdowns. The engine break-in and operational conditions are specified in Annex A12. The total break-in time is 85 min. During the break-in, fix all leaks and make adjustments to ensure proper engine operation. Record the ECM personality module part number and release date. After the break-in period and while the engine is hot, drain the oil from the crankcase, oil cooler, engine oil filter, and weigh scale for 30 min. Then weigh 5800 ± 50 g of new test oil into the engine. Start the engine, warm it up, and operate it for 360 h at the test conditions specified in step five of Annex A12 with no oil changes. Turn on the oil scale pumps once the engine has reached the beginning of Step 5 of the warm-up sequence. Record the oil weight in the oil scale as the full mark at the end of the first test hour. Throughout the test, record the oil scale reading at least once every 6 min. Count test time from the moment the warm-up time is completed. The oil sample frequency is described in section eight. Do not remove the cylinder head, piston, or power assembly from the engine during a test.

11.1.1 Reinitialize engine timing calibration after the cam shaft/gear or cylinder head has been removed. See the electronic installation and operation manual. Complete this during the first step of the break-in.

11.2 *Cool-down Procedure*—Except for emergency (uncontrolled) stops, shut the engine down by operating it at conditions shown in Steps 4, 3, 2, and then 1 in Annex A12.

11.3 *Warm-up Procedure*—Use the same procedure used for engine break-in to warm-up the engine for all subsequent starts throughout the test.

11.4 *Shutdowns and Lost Time*—Record the test h, date, and length of off-test conditions for all occurrences. Record when the engine has early inspections or early test termination with the reasons for the occurrences. If the cool down procedure is not used, identify the shutdown as an *Emergency Shutdown*. A maximum of 125 h of off-test conditions is allowed. If the engine shuts down, immediately stop the oil scale pumps. In the event of an emergency shutdown, leave the engine shut down for 2 h (or more) to allow complete engine cool down before restarting. In order to limit foreign matter entering the combustion chamber and to protect piston deposits, rotate the engine to top dead center of the compression stroke during downtime.

11.5 *Periodic Measurements*—Record all engine conditions listed in Step 5 of Annex A12 as a snapshot at least once every 6 min. Record humidity readings using the laboratory's primary humidity measurement system. Correct the recorded humidity values to standard pressure conditions of 101.12 kPa. Record the fuel position as indicated by the electronic technician at test hours 24, 240, and 360.

11.6 *Engine Control Systems*:

11.6.1 *Engine Coolant*—Pressurize the coolant system to 35.0 ± 7 kPa as shown in Annex A3 to ensure the water does not boil out of the antifreeze. Manually adjust the coolant flow rate by turning the valve on top of the coolant tower to maintain the conditions specified in Annex A12.

11.6.2 *Engine Fuel System*—Control the fuel rate by modifying the fuel limit adjusting the ECM using a facility controller that compares the actual fuel rate to the specified fuel rate listed in Annex A12. See the Electronic Installation and Operation manual for more details. Manually adjust the Fisher regulator to control fuel pressure. Maintain the fuel pressure and temperature as specified in Annex A12.

11.6.3 *Engine Oil Temperature*—Maintain the oil manifold temperature to test specifications as shown in Annex A12. The temperature of the Paratherm NF shall not exceed 165 °C at any time during break-in, warm-up, or testing. Shut off the external oil heater (but not its circulating pump) the moment the engine goes to cool-down.

11.6.4 *Exhaust Pressure*—Set the pressure as specified in Annex A12 using a facility feedback-controlled restrictor valve.

11.6.5 *Intake Air*—Filter, compress, and humidify the inlet air to the conditions specified in Annex A12. Heat (or cool, if necessary) the inlet air to the conditions in Annex A12.

11.7 *Post-Test Procedures*—Remove the piston and ring assembly from the engine. Mark the location of the ring gaps on top of the piston.

11.7.1 *Piston Ring Side Clearances*—Measure the piston ring side clearances prior to removal of the rings to determine the level of deposit formation (see Annex A10). Align ring gaps to the EOT ring gap marks on the top of the piston. Do not force the feeler gages between the ring and groove to disturb or remove the deposits.

11.7.2 *Piston Ratings*—Immerse the piston assembly in Stoddard solvent and air-dry it prior to any rating. Process and measure the piston deposits according to the Modified CRC Diesel Piston Rating Method described in CRC Manual No. 18 modified by the directions listed in Annex A13. Rate only two levels of carbon (heavy and light) on the second groove and all lands, and only one level of carbon (light) for the under-crown and cooling groove. Use a combined varnish rating method for the third groove, third land, fourth land, under-crown, and cooling groove (see Annex A13). An example rating worksheet is shown in Appendix X1. Another heavy-duty engine deposit rater shall verify all piston deposit ratings done by the testing laboratory. In special cases where another rater is not available, the rating may be verified by other qualified laboratory personnel. Record the initials of both the rater and the verifying rater.

11.7.2.1 *Referee Ratings*—The referee laboratory rates the entire piston. Wrap all pistons to be referee-rated in paper with CRC desiccant chips. Then place them in plastic and seal before shipping to the referee laboratory. Report referee ratings to the TMC within ten days of EOT for calibration tests. Referee-rate piston deposits for all non-reference tests reviewed by Caterpillar.

11.7.3 *Ring End Gap Increase*—Remove all carbon from the rings. If scraping of the rings is necessary, use only a wooden instrument or equivalent. Measure and record the ring end gaps.

11.7.4 *Cylinder Liner Wear*—Use a surface profile measurement to determine the liner wear step in both transverse and longitudinal directions relative to the crankshaft. Remove deposits on the liner above the piston ring travel. Take transverse and longitudinal measurements at the wear step location approximately 13 mm from the top of the liner at four locations. Record the measurements as the liner wear step.

11.7.5 *Cylinder Liner Bore Polish*—Section the cylinder liner through the front and rear axis and measure the cylinder liner to determine the amount of bore polishing. Use the liner rating method listed in Annex A13.

11.7.6 *Photographs*—Photograph the piston and rings showing the thrust, anti-thrust, front, rear, and undercrown positions (see Appendix X1). Place the rings on top of the piston to show ring gaps (thrust view) and 180° from gaps (anti-thrust view). Show the piston from the crown down to at least the bottom of the pin bore. Photograph the piston crown and skirt as one assembly. Photograph the bore ID of the sectioned liner (see Appendix X1).

12. Calculation or Interpretation of Results

12.1 *Test Validity*—If a test was run for 360 h according to this test method, declare the test valid. If a test was not run as specified by this test method, then the test is operationally invalid. Some examples of an invalid test are: use of non-specified hardware, non-specified assembly methods, a test run whose downtime is greater than 125 h, a test that has a Quality Index value for a controlled parameter below the threshold of zero (see DACA II Report),[31] and so forth. If a test has greater than four consecutive hours without data acquisition on any controlled parameter, the test will be considered operationally invalid. If a test completes 360 h and the piston, rings, or liner exhibit distress, then consider the test to be non-interpretable. Likewise, if the test is terminated *prior* to completing 360 h for reasons including purchaser request, excessive oil consumption, or piston, ring, or liner distress, then consider the test non-interpretable.

12.2 *Calculations*—Use the same set of data for all calculations and graphs in the test report.

12.2.1 *Quality Index*—Calculate and plot the Quality Index according to the instructions in Annex A2.

12.2.2 *Oil Consumption*—Calculate oil consumption in g/h over 24 h intervals. Delete the first 4 h of readings after an oil add from the linear regression. The linear regression technique is shown in Figs. A6.5 and A6.6. Calculate the overall average oil consumption, the initial average oil consumption, and end-of-test (EOT) average oil consumption. The initial average is the average of the 24th and 48th h data points from the oil consumption graph. The EOT average is the average of the 336th and 360th h data points for a full length test, or for a short-term test it is the average of the last two data points from the oil consumption graph. Calculate the natural logarithmic transformation of the average and EOT oil consumption values using the following equations:

$$\text{transformed average oil consumption} = \ln(\text{average oil consumption}) \tag{2}$$

$$\text{transformed EOT oil consumption} = \ln(\text{EOT oil consumption}) \tag{3}$$

12.2.3 For a 24-h period including a shutdown, calculate the oil consumption as follows:

12.2.3.1 Do not include the first 4-h oil weight readings after a shutdown in the linear regression.

12.2.3.2 Calculate the linear regression for the period before the shutdown.

12.2.3.3 Calculate the linear regression for the period after the shutdown.

12.2.3.4 Calculate a time weighted average from both regressions to obtain the oil consumption for that 24–h period. For example, a test experiences a 7-h shutdown at test hour 12. The slope for the first 8-h period (hour 4 to 12) is 10.7 g/h, and the slope for the second 8-h period (hour 16 to 24) is 2.1 g/h. The weighted average is calculated as follows:

$$\text{weighted average} = \frac{(10.7g/h)(8h) + (2.1g/h)(8h)}{8h + 8h} \tag{4}$$

13. Report

13.1 *Forms and Data Dictionary*—Refer to Annex A15 and Annex A16 for the forms and data dictionary used by this test method. Test report forms should closely resemble those listed in Annex A15. Report values for all the field names listed in the report forms. Some fields may be blank for short-term tests. Report all deposits, wear, and engine operational data as shown in the test report. The data dictionary defines the field lengths, decimal size, data type, units and format for the field names listed in the test report forms.

13.2 *Test Validity*—Document on the first sheet of the test report in Annex A15 whether the test is Valid, Invalid, or Non-interpretable. For a *valid stand calibration run*, report the test data to TMC who will include the test data in the operationally valid database and determine statistical validity using the LTMS method.[32] For an *invalid or non-interpretable stand calibration run*, report the test data to TMC with comments describing why the test is considered invalid or non-interpretable. TMC will not include the test data in the operationally valid database. All operationally invalid and non-interpretable calibration tests are reported by the TMC to the ASTM Single Cylinder Diesel Surveillance Panel in periodic testing summaries. For a *valid CMA Registered Oil Test*, report the data to Registration Systems, Inc. (RSI).[33] For

[31] Available from ASTM Test Monitoring Ctr., 6555 Penn Ave., Pittsburgh, PA 15206–4489.

[32] The LTMS method tracks the severity and precision of stand and laboratory test results. For a complete definition, refer to the LTMS manual which is available from ASTM Test Monitoring Center, 6555 Penn Avenue, Pittsburgh, PA 15206-4489.

[33] Registration Systems, Inc., CMA Monitoring Agency, 4139 Gardendale, Suite 205, San Antonio, TX 78229.

an *invalid or non-interpretable CMA Registered Oil Test*, report the test data to RSI with supporting comments describing why the test is considered invalid or non-interpretable. When non-calibration oil tests are presented to Caterpillar for review, include the data from all tests that were registered with RSI as part of the program.

13.3 *Report Specifics*:

13.3.1 If more than one fuel batch is used, report the fuel batch analysis that is most representative of the fuel in the tank.

13.3.2 Report any causes for any missing or bad test data in the comment section of Form 7. If any alternative data acquisition method is used, document it in the comment section of Form 7.

13.3.3 If a calibration period is extended beyond the normal nine-month period, make a note in the comment section of Form 7 and attach a written confirmation from the TMC to the test report. List the outcomes of previous calibration runs in the comment section of Form 7.

13.3.4 Include the fuel analysis provided by the fuel supplier as Form 14. For calibration tests, include a copy of the TMC control chart analysis as Form 17. It is recommended that test purchasers include the form shown in Fig. X1.8 as Form 18 when presenting the test results against specification limits, such as those in Specification D 4485 or military specifications.

14. Precision and Bias

14.1 *Precision*—Test precision is established on the basis of operationally valid reference oil test results monitored by the ASTM Test Monitoring Center. Table 1 summarizes reference oil precision and reproducibility of the test as of February 13, 2001.

14.1.1 *Intermediate Precision (IP)*—The difference between two results obtained by the same operator or laboratory using the same test method on the same oil would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 1 in only one case in twenty.

14.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators working in different laboratories on the same oil would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 1 in only one case in twenty.

14.2 *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. Currently, there are two types of severity adjustments - Industry and Laboratory. There are no test stand severity adjustments. Industry severity adjustments are determined by the Single Cylinder Surveillance Panel under ASTM Committee D02, Subcommittee B. Laboratory severity adjustments are determined by the instructions listed in the Lubricant Test Monitoring System (LTMS) document.[31]

15. Keywords

15.1 caterpillar 1P test procedure; oil consumption; piston deposits; single cylinder oil test

TABLE 1 Reference Oil Test Precision

NOTE—Legend:
S_{ip} = standard deviation for intermediate precision
IP = intermediate precision
S_r = standard deviation for reproducibility
R = reproducibility

Test Parameter	S_{ip}	*IP*	S_r	*R*
WDP (weighted demerits for the 1P test method)	46.06	128.97	49.79	139.41
TGC (top groove carbon piston deposits)	8.15	22.82	8.15	22.82
TLC (top land carbon piston deposits)	10.06	28.17	10.07	28.17
LN(AOC) (natural log of the average oil consumption)	0.2633	0.7372	0.2994	0.8383
LN(FOC) (natural log of the final oil consumption)	0.4816	1.3485	0.4816	1.3485

ANNEXES

(Mandatory Information)

A1. ENGINE AND PARTS WARRANTY

A1.1 *Engine Warranty*—Caterpillar Inc. warrants single cylinder test engines sold by it to be free from defects in material and workmanship for a period of 12 months starting from the date of delivery to the first user. If a defect in material or workmanship is found during the warranty period, Caterpillar will provide the replacement parts to be installed by the user. There will be no charge to the user for parts furnished by Caterpillar. User at its own expense, shall return all defective parts to Caterpillar at Caterpillar's request. User will be responsible for giving Caterpillar timely notice of a warranty failure. User will also be responsible for labor costs and any applicable local taxes. Caterpillar is not responsible for failures resulting from abuse, neglect, and/or improper repair. THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSE. REMEDIES UNDER THIS WARRANTY ARE LIMITED TO THE PROVISION OF PARTS AS SPECIFIED HEREIN. CATERPILLAR IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

A1.2 *Engine Parts Warranty*—All parts for the 1Y3700 engine which are nonconforming by reason of faulty manufacture should be discussed with Engine System Technology Development (ESTD).

A1.2.1 The test laboratories should contact ESTD (R.A. Riviere, Telephone: 309-636-5247, Fax: 309-675-1598) when they believe a part is nonconforming:

A1.2.2 ESTD will determine if they want the part returned, or provide warranty without viewing the part.

A1.2.3 If ESTD determines that the part is nonconforming without viewing the part, the test laboratories will be asked to return the part to their Caterpillar dealer. ESTD will contact the Dealer and let them know the part is coming and to provide warranty for it.

A1.2.4 If ESTD wants to view the part, they will issue a Return Goods Authorization No. (RGA) to the test laboratory. The laboratory will fill out the form shown in Annex A9 and send the part and the form to Caterpillar Inc., Tech Center TC-L, Wing 4 - Rm 406, 14009 Old Galena Rd., Mossville, IL 61552, Att: A.C. Hahn.

A1.2.5 The test laboratories should fax a copy of the RGA claim form to Caterpillar Inc., Tech Services Div., Tech Center Bldg L, Fax: 309-578-4232, Att: A.C. Hahn.

A1.2.6 If ESTD determines that the part is nonconforming, they will contact the dealer for the test laboratory and have the dealer provide warranty.

A1.2.7 A sample of the RGA claim form is shown in Annex A9 and should include: return goods authorization no., part name, hours on the part, part no., quantity, engine serial no., date purchased, test laboratory that purchased the part and contact person's name, phone, fax, and address, dealer's name that sold the part, measurements or photographs, or both, to document the nonconformance.

A2. INSTRUMENT LOCATIONS, MEASUREMENTS, AND CALCULATIONS

A2.1 Tables A2.1-A2.6 and Figs. A2.1-A2.5 provide detailed information.

A2.2 *Requirements for the Quality Index Calculation*:

A2.2.1 Round the recorded values in accordance with the specifications listed in Table A2.5.

A2.2.2 Use the values listed in Table A2.6 for all calculations.

A2.2.3 Use 6-min data to calculate the Quality Index.

A2.2.4 Reset data that is greater than the high values listed in Table A2.6 from the Over and Under Range Values column to the high value for that particular parameter.

A2.2.5 Reset data that is less than the low values listed in Table A2.6 from the Over and Under Range Values column to the low value for that particular parameter.

A2.2.6 Round the Quality Index values to the nearest 0.001.

A2.2.7 Report Quality Index values on Form 2 of the test report.

NOTE A2.1—Refer to the DACA II Final Report for calculating the Quality Index involving the loss of test data or bad quality test data.

A2.3 Formula to calculate the Quality Index:

$$QI = 1 - \frac{1}{n}\sum\left(\frac{U + L - 2X_i}{U - L}\right)^2 \quad \text{(A2.1)}$$

where:

X_i = recorded test measurement parameter,
U = upper specification for that parameter,
L = lower specification for that parameter, and
n = total number of data points taken as determined from test length and procedural specified sampling rate.

TABLE A2.1 Instrument Locations

Parameter	Data Acquisition and Control	Engine Computer Sensors	Facility Feedback Control (if separate sensor is required)
Cam speed and timing sensor		A	
Crankshaft speed and timing sensor		B	(at dyno)
Coolant pressure to jug	1		
Coolant temperature to jug	2		
Oil temperature to cooler	3		
Atmospheric pressure		C	
Crankcase pressure	4	D	
Facility air pressure to cooling tower	5		
Oil manifold temperature	6	E	6 or W
Oil sampling valve	7		
Oil manifold pressure	8	F	
Coolant temperature from engine	9	H	9 or X
Coolant pressure from engine		G	
Coolant flow barco delta pressure	10		
Air inlet manifold pressure	(at barrel)	I	(at barrel)
Air inlet manifold temperature	11		11 or Y
Fuel temperature from filter	Z		12
Fuel pressure from head	13		
Fuel flow rate	(at micro motion)		(at micro motion)
Exhaust manifold temperature	14	J	
Exhaust manifold pressure	(at barrel)		(at barrel)
Humidity	(at barrel)		(at barrel)
Air flow rate	(at meter)		
Blowby flow rate	(at meter)		

TABLE A2.2 Thermocouple Diameters, Lengths and Immersion Depths

Location	Diameter, in.	Length, in., max	Depth, ± 3 mm
Oil to manifold	not applicable	6	22
Oil to cooler	not applicable	6	27
External heating oil	not applicable	6	27
Coolant in	not applicable	6	40
Coolant out	not applicable	6	26
Inlet air	not applicable	6	57
Exhaust	not applicable	6	67
Fuel	not applicable	6	34

TABLE A2.3 Calibration Tolerances

Parameters	Tolerance
Load	not applicable due to differences within the industry; TMC will verify each laboratory it visits
Fuel flow rate	0.4 g/min
Air flow rate	±2 % of reading from 10-100 % of calibrated range; ±0.5 % of FS below 10 % of calibrated range
Humidity	listed in this test method
Temperatures	**°C**
Fuel at filter	0.5
Coolant to jug	0.25
Coolant from engine	0.25
Oil to cooler	0.5
Oil manifold	0.5
External heating oil	0.5
Air inlet manifold	0.5
Exhaust manifold	1.0
Pressures	**kPa**
Fuel from head	0.7
Oil manifold	0.7
Air inlet	0.3
Exhaust	0.3
Crankcase	0.02

TABLE A2.4 Maximum Allowable System Time Constants

Measurements	Time, s
Speed	3.0
Fuel flow rate	20.0
Air flow rate	3.0
Oil weight	TBD
Temperatures	
Fuel at filter	3.0
Coolant to jug	3.0
Coolant from engine	3.0
Oil to cooler	3.0
Oil manifold	3.0
External heating oil	3.0
Air inlet manifold	3.0
Exhaust manifold	3.0
Pressures	
Fuel from head	3.0
Oil manifold	3.0
Air inlet	3.0
Exhaust	3.0
Crankcase	3.0

TABLE A2.5 Measurement and Reporting Resolutions

Parameter	Units	Tol	Specification	Minimum Measurement Resolution	Round Values to the Nearest Whole Number
Speed	RPM	±3	1800	1	whole number
Power	kW	approximately	55	0.1	tenth
Torque	N·m	approximately	285	0.1	tenth
Fuel rate	g/min	±1	185	0.1	tenth
Fuel timing	BTC		13		
Humidity	g/kg	±1.7	17.8	0.1	tenth
Oil weight	g			2	whole number
Temperatures °C					
Fuel into head		±3	42	0.1	tenth
Coolant into jug		approximately	86	0.1	tenth
Coolant from head		±3	90	0.1	tenth
Oil to cooler		approximately	128	0.1	tenth
Oil manifold		±3	130	0.1	tenth
External heating oil			165 max	0.1	tenth
Inlet air manifold		±3	60	0.1	tenth
Exhaust manifold		approximately	480	1	whole number
Pressures kPa					
Fuel from head		±20	275	1	whole number
Coolant into jug		approximately	81	1	whole number
Oil manifold		±20	415	1	whole number
Inlet air barrel (abs)		±1	272	0.1	tenth
Exhaust barrel (abs)		±1	265	0.1	tenth
Crankcase		approximately	0.10	0.01	hundredth
Flows					
Coolant	L/min	±2	75	0.1	tenth
Blowby	L/min	approximately	35	1	whole number
Air	kg/h	approximately	315	0.1	tenth

TABLE A2.6 Quality Index Calculation Values and Plotting Axis Scale Definitions

Controlled Parameters	units	Quality Index U and L Values[A] L	U	Over and Under Range Values[B] low	high	Plot Axes Ranges[C] min	max	increment
Speed	r/min	1798.530	1801.470	1710	1890	1770	1830	10
Fuel flow	g/min	183.970	186.030	125	245	175	200	5
Humidity	g/kg	16.780	18.820	5	21	5	40	5
Coolant flow	L/min	73.060	76.940	0	82	60	90	5
Coolant out temperature	°C	89.379	90.622	55	125	70	110	5
Oil to Manifold Temperature	°C	128.798	131.202	60	200	120	150	5
Inlet air temperature	°C	59.360	60.640	20	100	50	70	5
Fuel into head temperature	°C	40.885	43.116	0	75	30	60	5
Oil to manifold pressure	kPa	404.384	425.616	0	690	380	450	10
Inlet air pressure	kPa	271.449	272.551	242	302	265	280	5
Exhaust pressure	kPa	264.150	265.850	215	315	250	280	5
Fuel pressure	kPa	271.471	278.529	125	425	230	300	10
Uncontrolled Parameters								
Power	kW					50	60	1
Torque	N·m					230	310	10
Blowby	L/min					5	65	5
Coolant in temperature	°C					75	100	5
Coolant delta	°C					0	10	1
Oil cooler in temperature	°C					120	140	5
Heating oil temperature	°C					120	165	5
Exhaust temperature	°C					450	500	10
Crankcase pressure	kPa					0.0	1.5	0.1
Coolant pressure	kPa					60	95	5

[A] The threshold for operational validity is 0.00.
[B] Only to be used in the calculation of Quality Index and Average and does not affect how process is graphed.
[C] Quality Index Scales are to range from -0.3 to 1.0 with increments of 0.1. The axis for test time is 0 to 360 h in 30-h increments. X-axis length should be at least 8.0 in. Y-axis length should be at least 5.5 in.

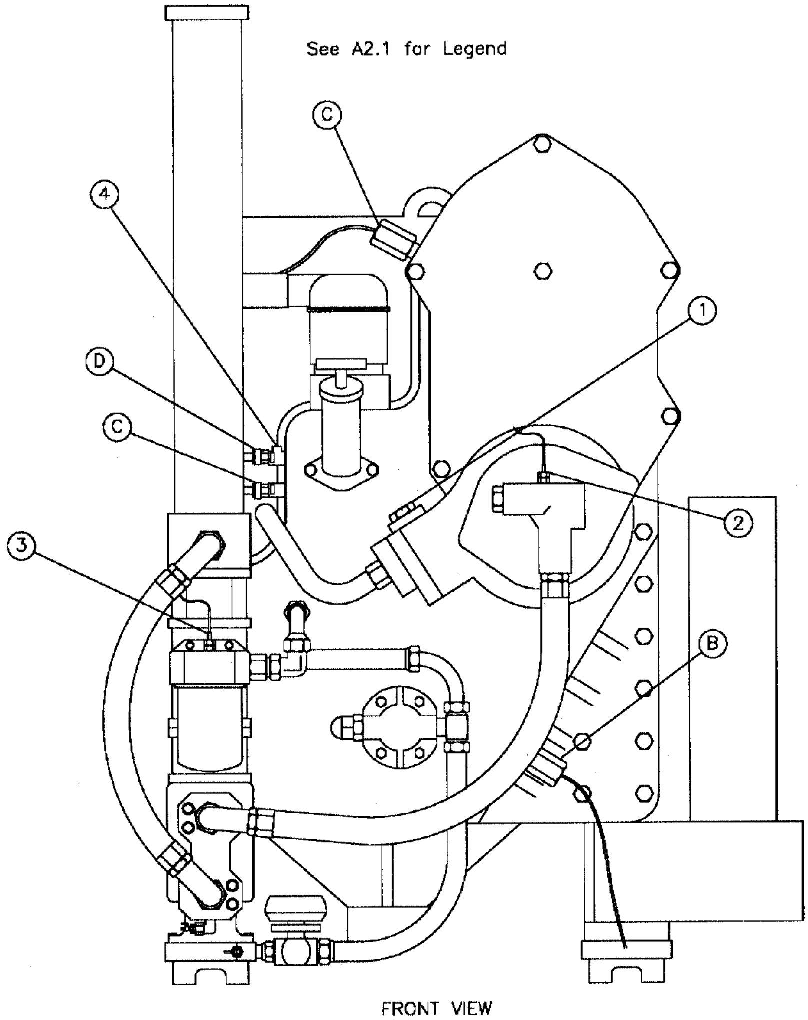


FIG. A2.1 Instrument Locations—Engine Front View

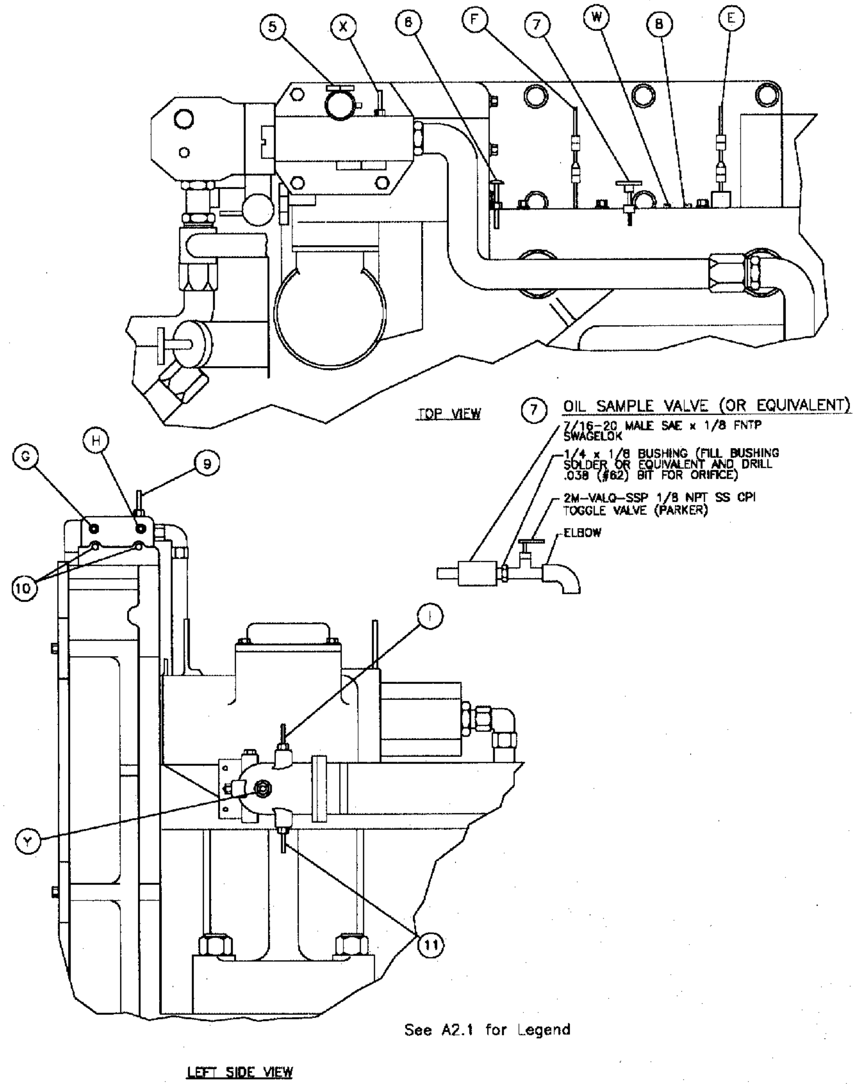


FIG. A2.2 Instrument Locations—Top and Left Engine Views

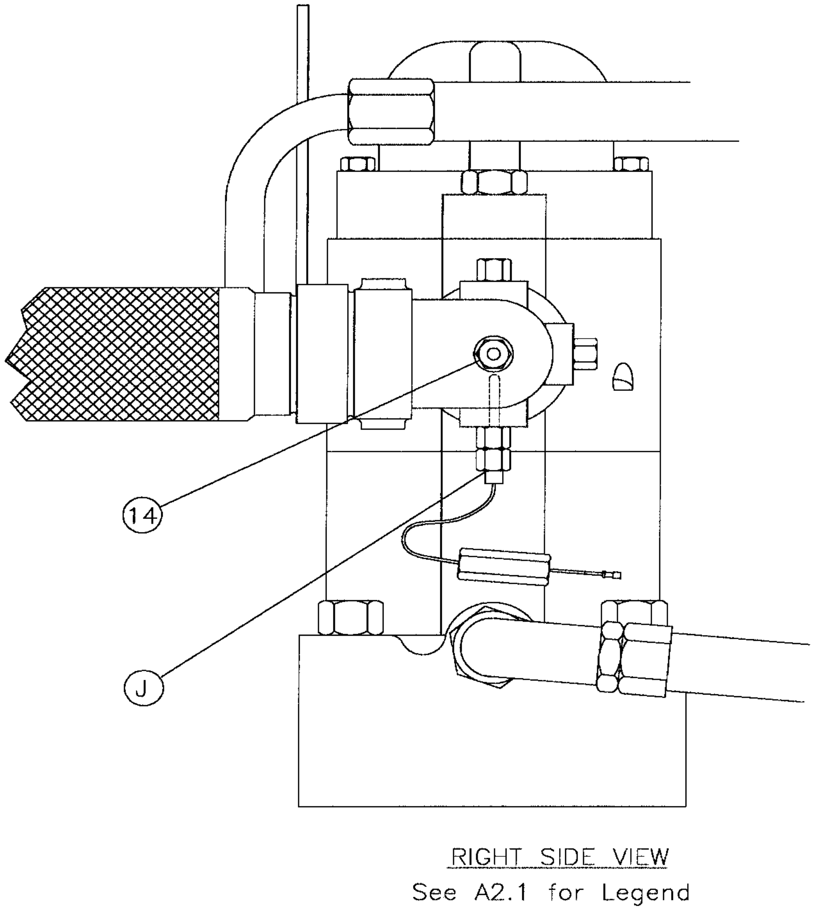


FIG. A2.3 Instrument Locations—Right Engine View

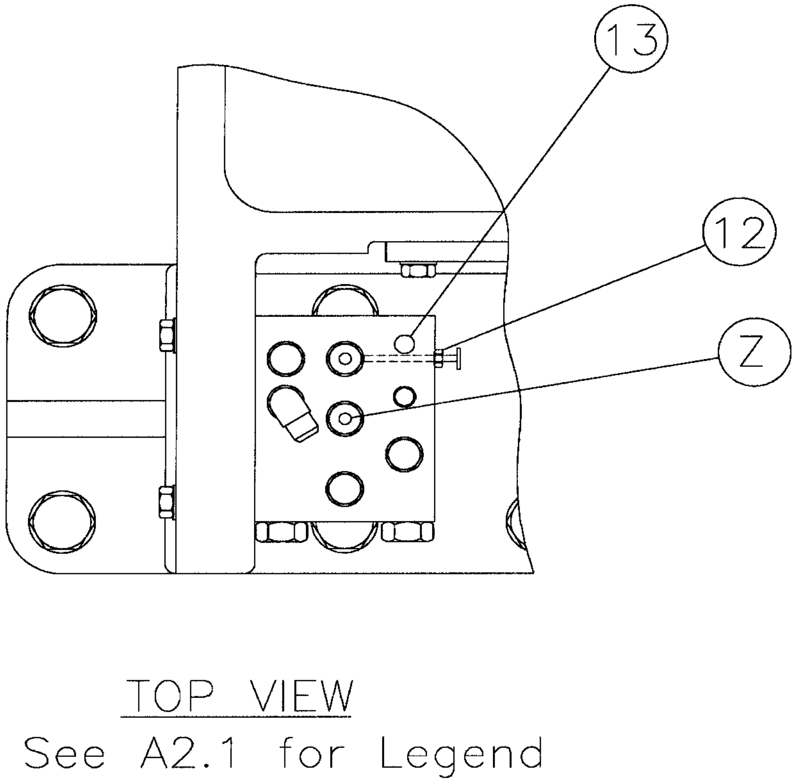
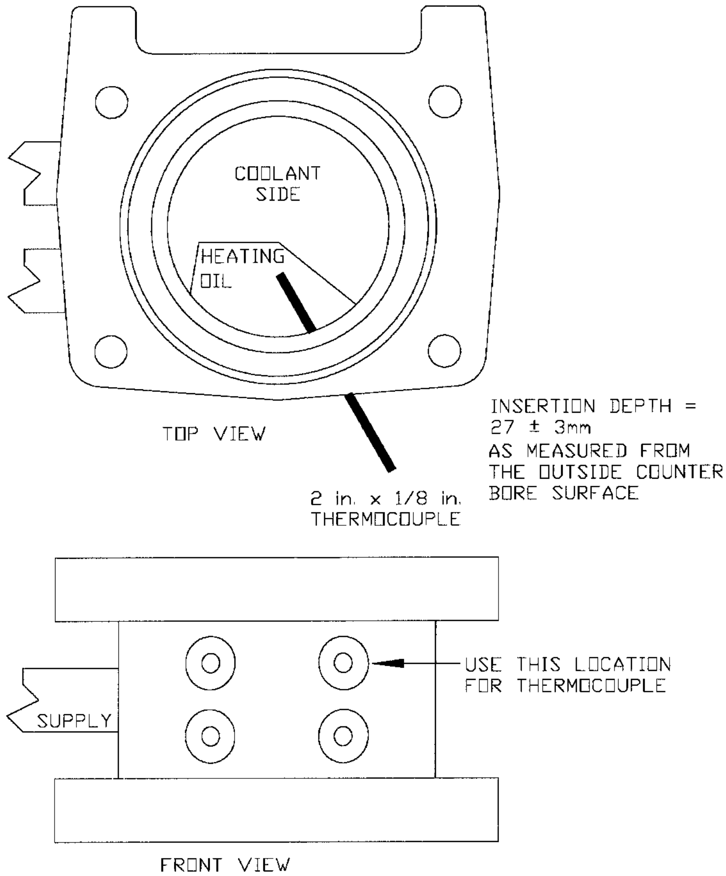


FIG. A2.4 Instrument Locations—Top Engine View



NOTE—Turn oil filter block drain valve 180° so that it is facing out and easier to use.

FIG. A2.5 Engine Heating Oil Thermocouple Location

A3. COOLING SYSTEM ARRANGEMENT

A3.1 Install a sight glass as shown using the following components listed in Table A3.1.

A3.1.1 Reuse one of the straight 37° flare swivel hose fittings on the existing hose for the tower side of assembly. The 90° fitting in the cylinder head is also still used. Installation angle will be slightly different.

A3.2 *Cleaning Procedure for the Engine Coolant System*—Clean the coolant system when visual inspections show the presence of any oil, grease, mineral deposits, or rust. The engine cooling system arrangement is shown in Fig. A3.1.

A3.2.1 To remove oil and grease from the cooling system:

A3.2.1.1 Operate the engine until oil and water operating temperatures are attained; shutdown the engine and drain the cooling system.

A3.2.1.2 Fill the cooling system with a solution of 454 g of trisodium phosphate (Na_3PO_4) to 38 L of water; operate the engine for 5 min to ensure complete mixing of the solution with any material remaining from the previous fill.

A3.2.1.3 Shutdown the engine and drain and flush the engine with fresh water and drain the water from the system.

TABLE A3.1 Coolant Sight Glass Components

Item	Quantity	Part No.	Source	Description	Location
1	1	2061-20-20S	Aeroquip	45° SAE O-ring port to 37° flare	inlet to top of coolant tower
2	1	190265-20S	Aeroquip	45° Elbow – SAE O-ring to 37° flore swivel	head outlet
3	2	412-16-20S	Aeroquip	Male pipe re-usable fitting	inlet and outlet of sight glass
4	1	4288 1 in. NPT Female	Gits[A]	style OL flow gage (sight glass)	locate in middle of hose assembly
5	1	FC350-20	Aeroquip	hose ~ 5½ in.	head side of assembly
6	1	FC350-20	Aeroquip	hose ~ 6½ in.	tower side of assembly

[A] Gits Manufacturing Co.

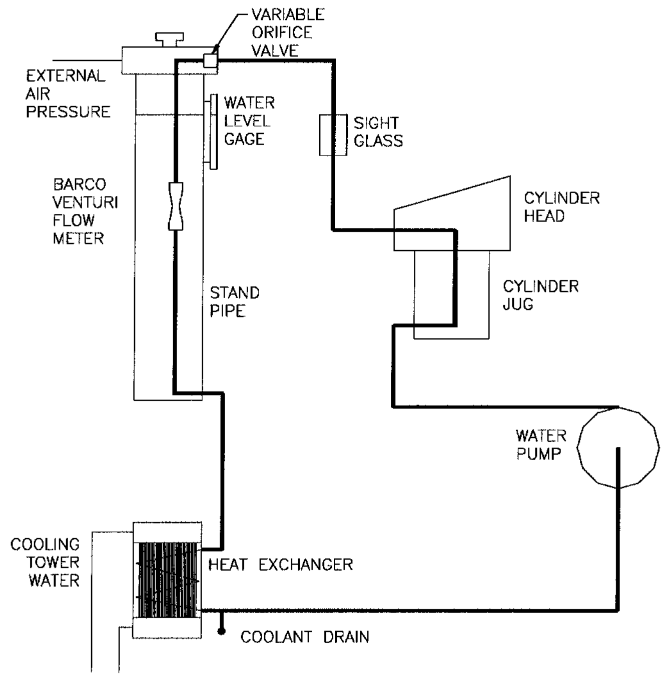


FIG. A3.1 Engine Cooling System Arrangement

A3.2.2 To remove mineral deposits from the cooling system:

A3.2.2.1 Operate the engine until oil and water operating temperatures are attained; shutdown the engine and drain the cooling system.

A3.2.2.2 Fill the cooling system with a solution of 454 g of commercial sodium bisulfate ($NaHSO_4$) to 19 L of water; then run the engine at operating temperatures for 30 min.

A3.2.2.3 Shutdown the engine, drain and flush the engine with fresh water and drain the water from the system.

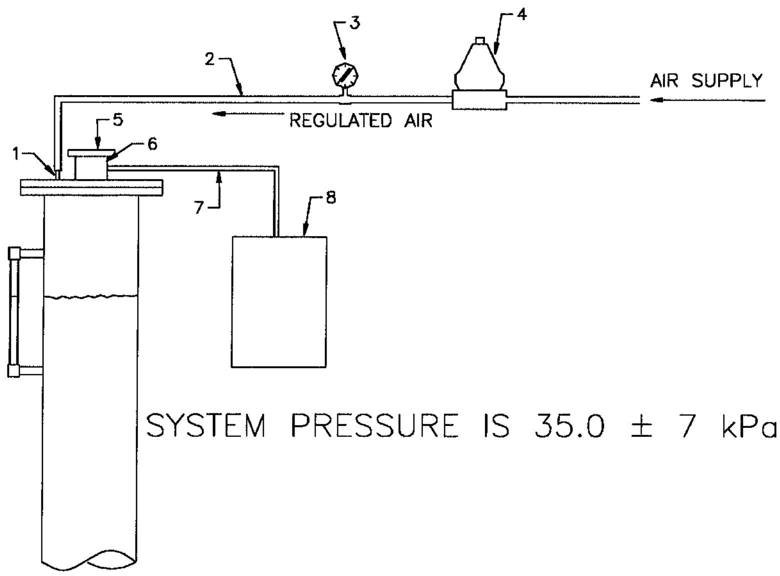
A3.2.2.4 Fill the cooling system with a solution of 454 g of trisodium phosphate (Na_3PO_4) to 38 L of water; operate the engine for 5 min to ensure complete mixing of the solution with any material remaining from the previous flush.

A3.2.2.5 Shutdown the engine and drain the engine, flush with clear water and drain after flushing.

A3.2.2.6 Disassemble the engine and prepare for the next test.

A3.2.3 If the cooling system is contaminated by oil and mineral deposits, remove the oil from the system, then remove the mineral deposits. Alternatively, the cylinder head coolant passages may be cleaned after the head is removed.

A3.2.4 The coolant pressurization system is shown in Fig. A3.2 and the cooling tower water circuit is shown in Fig. A3.3.



NOTE—Legend:
1. ¼ in. NPT-to-No.4AN (male connector)
2. No. 4 hose
3. Pressure gage 0–15 psig
4. Pressure regulator (self bleeding)
5. Radiator cap 15–16 psig
6. Radiator filler neck
7. Overflow tube (optional)
8. Overflow tank (optional)

FIG. A3.2 Coolant Pressurization System

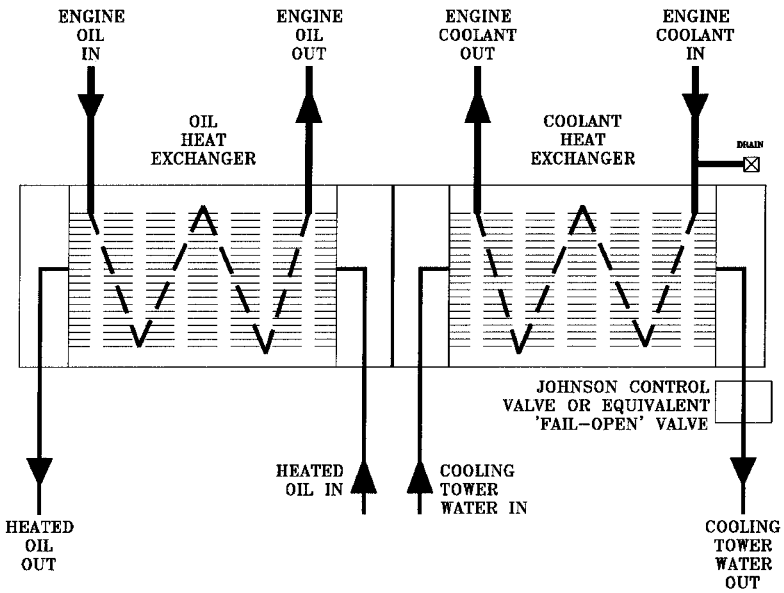
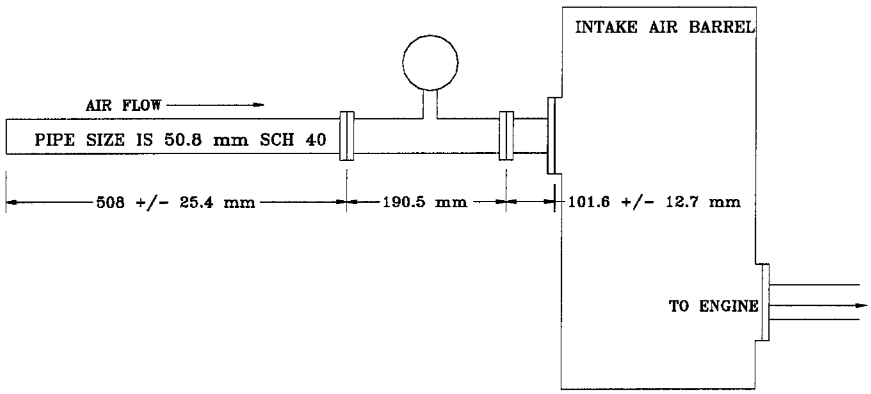


FIG. A3.3 Cooling Tower Water Circuit

A4. INTAKE AIR MASS FLOW SENSOR INSTALLATION

A4.1 The intake air sensor installation is shown in Fig. A4.1.



NOTE—Meter: Model 780 in-line mass flow meter by Sierra Instruments;
Accuracy: ±2 %;
Part No.: 780–F6–CG–(other options).

FIG. A4.1 Intake Air Sensor Installation

A5. FUEL SYSTEM DESIGN AND REQUIRED COMPONENTS

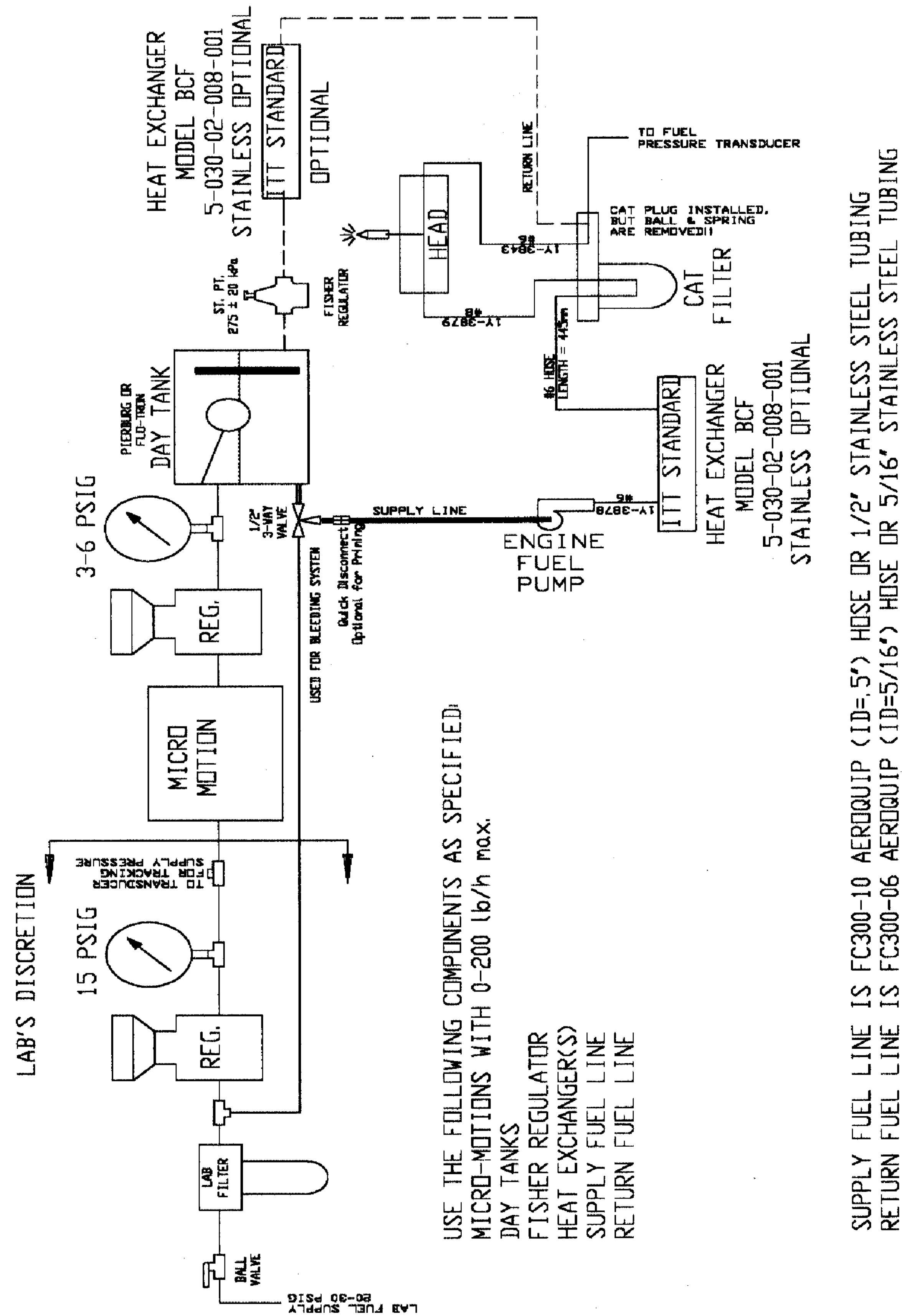


FIG. A5.1 Fuel System Design and Required Components

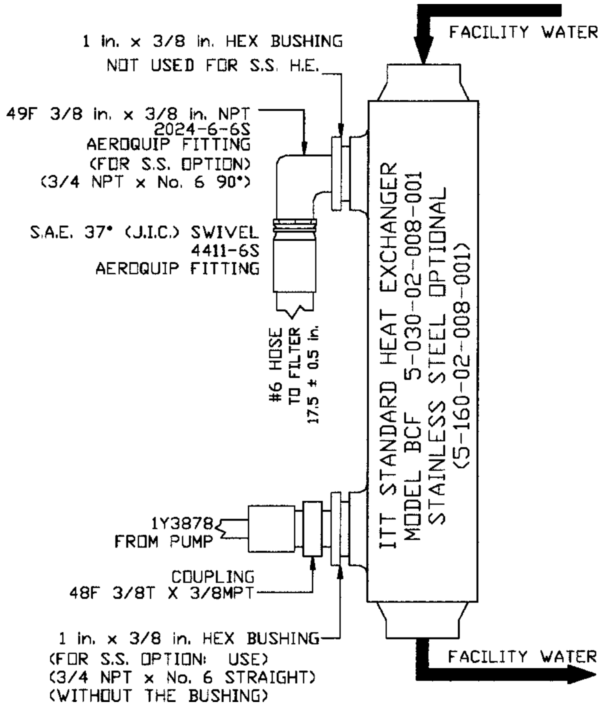


FIG. A5.2 Fuel Heat Exchanger Plumbing Connections

TABLE A5.1 Fisher Regulator Information

NOTE—Information as it appears on regulator tag.

Type 98	Pressure Units	Inlet, max	Spring Range	Trim Material	Allowable Inlet Pressure, max
H-17	PSIG	75	22-75	SST	250

A6. OIL SYSTEM

A6.1 *Verification of Oil Scale Pump Flows*—Verify the oil scale pump flow rates with EF-411 at 26.5 ± 5.5°C as the test fluid using the following procedure. The following equipment is needed.

A6.1.1 One stopwatch.

A6.1.2 One to 2 gal of EF411 oil at 26.5 ± 5.5°C.

A6.1.3 One temporary reservoir pan.

A6.1.4 One temporary discharge pan.

A6.2 *Procedure for Flow from Oil Pan to Oil Scale*:

A6.2.1 Disconnect the line from the oil pan and place in temporary reservoir pan.

A6.2.2 Disconnect the line from the oil scale and place in the temporary discharge pan.

A6.2.3 The height of the pump relative to the reservoir and discharge pans shall be within 3 ft to reduce any head pressure differences, which may affect the flow rates.

A6.2.4 Prime the system (both hoses and pump), then shutdown.

A6.2.5 Empty the discharge pan and record the weight of it.

A6.2.6 Turn the system on and start the stop watch at the same time.

A6.2.7 Let the system run for 4 min and then stop it.

A6.2.8 Weigh the oil in the discharge pan, subtracting the empty weight.

A6.2.9 Determine the flow rate.

A6.3 *Procedure for Flow from the Oil Scale to the Oil Pan*:

A6.3.1 Repeat the above procedure by disconnecting the line from the oil scale and placing it in the temporary reservoir pan and disconnecting the line at the oil pan and placing it in the temporary discharge pan.

A6.3.2 The following materials are needed.

A6.3.2.1 *Steel Tubing*, ¼ in. OD, 3⁄16 in. ID, approximately 1 in. long.

A6.3.2.2 *Adapter Fitting*, ¼ in. NPT to desired connection type (Fig. A6.4 shows an Aeroquip No. 2000-4-4B for a #4, 45° flare).

A6.3.2.3 *Silver Solder*.

A6.3.3 *Procedure*:

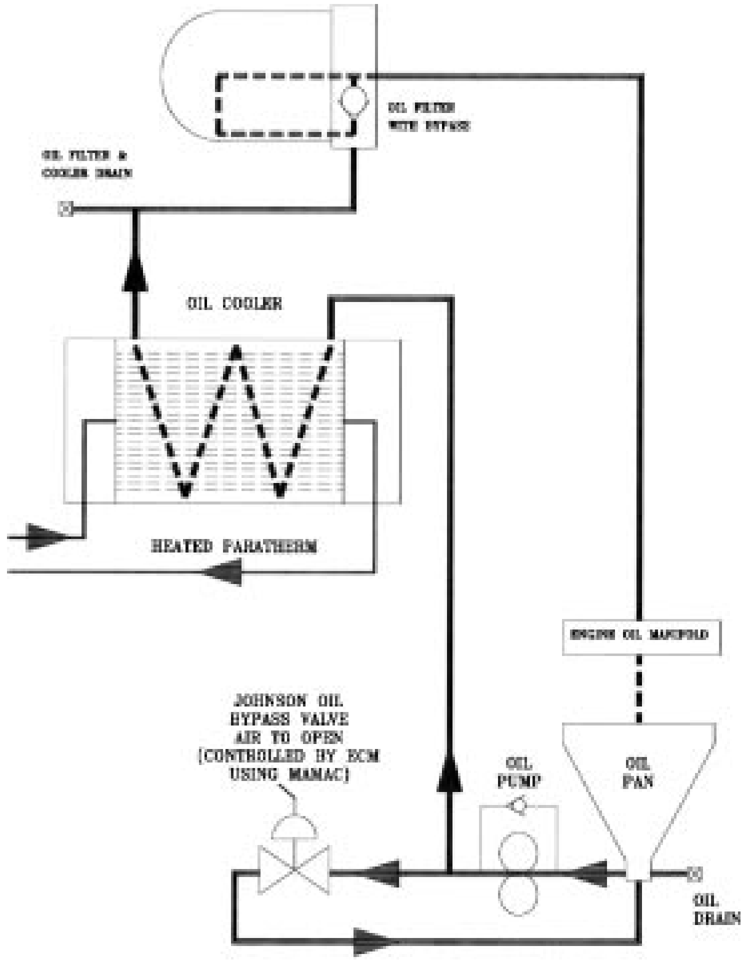


FIG. A6.1 Oil System

A6.3.3.1 Drill adapter fitting on pipe thread end to ¼ in. nominal diameter, ⅜ in. min depth.

A6.3.3.2 Insert tube into fitting until bottomed out in the ¼ in. hole.

A6.3.3.3 Silver solder the tube-to-fitting joint.

A6.3.3.4 Remove oil pan from engine and install the fitting in location specified.

A6.3.3.5 Mark the tube location to achieve 5 ± 1 mm protrusion into the oil pan.

A6.3.3.6 Remove the fitting and cut to length.

A6.3.3.7 Re-install fitting in pan, check protrusion, and re-install oil pan on engine.

A6.4 *Oil Consumption Linear Regression Method*—If there is good reason to assume that a variable *Y* is dependent upon another variable *X* and that the relationship is linear, the best-fit line describing this relationship can be plotted using the following equations. Also see Figs. A6.5 and A6.6.

$$m = \frac{\sum x_i y_i - \frac{\sum x_i \sum y_i}{n}}{\sum x_i^2 - \frac{(\sum x_i)^2}{n}} \tag{A6.1}$$

$$b = \left[\frac{\sum y_i}{n} - m\frac{\sum x_i}{n}\right] \tag{A6.2}$$

$$r^2 = \frac{\left[\sum x_i y_i - \frac{\sum x_i \sum y_i}{n}\right]^2}{\left[\sum (x_i)^2 - \frac{(\sum x_i)^2}{n}\right]\left[\sum (y_i)^2 - \frac{(\sum y_i)^2}{n}\right]} \tag{A6.3}$$

where:

y_i = oil weights taken at time *x*,
x_i = times at which oil weight observation *x* are made,
m = slope of best-fit line = oil consumption,
b = *y* intercept, and
r^2 = goodness of fit (1 if perfect, 0 if not fit at all).

A6.5 *Oil Sampling Procedure*:

A6.5.1 Record oil scale reading at test hour four _____ g. This is the *Full Mark.*

A6.5.2 Record the *oil weight* from the 24th hourly reading _____ g.

A6.5.3 Remove *250 mL purge sample* from sample valve on the oil manifold.

$$\frac{}{purge + container} - \frac{}{container} = \frac{g}{purge}$$

A6.5.4 For *test hours 24, 96, 240, 288 and 360,* remove a *90 mL sample* from the sample valve on the oil manifold.

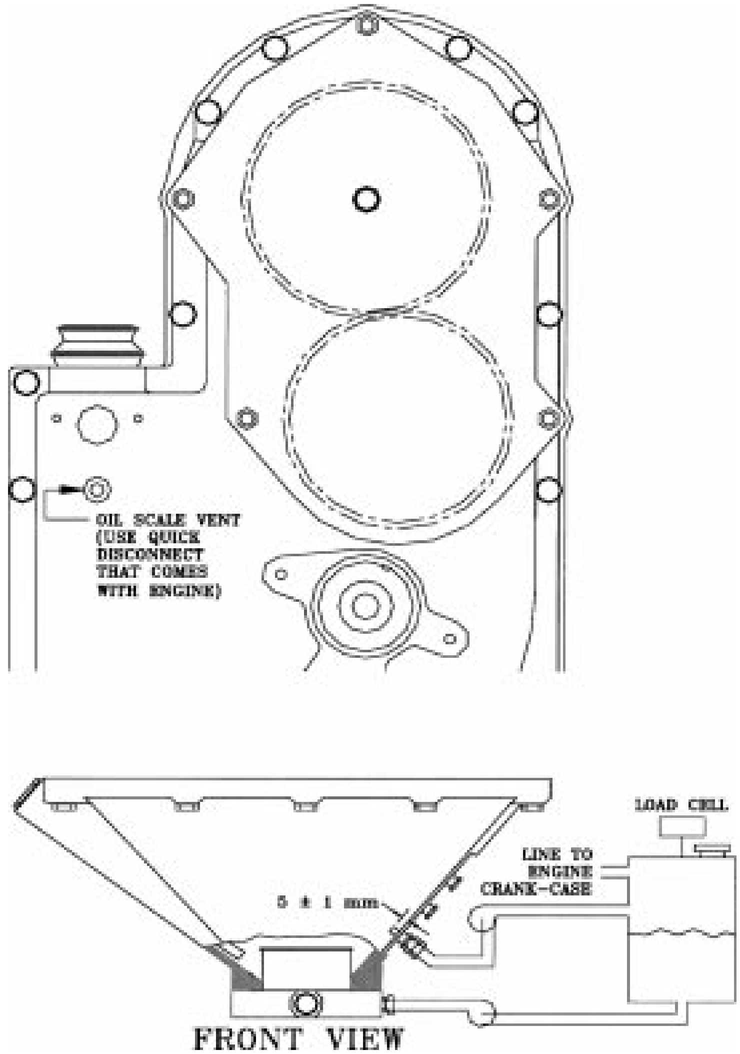


FIG. A6.2 Oil Scale Measurement System

$$\frac{}{\textit{sample + container}} - \frac{}{\textit{container}} = \frac{g}{\textit{sample}}$$

A6.5.4.1 Add 370 ± 10 g of *NEW test oil* to the oil weigh tank.

$$\frac{}{\textit{new oil + container}} - \frac{}{\textit{container}} = \frac{g}{\textit{new oil}}$$

A6.5.5 For *test hours 48, 72, 120, 144, 168, 192, 216, 264, 312 and 336,* remove a *30 mL sample* from the sample valve on the oil manifold.

$$\frac{}{\textit{sample + container}} - \frac{}{\textit{container}} = \frac{g}{\textit{sample}}$$

A6.5.5.1 Add 317 ± 10 g of *NEW test oil* to the oil weigh tank.

$$\frac{}{\textit{new oil + container}} - \frac{}{\textit{container}} = \frac{g}{\textit{new oil}}$$

A6.5.6 Add back enough purge sample to return the oil weigh tank to its Full Mark using the following formula:

$$\text{purged to be returned} = FM - A \tag{A6.4}$$

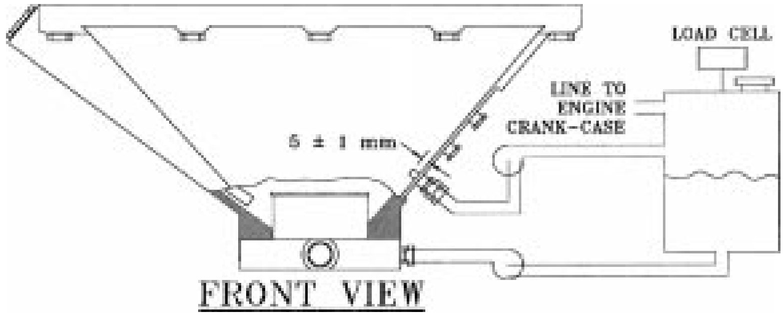
where:

$$A = \frac{}{\#2;\ 24\textit{th Hourly Reading};\ (\textit{Scale Weight})} - \frac{}{\#3;\ \textit{Purge Weight}}$$
$$- \frac{}{\#4;\ \textit{Sample Weight};\ (\textit{if taken})} + \frac{}{\#5;\ \textit{New Oil Weight}}$$

A6.5.7 Record the weight of *unused* purge sample by using scale.

$$\frac{}{\textit{unused purge + container}} - \frac{}{\textit{container}} = \frac{g}{\textit{unused purge left over}}$$

NOTE A6.1—If you are short in returning to the full mark, use fresh oil to make up the difference.



NOTE—(*1*) Suction Pump and Hose (or equivalent)
Type: Viking C-90 Pump
Flow: 6 ± 1.5 g/h
Speed: 285 r/min
Hose: 0.25 in. ID TFE-fluorocarbon steel braided 9 ft max length
Pulley: 4.95 in. OD
(*2*) Return Pump and Hose (or equivalent)
Type: Viking C-92 Pump
Flow Differential: 3 ± 1 g/h
Speed: 163 r/min
Hose: 0.25 in. ID TFE-fluorocarbon steel braided 9 ft max length
Pulley: 8 in. OD
(*3*) Pump Motor (both pumps) (or equivalent)
Type: 56 Nema Grainger 6K949
Speed: 1140 r/min
HP: ¾
Pulley: 1.5 in. OD
(*4*) Vent Line: 0.25 in. ID hose
(*5*) Oil in Reservoir: 1000 g (approximately)
(*6*) Scale Precision: See Procedure
(*7*) Flexible Hose: (to and from fixed external sump support) (or equivalent): Aeroquip FC352-08

FIG. A6.3 Low Flow Oil Scale System

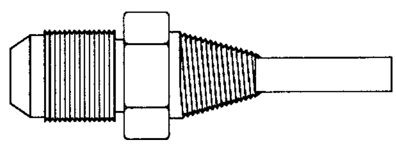


FIG. A6.4 Oil Pan Suction Fitting to Oil Scale

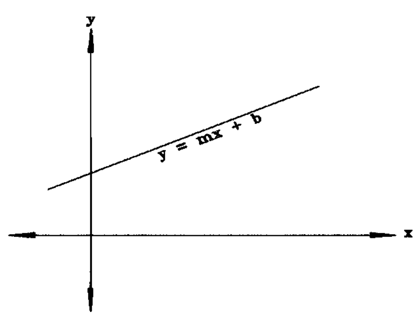


FIG. A6.5 Equation of a Straight Line

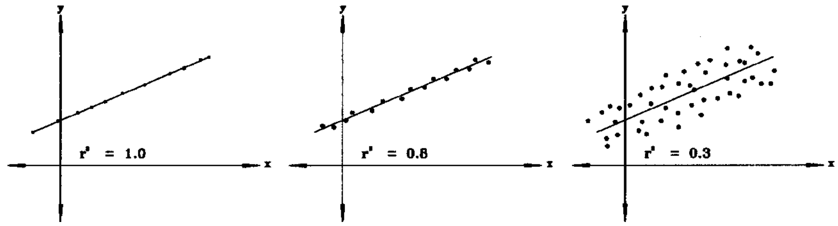
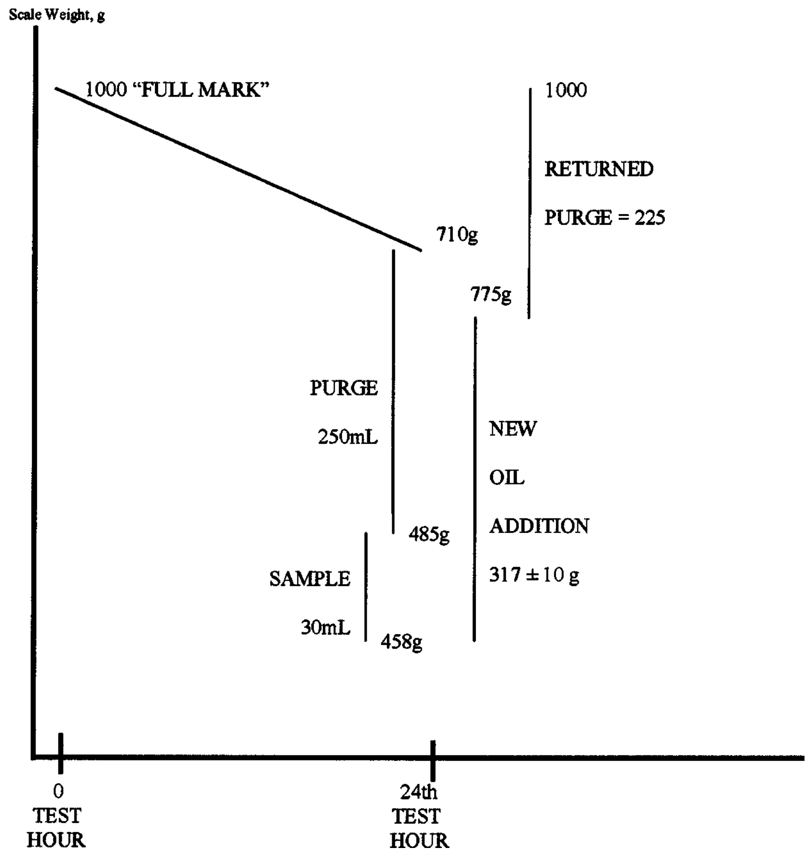
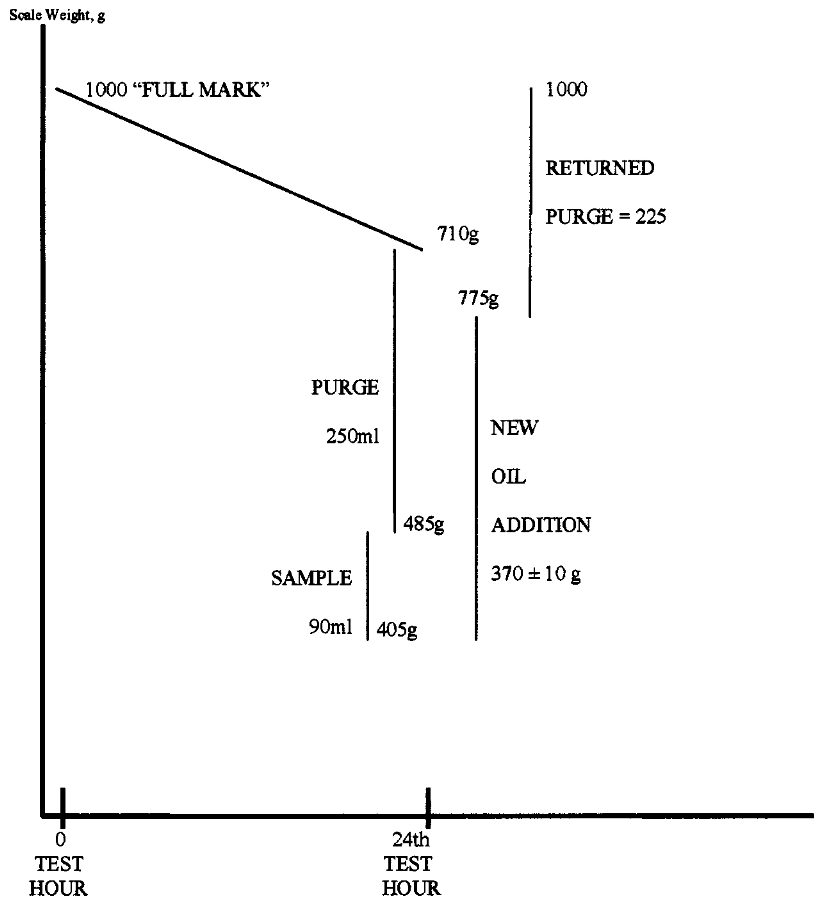


FIG. A6.6 Examples of the Goodness of Fit



NOTE—Taken at 48, 72, 120, 144, 168, 192, 216, 264, 312, 336 h.

FIG. A6.7 Example of Oil Addition Procedure with 30 mL Sample



NOTE—Taken at NEW, 24, 96, 240, 288, 360 h.

FIG. A6.8 Example of Oil Addition Procedure with 90mL Sample

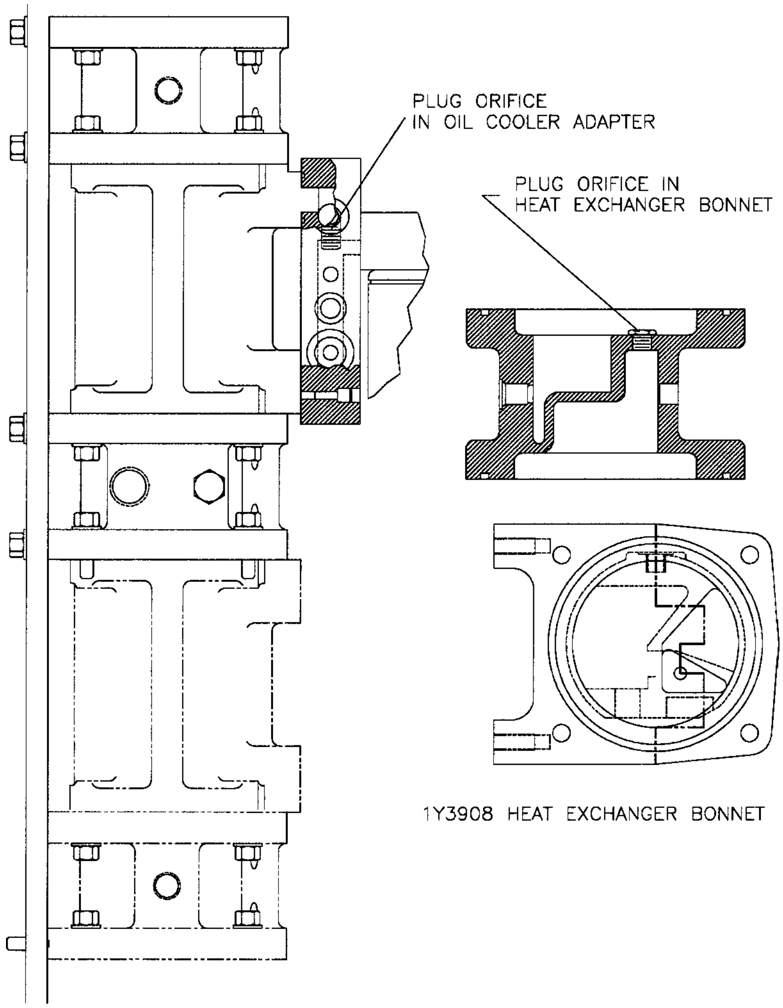


FIG. A6.9 Engine Oil Heating Hardware

A7. EXHAUST AND INTAKE BARREL PIPING

A7.1 The exhaust and intake barrel piping are illustrated in Figs. A7.1 and A7.2.

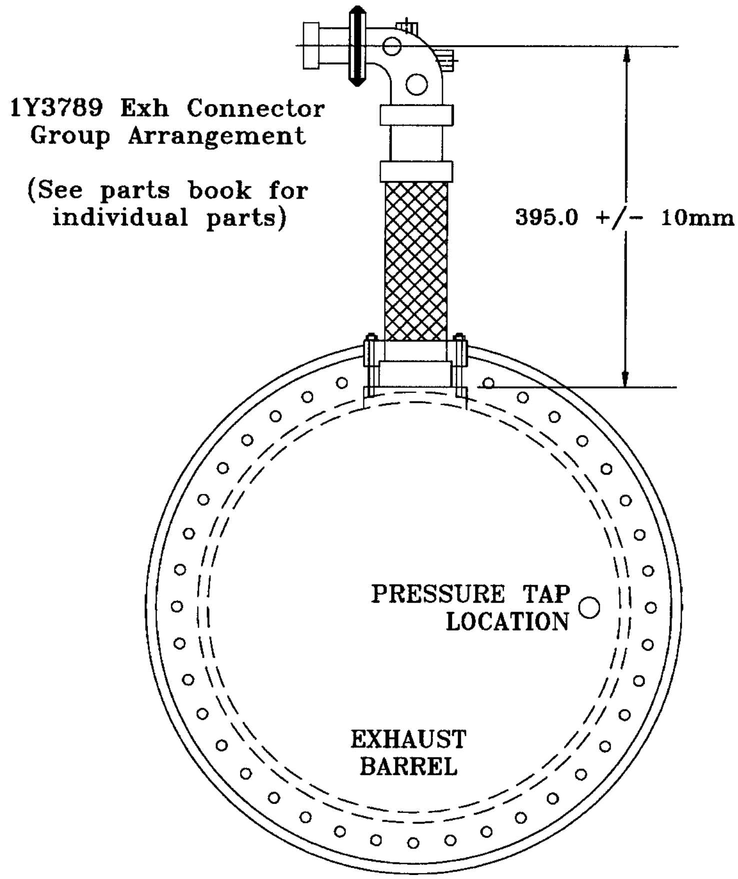
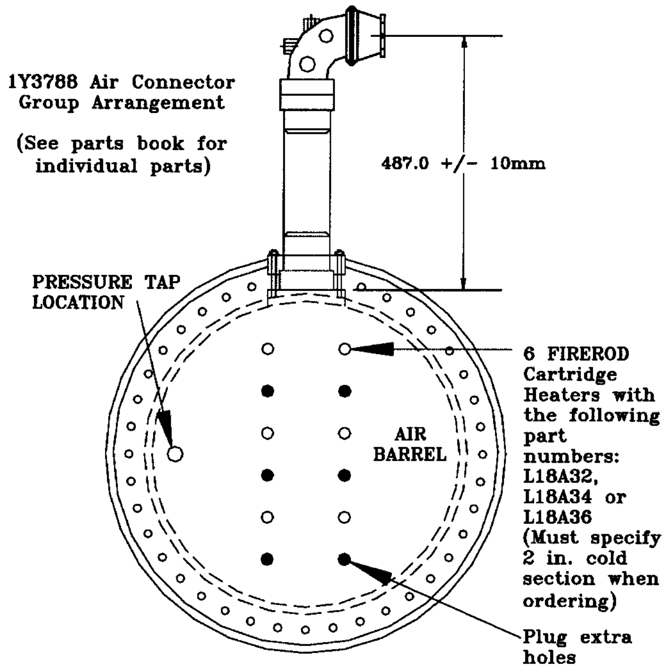


FIG. A7.1 1Y3978 Exhaust Barrel and Piping



NOTE 1—Dummy heater elements may be substituted for the FIREROD cartridge heaters, as long as they are the same dimension of 21 in. × ⅝ in. diameter. The 21 in. is from end-to-end. Length tolerance is 3 in. and the diameter tolerance is 1⁄64 in.

NOTE 2—FIREROD cartridge heaters may be purchased from Southwest Heater and Controls, 12052 Forestgate Dr., Dallas, TX 75243.

FIG. A7.2 1Y3976 Intake Air Barrel and Piping

A8. HUMIDITY PROBE INSTALLATION

A8.1 Figs. A8.1 and A8.2 illustrate the humidity probe installation locations.

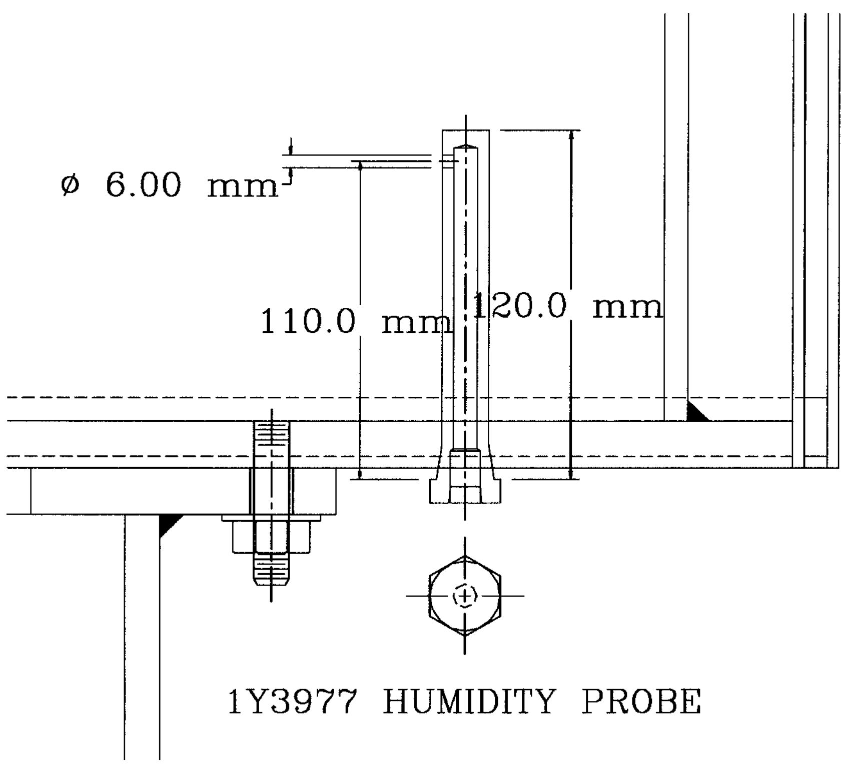


FIG. A8.1 Humidity Probe Installation Location

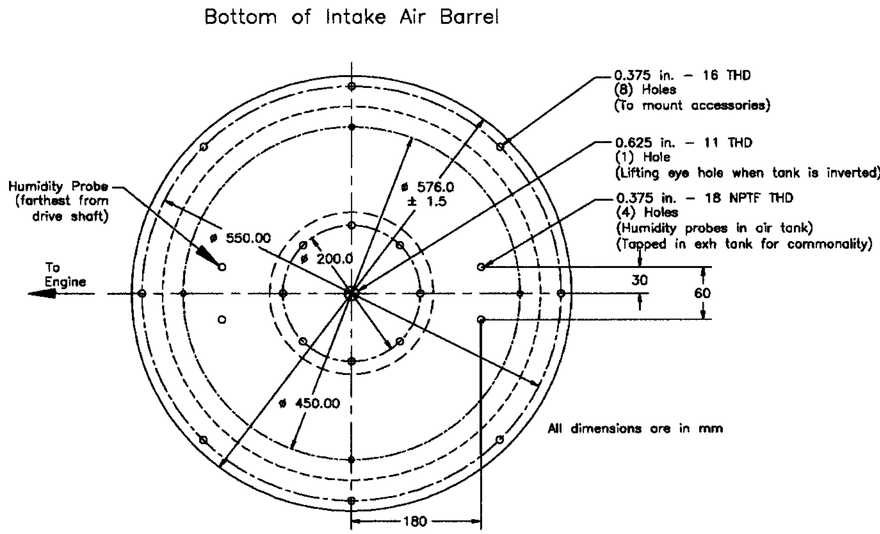


FIG. A8.2 Humidity Probe Installation Location—Barrel Bottom

A9. RETURN GOODS AUTHORIZATION

A9.1 Fig. A9.1 is a sample return goods authorization claim form.

Return Goods Authorization Number: ____________________.

Claim Date: ______________.

Contact: Caterpillar Inc
Engine System Tech Dev.
P.O. Box 610
Mossville, Il 61552
Phone: 309-636-5247
Fax: 309-675-1598
Attn: R.A. Riviere

Part Number / Quantity: ____________________/_________.

Part Name / Hrs On Part: ___________________/_________.

Date Part Purchased: ______________.

Engine Serial Number: ____________________.

Test Lab

Name: ____.

Address: ____.

Contact Person's Name: ______________________________.

Phone Number: ___________________________.

Fax Number: ___________________________.

Name of Dealer That Sold Part: ________________________________.

INCLUDE DOCUMENTATION AND PHOTOS OF NONCONFORMING PART

FIG. A9.1 Sample Return Goods Authorization Claim Form

A10. ENGINE ASSEMBLY INFORMATION

A10.1 *1Y3700 Engine Mechanical Timing*—Remove the camshaft gear to replace cylinder head components after test and re-time as follows (see Fig. A10.6):

A10.1.1 Rotate the engine to position the piston at TDC.

NOTE A10.1—The TDC mark on the flywheel will align with the timing pointer. The 6.28 mm diameter 1Y3919 timing pin will insert in the crank gear key-way slot through the timing hole in the front housing near the oil pump flange.

A10.1.2 Pin the camshaft with a second 6.28 mm diameter 1Y3919 timing pin.

A10.1.3 Mesh the camshaft gear with the adjustable idler gear and with the UP mark on the front face of the camshaft gear in the 12:00 o'clock position. Assemble the camshaft gear to the camshaft.

A10.1.4 Set lash between the adjustable idler gear and the camshaft gear and torque the six socket head bolts at the stub-shaft flange.

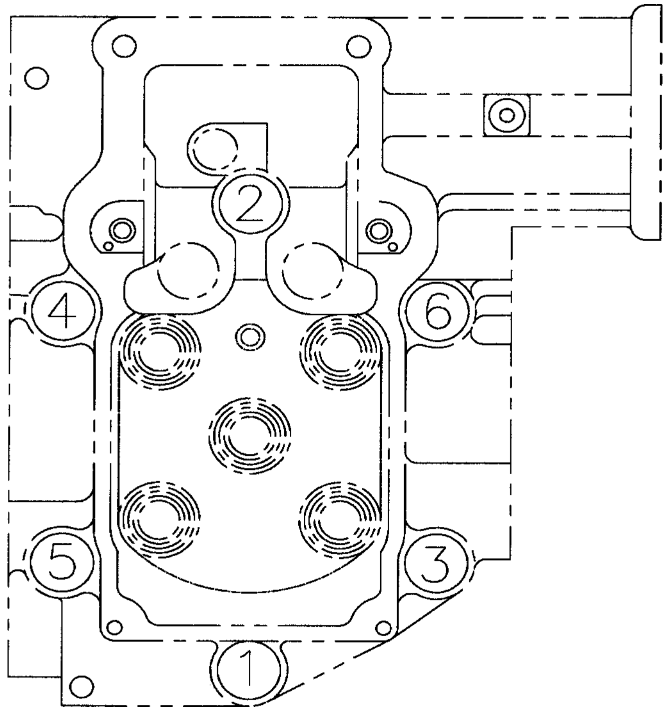
A10.1.5 Remove both 6.28 mm diameter timing pins.

A10.2 *1Y3700 Engine Mechanical Timing—General Information*:

NOTE A10.2—This is not part of the normal engine timing procedure.

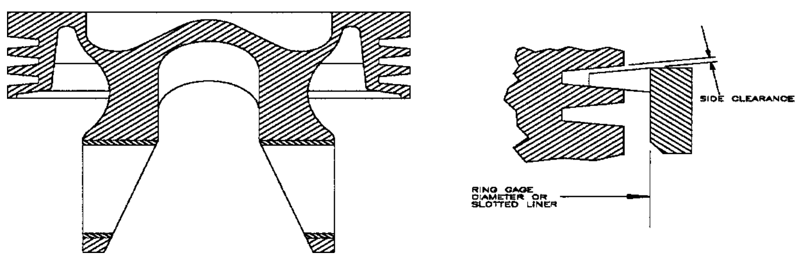
A10.2.1 This procedure is to be followed only on new engine assembly or in the event that a new timing disk, or crankshaft, or flywheel, or front housing is assembled on an old engine.

A10.2.2 With the crankshaft connecting rod journal at top dead center (TDC), the tooth valley V mark on the crankshaft gear is 35.38° clockwise from the vertical and the key-way is 68.48° clockwise from vertical. With the crankshaft gear fixed, assembly of the cluster idler gear on its stub-shaft causes the cluster idler gear to rotate 2.87° clockwise, so that its dash marked tooth is 145.73° counterclockwise from vertical. The V and dash marks line up valley-to-tooth.



NOTE 1—(*1*) Lubricate stud threads and both washer faces with Mobil EF411 engine oil.
(*2*) Tighten cylinder head nuts with hand torque wrench:
(*a*) Tighten nuts 1 through 6 in numerical sequence to 100 ± 15 N·m.
(*b*) Tighten nuts 1 through 6 in numerical sequence to 200 ± 15 N·m.
(*c*) Tighten nuts 1 through 6 in numerical sequence to 400 ± 15 N·m.
NOTE 2—Coat valve stems with Mobil EF411 engine oil immediately prior to installation.

FIG. A10.1 Cylinder Head Tightening Procedure



NOTE—Piston part nos: Skirt 1Y3659, Crown 1Y3400;
Rings part nos: Top 1Y3802, Intermediate 1Y3803, Oil 1Y3804.

FIG. A10.2 Piston and Ring Specifications

A10.2.3 Assembly of the adjustable idler gear with its UP mark at the top orients the three kidney-shaped openings in the gear web to allow access to the socket head bolts that attach the adjustable idler gear stub-shaft to the front housing plate.

A10.2.4 Assembly of the camshaft gear with its V mark and UP mark at the top and with the camshaft pinned to the cylinder head, by design, results with the 0.50 in. bolts on-center of the 17 mm diameter clearance holes in the camshaft gear. Additive tolerances for all the involved parts can cause the bolts to be off-center in either direction. The purpose of the oversize holes is to ensure that the gears will mesh at all off-nominal, but in tolerance dimensions of the parts.

A10.2.5 With the camshaft and the crankshaft pinned, the engine is necessarily at top dead center on the firing stroke. The flywheel pointer is at 0° (TDC). The leading edge of a 3° timing notch on the camshaft gear is on the centerline of the cam sensor hole in the front housing. The leading edge of a 6° notch on the crankshaft timing disk is on the centerline of the crankshaft sensor hole in the front housing.

A10.2.6 With the flywheel pointer at 3° after top dead center, a 1Y3918 pin inserted in the crank timing sensor hole in the front housing shall also slide into a 6° wide notch of the crankshaft timing disk. This verifies that the leading edge of a notch on the timing disk is on the centerline of the crankshaft sensor which sets TDC for the electronic control module (ECM).

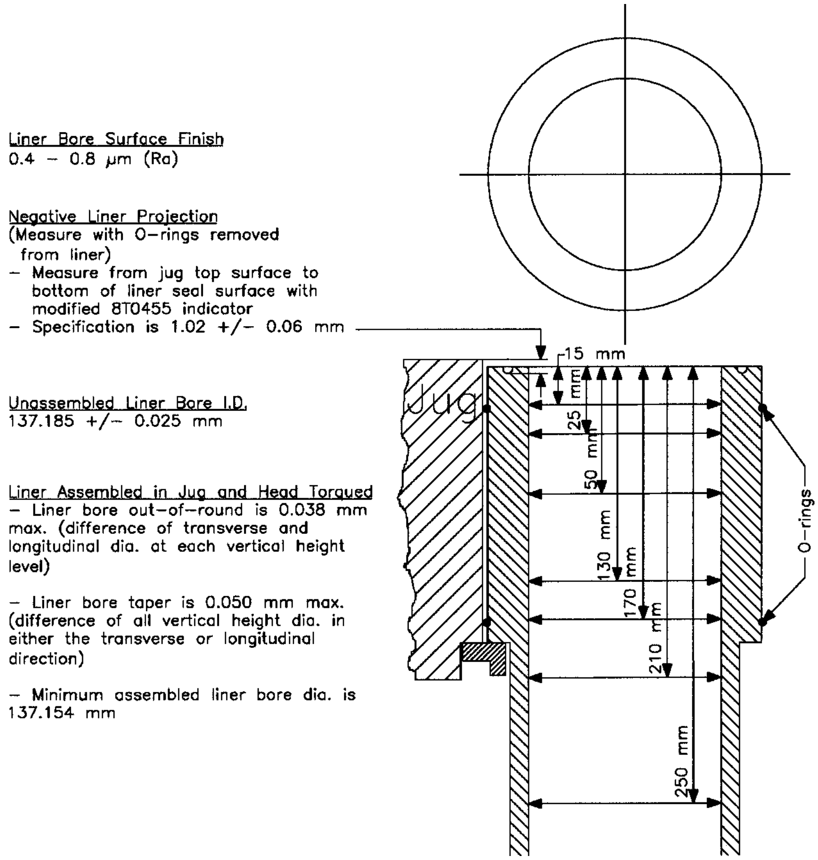
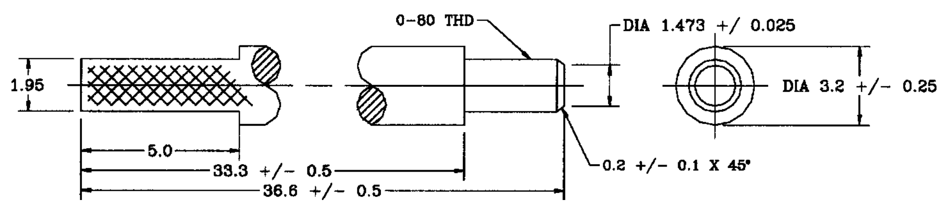


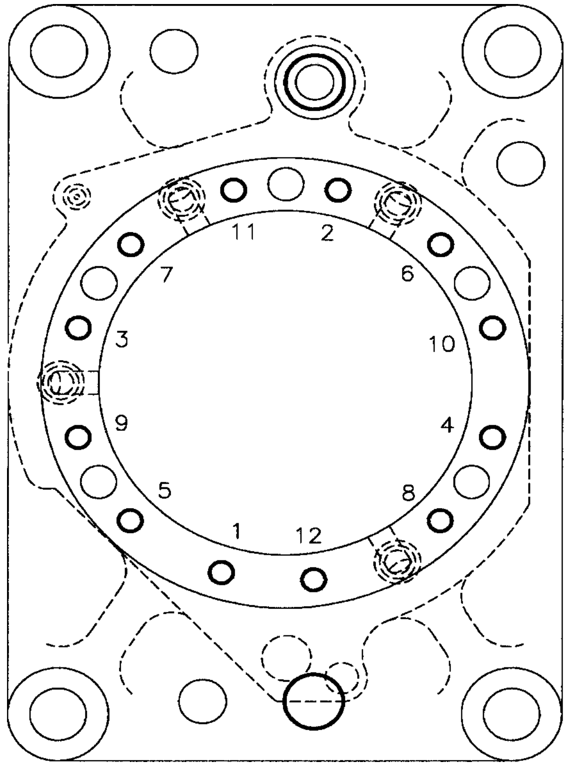
FIG. A10.3 Cylinder Liner Measurements and Specifications



NOTE 1—Grind the tip to 1.95 ± 0.02 mm diameter for 5.0 ± 0.5 mm long from spherical end. All dimensions are in mm.

NOTE 2—Indicator measures liner recession from the jug deck surface to the bottom of the liner combustion seal groove. The tip of the 8T0455 indicator rod requires modifications as indicated.

FIG. A10.4 Cylinder Liner Projection Measurement Indicator Modifications



NOTE 1—Center the support ring I.D. to the cylinder liner with four feeler gages of equal thickness, hand tighten the stud nuts, but remove feeler gages before tightening stud nuts.

NOTE 2—Tighten the stud nuts in numerical order as shown with a sequence level of 15, 55, and 105 ± 10 N·m.

NOTE 3—The cylinder liner support ring torque sequence may be used after the cylinder head torque sequence as an alternate method if the liner bore distortion is out of test specifications.

FIG. A10.5 Cylinder Liner Support Ring Tightening Procedure

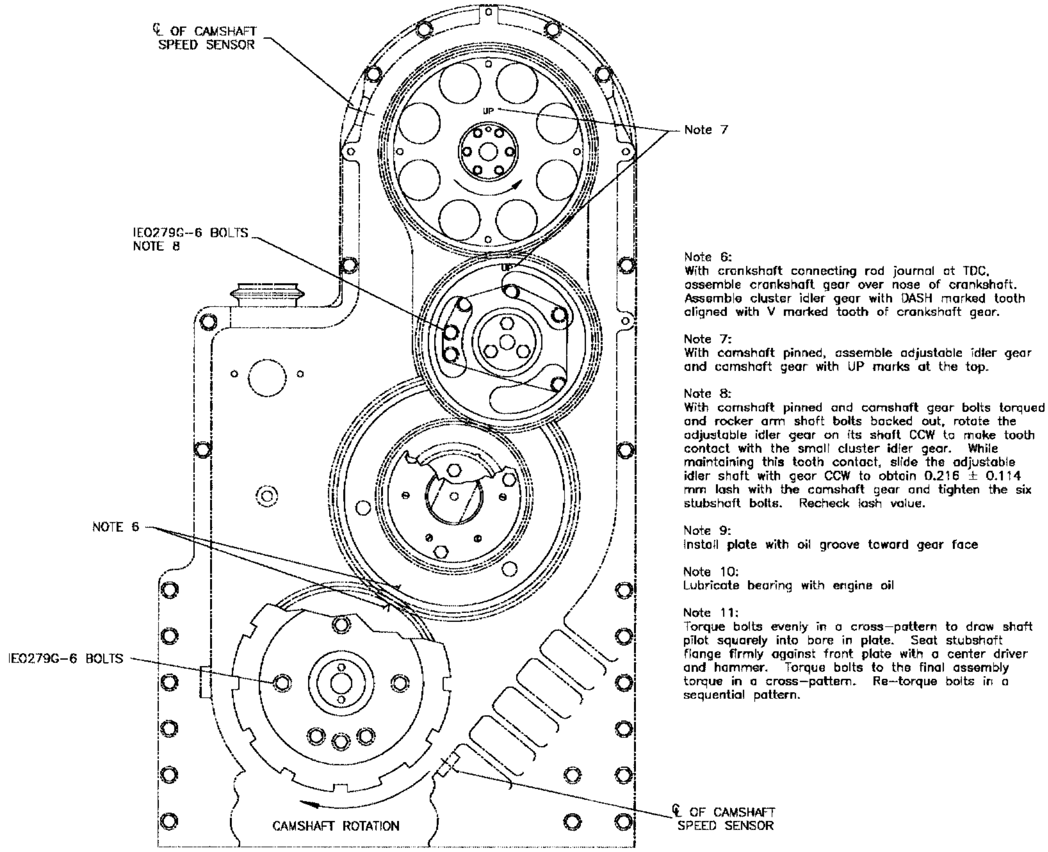
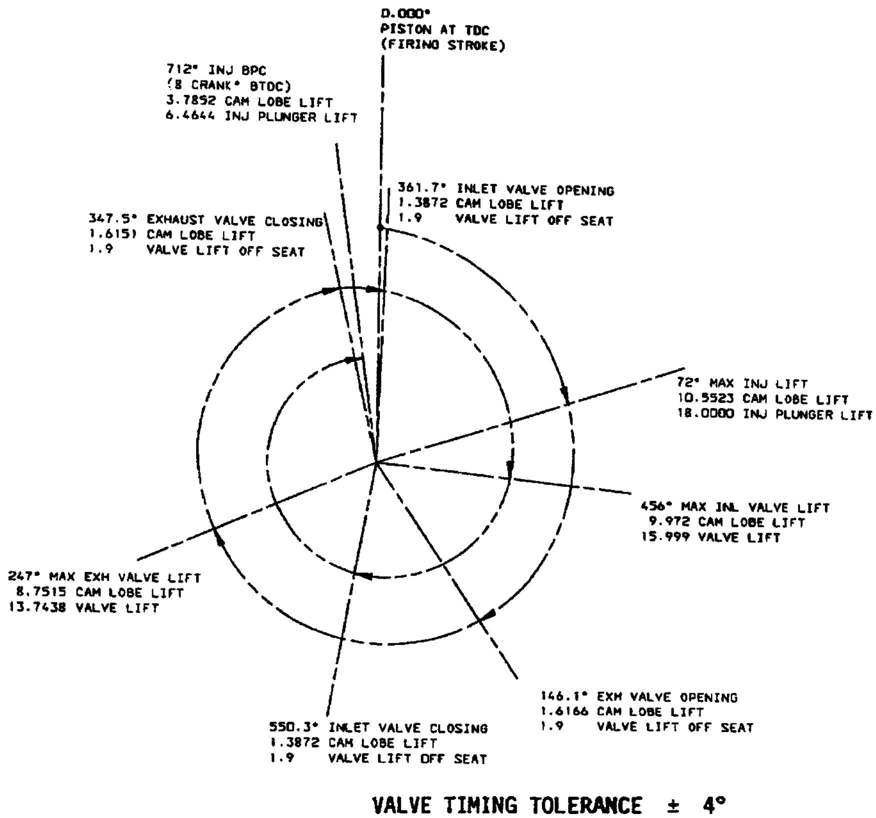


FIG. A10.6 1Y3700 Engine Timing



NOTE—(*a*) Timing events in crankshaft degrees (reference only).
(*b*) As viewed from front.
(*c*) intake valve clearance set cold at 0.38.
(*d*) intake valve clearance set cold at 0.76.
(*e*) 1998 Scote engine.

FIG. A10.7 Timing Events in Crankshaft Degrees (for reference purpose only)

TABLE A10.1 Piston and Ring Specifications

	Top Ring[A]	Intermediate Ring[A]	Oil Control Ring[A]
Width of groove in piston for piston ring (new)			3.21 ± 0.01 mm
Thickness of piston ring (new)			3.137 ± 0.006 mm
Side clearance between groove and piston ring (new)	0.080 mm, min	0.140 - .214 mm	0.057 - 0.089 mm
End gap clearance between end of ring (new) installed in 137.160 mm diameter gage	0.585 - 0.737 mm	1.004 - 1.156 mm	0.382 - 0.636 mm

[A] This engine uses keystone style piston rings and grooves in the piston. The piston ring lands are also elliptically ground; therefore, measure ring side clearance as follows:

(*a*) Assemble piston ring on the piston with UP side toward the top of the piston.
(*b*) Install piston and ring in a 137.60 mm diameter ring gage or modified slotted liner (see Appendix X1).
(*c*) Push piston and ring until ring to be measured is at the top of the gage. Keep the piston in the center of the gage.
(*d*) Measure the side clearance with a feeler gage at both major (90° from the centerline of the pin bore) and minor diameters. Each measurement should be within specification shown.
(*e*) Install the oil control ring with gap in the spring 180° away from the gap in the ring.

TABLE A10.2 Engine Assembly Measurements, mm

Items to be checked	Specifications min	mean	max	Actual
Crankshaft end play	0.11	0.34	0.57	
Camshaft end play	0.175	0.25	0.325	
Main bearing clearance (no.1) (front)	0.089	0.138	0.187	
Main bearing clearance (no.2)	0.089	0.138	0.187	
Main bearing clearance (no.3)	0.089	0.138	0.187	
Main bearing clearance (no.4)	0.089	0.138	0.187	
Nozzle tip projection	1	1.3	1.6	
Cam gear backlash	0.102	0.216	0.33	
Piston to head clearance	1.55	1.62	1.69	
Intake valve (1) Recess (closest to manifold)	2.2	2.5	2.8	
Intake valve (2) Recess	2.2	2.5	2.8	
Exhaust valve (1) Recess (closest to manifold)	1.2	1.5	1.8	
Exhaust valve (2) Recess	1.2	1.5	1.8	
Initial intake valve lash (cold)		0.38		
Initial exhaust valve lash (cold)		0.76		
Initial injector setting		78[A]		[A]
After test intake valve lash (cold)	0.3	0.38	0.46	
After test exhaust valve lash (cold)	0.68	0.76	0.84	
After test injector setting	77.8[A]	78[A]	78.2[A]	[A]
Flywheel adapter runout (bore TIR)			0.15	
Flywheel adapter runout (face TIR)(at R95)			0.15	
Timing sensor location in front housing	2° ATDC	3° ATDC	4° ATDC	
Liner negative projection	1.12	1.17	1.22	
Liner ID taper			0.051	
Liner ID out of roundness			0.038	
Liner ID smallest anywhere			137.154	
Align pointer with TDC mark on flywheel.				
Verify top of liner is below jug surface.				
Flow cooling jet to verify aim.				
Injector and valve max lifts				
Injector plunger lift at 72° crank	17.3	18.0 mm	18.7	
Exhaust valve lift at 247° crank	13.0	13.7 mm	14.4	
Intake valve lift at 456° crank	15.3	16.0 mm	16.7	

[A] Go/No-Go gage

A11. FLUSHING INSTRUCTIONS AND APPARATUS

A11.1 Table A11.1 is the flushing instruction sheet and Figs. A11.1-A11.3 illustrate the flushing apparatus.

TABLE A11.1 Flushing Instruction Sheet

Step	Procedure	Flushing Fluid	Relief Valve[A]
1	Drain used oil from sump, cooler, oil scale and remove oil filter Install 1Y3916 plug in front plate (in place of fuel cam/cylinder head) Install 1Y3979 cover on top of block Install 1Y3980 piston jet aim fixture on top of 1Y3979 cover Connect flush cart outlet to filter flush adapter 1Y3935 and 5 spray nozzles		open
2	Connect flush cart pump inlet to solvent tank Install new oil filter on the oil flush cart Open engine sump drain. Then pump solvent into engine to flush used oil	7.6 L Stoddard solvent no recirculation	closed
3	Connect flush cart pump inlet to engine oil sump Close engine sump drain Circulate fluid with flush cart and oil scale pumps turned on	Cleaning mixture of 1.9 L Dispersant Engine Cleaner 5.7 L Stoddard Solvent	closed 5 min. open 5 min.
4	Drain mixture from sump, cooler, oil scale, flush cart and filters		open
5	Circulate fluid with flush cart and oil scale pumps turned on	7.6 L Stoddard Solvent	open 5 min. closed 5 min.
6	Drain fluid from sump, cooler, oil scale, flush cart and filters		open
7	Repeat steps 5 and 6 two times or as needed until solvent remains clean		
8	Circulate EF-411 to flush Stoddard solvent	5.6 L EF-411	open 5 min. closed 5 min.
9	Drain oil from sump, cooler, oil scale, flush cart and filters		open
10	Circulate EF-411 at 415 kPa manifold pressure and align piston jets	5.6 L EF-411	open 5 min.
11	Drain oil from sump, cooler and oil scale. Rebuild engine for test		open
12	After engine is rebuilt, motor engine at a minimum of 200 r/min	5.6 L EF-411	Reconnect for normal operation
13	Drain oil from sump, cooler and oil scale		open

[A] Supply 50 kPa air pressure to open the Johnson Controls oil relief valve.

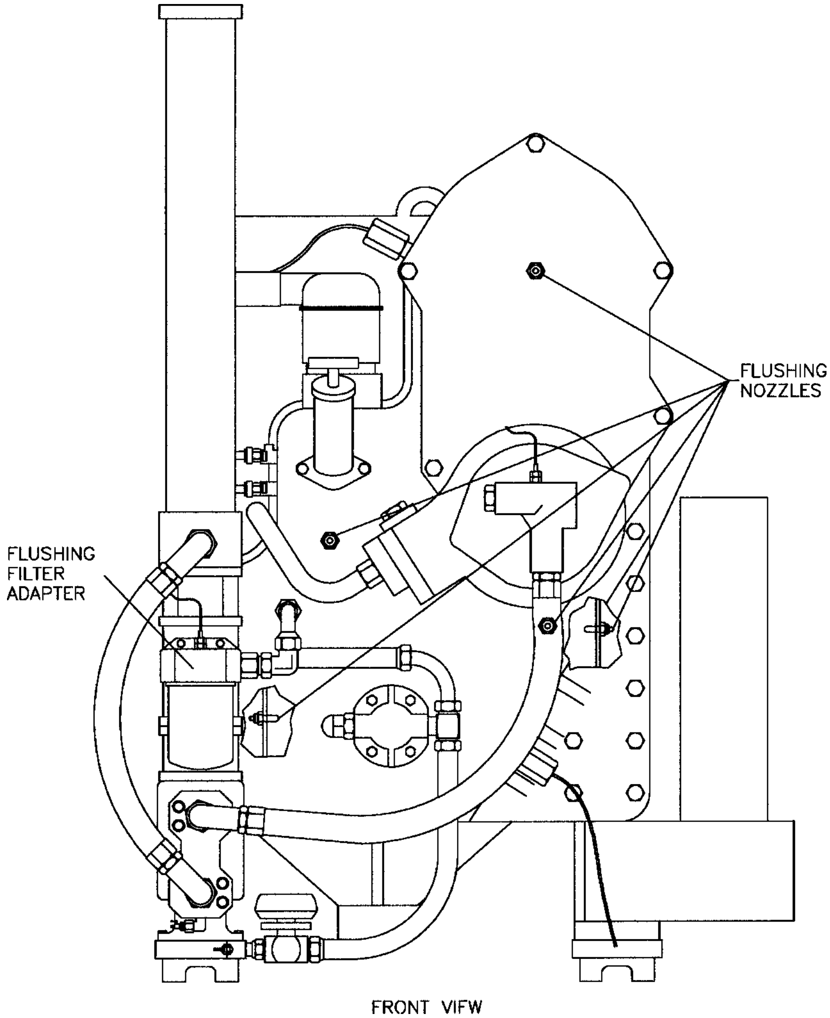


FIG. A11.1 Flushing Nozzle Locations

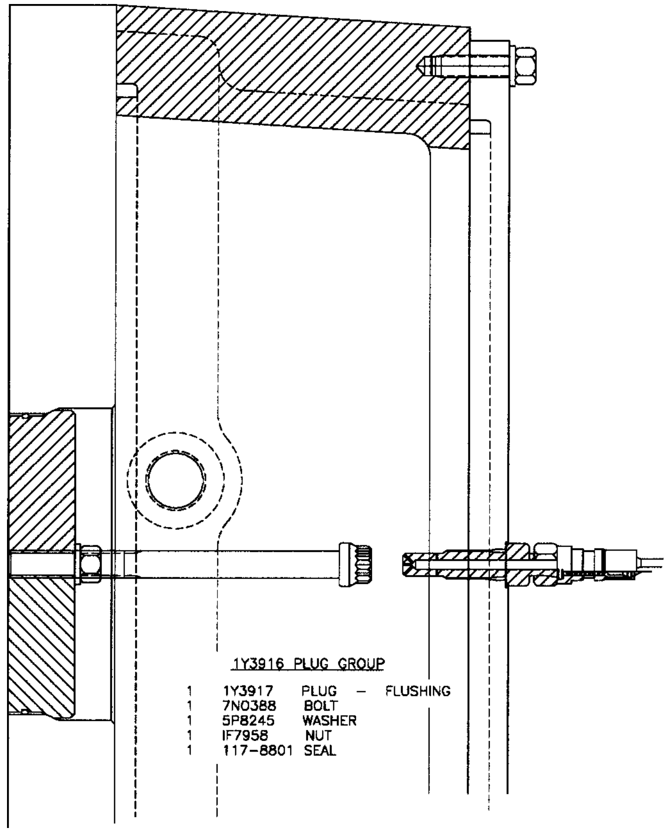


FIG. A11.2 Flushing Plug

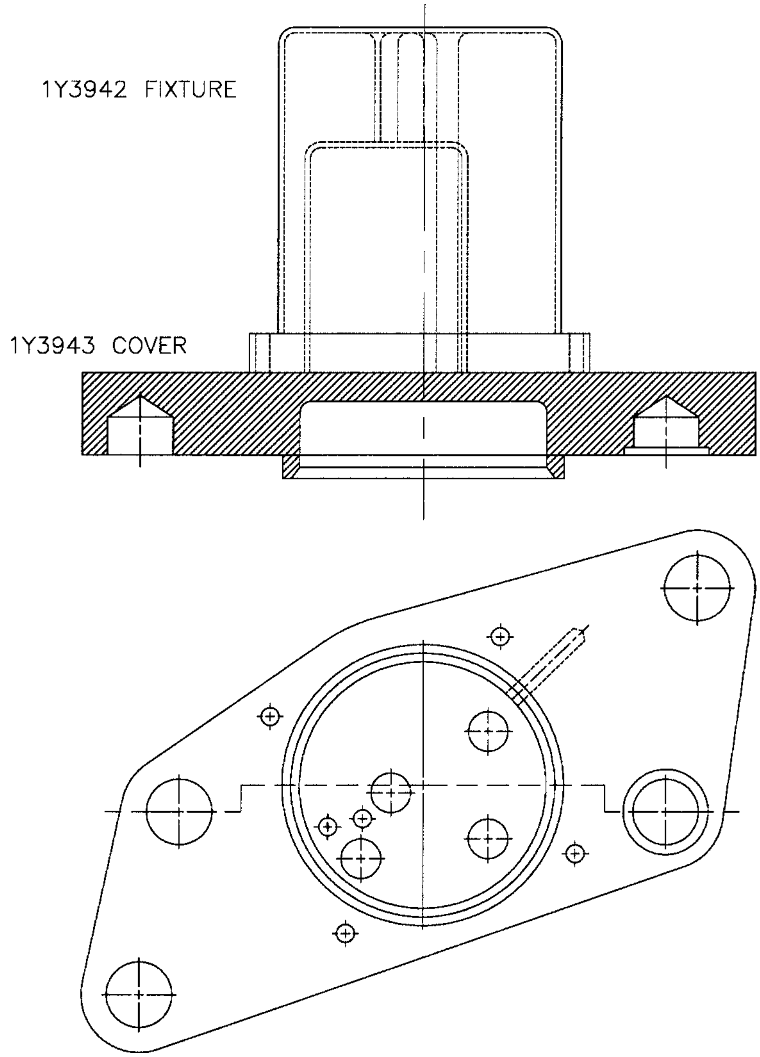


FIG. A11.3 Flushing Fixture

A12. WARM-UP, COOL-DOWN, AND TESTING CONDITIONS

A12.1 See Table A12.1.

TABLE A12.1 Warm-up, Cool-down, and Testing Conditions

Parameter	Units	Tol	Test Specifications Step 1 5 min	Step 2 5 min	Step 3 5 min	Step 4 10 min	Step 5 60 min
Speed	r/min	±3	1000	1000	1400	1800	1800
Power	kW		idle	10	26	41	~55
Torque	N·m	(a) ±5		100	176	219	~285
Fuel rate	g/min	(b) ±1		48	95	148	185
Fuel timing	BTC		13	13	13	13	13
Humidity	g/kg	±1.7					17.8
Temperatures °C							
Fuel into head		±3	~31	~32	~33	~36	42
Coolant into jug			~41	~51	~82	~86	86
Coolant from head		±3	42	52	83	90	90
Oil to cooler							~128
Oil manifold		±3					130
External heating oil			165 max	165 max	165 max	165 max	165 max
Intake air manifold		±3			60	60	60
Exhaust manifold			~120	~275	~340	~370	~480
Pressures kPa							
Fuel from head		±20	275	275	275	275	275
Coolant into jug		(c)	~44	~44	~70	~81	~81
Oil manifold		±20	415	415	415	415	415
Intake air barrel (abs)		±1	120	120	157	225	272
Exhaust barrel (abs)		±1		104	146	217	265
Crankcase						~.05	~.10
Flows							
Coolant	L/min	±2	~34	~34	~55	75	75
Blowby	L/min					~35	~35
Air	kg/h						~315

NOTE 1—(*a*) Engine controlled to torque specification for Steps 2, 3, 4 and 5 min of Step 5.
(*b*) Engine controlled to fuel rate specification for last 55 min of Step 5.
(*c*) Air pressure at coolant tower controlled to 35 kPa.

NOTE 2—Ramp Up Conditions Between Warm-up Steps:
(*a*) Torque (Nm/min); at 5 min (beginning at Step 2)— 20 Nm/min.
(*b*) Speed (r/min); at 10 min (beginning at Step 3)— 100 r/min/min.
(*c*) Inlet air pressure (kPa); at 10 min (beginning at Step 3)— 12 kPa/min.
(*d*) Exhaust air pressure (kPa); at 10 min (beginning at Step 3)— 12 kPa/min.
(*e*) Inlet air temperature (°C); at 10 min (at start of test)— 5°C/min.

A13. PISTON AND LINER RATING MODIFICATIONS

A13.1 The 1P piston deposits are accessed using the Modified CRC Diesel Piston Rating Method described in CRC Manual No. 18. Three levels of carbon (heavy, medium, and light) are rated for grooves one and three. Only two levels of carbon (heavy and light) are rated for the second groove and all lands, and only one level of carbon (light) is rated for the cooling gallery and under-crown. The carbon deposit factors are 1.00 for heavy, 0.5 for medium, and 0.25 for light carbon. The varnish merit values range from 1.0 to 10 using the CRC Rust/Varnish Rating Scale where 10 is clean and 1.0 is maximum intensity. The merit varnish values are converted to demerit values resulting in deposit factors that range from 0 for clean to 9.0 for maximum intensity. The merit varnish values are converted to demerit values using Eq A13.1:

$$\text{Demerit Varnish Zonal Rating} = \text{Area \%} \times (10 - \text{Merit Rating}) \quad (A13.1)$$

A13.1.1 *Example*—15 % × (10.0 – 8.5) = 0.15 × 1.5 = 0.22 demerits using rounding guidelines presented in Practice E 29.

A13.1.2 Fig. A13.1 shows the deposit rating areas for the under-crown and cooling gallery of the piston crown.

A13.2 The rating location factors were chosen to yield separation between low and high calibration oils. All required rating equipment, such as the rating booth and particular lamp used, are described in CRC Manual No. 18.

A13.3 Use the following procedure for calculating this test method's piston deposit ratings:

A13.3.1 Rate the piston as is normally done according to the Modified CRC Diesel Piston Rating Method described in CRC Manual No. 18.

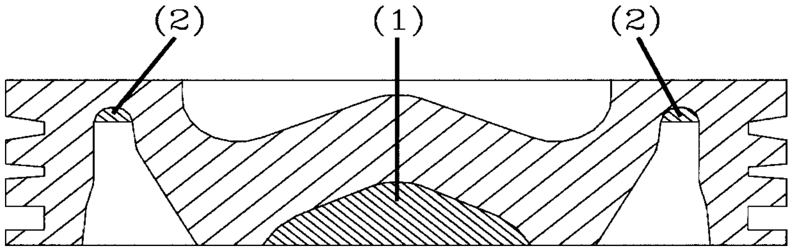
A13.3.2 For groove three, land three, land four, the cooling gallery and under-crown, replace the rater-assigned varnish merit values with the restricted factors listed in Table A13.1.

A13.3.3 Calculate a demerit value for each area.

A13.3.4 Round each demerit to the nearest 0.01 demerits according to Practice E 29.

A13.3.5 Add the demerits to get the individual unweighted demerit value for each piston location.

A13.3.6 Multiply the unweighted demerit value by its location factor to get the individual weighted demerit rating for each piston location.



NOTE—Area 1—Under-crown: All surfaces of the under-crown including transition radius, but not the vertical sides of the pin bore struts. Area 2—Cooling gallery: Only the upper radius area.

FIG. A13.1 Under-crown and Cooling Gallery Rating Areas

TABLE A13.1 Grouped Varnish Rating Factors

Rater-Assigned Varnish Merit Value	Restricted Factor
1.0–4.0	7.5
4.1–7.0	4.5
7.1–9.9	1.5

A13.3.7 Round each individual weighted demerit rating to the nearest 0.01 demerits.

A13.3.8 Add all individual weighted demerit ratings to get WDP.

A13.3.9 Round WDP to the nearest 0.1 demerits.

A13.3.10 Top groove carbon (TGC) equals the total carbon demerits for groove one.

A13.3.11 Top land carbon (TLC) equals the total carbon demerits for land one.

A13.4 *Liner Rating Procedure*—Liner rating should follow the sequence outlined herein. If deposits above ring travel are to be evaluated this should be done immediately upon completion of the test or disassembly.

A13.4.1 *Liner Preparation*:

A13.4.1.1 *Marking*—Thrust and anti-thrust sides are marked T & AT along with appropriate test identification (run number, and so forth). See Fig. A13.2.

A13.4.1.2 *Cutting*—Liners are cut along the front and rear, leaving the thrust and anti-thrust halves.

A13.4.1.3 *Surface Preparation*—Caution should be observed in the handling of the liners due to the sharpness of the cut edges. Wipe both halves of the liner using Stoddard solvent on a dampened soft rag followed by a clean soft dry rag.

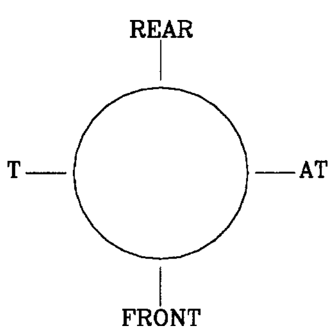


FIG. A13.2 Liner Thrust and Anti-Thrust Locations

A13.4.2 *Definition of Terms*—A clear plastic segmented overlay (see Fig. X1.6) is recommended as a useful rating aid in estimating the percentage of the area covered.

A13.4.2.1 *Bore Polishing*—Those areas of surface which are instantly recognizable as mirror finish regardless of random crosshatch honing marks.

A13.4.2.2 *Scuffing*—Localized adhesive wear distinguished by concentrated marks in the direction of motion, observed as a matte finish which is caused by a momentary welding and tearing of metal.

NOTE A13.1—Bore polishing and scuffing should be differentiated between and reported separately.

A13.4.2.3 *Scratching*—Random singular lines in the direction of motion generally a result of debris or installation of components. These need not be quantified, but should be noted in the appropriate remarks section.

A13.4.3 *Liner Rating*:

A13.4.3.1 *Rating Environment*—Rate liners in the CRC rating booth with the same light as specified to rate pistons or a two-bulb fluorescent desk lamp.

A13.4.3.2 *Bore Polishing*—The overlay is inserted in the liner half and the 10 to 15 % segments with 1 % indicators used as a guide in estimating the amount of polishing. Record the percent polish for each segment and then summarize those ten areas for each half. Tracing paper or equivalent may be used for a permanent record of the liner polishing.

A13.4.3.2.1 *Area Rated*—The area to be rated is generally defined as the area swept by the rings which is the distance from the top of the first ring at TDC to the bottom of the ring at BDC. On many occasions, it is required that the area above top ring travel be rated.

A13.4.3.3 *Liner Scuffing Rating*—Liner scuffing can be rated in a similar manner as bore polishing.

A13.4.3.4 *Above Top Ring Travel Conditions*—Area percentages may be determined in the liner by use of the 20-segmented template. Carbon deposits can be rated in two levels. Other conditions such as polishing, scratching/scuffing can be reported in area covered, if required.

A14. ADDITIONAL REPORT FORMS

A14.1 Figs. A14.1 and A14.2 are sample report forms.

LSRD4

Product: ____________

Product No.: ____________

Batch No.: ____________
TMC No.: ____________
TMO No.: ____________
Tank No.: ____________
Analysis Date: ____________
Shipment Date: ____________

TEST	METHOD	UNITS	SPECIFICATIONS			RESULTS °C	RESULTS °F
			MIN	TARGET	MAX		
Distillation - IBF	D-86	(°C) °F	(177) 350		(199) 390		
10%		(°C) °F	(210) 410		(232) 450		
50%		(°C) °F	(249) 480		(277) 530		
90%		(°C) °F	(299) 570		(327) 620		
Distillation - EP		(°C) °F	(327) 620		(360) 680		
Recovery		vol%		REPORT			
Residue		vol%		REPORT			
Loss		vol%		REPORT			
Gravity	D-4052	°API	32.0		36.0		
Pour Point	D-97	(°C) °F			(-17) 0		
Cloud Point	D-2500	(°C) °F			(-12) 10		
Flash Point	D-93	(°C) °F	(54) 130				
Viscosity @ 40°C	D-445	cSt	2		3.2		
Mercaptan Sulfur	D-3227	wt %		REPORT			
Sulfur	D-2622	wt %	0.030		0.050		
Composition, Aromatics	D-1319	vol%	28.0		35.0		
Composition, Olefins	D-1319	vol%		REPORT			
Composition, Saturates	D-1319	vol%		REPORT			
Basic sediment & water	D-2709	vol%			0.05		
Ramsbottom Carbon, 10 % residue	D-524	wt %			0.35		
Ash content	D-482	wt %			0.01		
Total Acid Number	D-664	mg KOH/g		REPORT			
Strong Acid Number	D-664	mg KOH/g		REPORT			
Accelerated Stability	D-2274	mg/100 ml		REPORT			
Copper Corrosion	D-130				3		
Cetane Number	D-613		42.0		48.0		
Aliphatic paraffins	D-2425	wt %		REPORT			
Monocycloparaffins	D-2425	wt %		REPORT			
Dicycloparaffins	D-2425	wt %		REPORT			
Tricycloparaffins	D-2425	wt %		REPORT			
Alkylbenzenes	D-2425	wt %		REPORT			
Indanes/Tetralins	D-2425	wt %		REPORT			
Indenes	D-2425	wt %		REPORT			
Naphthalene	D-2425	wt %		REPORT			
Naphthalnenes	D-2425	wt %		REPORT			
Acenaphthenes	D-2425	wt %		REPORT			
Acenaphthylenes	D-2425	wt %		REPORT			
Tricyclic aromatices	D-2425	wt %		REPORT			

Approved by: ____________________ Analyst ____________

NOTE—Include a copy of Suppliers Fuel Sheet in the Test Report.

FIG. A14.1 Fuel Batch Analysis Example

Fax To:
Company:
Fax Number:

**** ASTM Test Monitoring Center *****
*** 1P Control Charts Analysis ***

Start	=	Lab	=	CMIR	=
EOT date	=	Stand	=	IND	=
EOT time	=	Run	=		
LTMS date	=	Reported	=	Analysis Compiled:	
LTMS time	=				

Parameter	Reported Value	Transformed Value	Targets Effective 19970219 to *** Mean	s
WDP				
TGC				
TLC				
AOC				
EOTOC				

Note: When two Limits given, the upper is the Warning Limit and the lower is the Action Limit.

Keys: A = Action alarm
W = Warning alarm

Stand Analysis

		EWMA						SHEWHART					
			Severity			Precision			Severity			Precision	
	N	Z(i)	Limit	Al	Q(i)	Limit	Al	Y(i)	Limit	Al	R(i)	Limit	Al
WDP													
TGC													
TLC													
AOC													
EOTOC													

Laboratory Analysis

		EWMA						SHEWHART					
			Severity			Precision			Severity			Precision	
	N	Z(i)	Limit	Al	Q(i)	Limit	Al	Y(i)	Limit	Al	R(i)	Limit	Al
WDP													
TGC													
TLC													
AOC													
EOTOC													

**** Laboratory Level Severity Adjustments ****

WDP SA = TGC SA = TLC SA =
AOC SA = EOTOC SA =

STAND is Calibrated: YES NO (Circle Required)

Calibration Expiration Date: ________________

[A] TMC Validity Code:_______ AC = Acceptable Calibration.
OC = Oper. Valid, Failed Acceptance Criteria.

_____ STAND PULLED FROM LTMS SYSTEM (Check required) Reviewer Initials:_______

[A] Based on review of call-in report of operational data and control chart analysis shown above.

FIG. A14.2 Example of Fax Copy of TMC Control Chart Analysis for Calibration Tests

A15. REPORT FORMS

A15.1 Figs. A15.1-A15.20 are example report forms.

VERSION ***19980921***

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 IN DETERMINING AN AVERAGE TEST RESULT USING MULTIPLE TEST CRITERIA

Test Number		
Test Stand: *STAND*	Engine Run No.: *ENRUN*	
EOT Time: *EOTTIME*	EOT Date: *DTCOMP*	
Oil Code[A]: *OILCODE/CMIR*		
Formulation/Stand Code: *FORM*		
Alternate Codes: *ALTCODE1*	*ALTCODE2*	*ALTCODE3*

In my opinion this test *OPVALID* been conducted in accordance with the 1P TestMethod (D-XXXX) and the appropriate amendments through the information letter system. The remarks included in the report describe the anomalies associated with this test.

[A]Oil Code (or CMIR if this is a reference oil test)

SUBMITTED BY: *SUBLAB*
Testing Laboratory

SUBSIGIM
Signature

SUBNAME
Typed Name

SUBTITLE
Title

FIG. A15.1 Final Report Cover Sheet

1P

Form 1

TEST REPORT SUMMARY

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

START DATE: *DTSTRT*	TOTAL TEST LENGTH: *TESTLEN*	TMC OIL TYPE:[A] *IND*
LAB INTERNAL OIL CODE: *LABOCODE*	ENGINE SERIAL NUMBER: *ENGSN*	

	CORRECTION EFFECTIVE DATE	WDP	TGC	TLC	OIL CONSUMPTION g/h	TRANSFORMED OIL CONSUMPTION	EOTOC g/h	TRANSFORMED EOTOC
UNADJUSTED LAB RATING		*WD*	*TGC*	*TLC*	*OC*	*OCT*	*EOTOC*	*ETOCT*
INDUSTRY CORRECTION (IF ANY)	*DATECF*	*WDCF*	*TGCCF*	*TLCCF*		*OCTCF*		*ETOCTCF*
SUBTOTAL		*WDCOR*	*TGCCOR*	*TLCCOR*		*OCTCOR*		*ETOCTCOR*
LAB SEVERITY ADJUSTMENT[B] (IF ANY)	*DATESA*	*WDSA*	*TGCSA*	*TLCSA*		*OCTSA*		*ETOCTSA*
TOTAL		*WDFNL*	*TGCFNL*	*TLCFNL*	*OCFNL*	*OCTFNL*	*EOTOCFNL*	*ETOCTFNL*

	EFFECTIVE DATE	WDP	TGC	TLC	OIL CONSUMPTION g/h	TRANSFORMED OIL CONSUMPTION	EOTOC g/h	TRANSFORMED EOTOC
TEST TARGET MEAN[A]	*EFFDATE*	*WDM*	*TGCM*	*TLCM*		*OCTM*		*EOTOCTM*
TEST TARGET STD[A]	*EFFDATE*	*WDS*	*TGCS*	*TLCS*		*OCTS*		*EOTOCTS*

	REFEREE LAB	WDP	TGC	TLC				
REFEREE RATINGS[A]	*RRLAB*	*RRWD*	*RRTGC*	*RRTLC*				

	TOP	INT.1	OIL	PISTON CROWN	PISTON SKIRT	LINER
RING LOSS OF SIDE CLEARANCE (mm)	*LSCTOP*	*LSCINT1*	*LSCOIL*			
RING END GAP INCREASE (mm)	*RINGGTI*	*RINGGII1*	*RINGFOI*			
IS THE RING STUCK?	*STUCKTOP*	*STUCKINI*	*STUCKOIL*			
SCUFFED AREA %	*SCUFFTOP*	*SCUFFINI*	*SCUFFOIL*	*SCUFCRON*	*SCUFSKRT*	*SCUFFLIN*
AVERAGE WEAR STEP (mm)						*AWEARST*
% BORE POLISH						*BOREPOL*

Notes: [A]Reference oil tests or referee ratings requested by the test sponsor
[B]Non-reference oil test only

FIG. A15.2 Test Report Summary

1P
FORM 2
OPERATIONAL SUMMARY

LAB: LAB	EOT DATE: DTCOMP	END TIME: EOTTIME	METHOD: METHOD
STAND: STAND	RUN NUMBER: ENRUN		
FORMULATION/STAND CODE: FORM			
OILCODE (or CMIR): OILCODE/CMIR			

CONTROLLED PARAMETERS

OPERATING PARAMETER	QUALITY INDEX THRESHOLD	EOT QUALITY INDEX	PROCESS			TOTAL DATA POINTS		
			UNITS	TARGET	AVERAGE	SAMPLES[A]	BQD[B]	OVER/UNDER RANGE[C]
ENGINE SPEED	0.00	QRPM	r/min	1800	ARPM	NRPM	BRPM	ORPM
FUEL FLOW	0.00	QFFLO	g/min	185	AFFLO	NFFLO	BFFLO	OFFLO
HUMIDITY	0.00	QHUMID	g/kg	17.8	AHUMID	NHUMID	BHUMID	OHUMID
COOLANT FLOW	0.00	QCOLFLO	L/min	75	ACOLFLO	NCOLFLO	BCOLFLO	OCOLFLO
TEMPERATURE								
COOLANT OUT	0.00	QCOLOUT	°C	90	ACOLOUT	NCOLOUT	BCOLOUT	OCOLOUT
OIL TO MANIFOLD	0.00	QOMANTMP	°C	130	AOMANTMP	NOMANTMP	BOMANTMP	OOMANTMP
INLET AIR	0.00	QINAIRT	°C	60	AINAIRT	NINAIRT	BINAIRT	OINAIRT
FUEL INTO HEAD	0.00	QFUELTMP	°C	42	AFUELTMP	NFUELTMP	BFUELTMP	OFUELTMP
PRESSURES								
OIL TO MANIFOLD	0.00	QOMANPR	kPa	415	AOMANPR	NOMANPR	BOMANPR	OOMANPR
INLET AIR (ABSOLUTE)	0.00	QINAIRP	kPa	272	AINAIRP	NINAIRP	BINAIRP	OINAIRP
EXHAUST (ABSOLUTE)	0.00	QEBP	kPa	265	AEBP	NEBP	BEBP	OEBP
FUEL FROM HEAD	0.00	QFUELPR	kPa	275	AFUELPR	NFUELPR	BFUELPR	OFUELPR

NON-CONTROLLED PARAMETERS

OPERATING PARAMETER	PROCESS			TOTAL DATA POINTS		
	UNITS	TYPICAL RANGE[D]	AVERAGE	SAMPLES[A]	BQD[B]	OVER/UNDER RANGE[C]
INTAKE AIR FLOW(reference test only)	kg/h	312-378	AAIRFLO			
POWER	kW	53-57	APWR	NPWR	BPWR	OPWR
TORQUE	Nm	248-301	ATORQUE	NTORQUE	BTORQUE	OTORQUE
BLOWBY	L/min	20-56	ABLOBY	NBLOBY	BBLOBY	OBLOBY
TEMPERATURE						
COOLANT IN	°C	85-88	ACOLIN	NCOLIN	BCOLIN	OCOLIN
COOLANT DELTA T	°C	2-6	ACOLDT	NCOLDT	BCOLDT	OCOLDT
OIL COOLER IN	°C	128-131	AOCOOLIN	NOCOOLIN	BOCOOLIN	OOCOOLIN
HEATING OIL	°C	165 maximum	AHEATOIL	NHEATOIL	BHEATOIL	OHEATOIL
EXHAUST	°C	463-492	AEXHTMP	NEXHTMP	BEXHTMP	OEXHTMP
PRESSURES						
CRANKCASE	kPa	0.09-0.33	ACCV	NCCV	BCCV	OCCV
COOLANT TO JUG	kPa	64-92	ACOLPR	NCOLPR	BCOLPR	OCOLPR

A - Total number of data points taken as determined from test length and procedural specified sampling rate

B - Number of Bad Quality Data points not used in the calculation of the statistical measures

C - Number of points clipped by over/under range limits of the statistical measures

D - Gathered from 1P Matrix Test data

FIG. A15.3 Operational Summary

1P

FORM 3
ASSEMBLY MEASUREMENTS AND PARTS RECORD

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OILCODE: *OILCODE/CMIR*			

ASSEMBLY MEASUREMENTS AND PARTS RECORD	
INJECTOR SETTING (GO / NO-GO)	*INJSET*
WAS TIMING INITIALIZED? (YES/NO)	*TINIT*
PISTON/HEAD CLEARANCE mm	*PISTONCL*
CAM GEAR BACKLASH mm	*CAMLASH*
DESIRED FUEL TIMING °BTC	*FUELTIM*
INTAKE VALVE OPEN °ATC	*INVALOPN*
INJECTOR PLUNGER LIFT mm @ 72°	*PLUNLIFT*
INTAKE VALVE LIFT mm @ 456°	*INLIFT*
EXHAUST VALVE LIFT mm @ 247°	*EXLIFT*

	PART NUMBER	SERIAL NUMBER	DATE CODE	INSPECTION CODE
LINER	*LINERPN* A	*LINERSN* A	*LINERDC* B	
TOP RING	*TOPPN* C	*TOPSN* E		
INTERMEDIATE RING	*INTPN* C	*INTSN* E		
OIL RING	*OILPN* C	*OILSN* E		
PISTON CROWN	*CROWNPN* D	*CROWNSN* D	*CROWNDC* F	*CROWNIC* G
PISTON SKIRT	*SKIRTPN* H	*SKIRTSN* I		
FUEL INJECTOR	*NOZZLEPN* J	*NOZZLESN* K		
ECM EPROM	*ECMPN*		*ECMDC*	
PISTON COOLING JET	*PTUBEPN*	*PTUBESN*		

A On liner O.D.
B On liner O.D. (NNAN)
C On box label
D On top of piston
E On paper envelope containing the ring
F Number below "E" located on piston top
G Number above "E" located on piston top
H On bottom surface of skirt rim
I On bottom surface under pin bore
J On top surface of plunger
K On top surface of plunger -6 digits

FIG. A15.4 Assembly Measurements and Parts Record

1P

FORM 4

PISTON RATING SUMMARY

TEST IDENTIFICATION	LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	STAND: *STAND*	RUN #: *ENRUN* / METHOD: *METHOD*
FORMULATION/STAND CODE: *FORM*			OILCODE/CMIR: *OILCODE/CMIR*		
TEST FUEL: *TESTFUEL*	FUEL BATCH: *FUELBTID*	DATE RATED: *DTRATE*	RATER INITIALS: *RINIT*	VERIFIED BY: *VRINIT*	
LAST STAND REFERENCE INFORMATION	DATE COMPLETED: *LRDTCOMP*	STAND #: *STAND*	RUN #: *LRENRUN*	TMC OIL CODE: *LIND*	

	WDP	TGC	TLC	OIL CONSUMPTION g/h	TRANSFOMED OIL CONSUMPTION	EOTOC g/h	TRANSFORMED EOTOC
LAST REF. THIS STAND	*LRWD*	*LRTGC*	*LRTLC*	*LROC*	*LROCT*	*LREOTOC*	*LRETOCT*
INDUSTRY AVERAGE	*LRAWD*	*LRATGC*	*LRATLC*		*LRAOCT*		*LRAETOCT*
INDUSTRY STD	*LRSWD*	*LRSTGC*	*LRSTLC*		*LRSOCT*		*LRSETOCT*

TOTAL PISTON RATINGS SUMMARY

	DEP. FACTOR	GROOVES NO. 1 A,%	GROOVES NO. 1 DEM.	GROOVES NO. 2 A,%	GROOVES NO. 2 DEM.	LANDS NO. 1 A,%	LANDS NO. 1 DEM.	LANDS NO. 2 A,%	LANDS NO. 2 DEM.
CARBON	HC - 1.0	G1HCA	G1HCD	G2HCA	G2HCD	L1HCA	L1HCD	L2HCA	L2HCD
	MC - 0.5	G1MCA	G1MCD						
	LC - .25	G1LCA	G1LCD	G2LCA	G2LCD	L1LCA	L1LCD	L2LCA	L2LCD
	TOTAL	G1ACTOT	G1DCTOT	G2ACTOT	G2DCTOT	L1ACTOT	L1DCTOT	L2ACTOT	L2DCTOT
VARNISH	8 - 9	G1V9A	G1V9D	G2V9A	G2V9D	L1V9A	L1V9D	L2V9A	L2V9D
	7 - 7.9	G1V8A	G1V8D	G2V8A	G2V8D	L1V8A	L1V8D	L2V8A	L2V8D
	6 - 6.9	G1V7A	G1V7D	G2V7A	G2V7D	L1V7A	L1V7D	L2V7A	L2V7D
	5 - 5.9	G1V6A	G1V6D	G2V6A	G2V6D	L1V6A	L1V6D	L2V6A	L2V6D
	4 - 4.9	G1V5A	G1V5D	G2V5A	G2V5D	L1V5A	L1V5D	L2V5A	L2V5D
	3 - 3.9	G1V4A	G1V4D	G2V4A	G2V4D	L1V4A	L1V4D	L2V4A	L2V4D
	2 - 2.9	G1V3A	G1V3D	G2V3A	G2V3D	L1V3A	L1V3D	L2V3A	L2V3D
	1 - 1.9	G1V2A	G1V2D	G2V2A	G2V2D	L1V2A	L1V2D	L2V2A	L2V2D
	>0 - 0.9	G1V1A	G1V1D	G2V1A	G2V1D	L1V1A	L1V1D	L2V1A	L2V1D
	CLEAN	G1VCLNA	0	G2VCLNA	0	L1VCLNA	0	L2VCLNA	0
	TOTAL	G1AVTOT	G1DVTOT	G2AVTOT	G2DVTOT	L1AVTOT	L1DVTOT	L2AVTOT	L2DVTOT
RATING		*G1UWD*		*G2UWD*		*L1UWD*		*L2UWD*	
LOCATION FACTOR		2		3		1		3	
IND RATING		*G1WD*		*G2WD*		*L1WD*		*L2WD*	

DEP. FACTOR	GROOVE NO. 3 A,%	GROOVE NO. 3 DEM.	LANDS NO. 3 A,%	LANDS NO. 3 DEM.	LANDS NO. 4 A,%	LANDS NO. 4 DEM.	OIL COOLING GALLERY A,%	OIL COOLING GALLERY DEM.	UNDER CROWN A,%	UNDER CROWN DEM.
(HC)	G3HCA	G3HCD	L3HCA	L3HCD	L4HCA	L4HCD				
(MC)	G3MCA	G3MCD								
(LC)	G3LCA	G3LCD	L3LCA	L3LCD	L4LCA	L4LCD	OGLCA	OGLCD	UCLCA	UCLCD
(TOTAL)	G3ACTOT	G3DCTOT	L3ACTOT	L3DCTOT	L4ACTOT	L4DCTOT	OGACTOT	OGDCTOT	UCACTOT	UCDCTOT
7.5	G3V75A	G3V75D	L3V75A	L3V75D	L4V75A	L4V75D	OGV75A	OGV75D	UCV75A	UCV75D
4.5	G3V45A	G3V45D	L3V45A	L3V45D	L4V45A	L4V45D	OGV45A	OGV45D	UCV45A	UCV45D
1.5	G3V15A	G3V15D	L3V15A	L3V15D	L4V15A	L4V15D	OGV15A	OGV15D	UCV15A	UCV15D
CLEAN	G3VCLNA	0	L3VCLNA	0	L4VCLNA	0	OGVCLNA	0	UCVCLNA	0
(TOTAL)	G3AVTOT	G3DVTOT	L3AVTOT	L3DVTOT	L4AVTOT	L4DVTOT	OGAVTOT	OGDVTOT	UCAVTOT	UCDVTOT
(RATING)	*G3UWD*		*L3UWD*		*L4UWD*		*OGUWD*		*UCUWD*	
(LOCATION FACTOR)	20		20		60		0.6		1	
(IND RATING)	*G3WD*		*L3WD*		*L4WD*		*OGWD*		*UCWD*	

WDP	TGC	TLC	UNWEIGHTED DEP.	T.L. FLAKED CARBON %
WD	*TGC*	*TLC*	*UWD*	*TLFC*

FIG. A15.5 Piston Rating Summary

1P

Form 4A

PISTON RATING WORKSHEET[A]

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

RATEWSIM

[A]Refer to Appendix X1 for an example of a Piston Rating Worksheet.

FIG. A15.6 Piston Rating Worksheet

1P

FORM 5
SUPPLEMENTAL PISTON DEPOSITS (GROOVE SIDES AND RINGS)

LAB: *LAB*	EOT DATE: *DTCOMP*		END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*			
FORMULATION/STAND CODE: *FORM*				
OILCODE/CMIR: *OILCODE/CMIR*				

			CARBON			VARNISH									
DEPOSIT TYPE			HC	MC	LC	8 - 9	7 - 7.9	6 - 6.9	5 - 5.9	4 - 4.9	3 - 3.9	2 - 2.9	1 - 1.9	>0 - 0.9	CLEAN
GROOVE TOP AND BOTTOM	1	T	G1THCA	G1TMCA	G1TLCA	G1T9A	G1T8A	G1T7A	G1T6A	G1T5A	G1T4A	G1T3A	G1T2A	G1T1A	G1TCLNA
		B	G1BHCA	G1BMCA	G1BLCA	G1B9A	G1B8A	G1B7A	G1B6A	G1B5A	G1B4A	G1B3A	G1B2A	G1B1A	G1BCLNA
	2	T	G2THCA	G2TMCA	G2TLCA	G2T9A	G2T8A	G2T7A	G2T6A	G2T5A	G2T4A	G2T3A	G2T2A	G2T1A	G2TCLNA
		B	G2BHCA	G2BMCA	G2BLCA	G2B9A	G2B8A	G2B7A	G2B6A	G2B5A	G2B4A	G2B3A	G2B2A	G2B1A	G2BCLNA
	3	T	G3THCA	G3TMCA	G3TLCA	G3T9A	G3T8A	G3T7A	G3T6A	G3T5A	G3T4A	G3T3A	G3T2A	G3T1A	G3TCLNA
		B	G3BHCA	G3BMCA	G3BLCA	G3B9A	G3B8A	G3B7A	G3B6A	G3B5A	G3B4A	G3B3A	G3B2A	G3B1A	G3BCLNA
TOP BOTTOM AND BACK OF RINGS	1	T	R1THCA	R1TMCA	R1TLCA	R1T9A	R1T8A	R1T7A	R1T6A	R1T5A	R1T4A	R1T3A	R1T2A	R1T1A	R1TCLNA
		B	R1BHCA	R1BMCA	R1BLCA	R1B9A	R1B8A	R1B7A	R1B6A	R1B5A	R1B4A	R1B3A	R1B2A	R1B1A	R1BCLNA
		BK	R1BKHCA	R1BKMCA	R1BKLCA	R1BK9A	R1BK8A	R1BK7A	R1BK6A	R1BK5A	R1BK4A	R1BK3A	R1BK2A	R1BK1A	R1BKCLNA
	2	T	R2THCA	R2TMCA	R2TLCA	R2T9A	R2T8A	R2T7A	R2T6A	R2T5A	R2T4A	R2T3A	R2T2A	R2T1A	R2TCLNA
		B	R2BHCA	R2BMCA	R2BLCA	R2B9A	R2B8A	R2B7A	R2B6A	R2B5A	R2B4A	R2B3A	R2B2A	R2B1A	R2BCLNA
		BK	R2BKHCA	R2BKMCA	R2BKLCA	R2BK9A	R2BK8A	R2BK7A	R2BK6A	R2BK5A	R2BK4A	R2BK3A	R2BK2A	R2BK1A	R2BKCLNA
	3	T	R3THCA	R3TMCA	R3TLCA	R3T9A	R3T8A	R3T7A	R3T6A	R3T5A	R3T4A	R3T3A	R3T2A	R3T1A	R3TCLNA
		B	R3BHCA	R3BMCA	R3BLCA	R3B9A	R3B8A	R3B7A	R3B6A	R3B5A	R3B4A	R3B3A	R3B2A	R3B1A	R3BCLNA
		BK	R3BKHCA	R3BKMCA	R3BKLCA	R3BK9A	R3BK8A	R3BK7A	R3BK6A	R3BK5A	R3BK4A	R3BK3A	R3BK2A	R3BK1A	R3BKCLNA

ADDITIONAL DEPOSIT & CONDITION RATINGS	
PISTON CROWN	*CROWNAD*
PISTON SKIRT	*SKIRTAD*
RINGS	*RINGSAD*
LINER	*LINERAD*

FIG. A15.7 Supplemental Piston Deposits (Groove Sides and Rings)

1P

FORM 5A
REFEREE RATING

TEST IDENTIFICATION			
LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN #: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OILCODE/CMIR: *OILCODE/CMIR*			
REFEREE RATING INFORMATION			
COMPANY: *RRLAB*	RATING NUMBER: *RRNO*	DATE RATED: *RRDATE*	RATER: *RRINIT*

TOTAL PISTON RATINGS SUMMARY

		GROOVES				LANDS					GROOVES		LANDS				OIL COOLING GALLERY		UNDER CROWN	
	DEP. FACTOR	NO. 1		NO. 2		NO. 1		NO. 2		DEP. FACTOR	NO. 3		NO. 3		NO. 4					
		A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.		A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.
CARBON	HC-1.0	RRG1HCA	RRG1HCD	RRG2HCA	RRG2HCD	RRL1HCA	RRL1HCD	RRL2HCA	RRL2HCD		RRG3HCA	RRG3HCD	RRL3HCA	RRL3HCD	RRL4HCA	RRL4HCD				
	MC-0.5	RRG1MCA	RRG1MCD								RRG3MCA	RRG3MCD								
	LC-.25	RRG1LCA	RRG1LCD	RRG2LCA	RRG2LCD	RRL1LCA	RRL1LCD	RRL2LCA	RRL2LCD		RRG3LCA	RRG3LCD	RRL3LCA	RRL3LCD	RRL4LCA	RRL4LCD	RROGLCA	RROGLCD	RRUCLCA	RRUCLCD
	TOTAL	G1ACTO	RG1DCTOT	G2ACTO	RG2DCTOT	L1ACTOT	RL1DCTOT	L2ACTOT	RL2DCTOT		G3ACTO	RG3DCTOT	L3ACTOT	RL3DCTOT	L4ACTOT	RL4DCTOT	OGACTO	ROGDCTOT	UCACTO	RUCDCTOT
VARNISH	8 - 9	RRG1V9A	RRG1V9D	RRG2V9A	RRG2V9D	RRL1V9A	RRL1V9D	RRL2V9A	RRL2V9D											
	7 - 7.9	RRG1V8A	RRG1V8D	RRG2V8A	RRG2V8D	RRL1V8A	RRL1V8D	RRL2V8A	RRL2V8D	7.5	RRG3V75A	RRG3V75D	RRL3V75A	RRL3V75D	RRL4V75A	RRL4V75D	RROGV75A	RROGV75D	RRUCV75A	RRUCV75D
	6 - 6.9	RRG1V7A	RRG1V7D	RRG2V7A	RRG2V7D	RRL1V7A	RRL1V7D	RRL2V7A	RRL2V7D											
	5 - 5.9	RRG1V6A	RRG1V6D	RRG2V6A	RRG2V6D	RRL1V6A	RRL1V6D	RRL2V6A	RRL2V6D											
	4 - 4.9	RRG1V5A	RRG1V5D	RRG2V5A	RRG2V5D	RRL1V5A	RRL1V5D	RRL2V5A	RRL2V5D	4.5	RRG3V45A	RRG3V45D	RRL3V45A	RRL3V45D	RRL4V45A	RRL4V45D	RROGV45A	RROGV45D	RRUCV45A	RRUCV45D
	3 - 3.9	RRG1V4A	RRG1V4D	RRG2V4A	RRG2V4D	RRL1V4A	RRL1V4D	RRL2V4A	RRL2V4D											
	2 - 2.9	RRG1V3A	RRG1V3D	RRG2V3A	RRG2V3D	RRL1V3A	RRL1V3D	RRL2V3A	RRL2V3D											
	1 - 1.9	RRG1V2A	RRG1V2D	RRG2V2A	RRG2V2D	RRL1V2A	RRL1V2D	RRL2V2A	RRL2V2D	1.5	RRG3V15A	RRG3V15D	RRL3V15A	RRL3V15D	RRL4V15A	RRL4V15D	RROGV15A	RROGV15D	RRUCV15A	RRUCV15D
	>0 - 0.9	RRG1V1A	RRG1V1D	RRG2V1A	RRG2V1D	RRL1V1A	RRL1V1D	RRL2V1A	RRL2V1D											
	CLEAN	RRG1VCLA	0	RRG2VCLA	0	RRL1VCLA	0	RRL2VCLA	0		RRG3VCLA	0	RRL3VCLA	0	RRL4VCLA	0	RROGVCLA	0	RRUCVCLA	0
	TOTAL	G1AVTO	RG1DVTOT	G2AVTO	RG2DVTOT	L1AVTOT	RL1DVTOT	L2AVTOT	RL2DVTOT		G3AVTO	RG3DVTOT	L3AVTOT	RL3DVTOT	L4AVTOT	RL4DVTOT	OGAVTO	ROGDVTOT	UCAVTO	RUCDVTOT
RATING		RRG1UWD		RRG2UWD		RRL1UWD		RRL2UWD			RRG3UWD		RRL3UWD		RRL4UWD		RROGUWD		RRUCUWD	
LOCATION FACTOR		2		3		1		3			20		20		60		0.5		1	
IND RATING		RRG1WD		RRG2WD		RRL1WD		RRL2WD			RRG3WD		RRL3WD		RRL4WD		RROGWD		RRUCWD	

WDP	TGC	TLC	UNWEIGHTED DEP.	T.L. FLAKED CARBON %
RRWD	*RRTGC*	*RRTLC*	*RRUWD*	*RRTLFC*

FIG. A15.8 Referee Rating

1P

FORM 6

OIL ANALYSIS

TEST IDENTIFICATION			
LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OILCODE/CMIR: *OILCODE/CMIR*			
TEST FUEL: *TESTFUEL*	FUEL BATCH: *FUELBTID*		

OIL ANALYSIS	NEW:	24	48	72	96	120	144	168	192	216	240	264	288	312	336	360
VISC @ 100°C	*V100HNEW*	*V100H024*			*V100H096*						*V100H240*		*V100H288*			*V100H360*
VISC @ 40°C	*V40_HNEW*	*V40_H024*			*V40_H096*						*V40_H240*		*V40_H288*			*V40_H360*
TBN D4739	*TBN_HNEW*	*TBN_H024*			*TBN_H096*						*TBN_H240*		*TBN_H288*			*TBN_H360*
TAN D664	*TAN_HNEW*	*TAN_H024*			*TAN_H096*						*TAN_H240*		*TAN_H288*			*TAN_H360*
WEAR METALS Fe (ppm)	*FEWMHNEW*	*FEWMH024*			*FEWMH096*						*FEWMH240*		*FEWMH288*			*FEWMH360*
Al (ppm)	*ALWMHNEW*	*ALWMH024*			*ALWMH096*						*ALWMH240*		*ALWMH288*			*ALWMH360*
Si (ppm)	*SIWMHNEW*	*SIWMH024*			*SIWMH096*						*SIWMH240*		*SIWMH288*			*SIWMH360*
Cu (ppm)	*CUWMHNEW*	*CUWMH024*			*CUWMH096*						*CUWMH240*		*CUWMH288*			*CUWMH360*
Cr (ppm)	*CRWMHNEW*	*CRWMH024*			*CRWMH096*						*CRWMH240*		*CRWMH288*			*CRWMH360*
Pb (ppm)	*PBWMHNEW*	*PBWMH024*			*PBWMH096*						*PBWMH240*		*PBWMH288*			*PBWMH360*
FUEL DILUTION %		*FDILH024*									*FDILH240*					*FDILH360*
BLOWBY (L/min)		*BLBYH024*	*BLBYH048*	*BLBYH072*	*BLBYH096*	*BLBYH120*	*BLBYH144*	*BLBYH168*	*BLBYH192*	*BLBYH216*	*BLBYH240*	*BLBYH264*	*BLBYH288*	*BLBYH312*	*BLBYH336*	*BLBYH360*
Oil Consumption g/h for hrs ending		*OCONH024*	*OCONH048*	*OCONH072*	*OCONH096*	*OCONH120*	*OCONH144*	*OCONH168*	*OCONH192*	*OCONH216*	*OCONH240*	*OCONH264*	*OCONH288*	*OCONH312*	*OCONH336*	*OCONH360*
Oil Consumption r^2		*OCRRH024*	*OCRRH048*	*OCRRH072*	*OCRRH096*	*OCRRH120*	*OCRRH144*	*OCRRH168*	*OCRRH192*	*OCRRH216*	*OCRRH240*	*OCRRH264*	*OCRRH288*	*OCRRH312*	*OCRRH336*	*OCRRH360*
FUEL POSITION (mm)		*FPOSH024*									*FPOSH240*					*FPOSH360*

FIG. A15.9 Oil Analysis

1P

FORM 7

DOWNTIME SUMMARY

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: : *FORM*			
OILCODE/CMIR: *OILCODE/CMIR*			

Number of Downtime Occurrences		*DWNOCR*	
TEST HOURS	DATE	DOWNTIME	REASONS
DOWNH001	*DDATH001*	*DTIMH001*	*DREAH001*
		TOTLDOWN	TOTAL DOWNTIME (126 HR. MAX)

Comments		
Number of Comment Lines	*TOTCOM*	
OCOMH001		

FIG. A15.10 Downtime Summary

1P
FORM 8
RING MEASUREMENTS

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

ALL RING MEASUREMENTS ARE MADE USING METRIC FEELER GAGES

RING GAPS (mm)	1Y3802 TOP	1Y3803 INTERMEDIATE	1Y3804 OIL
SPECIFICATIONS	**0.66 ± 0.08 mm**	**1.08 ± 0.08 mm**	**0.51 ± 0.13 mm**
PRE-TEST	*RINGGTE*	*RINGFI1E*	*RINGGOE*
POST-TEST	*RINGFTO*	*RINGGI1O*	*RINGGOO*
INCREASE	*RINGGTI*	*RINGGI1I*	*RINGGOI*

RING SIDE CLEARANCE[A]		A	B	C	D	AVG.	MIN.	SPECIFICATION
TOP	PRE-TEST	*SIDETPE1*	*SIDETPE2*	*SIDETPE3*	*SIDETPE4*	*ASIDETPE*	*ISIDETPE*	0.13 ± 0.04 mm
	POST-TEST	*SIDETO1*	*SIDETPO2*	*SIDETPO3*	*SIDETPO4*	*ASIDETPO*	*ISIDETPO*	
	LSC	*LSCT1*	*LSCT2*	*LSCT3*	*LSCT4*	*LSCTOP*	*ILSCT*	
INT	PRE-TEST	*SIDE1PE1*	*SIDE1PE2*	*SIDE1PE3*	*SIDE1PE4*	*ASIDE1PE*	*ISIDE1PE*	0.18 ± 0.04 mm
	POST-TEST	*SIDE1PO1*	*SIDE1PO2*	*SIDE1PO3*	*SIDE1PO4*	*ASIDE1PO*	*ISIDE1PO*	
	LSC	*LSCI1*	*LSCI2*	*LSCI3*	*LSCI4*	*LSCINT1*	*ILSCINT*	
OIL	PRE-TEST	*SIDEOPE1*	*SIDEOPE2*	*SIDEOPE3*	*SIDEOPE4*	*ASIDEOPE*	*ISIDEOPE*	0.07 ± 0.02 mm
	POST-TEST	*SIDEOPO1*	*SIDEOPO2*	*SIDEOPO3*	*SIDEOPO4*	*ASIDEOP O*	*ISIDEOPO*	
	LSC	*LSCO1*	*LSCO2*	*LSCO3*	*LSCO4*	*LSCOIL*	*ILSCO*	

[A] 1. Write STUCK in place of dimension when applicable.

2. Write <0.03 mm for clearance when applicable.
3. Write > before calculated decrease or average decrease values that incorporate a <0.03 mm in the calculation.
4. LSC = Loss of Side Clearance.
5. MIN: Oil ring minimum side clearance is measured 360° around piston.

FIG. A15.11 Ring Measurements

1P
FORM 9
LINER MEASUREMENTS

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

LINER SURFACE FINISH (MICROMETER)			
DISTANCE FROM TOP	TRANSVERSE	LONGITUDINAL	AVERAGE
130 mm	*BBLFINT1*	*BBLFINL1*	*BBLFINA1*
50 mm	*BBLFINT2*	*BBLFINL2*	*BBLFINA2*
25 mm	*BBLFINT3*	*BBLFINL3*	*BBLFINA3*
		TOTAL AVERAGE (Spec: 0.4 – 0.8 µm)	*BBLFIN*

% LINER BORE POLISH (ADD T/AT VALUES FROM GRID)	
THRUST	*BOREPT*
ANTI-THRUST	*BOREPAT*
TOTAL	*BOREPOL*

LINER BORE MEASUREMENT (137.154 mm min)			
BEFORE TEST – DIAMETER (DIAL BORE GAGE)			
BORE HEIGHT	**LONGITUDINAL**	**TRANSVERSE**	**OUT OF ROUND (0.038 mm max)**
250 mm	*BBLONG1*	*BBTRAN1*	*OOR1*
210 mm	*BBLONG2*	*BBTRAN2*	*OOR2*
170 mm	*BBLONG3*	*BBTRAN3*	*OOR3*
130 mm	*BBLONG4*	*BBTRAN4*	*OOR4*
50 mm	*BBLONG5*	*BBTRAN5*	*OOR5*
25 mm	*BBLONG6*	*BBTRAN6*	*OOR6*
15 mm	*BBLONG7*	*BBTRAN7*	*OOR7*
TAPER (0.050 max)	*TAPRLONG*	*TAPRTRAN*	

AFTER TEST – (SURFACE PROFILE)				
	LONGITUDINAL		**TRANSVERSE**	
	FRONT	**REAR**	**T**	**AT**
WEAR STEP @ 13 mm	AWEARLF	AWEARLR	AWEARTT	AWEARTAT

FIG. A15.12 Liner Measurements

1P

FORM 10

CHARACTERISTICS OF THE DATA ACQUISITION SYSTEM

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OILCODE/CMIR: *OILCODE/CMIR*			

PARAMETER (1)	SENSING DEVICE (2)	CALIBRATION FREQUENCY (3)	RECORD DEVICE (4)	OBSERVATION FREQUENCY (5)	RECORD FREQUENCY (6)	LOG FREQUENCY (7)	SYSTEM RESPONSE (8)
OPERATION CONDITIONS							
ENGINE SPEED (R\min)	*RPMSENS*	*RPMCALF*	*RPMRECD*	*RPMOBSF*	*RPMRECF*	*RPMLOGF*	*RPMSYSR*
ENGINE POWER (kW)	*PWRSENS*	*PWRCALF*	*PWRRECD*	*PWROBSF*	*PWRRECF*	*PWRLOGF*	*PWRSYSR*
FUEL FLOW (g/min)	*FFLOSENS*	*FFLOCALF*	*FFLORECD*	*FFLOOBSF*	*FFLORECF*	*FFLOLOGF*	*FFLOSYSR*
HUMIDITY (g/kg)	*HUMSENS*	*HUMCALF*	*HUMRECD*	*HUMOBSF*	*HUMRECF*	*HUMLOGF*	*HUMSYSR*
TEMPERATURES (°C)							
COOLANT OUT	*COTSENS*	*COTCALF*	*COTRECD*	*COTOBSF*	*COTRECF*	*COTLOGF*	*COTSYSR*
COOLANT IN	*CONSENS*	*CONCALF*	*CONRECD*	*CONOBSF*	*CONRECF*	*CONLOGF*	*CONSYSR*
OIL TO MANIFOLD	*OBRGSENS*	*OBRGCALF*	*OBRGRECD*	*OBRGOBSF*	*OBRGRECF*	*OBRGLOGF*	*OBRGSYSR*
OIL COOLER IN	*OCOLSENS*	*OCOLCALF*	*OCOLRECD*	*OCOLOBSF*	*OCOLRECF*	*OCOLLOGF*	*OCOLSYSR*
INLET AIR	*AIRTSENS*	*AIRTCALF*	*AIRTRECD*	*AIRTOBSF*	*AIRTRECF*	*AIRTLOGF*	*AIRTSYSR*
EXHAUST	*EXTSENS*	*EXTCALF*	*EXTRECD*	*EXTOBSF*	*EXTRECF*	*EXTLOGF*	*EXTSYSR*
FUEL TO HEAD	*FUELSENS*	*FUELCALF*	*FUELRECD*	*FUELOBSF*	*FUELRECF*	*FUELLOGF*	*FUELSYSR*
PRESSURES (kPa)							
OIL TO MANIFOLD	*OBRPSENS*	*OBRPCALF*	*OBRPRECD*	*OBRPOBSF*	*OBRPRECF*	*OBRPLOGF*	*OBRPSYSR*
INLET AIR	*AIRPSENS*	*AIRPCALF*	*AIRPRECD*	*AIRPOBSF*	*AIRPRECF*	*AIRPLOGF*	*AIRPSYSR*
EXHAUST	*EXPSENS*	*EXPCALF*	*EXPRECD*	*EXPOBSF*	*EXPRECF*	*EXPLOGF*	*EXPSYSR*
FUEL FROM HEAD	*FFILSENS*	*FFILCALF*	*FFILRECD*	*FFILOBSF*	*FFILRECF*	*FFILLOGF*	*FFILSYSR*
CRANKCASE	*CCVSENS*	*CCVCALF*	*CCVRECD*	*CCVOBSF*	*CCVRECF*	*CCVLOGF*	*CCVSYSR*
FLOWS (L/min)							
BLOWBY	*BLBYSENS*	*BLBYCALF*	*BLBYRECD*	*BLBYOBSF*	*BLBYRECF*	*BLBYLOGF*	*BLBYSYSR*
COOLANT FLOW	*CFLWSENS*	*CFLWCALF*	*CFLWRECD*	*CFLWOBSF*	*CFLWRECF*	*CFLWLOGF*	*CFLWSYSR*

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 AREA OBSERVED BUT ONLY RECORDED IF OFF SPEC.
(6) DATA ARE RECORDED BUT ARE NOT RETAINED AT EOT
(7) DATA ARE LOGGED AS PERMANENT RECORD, NOTE 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. A15.13 Characteristics of the Data Acquisition System

1P

FORM 11

ENGINE OPERATIONAL DATA PLOTS[A]

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

[A]Refer to Table A2.6 for plotting axes ranges and increments.

FIG. A15.14 Engine Operational Data Plots

1P
FORM 12
TORQUE AND EXHAUST TEMPERATURE HISTORY

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

Data From Last 10 Tests

Test No.	1	2	3	4	5	6	7	8	9	10
Avg. Exh. Temp. °C	*AEXHH001*	*AEXHH002*	*AEXHH003*	*AEXHH004*	*AEXHH005*	*AEXHH006*	*AEXHH007*	*AEXHH008*	*AEXHH009*	*AEXHH010*
Avg. Eng. Torque N·m	*ATORH001*	*ATORH002*	*ATORH003*	*ATORH004*	*ATORH005*	*ATORH006*	*ATORH007*	*ATORH008*	*ATORH009*	*ATORH010*

FIG. A15.15 Torque and Exhaust Temperature History

1P
FORM 13
OIL CONSUMPTION PLOT

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OILCODE/CMIR: *OILCODE/CMIR*			

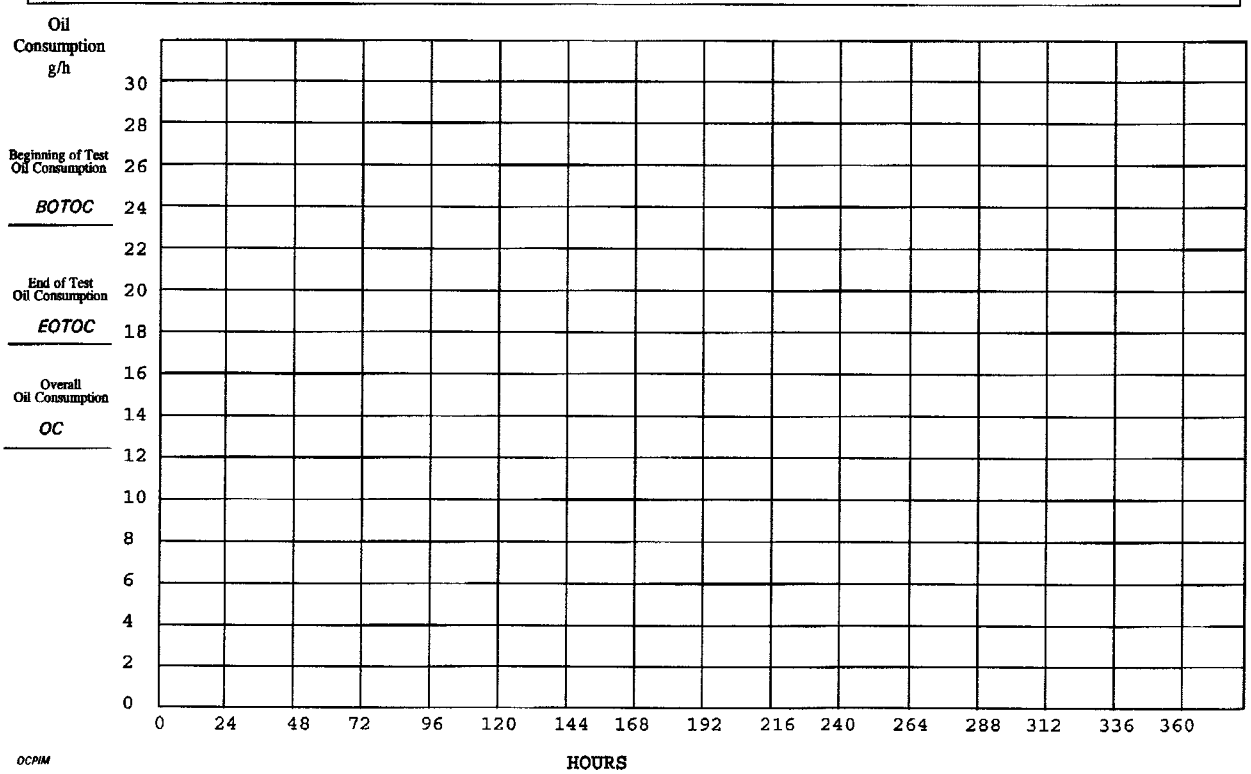


FIG. A15.16 Oil Consumption Plot

1P
Form 14
PISTON, RING AND LINER PHOTOGRAPHS[A]

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

PRLIM

[A]Refer to Fig. X1.7 for an example of a Photo Layout.

FIG. A15.17 Piston, Ring, and Liner Photographs

1P
FORM 15
SEVERITY ADJUSTMENT HISTORY

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OILCODE/CMIR: *OILCODE/CMIR*			

USAGE DATES		WDP		TGC		TLC		TRANSFORMED OC		TRANSFORMED EOTOC	
START	TIME	Zi	S.A.	Zi	S.A.	Zi	S.A.	Zi	S.A.	Zi	S.A.
DTSTR001	*DTTMR001*	*WDZIR001*	*WDSAR001*	*TGZIR001*	*TGSAR001*	*TLZIR001*	*TLSAR001*	*OCZIR001*	*OCSAR001*	*ETZIR001*	*ETSAR001*

FIG. A15.18 Severity Adjustment History

1P
Form 16
FUEL BATCH ANALYSIS[A]

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

FUELIM

[A]Refer to Annex A14 for an example of a Fuel Batch Analysis page. Include a copy of the supplier fuel sheet in the test report.

FIG. A15.19 Fuel Batch Analysis

1P
Form 17
TMC CONTROL CHART ANALYSIS[A]
(Reference Oil Test Only)

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OIL CODE/CMIR: *OILCODE/CMIR*			

CCHIM

[A]Refer to Annex A14 for an example of a TMC Control Chart Analysis. Include a copy of the TMC Control Chart Analysis in the test report.

FIG. A15.20 TMC Control Chart Analysis

A16. DATA DICTIONARY

A16.1 Fig. A16.1 presents the data dictionary.

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
10	0	1P	VERSION	8	0	C	YYYYMMDD	1P VERSION 19980921 BETA
20	0	1P	METHOD	2	0	C		METHOD
30	0	1P	TSTSPON1	40	0	C		CONDUCTED FOR, FIRST LINE
40	0	1P	TSTSPON2	40	0	C		CONDUCTED FOR, SECOND LINE
50	0	1P	LABVALID	1	0	C	V, I OR N	TEST LAB VALIDATION (V, I OR N)
60	0	1P	STAND	5	0	C		STAND
70	0	1P	ENRUN	4	0	C		ENGINE RUN
80	0	1P	EOTTIME	5	0	C	HH:MM	END OF TEST TIME (HH:MM)
90	0	1P	DTCOMP	8	0	C	YYYYMMDD	COMPLETED DATE (YYYYMMDD)
100	0	1P	OILCODE	38	0	C		OIL CODE
110	0	1P	CMIR	6	0	C		CMIR
120	0	1P	FORM	38	0	C		FORMULATION/STAND CODE
130	0	1P	ALTCODE1	10	0	C		ALTERNATE OIL CODE 1
140	0	1P	ALTCODE2	10	0	C		ALTERNATE OIL CODE 2
150	0	1P	ALTCODE3	10	0	C		ALTERNATE OIL CODE 3
160	0	1P	OPVALID	8	0	C		OPERATIONAL VALIDITY -- HAS/HAS NOT
170	0	1P	SUBLAB	40	0	C		SUBMITTED BY: TESTING LABORATORY
180	0	1P	SUBSIGIM	70	0	C		SUBMITTED BY: SIGNATURE IMAGE
190	0	1P	SUBNAME	40	0	C		SUBMITTED BY: SIGNATURE TYPED NAME
200	0	1P	SUBTITLE	40	0	C		SUBMITTED BY: TITLE
210	1	1P	LAB	2	0	C		LAB CODE
220	1	1P	DTSTRT	8	0	C	YYYYMMDD	STARTING DATE (YYYYMMDD)
230	1	1P	TESTLEN	3	0	Z	HHH	TOTAL TEST LENGTH (HHH)
240	1	1P	IND	6	0	C		TMC OIL CODE
250	1	1P	LABOCODE	12	0	C		LABORATORY INTERNAL OIL CODE
260	1	1P	ENGSN	11	0	C		ENGINE SERIAL NUMBER
270	1	1P	WD	7	1	N	DEMERITS	WEIGHTED TOTAL DEMERITS UNADJUSTED LAB RATING (DEMERITS)
280	1	1P	TGC	6	2	N	DEMERITS	TOP GROOVE CARBON UNADJUSTED LAB RATING (DEMERITS)
290	1	1P	TLC	6	2	N	DEMERITS	TOP LAND CARBON (DEMERITS)
300	1	1P	OC	5	1	N	g/h	UNADJUSTED LAB RATING OIL CONSUMPTION (g/h)
310	1	1P	OCT	6	3	N	TRANS UNITS	UNADJUSTED LAB RATING TRANSFORMED OIL CONSUMPT (TRANS UNITS)
320	1	1P	EOTOC	5	1	N	g/h	UNADJUSTED LAB RATING EOTOC (g/h)
330	1	1P	ETOCT	6	3	N	TRANS UNITS	UNADJUSTED LAB RATING TRANSFORMED EOTOC (TRANS UNITS)
340	1	1P	DATECF	8	0	C	YYYYMMDD	INDUSTRY CORRECTION DATE (YYYYMMDD)
350	1	1P	WDCF	7	1	N	DEMERITS	INDUSTRY CORRECTION TOTAL WEIGHTED DEMERITS (DEMERITS)
360	1	1P	TGCCF	6	2	N	DEMERITS	INDUSTRY CORRECTION TOP GROOVE CARBON (DEMERITS)
370	1	1P	TLCCF	6	2	N	DEMERITS	INDUSTRY CORRECTION TOP LAND CARBON (DEMERITS)
380	1	1P	OCTCF	6	3	N	TRANS UNITS	INDUSTRY CORRECTION TRANSFORMED OIL CONSUMPTIO (TRANS UNITS)
390	1	1P	ETOCTCF	6	3	N	TRANS UNITS	INDUSTRY CORRECTION TRANSFORMED EOTOC (TRANS UNITS)
400	1	1P	WDCOR	7	1	N	DEMERITS	CORRECTED WEIGHTED TOTAL DEMERITS (DEMERITS)
410	1	1P	TGCCOR	6	2	N	DEMERITS	CORRECTED TOP GROOVE CARBON (DEMERITS)
420	1	1P	TLCCOR	6	2	N	DEMERITS	CORRECTED TOP LAND CARBON (DEMERITS)
430	1	1P	OCTCOR	6	3	N	TRANS UNITS	CORRECTED TRANSFORMED OIL CONSUMPTION (TRANS UNITS)
440	1	1P	ETOCTCOR	6	3	N	TRANS UNITS	CORRECTED TRANSFORMED EOTOC (TRANS UNITS)
450	1	1P	DATESA	8	0	C	YYYYMMDD	LAB SEVERITY ADJUSTMENT DATE (YYYYMMDD)
460	1	1P	WDSA	7	1	N	DEMERITS	LAB SEVERITY ADJUSTMENT WEIGHTED TOTAL DEMERITS (DEMERITS)
470	1	1P	TGCSA	6	2	N	DEMERITS	LAB SEVERITY ADJUSTMENT TOP GROOVE CARBON (DEMERITS)
480	**1**	**1P**	**TLCSA**	**6**	2	N	DEMERITS	LAB SEVERITY ADJUSTMENT TOP LAND CARBON (DEMERITS)
490	1	1P	OCTSA	6	3	N	TRANS UNITS	LAB SEVERITY ADJUSTMENT TRANSFORMED OIL CONSUM (TRANS UNITS)
500	1	1P	ETOCTSA	6	3	N	TRANS UNITS	LAB SEVERITY ADJUSTMENT TRANSFORMED EOTOC (TRANS UNITS)

FIG. A16.1 Data Dictionary

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
510	1	1P	WDFNL	7	1	N	DEMERITS	FINAL WEIGHTED TOTAL DEMERITS (DEMERITS)
520	1	1P	TGCFNL	6	2	N	DEMERITS	FINAL TOP GROOVE CARBON (DEMERITS)
530	1	1P	TLCFNL	6	2	N	DEMERITS	FINAL TOP LAND CARBON (DEMERITS)
540	1	1P	OCFNL	5	1	N	g/h	FINAL OIL CONSUMPTION (g/h)
550	1	1P	OCTFNL	6	3	N	TRANS UNITS	FINAL TRANSFORMED OIL CONSUMPTION (TRANS UNITS)
560	1	1P	EOTOCFNL	5	1	N	g/h	FINAL EOTOC (g/h)
570	1	1P	ETOCTFNL	6	3	N	TRANS UNITS	FINAL TRANSFORMED EOTOC (TRANS UNITS)
580	1	1P	EFFDATE	8	0	C	YYYYMMDD	TEST TARGET EFFECTIVE DATE (YYYYMMDD)
590	1	1P	WDM	7	1	N	DEMERITS	TEST TARGET MEAN WEIGHTED TOTAL DEMERITS (DEMERITS)
600	1	1P	TGCM	6	2	N	DEMERITS	TEST TARGET MEAN TOP GROOVE CARBON (DEMERITS)
610	1	1P	TLCM	6	2	N	DEMERITS	TEST TARGET MEAN TOP LAND CARBON (DEMERITS)
620	1	1P	OCTM	6	3	N	TRANS UNITS	TEST TARGET MEAN TRANSFORMED OIL CONSUMPTION (TRANS UNITS)
630	1	1P	EOTOCTM	6	3	N	TRANS UNITS	TEST TARGET MEAN TRANSFORMED EOTOC (TRANS UNITS)
640	1	1P	WDS	7	1	N	DEMERITS	TEST TARGET STD WEIGHTED TOTAL DEMERITS (DEMERITS)
650	1	1P	TGCS	6	2	N	DEMERITS	TEST TARGET STD TOP GROOVE CARBON (DEMERITS)
660	1	1P	TLCS	6	2	N	DEMERITS	TEST TARGET STD TOP LAND CARBON (DEMERITS)
670	1	1P	OCTS	6	3	N	TRANS UNITS	TEST TARGET STD TRANSFORMED OIL CONSUMPTION (TRANS UNITS)
680	1	1P	EOTOCTS	6	3	N	TRANS UNITS	TEST TARGET STD TRANSFORMED EOTOC (TRANS UNITS)
690	1	1P	DTCEFF	8	0	C	YYYYMMDD	NON-REFERENCE PASS LIMIT EFFECTIVE DATE (YYYYMMDD)
700	1	1P	WDPL	7	1	N	DEMERITS	NON-REFERENCE PASS LIMIT WEIGHTED TOTAL DEMERITS (DEMERITS)
710	1	1P	TGCPL	6	2	N	DEMERITS	NON-REFERENCE PASS LIMIT TOP GROOVE CARBON (DEMERITS)
720	1	1P	TLCPL	6	2	N	DEMERITS	NON-REFERENCE PASS LIMIT TOP LAND CARBON (DEMERITS)
730	1	1P	OCPL	5	1	N	g/h	NON-REFERENCE PASS LIMIT OIL CONSUMPTION (g/h)
740	1	1P	EOTOCPL	5	1	N	g/h	NON-REFERENCE PASS LIMIT EOTOC (g/h)
750	1	1P	CATEGORY	8	0	C		API CATEGORY PASS LIMIT
760	1	1P	RRLAB	2	0	C		REFEREE LAB CODE
770	1	1P	RRWD	7	1	N	DEMERITS	REFEREE RATING WEIGHTED TOTAL DEMERITS (DEMERITS)
780	1	1P	RRTGC	6	2	N	DEMERITS	REFEREE RATING TOP GROOVE CARBON (DEMERITS)
790	1	1P	RRTLC	6	2	N	DEMERITS	REFEREE RATING TOP LAND CARBON (DEMERITS)
800	1	1P	LSCTOP	6	3	N	mm	TOP RING SIDE CLEARANCE LSC (mm)
810	1	1P	LSCINT1	6	3	N	mm	INT. 1 RING SIDE CLEARANCE LSC (mm)
820	1	1P	LSCOIL	6	3	N	mm	OIL RING SIDE CLEARANCE LSC (mm)
830	1	1P	RINGGTI	6	3	N	mm	TOP RING END GAP INCREASE (mm)
840	1	1P	RINGGI1I	6	3	N	mm	INTERMEDIATE 1 RING END GAP INCREASE (mm)
850	1	1P	RINGGOI	6	3	N	mm	OIL RING END GAP INCREASE (mm)
860	1	1P	STUCKTOP	3	0	C		IS THE TOP RING STUCK? YES OR NO!!
870	1	1P	STUCKIN1	3	0	C		IS THE INT. 1 RING STUCK? YES OR NO!!
880	1	1P	STUCKOIL	3	0	C		IS THE OIL RING STUCK? YES OR NO!!
890	1	1P	SCUFFTOP	4	0	N	%	SCUFFED AREA TOP (%)
900	1	1P	SCUFFIN1	4	0	N	%	SCUFFED AREA INT. 1 (%)
910	1	1P	SCUFFOIL	4	0	N	%	SCUFFED AREA OIL (%)
920	1	1P	SCUFCRON	4	0	N	%	SCUFFED AREA PISTON CROWN (%)
930	1	1P	SCUFSKRT	4	0	N	%	SCUFFED AREA PISTON SKIRT (%)
940	1	1P	SCUFFLIN	4	0	N	%	SCUFFED AREA LINER (%)
950	1	1P	AWEARST	6	3	N	mm	AVERAGE WEAR STEP LINER (mm)
960	1	1P	BOREPOL	6	1	N	%	LINER BORE POLISH (%)
970	2	1P	QRPM	7	3	N		EOT QUALITY INDEX ENGINE SPEED
980	2	1P	ARPM	7	1	N	r/min	AVG ENGINE SPEED (r/min)
990	2	1P	NRPM	5	0	N		SAMPLES ENGINE SPEED TOTAL DATA POINTS

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
1000	2	1P	BRPM	5	0	N		BQD ENGINE SPEED TOTAL DATA POINTS
1010	2	1P	ORPM	5	0	N		OVER/UNDER RANGE ENGINE SPEED TOTAL DATA POINTS
1020	2	1P	QFFLO	7	3	N		EOT QUALITY INDEX FUEL FLOW
1030	2	1P	AFFLO	7	1	N	g/min	AVG FUEL FLOW (g/min)
1040	2	1P	NFFLO	5	0	N		SAMPLES FUEL FLOW TOTAL DATA POINTS
1050	2	1P	BFFLO	5	0	N		BQD FUEL FLOW TOTAL DATA POINTS
1060	2	1P	OFFLO	5	0	N		OVER/UNDER RANGE FUEL FLOW TOTAL DATA POINTS
1070	2	1P	QHUMID	7	3	N		EOT QUALITY INDEX HUMIDITY
1080	2	1P	AHUMID	5	1	N	g/kg	AVG HUMIDITY (g/kg)
1090	2	1P	NHUMID	5	0	N		SAMPLES HUMIDITY TOTAL DATA POINTS
1100	2	1P	BHUMID	5	0	N		BQD HUMIDITY TOTAL DATA POINTS
1110	2	1P	OHUMID	5	0	N		OVER/UNDER RANGE HUMIDITY TOTAL DATA POINTS
1120	2	1P	QCOLFLO	7	3	N		EOT QUALITY INDEX COOLANT FLOW
1130	2	1P	ACOLFLO	7	1	N	L/min	AVG COOLANT FLOW (L/min)
1140	2	1P	NCOLFLO	5	0	N		SAMPLES COOLANT FLOW TOTAL DATA POINTS
1150	2	1P	BCOLFLO	5	0	N		BQD COOLANT FLOW TOTAL DATA POINTS
1160	2	1P	OCOLFLO	5	0	N		OVER/UNDER RANGE COOLANT FLOW TOTAL DATA POINTS
1170	2	1P	QCOLOUT	7	3	N		EOT QUALITY INDEX COOLANT OUT
1180	2	1P	ACOLOUT	5	1	N	øC	AVG COOLANT OUT (øC)
1190	2	1P	NCOLOUT	5	0	N		SAMPLES COOLANT OUT TOTAL DATA POINTS
1200	2	1P	BCOLOUT	5	0	N		BQD COOLANT OUT TOTAL DATA POINTS
1210	2	1P	OCOLOUT	5	0	N		OVER/UNDER RANGE COOLANT OUT TOTAL DATA POINTS
1220	2	1P	QOMANTMP	7	3	N		EOT QUALITY INDEX OIL TO MANIFOLD TEMPERATURE
1230	2	1P	AOMANTMP	6	1	N	øC	AVG OIL TO MANIFOLD TEMPERATURE (øC)
1240	2	1P	NOMANTMP	5	0	N		SAMPLES OIL TO MANIFOLD TEMPERATURE TOTAL DATA POINTS
1250	2	1P	BOMANTMP	5	0	N		BQD OIL TO MANIFOLD TEMPERATURE TOTAL DATA POINTS
1260	2	1P	OOMANTMP	5	0	N		OVER/UNDER RANGE OIL TO MANIFOLD TEMP. TOTAL DATA POINTS
1270	2	1P	QINAIRT	7	3	N		EOT QUALITY INDEX INLET AIR TEMPERATURE
1280	2	1P	AINAIRT	6	1	N	øC	AVG INLET AIR TEMPERATURE (øC)
1290	2	1P	NINAIRT	5	0	N		SAMPLES INLET AIR TEMPERATURE TOTAL DATA POINTS
1300	2	1P	BINAIRT	5	0	N		BQD INLET AIR TEMPERATURE TOTAL DATA POINTS
1310	2	1P	OINAIRT	5	0	N		OVER/UNDER RANGE INLET AIR TEMPERATURE TOTAL DATA POINTS
1320	2	1P	QFUELTMP	7	3	N		EOT QUALITY INDEX FUEL @ INJECTOR HOUSING TEMP
1330	2	1P	AFUELTMP	6	1	N	øC	AVERAGE FUEL @ INJECTOR HOUSING TEMP (øC)
1340	2	1P	NFUELTMP	5	0	N		SAMPLES FUEL @ INJECTOR HOUSING TEMP TOTAL DATA POINTS
1350	2	1P	BFUELTMP	5	0	N		BQD FUEL @ INJECTOR HOUSING TEMP TOTAL DATA POINTS
1360	2	1P	OFUELTMP	5	0	N		OVER/UNDER RANGE FUEL@INJECTOR HOUSING TEMP TOTAL DATA POINT
1370	2	1P	QOMANPR	7	3	N		EOT QUALITY INDEX OIL TO MANIFOLD PRESSURE
1380	2	1P	AOMANPR	6	1	N	kPa	AVG OIL TO MANIFOLD PRESSURE (kPa)
1390	2	1P	NOMANPR	5	0	N		SAMPLES OIL TO MANIFOLD PRESSURE TOTAL DATA POINTS
1400	2	1P	BOMANPR	5	0	N		BQD OIL TO MANIFOLD PRESSURE TOTAL DATA POINTS
1410	2	1P	OOMANPR	5	0	N		OVER/UNDER RANGE OIL TO MANIFOLD PRESSURE TOTAL DATA POINTS
1420	2	1P	QINAIRP	7	3	N		EOT QUALITY INDEX INLET AIR PRESSURE
1430	2	1P	AINAIRP	6	1	N	kPa	AVG INLET AIR PRESSURE (kPa)
1440	2	1P	NINAIRP	5	0	N		SAMPLES INLET AIR PRESSURE TOTAL DATA POINTS
1450	2	1P	BINAIRP	5	0	N		BQD INLET AIR PRESSURE TOTAL DATA POINTS
1460	2	1P	OINAIRP	5	0	N		OVER/UNDER RANGE INLET AIR PRESSURE TOTAL DATA POINTS
1470	2	1P	QEBP	7	3	N		EOT QUALITY INDEX EXHAUST PRESSURE
1480	2	1P	AEBP	6	1	N	kPa	AVG EXHAUST PRESSURE (kPa)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
1490	2	1P	NEBP	5	0	N		SAMPLES EXHAUST PRESSURE TOTAL DATA POINTS
1500	2	1P	BEBP	5	0	N		BQD EXHAUST PRESSURE TOTAL DATA POINTS
1510	2	1P	OEBP	5	0	N		OVER/UNDER RANGE EXHAUST PRESSURE TOTAL DATA POINTS
1520	2	1P	QFUELPR	7	3	N		EOT QUALITY INDEX FUEL @ FILTER HOUSING PRESSURE
1530	2	1P	AFUELPR	6	1	N	kPa	AVG FUEL @ FILTER HOUSING PRESSURE (kPa)
1540	2	1P	NFUELPR	5	0	N		SAMPLES FUEL @ FILTER HOUSING PRESSURE TOTAL DATA POINTS
1550	2	1P	BFUELPR	5	0	N		BQD FUEL @ FILTER HOUSING PRESSURE TOTAL DATA POINTS
1560	2	1P	OFUELPR	5	0	N		OVER/UNDER FUEL @ FILTER HOUSING PRESSURE TOTAL DATA POINTS
1570	2	1P	AAIRFLO	7	1	N	kg/h	AVG INTAKE AIR FLOW (kg/h)
1580	2	1P	APWR	6	1	N	kW	AVG ENGINE POWER (kW)
1590	2	1P	NPWR	5	0	N		SAMPLES ENGINE POWER TOTAL DATA POINTS
1600	2	1P	BPWR	5	0	N		BQD ENGINE POWER TOTAL DATA POINTS
1610	2	1P	OPWR	5	0	N		OVER/UNDER RANGE ENGINE POWER TOTAL DATA POINTS
1620	2	1P	ATORQUE	7	1	N	Nm	AVG TORQUE (Nm)
1630	2	1P	NTORQUE	5	0	N		SAMPLES TORQUE TOTAL DATA POINTS
1640	2	1P	BTORQUE	5	0	N		BQD TORQUE TOTAL DATA POINTS
1650	2	1P	OTORQUE	5	0	N		OVER/UNDER RANGE TORQUE TOTAL DATA POINTS
1660	2	1P	ABLOBY	6	1	N	L/min	AVG BLOWBY (L/min)
1670	2	1P	NBLOBY	5	0	N		SAMPLES BLOWBY TOTAL DATA POINTS
1680	2	1P	BBLOBY	5	0	N		BQD BLOWBY TOTAL DATA POINTS
1690	2	1P	OBLOBY	5	0	N		OVER/UNDER RANGE BLOWBY TOTAL DATA POINTS
1700	2	1P	ACOLIN	5	1	N	øC	AVG COOLANT IN (øC)
1710	2	1P	NCOLIN	5	0	N		SAMPLES COOLANT IN TOTAL DATA POINTS
1720	2	1P	BCOLIN	5	0	N		BQD COOLANT IN TOTAL DATA POINTS
1730	2	1P	OCOLIN	5	0	N		OVER/UNDER RANGE COOLANT IN TOTAL DATA POINTS
1740	2	1P	ACOLDT	5	1	N	øC	AVG COOLANT DELTA (øC)
1750	2	1P	NCOLDT	5	0	N		SAMPLES COOLANT DELTA TOTAL DATA POINTS
1760	2	1P	BCOLDT	5	0	N		BQD COOLANT DELTA TOTAL DATA POINTS
1770	2	1P	OCOLDT	5	0	N		OVER/UNDER RANGE COOLANT DELTA TOTAL DATA POINTS
1780	2	1P	AOCOOLIN	6	1	N	øC	AVG OIL COOLER IN TEMPERATURE (øC)
1790	2	1P	NOCOOLIN	5	0	N		SAMPLES OIL COOLER IN TEMPERATURE TOTAL DATA POINTS
1800	2	1P	BOCOOLIN	5	0	N		BQD OIL COOLER IN TEMPERATURE TOTAL DATA POINTS
1810	2	1P	OOCOOLIN	5	0	N		OVER/UNDER RANGE OIL COOLER IN TEMPERATURE TOTAL DATA POINTS
1820	2	1P	AHEATOIL	6	1	N	øC	AVG HEATING OIL TEMPERATURE (øC)
1830	2	1P	NHEATOIL	5	0	N		SAMPLES HEATING OIL TEMPERATURE TOTAL DATA POINTS
1840	2	1P	BHEATOIL	5	0	N		BQD HEATING OIL TEMPERATURE TOTAL DATA POINTS
1850	2	1P	OHEATOIL	5	0	N		OVER/UNDER RANGE HEATING OIL TEMPERATURE TOTAL DATA POINTS
1860	2	1P	AEXHTMP	6	1	N	øC	AVG EXHAUST TEMPERATURE (øC)
1870	2	1P	NEXHTMP	5	0	N		SAMPLES EXHAUST TEMPERATURE TOTAL DATA POINTS
1880	2	1P	BEXHTMP	5	0	N		BQD EXHAUST TEMPERATURE TOTAL DATA POINTS
1890	2	1P	OEXHTMP	5	0	N		OVER/UNDER RANGE EXHAUST TEMPERATURE TOTAL DATA POINTS
1900	2	1P	ACCV	5	2	N	kPa	AVG CRANKCASE VACUUM PRESSURE (kPa)
1910	2	1P	NCCV	5	0	N		SAMPLES CRANKCASE VACUUM PRESSURE TOTAL DATA POINTS
1920	2	1P	BCCV	5	0	N		BQD CRANKCASE VACUUM PRESSURE TOTAL DATA POINTS
1930	2	1P	OCCV	5	0	N		OVER/UNDER RANGE CRANKCASE VACUUM PRESSURE TOTAL DATA POINTS
1940	2	1P	ACOLPR	5	1	N	kPa	AVG COOLANT TO JUG (kPa)
1950	2	1P	NCOLPR	5	0	N		SAMPLES COOLANT TO JUG TOTAL DATA POINTS
1960	2	1P	BCOLPR	5	0	N		BQD COOLANT TO JUG TOTAL DATA POINTS
1970	2	1P	OCOLPR	5	0	N		OVER/UNDER RANGE COOLANT TO JUG TOTAL DATA POINTS

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
1980	3	1P	INJSET	5	0	C	GO / NO-GO	INJECTOR SETTING (GO / NO-GO)
1990	3	1P	TINIT	3	0	C	YES / NO	WAS TIMING INITIALIZED ? (YES / NO)
2000	3	1P	PISTONCL	6	3	N	mm	PISTON/HEAD CLEAR ASSEM. MEASUREMENT (mm)
2010	3	1P	CAMLASH	6	2	N	mm	CAM GEAR BACKLASH (mm)
2020	3	1P	FUELTIM	3	0	N	ø BTC	FUEL TIMING (ø BTC)
2030	3	1P	INVALOPN	3	0	N	ø ATC	INTAKE VALVE OPEN (ø ATC)
2040	3	1P	PLUNLIFT	6	3	N	mm	INJECTOR PLUNGER LIFT (mm)
2050	3	1P	INLIFT	6	3	N	mm	INTAKE VALVE LIFT (mm)
2060	3	1P	EXLIFT	6	3	N	mm	EXHAUST VALVE LIFT (mm)
2070	3	1P	LINERPN	12	0	C		LINER PART NUMBER
2080	3	1P	LINERSN	12	0	C		LINER SERIAL NUMBER
2090	3	1P	LINERDC	12	0	C		LINER DATE CODE
2100	3	1P	TOPPN	12	0	C		TOP RING SET PART NUMBER
2110	3	1P	TOPSN	12	0	C		TOP RING SET SERIAL NUMBER
2120	3	1P	INTPN	12	0	C		INTERMEDIATE RING SET PART NUMBER
2130	3	1P	INTSN	12	0	C		INTERMEDIATE RING SET SERIAL NUMBER
2140	3	1P	OILPN	12	0	C		OIL RING SET PART NUMBER
2150	3	1P	OILSN	12	0	C		OIL RING SET SERIAL NUMBER
2160	3	1P	CROWNPN	12	0	C		PISTON CROWN PART NUMBER
2170	3	1P	CROWNSN	12	0	C		PISTON CROWN SERIAL NUMBER
2180	3	1P	CROWNDC	12	0	C		PISTON CROWN DATE CODE
2190	3	1P	CROWNIC	12	0	C		PISTON CROWN INSPECTION CODE
2200	3	1P	SKIRTPN	12	0	C		PISTON SKIRT PART NUMBER
2210	3	1P	SKIRTSN	12	0	C		PISTON SKIRT SERIAL NUMBER
2220	3	1P	NOZZLEPN	12	0	C		FUEL NOZZLE PART NUMBER
2230	3	1P	NOZZLESN	12	0	C		FUEL NOZZLE SERIAL NUMBER
2240	3	1P	ECMPN	12	0	C		ECM EPROM PART NUMBER
2250	3	1P	ECMDC	12	0	C		ECM EPROM DATE CODE
2260	3	1P	PTUBEPN	12	0	C		PISTON COOLING JET PART NUMBER
2270	3	1P	PTUBESN	12	0	C		PISTON COOLING JET SERIAL NUMBER
2280	4	1P	TESTFUEL	10	0	C		TEST FUEL
2290	4	1P	FUELBTID	10	0	C		FUEL BATCH ID NUMBER
2300	4	1P	DTRATE	8	0	C	YYYYMMDD	RATING DATE (YYYYMMDD)
2310	4	1P	RINIT	3	0	C		RATERS INITIALS
2320	4	1P	VRINIT	3	0	C		VERIFIED BY INITIALS
2330	4	1P	LRDTCOMP	8	0	C	YYYYMMDD	LAST STAND REFERENCE DATE COMPLETED (YYYYMMDD)
2340	4	1P	LRENRUN	4	0	C		LAST STAND REFERENCE RUN NUMBER
2350	4	1P	LIND	6	0	C		LAST STAND REFERENCE OIL CODE
2360	4	1P	LRWD	6	1	N	DEMERITS	LAST STAND REFERENCE TOTAL WEIGHTED DEMERITS (DEMERITS)
2370	4	1P	LRTGC	6	2	N	DEMERITS	LAST STAND REFERENCE TOP GROOVE CARBON (DEMERITS)
2380	4	1P	LRTLC	6	2	N	DEMERITS	LAST STAND REFERENCE TOP LAND CARBON (DEMERITS)
2390	4	1P	LROC	5	1	N	g/h	LAST STAND REFERENCE OIL CONSUMPTION (g/h)
2400	4	1P	LROCT	6	3	N	TRANS UNITS	LAST STAND REFERENCE TRANSFORMED OIL CONSUMPTI (TRANS UNITS)
2410	4	1P	LRETOCT	6	3	N	TRANS UNITS	LAST STAND REFERENCE TRANSFORMED EOTOC (TRANS UNITS)
2420	4	1P	LREOTOC	5	1	N	g/kW-h	LAST STAND REFERENCE EOTOC (g/kW-h)
2430	4	1P	LRAWD	6	1	N	DEMERITS	LAST STAND REFERENCE INDUSTRY AVG WDK (DEMERITS)
2440	4	1P	LRATGC	6	2	N	DEMERITS	LAST STAND REFERENCE INDUSTRY AVG TGC (DEMERITS)
2450	4	1P	LRATLC	6	2	N	DEMERITS	LAST STAND REFERENCE INDUSTRY AVG TLC (DEMERITS)
2460	4	1P	LRAOCT	6	3	N	TRANS UNITS	LAST STAND REFERENCE INDUSTRY AVG TRANS OC (TRANS UNITS)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
2470	4	1P	LRAETOCT	6	3	N	TRANS UNITS	LAST STAND REFERENCE INDUSTRY AVG TRANS EOTOC (TRANS UNITS)
2480	4	1P	LRSWD	6	1	N	DEMERITS	LAST STAND REFERENCE INDUSTRY STD WDK (DEMERITS)
2490	4	1P	LRSTGC	6	2	N	DEMERITS	LAST STAND REFERENCE INDUSTRY STD TGC (DEMERITS)
2500	4	1P	LRSTLC	6	2	N	DEMERITS	LAST STAND REFERENCE INDUSTRY STD TLC (DEMERITS)
2510	4	1P	LRSOCT	6	3	N	TRANS UNITS	LAST STAND REFERENCE INDUSTRY STD TRANS OC (TRANS UNITS)
2520	4	1P	LRSETOCT	6	3	N	TRANS UNITS	LAST STAND REFERENCE INDUSTRY STD TRANS EOTOC (TRANS UNITS)
2530	4	1P	G1HCA	4	0	N	% AREA	GROOVE #1 HC-1.0 CARBON AREA PERCENT (% AREA)
2540	4	1P	G1HCD	7	2	N	DEMERITS	GROOVE #1 HC-1.0 CARBON DEMERITS (DEMERITS)
2550	4	1P	G2HCA	4	0	N	% AREA	GROOVE #2 HC-1.0 CARBON AREA PERCENT (% AREA)
2560	4	1P	G2HCD	7	2	N	DEMERITS	GROOVE #2 HC-1.0 CARBON DEMERITS (DEMERITS)
2570	4	1P	L1HCA	4	0	N	% AREA	LAND #1 HC-1.0 CARBON AREA PERCENT (% AREA)
2580	4	1P	L1HCD	7	2	N	DEMERITS	LAND #1 HC-1.0 CARBON DEMERITS (DEMERITS)
2590	4	1P	L2HCA	4	0	N	% AREA	LAND #2 HC-1.0 CARBON AREA PERCENT (% AREA)
2600	4	1P	L2HCD	7	2	N	DEMERITS	LAND #2 HC-1.0 CARBON DEMERITS (DEMERITS)
2610	4	1P	G3HCA	4	0	N	% AREA	GROOVE #3 HC-1.0 CARBON AREA PERCENT (% AREA)
2620	4	1P	G3HCD	7	2	N	DEMERITS	GROOVE #3 HC-1.0 CARBON DEMERITS (DEMERITS)
2630	4	1P	L3HCA	4	0	N	% AREA	LAND #3 HC-1.0 CARBON AREA PERCENT (% AREA)
2640	4	1P	L3HCD	7	2	N	DEMERITS	LAND #3 HC-1.0 CARBON DEMERITS (DEMERITS)
2650	4	1P	L4HCA	4	0	N	% AREA	LAND #4 HC-1.0 CARBON AREA PERCENT (% AREA)
2660	4	1P	L4HCD	7	2	N	DEMERITS	LAND #4 HC-1.0 CARBON DEMERITS (DEMERITS)
2670	4	1P	G1MCA	4	0	N	% AREA	GROOVE #1 MC-1.0 CARBON AREA PERCENT (% AREA)
2680	4	1P	G1MCD	7	2	N	DEMERITS	GROOVE #1 MC-1.0 CARBON DEMERITS (DEMERITS)
2690	4	1P	G3MCA	4	0	N	% AREA	GROOVE #3 MC-1.0 CARBON AREA PERCENT (% AREA)
2700	4	1P	G3MCD	7	2	N	DEMERITS	GROOVE #3 MC-1.0 CARBON DEMERITS (DEMERITS)
2710	4	1P	G1LCA	4	0	N	% AREA	GROOVE #1 LC-1.0 CARBON AREA PERCENT (% AREA)
2720	4	1P	G1LCD	7	2	N	DEMERITS	GROOVE #1 LC-1.0 CARBON DEMERITS (DEMERITS)
2730	4	1P	G2LCA	4	0	N	% AREA	GROOVE #2 LC-1.0 CARBON AREA PERCENT (% AREA)
2740	4	1P	G2LCD	7	2	N	DEMERITS	GROOVE #2 LC-1.0 CARBON DEMERITS (DEMERITS)
2750	4	1P	L1LCA	4	0	N	% AREA	LAND #1 LC-1.0 CARBON AREA PERCENT (% AREA)
2760	4	1P	L1LCD	7	2	N	DEMERITS	LAND #1 LC-1.0 CARBON DEMERITS (DEMERITS)
2770	4	1P	L2LCA	4	0	N	% AREA	LAND #2 LC-1.0 CARBON AREA PERCENT (% AREA)
2780	4	1P	L2LCD	7	2	N	DEMERITS	LAND #2 LC-1.0 CARBON DEMERITS (DEMERITS)
2790	4	1P	G3LCA	4	0	N	% AREA	GROOVE #3 LC-1.0 CARBON AREA PERCENT (% AREA)
2800	4	1P	G3LCD	7	2	N	DEMERITS	GROOVE #3 LC-1.0 CARBON DEMERITS (DEMERITS)
2810	4	1P	L3LCA	4	0	N	% AREA	LAND #3 LC-1.0 CARBON AREA PERCENT (% AREA)
2820	4	1P	L3LCD	7	2	N	DEMERITS	LAND #3 LC-1.0 CARBON DEMERITS (DEMERITS)
2830	4	1P	L4LCA	4	0	N	% AREA	LAND #4 LC-1.0 CARBON AREA PERCENT (% AREA)
2840	4	1P	L4LCD	7	2	N	DEMERITS	LAND #4 LC-1.0 CARBON DEMERITS (DEMERITS)
2850	4	1P	OGLCA	4	0	N	% AREA	OIL COOLING GALLERY LC-.25 CARBON AREA PERCENT (% AREA)
2860	4	1P	OGLCD	7	2	N	DEMERITS	OIL COOLING GALLERY LC-.25 CARBON DEMERITS (DEMERITS)
2870	4	1P	UCLCA	4	0	N	% AREA	UNDER CROWN LC-.25 CARBON AREA PERCENT (% AREA)
2880	4	1P	UCLCD	7	2	N	DEMERITS	UNDER CROWN LC-.25 CARBON DEMERITS (DEMERITS)
2890	4	1P	G1ACTOT	4	0	N	% AREA	TOTAL GROOVE #1 CARBON AREA PERCENT (% AREA)
2900	4	1P	G1DCTOT	7	2	N	DEMERITS	TOTAL GROOVE #1 CARBON DEMERITS (DEMERITS)
2910	4	1P	G2ACTOT	4	0	N	% AREA	TOTAL GROOVE #2 CARBON AREA PERCENT (% AREA)
2920	4	1P	G2DCTOT	7	2	N	DEMERITS	TOTAL GROOVE #2 CARBON DEMERITS (DEMERITS)
2930	4	1P	L1ACTOT	4	0	N	% AREA	TOTAL LAND #1 CARBON AREA PERCENT (% AREA)
2940	4	1P	L1DCTOT	7	2	N	DEMERITS	TOTAL LAND #1 CARBON DEMERITS (DEMERITS)
2950	4	1P	L2ACTOT	4	0	N	% AREA	TOTAL LAND #2 CARBON AREA PERCENT (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
2960	4	1P	L2DCTOT	7	2	N	DEMERITS	TOTAL LAND #2 CARBON DEMERITS (DEMERITS)
2970	4	1P	G3ACTOT	4	0	N	% AREA	TOTAL GROOVE #3 CARBON AREA PERCENT (% AREA)
2980	4	1P	G3DCTOT	7	2	N	DEMERITS	TOTAL GROOVE #3 CARBON DEMERITS (DEMERITS)
2990	4	1P	L3ACTOT	4	0	N	% AREA	TOTAL LAND #3 CARBON AREA PERCENT (% AREA)
3000	4	1P	L3DCTOT	7	2	N	DEMERITS	TOTAL LAND #3 CARBON DEMERITS (DEMERITS)
3010	4	1P	L4ACTOT	4	0	N	% AREA	TOTAL LAND #4 CARBON AREA PERCENT (% AREA)
3020	4	1P	L4DCTOT	7	2	N	DEMERITS	TOTAL LAND #4 CARBON DEMERITS (DEMERITS)
3030	4	1P	OGACTOT	4	0	N	% AREA	TOTAL OIL COOLING GALLERY CARBON AREA PERCENT (% AREA)
3040	4	1P	OGDCTOT	7	2	N	DEMERITS	TOTAL OIL COOLING GALLERY CARBON DEMERITS (DEMERITS)
3050	4	1P	UCACTOT	4	0	N	% AREA	TOTAL UNDER CROWN CARBON AREA PERCENT (% AREA)
3060	4	1P	UCDCTOT	7	2	N	DEMERITS	TOTAL UNDER CROWN CARBON DEMERITS (DEMERITS)
3070	4	1P	G1V9A	4	0	N	% AREA	GROOVE #1 8-9 VARNISH AREA PERCENT (% AREA)
3080	4	1P	G1V9D	7	2	N	DEMERITS	GROOVE #1 8-9 VARNISH DEMERITS (DEMERITS)
3090	4	1P	G2V9A	4	0	N	% AREA	GROOVE #2 8-9 VARNISH AREA PERCENT (% AREA)
3100	4	1P	G2V9D	7	2	N	DEMERITS	GROOVE #2 8-9 VARNISH DEMERITS (DEMERITS)
3110	4	1P	L1V9A	4	0	N	% AREA	LAND #1 8-9 VARNISH AREA PERCENT (% AREA)
3120	4	1P	L1V9D	7	2	N	DEMERITS	LAND #1 8-9 VARNISH DEMERITS (DEMERITS)
3130	4	1P	L2V9A	4	0	N	% AREA	LAND #2 8-9 VARNISH AREA PERCENT (% AREA)
3140	4	1P	L2V9D	7	2	N	DEMERITS	LAND #2 8-9 VARNISH DEMERITS (DEMERITS)
3150	4	1P	G1V8A	4	0	N	% AREA	GROOVE #1 7-7.9 VARNISH AREA PERCENT (% AREA)
3160	4	1P	G1V8D	7	2	N	DEMERITS	GROOVE #1 7-7.9 VARNISH DEMERITS (DEMERITS)
3170	4	1P	G2V8A	4	0	N	% AREA	GROOVE #2 7-7.9 VARNISH AREA PERCENT (% AREA)
3180	4	1P	G2V8D	7	2	N	DEMERITS	GROOVE #2 7-7.9 VARNISH DEMERITS (DEMERITS)
3190	4	1P	L1V8A	4	0	N	% AREA	LAND #1 7-7.9 VARNISH AREA PERCENT (% AREA)
3200	4	1P	L1V8D	7	2	N	DEMERITS	LAND #1 7-7.9 VARNISH DEMERITS (DEMERITS)
3210	4	1P	L2V8A	4	0	N	% AREA	LAND #2 7-7.9 VARNISH AREA PERCENT (% AREA)
3220	4	1P	L2V8D	7	2	N	DEMERITS	LAND #2 7-7.9 VARNISH DEMERITS (DEMERITS)
3230	4	1P	G3V75A	4	0	N	% AREA	GROOVE #3 7.5 VARNISH AREA PERCENT (% AREA)
3240	4	1P	G3V75D	7	2	N	DEMERITS	GROOVE #3 7.5 VARNISH DEMERITS (DEMERITS)
3250	4	1P	L3V75A	4	0	N	% AREA	LAND #3 7.5 VARNISH AREA PERCENT (% AREA)
3260	4	1P	L3V75D	7	2	N	DEMERITS	LAND #3 7.5 VARNISH DEMERITS (DEMERITS)
3270	4	1P	L4V75A	4	0	N	% AREA	LAND #4 7.5 VARNISH AREA PERCENT (% AREA)
3280	4	1P	L4V75D	7	2	N	DEMERITS	LAND #4 7.5 VARNISH DEMERITS (DEMERITS)
3290	4	1P	OGV75A	4	0	N	% AREA	OIL COOLING GALLERY 7.5 VARNISH AREA PERCENT (% AREA)
3300	4	1P	OGV75D	7	2	N	DEMERITS	OIL COOLING GALLERY 7.9 VARNISH DEMERITS (DEMERITS)
3310	4	1P	UCV75A	4	0	N	% AREA	UNDER CROWN 7.5 VARNISH AREA PERCENT (% AREA)
3320	4	1P	UCV75D	7	2	N	DEMERITS	UNDER CROWN 7.5 VARNISH DEMERITS (DEMERITS)
3330	4	1P	G1V7A	4	0	N	% AREA	GROOVE #1 6-6.9 VARNISH AREA PERCENT (% AREA)
3340	4	1P	G1V7D	7	2	N	DEMERITS	GROOVE #1 6-6.9 VARNISH DEMERITS (DEMERITS)
3350	4	1P	G2V7A	4	0	N	% AREA	GROOVE #2 6-6.9 VARNISH AREA PERCENT (% AREA)
3360	4	1P	G2V7D	7	2	N	DEMERITS	GROOVE #2 6-6.9 VARNISH DEMERITS (DEMERITS)
3370	4	1P	L1V7A	4	0	N	% AREA	LAND #1 6-6.9 VARNISH AREA PERCENT (% AREA)
3380	4	1P	L1V7D	7	2	N	DEMERITS	LAND #1 6-6.9 VARNISH DEMERITS (DEMERITS)
3390	4	1P	L2V7A	4	0	N	% AREA	LAND #2 6-6.9 VARNISH AREA PERCENT (% AREA)
3400	4	1P	L2V7D	7	2	N	DEMERITS	LAND #2 6-6.9 VARNISH DEMERITS (DEMERITS)
3410	4	1P	G1V6A	4	0	N	% AREA	GROOVE #1 5-5.9 VARNISH AREA PERCENT (% AREA)
3420	4	1P	G1V6D	7	2	N	DEMERITS	GROOVE #1 5-5.9 VARNISH DEMERITS (DEMERITS)
3430	4	1P	G2V6A	4	0	N	% AREA	GROOVE #2 5-5.9 VARNISH AREA PERCENT (% AREA)
3440	4	1P	G2V6D	7	2	N	DEMERITS	GROOVE #2 5-5.9 VARNISH DEMERITS (DEMERITS)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
3450	4	1P	L1V6A	4	0	N	% AREA	LAND #1 5-5.9 VARNISH AREA PERCENT (% AREA)
3460	4	1P	L1V6D	7	2	N	DEMERITS	LAND #1 5-5.9 VARNISH DEMERITS (DEMERITS)
3470	4	1P	L2V6A	4	0	N	% AREA	LAND #2 5-5.9 VARNISH AREA PERCENT (% AREA)
3480	4	1P	L2V6D	7	2	N	DEMERITS	LAND #2 5-5.9 VARNISH DEMERITS (DEMERITS)
3490	4	1P	G1V5A	4	0	N	% AREA	GROOVE #1 4-4.9 VARNISH AREA PERCENT (% AREA)
3500	4	1P	G1V5D	7	2	N	DEMERITS	GROOVE #1 4-4.9 VARNISH DEMERITS (DEMERITS)
3510	4	1P	G2V5A	4	0	N	% AREA	GROOVE #2 4-4.9 VARNISH AREA PERCENT (% AREA)
3520	4	1P	G2V5D	7	2	N	DEMERITS	GROOVE #2 4-4.9 VARNISH DEMERITS (DEMERITS)
3530	4	1P	L1V5A	4	0	N	% AREA	LAND #1 4-4.9 VARNISH AREA PERCENT (% AREA)
3540	4	1P	L1V5D	7	2	N	DEMERITS	LAND #1 4-4.9 VARNISH DEMERITS (DEMERITS)
3550	4	1P	L2V5A	4	0	N	% AREA	LAND #2 4-4.9 VARNISH AREA PERCENT (% AREA)
3560	4	1P	L2V5D	7	2	N	DEMERITS	LAND #2 4-4.9 VARNISH DEMERITS (DEMERITS)
3570	4	1P	G3V45A	4	0	N	% AREA	GROOVE #3 4.5 VARNISH AREA PERCENT (% AREA)
3580	4	1P	G3V45D	7	2	N	DEMERITS	GROOVE #3 4.5 VARNISH DEMERITS (DEMERITS)
3590	4	1P	L3V45A	4	0	N	% AREA	LAND #3 4.5 VARNISH AREA PERCENT (% AREA)
3600	4	1P	L3V45D	7	2	N	DEMERITS	LAND #3 4.5 VARNISH DEMERITS (DEMERITS)
3610	4	1P	L4V45A	4	0	N	% AREA	LAND #4 4.5 VARNISH AREA PERCENT (% AREA)
3620	4	1P	L4V45D	7	2	N	DEMERITS	LAND #4 4.5 VARNISH DEMERITS (DEMERITS)
3630	4	1P	OGV45A	4	0	N	% AREA	OIL COOLING GALLERY 4.5 VARNISH AREA PERCENT (% AREA)
3640	4	1P	OGV45D	7	2	N	DEMERITS	OIL COOLING GALLERY 4.5 VARNISH DEMERITS (DEMERITS)
3650	4	1P	UCV45A	4	0	N	% AREA	UNDER CROWN 4.5 VARNISH AREA PERCENT (% AREA)
3660	4	1P	UCV45D	7	2	N	DEMERITS	UNDER CROWN 4.5 VARNISH DEMERITS (DEMERITS)
3670	4	1P	G1V4A	4	0	N	% AREA	GROOVE #1 3-3.9 VARNISH AREA PERCENT (% AREA)
3680	4	1P	G1V4D	7	2	N	DEMERITS	GROOVE #1 3-3.9 VARNISH DEMERITS (DEMERITS)
3690	4	1P	G2V4A	4	0	N	% AREA	GROOVE #2 3-3.9 VARNISH AREA PERCENT (% AREA)
3700	4	1P	G2V4D	7	2	N	DEMERITS	GROOVE #2 3-3.9 VARNISH DEMERITS (DEMERITS)
3710	4	1P	L1V4A	4	0	N	% AREA	LAND #1 3-3.9 VARNISH AREA PERCENT (% AREA)
3720	4	1P	L1V4D	7	2	N	DEMERITS	LAND #1 3-3.9 VARNISH DEMERITS (DEMERITS)
3730	4	1P	L2V4A	4	0	N	% AREA	LAND #2 3-3.9 VARNISH AREA PERCENT (% AREA)
3740	4	1P	L2V4D	7	2	N	DEMERITS	LAND #2 3-3.9 VARNISH DEMERITS (DEMERITS)
3750	4	1P	G1V3A	4	0	N	% AREA	GROOVE #1 2-2.9 VARNISH AREA PERCENT (% AREA)
3760	4	1P	G1V3D	7	2	N	DEMERITS	GROOVE #1 2-2.9 VARNISH DEMERITS (DEMERITS)
3770	4	1P	G2V3A	4	0	N	% AREA	GROOVE #2 2-2.9 VARNISH AREA PERCENT (% AREA)
3780	4	1P	G2V3D	7	2	N	DEMERITS	GROOVE #2 2-2.9 VARNISH DEMERITS (DEMERITS)
3790	4	1P	L1V3A	4	0	N	% AREA	LAND #1 2-2.9 VARNISH AREA PERCENT (% AREA)
3800	4	1P	L1V3D	7	2	N	DEMERITS	LAND #1 2-2.9 VARNISH DEMERITS (DEMERITS)
3810	4	1P	L2V3A	4	0	N	% AREA	LAND #2 2-2.9 VARNISH AREA PERCENT (% AREA)
3820	4	1P	L2V3D	7	2	N	DEMERITS	LAND #2 2-2.9 VARNISH DEMERITS (DEMERITS)
3830	4	1P	G1V2A	4	0	N	% AREA	GROOVE #1 1-1.9 VARNISH AREA PERCENT (% AREA)
3840	4	1P	G1V2D	7	2	N	DEMERITS	GROOVE #1 1-1.9 VARNISH DEMERITS (DEMERITS)
3850	4	1P	G2V2A	4	0	N	% AREA	GROOVE #2 1-1.9 VARNISH AREA PERCENT (% AREA)
3860	4	1P	G2V2D	7	2	N	DEMERITS	GROOVE #2 1-1.9 VARNISH DEMERITS (DEMERITS)
3870	4	1P	L1V2A	4	0	N	% AREA	LAND #1 1-1.9 VARNISH AREA PERCENT (% AREA)
3880	4	1P	L1V2D	7	2	N	DEMERITS	LAND #1 1-1.9 VARNISH DEMERITS (DEMERITS)
3890	4	1P	L2V2A	4	0	N	% AREA	LAND #2 1-1.9 VARNISH AREA PERCENT (% AREA)
3900	4	1P	L2V2D	7	2	N	DEMERITS	LAND #2 1-1.9 VARNISH DEMERITS (DEMERITS)
3910	4	1P	G3V15A	4	0	N	% AREA	GROOVE #3 1.5 VARNISH AREA PERCENT (% AREA)
3920	4	1P	G3V15D	7	2	N	DEMERITS	GROOVE #3 1.5 VARNISH DEMERITS (DEMERITS)
3930	4	1P	L3V15A	4	0	N	% AREA	LAND #3 1.5 VARNISH AREA PERCENT (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
3940	4	1P	L3V15D	7	2	N	DEMERITS	LAND #3 1.5 VARNISH DEMERITS (DEMERITS)
3950	4	1P	L4V15A	4	0	N	% AREA	LAND #4 1.5 VARNISH AREA PERCENT (% AREA)
3960	4	1P	L4V15D	7	2	N	DEMERITS	LAND #4 1.5 VARNISH DEMERITS (DEMERITS)
3970	4	1P	OGV15A	4	0	N	% AREA	OIL COOLING GALLERY 1.5 VARNISH AREA PERCENT (% AREA)
3980	4	1P	OGV15D	7	2	N	DEMERITS	OIL COOLING GALLERY 1.5 VARNISH DEMERITS (DEMERITS)
3990	4	1P	UCV15A	4	0	N	% AREA	UNDER CROWN 1.5 VARNISH AREA PERCENT (% AREA)
4000	4	1P	UCV15D	7	2	N	DEMERITS	UNDER CROWN 1.5 VARNISH DEMERITS (DEMERITS)
4010	4	1P	G1V1A	4	0	N	% AREA	GROOVE #1 0-0.9 VARNISH AREA PERCENT (% AREA)
4020	4	1P	G1V1D	7	2	N	DEMERITS	GROOVE #1 0-0.9 VARNISH DEMERITS (DEMERITS)
4030	4	1P	G2V1A	4	0	N	% AREA	GROOVE #2 0-0.9 VARNISH AREA PERCENT (% AREA)
4040	4	1P	G2V1D	7	2	N	DEMERITS	GROOVE #2 0-0.9 VARNISH DEMERITS (DEMERITS)
4050	4	1P	L1V1A	4	0	N	% AREA	LAND #1 0-0.9 VARNISH AREA PERCENT (% AREA)
4060	4	1P	L1V1D	7	2	N	DEMERITS	LAND #1 0-0.9 VARNISH DEMERITS (DEMERITS)
4070	4	1P	L2V1A	4	0	N	% AREA	LAND #2 0-0.9 VARNISH AREA PERCENT (% AREA)
4080	4	1P	L2V1D	7	2	N	DEMERITS	LAND #2 0-0.9 VARNISH DEMERITS (DEMERITS)
4090	4	1P	G1VCLNA	4	0	N	% AREA	GROOVE #1 CLEAN VARNISH AREA PERCENT (% AREA)
4100	4	1P	G2VCLNA	4	0	N	% AREA	GROOVE #2 CLEAN VARNISH AREA PERCENT (% AREA)
4110	4	1P	L1VCLNA	4	0	N	% AREA	LAND #1 CLEAN VARNISH AREA PERCENT (% AREA)
4120	4	1P	L2VCLNA	4	0	N	% AREA	LAND #2 CLEAN VARNISH AREA PERCENT (% AREA)
4130	4	1P	G3VCLNA	4	0	N	% AREA	GROOVE #3 CLEAN VARNISH AREA PERCENT (% AREA)
4140	4	1P	L3VCLNA	4	0	N	% AREA	LAND #3 CLEAN VARNISH AREA PERCENT (% AREA)
4150	4	1P	L4VCLNA	4	0	N	% AREA	LAND #4 CLEAN VARNISH AREA PERCENT (% AREA)
4160	4	1P	OGVCLNA	4	0	N	% AREA	OIL COOLING GALLERY CLEAN VARNISH AREA PERCENT (% AREA)
4170	4	1P	UCVCLNA	4	0	N	% AREA	UNDER CROWN CLEAN VARNISH AREA PERCENT (% AREA)
4180	4	1P	G1AVTOT	4	0	N	% AREA	TOTAL GROOVE #1 VARNISH AREA PERCENT (% AREA)
4190	4	1P	G1DVTOT	7	2	N	DEMERITS	TOTAL GROOVE #1 VARNISH DEMERITS (DEMERITS)
4200	4	1P	G2AVTOT	4	0	N	% AREA	TOTAL GROOVE #2 VARNISH AREA PERCENT (% AREA)
4210	4	1P	G2DVTOT	7	2	N	DEMERITS	TOTAL GROOVE #2 VARNISH DEMERITS (DEMERITS)
4220	4	1P	G3AVTOT	4	0	N	% AREA	TOTAL GROOVE #3 VARNISH AREA PERCENT (% AREA)
4230	4	1P	G3DVTOT	7	2	N	DEMERITS	TOTAL GROOVE #3 VARNISH DEMERITS (DEMERITS)
4240	4	1P	L1AVTOT	4	0	N	% AREA	TOTAL LAND #1 VARNISH AREA PERCENT (% AREA)
4250	4	1P	L1DVTOT	7	2	N	DEMERITS	TOTAL LAND #1 VARNISH DEMERITS (DEMERITS)
4260	4	1P	L2AVTOT	4	0	N	% AREA	TOTAL LAND #2 VARNISH AREA PERCENT (% AREA)
4270	4	1P	L2DVTOT	7	2	N	DEMERITS	TOTAL LAND #2 VARNISH DEMERITS (DEMERITS)
4280	4	1P	L3AVTOT	4	0	N	% AREA	TOTAL LAND #3 VARNISH AREA PERCENT (% AREA)
4290	4	1P	L3DVTOT	7	2	N	DEMERITS	TOTAL LAND #3 VARNISH DEMERITS (DEMERITS)
4300	4	1P	L4AVTOT	4	0	N	% AREA	TOTAL LAND #4 VARNISH AREA PERCENT (% AREA)
4310	4	1P	L4DVTOT	7	2	N	DEMERITS	TOTAL LAND #4 VARNISH DEMERITS (DEMERITS)
4320	4	1P	OGAVTOT	4	0	N	% AREA	TOTAL OIL COOLING GALLERY VARNISH AREA PERCENT (% AREA)
4330	4	1P	OGDVTOT	7	2	N	DEMERITS	TOTAL OIL COOLING GALLERY VARNISH DEMERITS (DEMERITS)
4340	4	1P	UCAVTOT	4	0	N	% AREA	TOTAL UNDER CROWN VARNISH AREA PERCENT (% AREA)
4350	4	1P	UCDVTOT	7	2	N	DEMERITS	TOTAL UNDER CROWN VARNISH DEMERITS (DEMERITS)
4360	4	1P	G1UWD	7	2	N	DEMERITS	GROOVE #1 UNWEIGHTED DEMERITS (DEMERITS)
4370	4	1P	G2UWD	7	2	N	DEMERITS	GROOVE #2 UNWEIGHTED DEMERITS (DEMERITS)
4380	4	1P	G3UWD	7	2	N	DEMERITS	GROOVE #3 UNWEIGHTED DEMERITS (DEMERITS)
4390	4	1P	L1UWD	7	2	N	DEMERITS	LAND #1 UNWEIGHTED DEMERITS (DEMERITS)
4400	4	1P	L2UWD	7	2	N	DEMERITS	LAND #2 UNWEIGHTED DEMERITS (DEMERITS)
4410	4	1P	L3UWD	7	2	N	DEMERITS	LAND #3 UNWEIGHTED DEMERITS (DEMERITS)
4420	4	1P	L4UWD	7	2	N	DEMERITS	LAND #4 UNWEIGHTED DEMERITS (DEMERITS)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
4430	4	1P	OGUWD	7	2	N	DEMERITS	OIL COOLING GALLERY UNWEIGHTED DEMERITS (DEMERITS)
4440	4	1P	UCUWD	7	2	N	DEMERITS	UNDER CROWN UNWEIGHTED DEMERITS (DEMERITS)
4450	4	1P	G1WD	7	2	N	DEMERITS	GROOVE #1 WEIGHTED DEMERITS (DEMERITS)
4460	4	1P	G2WD	7	2	N	DEMERITS	GROOVE #2 WEIGHTED DEMERITS (DEMERITS)
4470	4	1P	G3WD	7	2	N	DEMERITS	GROOVE #3 WEIGHTED DEMERITS (DEMERITS)
4480	4	1P	L1WD	7	2	N	DEMERITS	LAND #1 WEIGHTED DEMERITS (DEMERITS)
4490	4	1P	L2WD	7	2	N	DEMERITS	LAND #2 WEIGHTED DEMERITS (DEMERITS)
4500	4	1P	L3WD	7	2	N	DEMERITS	LAND #3 WEIGHTED DEMERITS (DEMERITS)
4510	4	1P	L4WD	7	2	N	DEMERITS	LAND #4 UNWEIGHTED DEMERITS (DEMERITS)
4520	4	1P	OGWD	7	2	N	DEMERITS	OIL COOLING GALLERY WEIGHTED DEMERITS (DEMERITS)
4530	4	1P	UCWD	7	2	N	DEMERITS	UNDER CROWN WEIGHTED DEMERITS (DEMERITS)
4540	4	1P	UWD	7	1	N	DEMERITS	UNWEIGHTED TOTAL DEMERITS (DEMERITS)
4550	4	1P	TLFC	7	0	N	%	T.L. FLAKED CARBON (%)
4560	4a	1P	RATEWSIM	70	0	C		PISTON RATING WORKSHEET PLOT IMAGE
4570	5	1P	G1THCA	4	0	N	% AREA	TOP GROOVE #1 HEAVY CARBON (% AREA)
4580	5	1P	G1TMCA	4	0	N	% AREA	TOP GROOVE #1 MEDIUM CARBON (% AREA)
4590	5	1P	G1TLCA	4	0	N	% AREA	TOP GROOVE #1 LIGHT CARBON (% AREA)
4600	5	1P	G1T9A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 9 - 8 (% AREA)
4610	5	1P	G1T8A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 7.9 - 7 (% AREA)
4620	5	1P	G1T7A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 6.9 - 6 (% AREA)
4630	5	1P	G1T6A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 5.9 - 5 (% AREA)
4640	5	1P	G1T5A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 4.9 - 4 (% AREA)
4650	5	1P	G1T4A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 3.9 - 3 (% AREA)
4660	5	1P	G1T3A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 2.9 - 2 (% AREA)
4670	5	1P	G1T2A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 1.9 - 1 (% AREA)
4680	5	1P	G1T1A	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT 0.9 - 0 (% AREA)
4690	5	1P	G1TCLNA	4	0	N	% AREA	TOP GROOVE #1 DEPOSIT CLEAN (% AREA)
4700	5	1P	G1BHCA	4	0	N	% AREA	BOTTOM GROOVE #1 HEAVY CARBON (% AREA)
4710	5	1P	G1BMCA	4	0	N	% AREA	BOTTOM GROOVE #1 MEDIUM CARBON (% AREA)
4720	5	1P	G1BLCA	4	0	N	% AREA	BOTTOM GROOVE #1 LIGHT CARBON (% AREA)
4730	5	1P	G1B9A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 9 - 8 (% AREA)
4740	5	1P	G1B8A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 7.9 - 7 (% AREA)
4750	5	1P	G1B7A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 6.9 - 6 (% AREA)
4760	5	1P	G1B6A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 5.9 - 5 (% AREA)
4770	5	1P	G1B5A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 4.9 - 4 (% AREA)
4780	5	1P	G1B4A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 3.9 - 3 (% AREA)
4790	5	1P	G1B3A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 2.9 - 2 (% AREA)
4800	5	1P	G1B2A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 1.9 - 1 (% AREA)
4810	5	1P	G1B1A	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT 0.9 - 0 (% AREA)
4820	5	1P	G1BCLNA	4	0	N	% AREA	BOTTOM GROOVE #1 DEPOSIT CLEAN (% AREA)
4830	5	1P	G2THCA	4	0	N	% AREA	TOP GROOVE #2 HEAVY CARBON (% AREA)
4840	5	1P	G2TMCA	4	0	N	% AREA	TOP GROOVE #2 MEDIUM CARBON (% AREA)
4850	5	1P	G2TLCA	4	0	N	% AREA	TOP GROOVE #2 LIGHT CARBON (% AREA)
4860	5	1P	G2T9A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 9 - 8 (% AREA)
4870	5	1P	G2T8A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 7.9 - 7 (% AREA)
4880	5	1P	G2T7A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 6.9 - 6 (% AREA)
4890	5	1P	G2T6A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 5.9 - 5 (% AREA)
4900	5	1P	G2T5A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 4.9 - 4 (% AREA)
4910	5	1P	G2T4A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 3.9 - 3 (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
4920	5	1P	G2T3A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 2.9 - 2 (% AREA)
4930	5	1P	G2T2A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 1.9 - 1 (% AREA)
4940	5	1P	G2T1A	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT 0.9 - 0 (% AREA)
4950	5	1P	G2TCLNA	4	0	N	% AREA	TOP GROOVE #2 DEPOSIT CLEAN (% AREA)
4960	5	1P	G2BHCA	4	0	N	% AREA	BOTTOM GROOVE #2 HEAVY CARBON (% AREA)
4970	5	1P	G2BMCA	4	0	N	% AREA	BOTTOM GROOVE #2 MEDIUM CARBON (% AREA)
4980	5	1P	G2BLCA	4	0	N	% AREA	BOTTOM GROOVE #2 LIGHT CARBON (% AREA)
4990	5	1P	G2B9A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 9 - 8 (% AREA)
5000	5	1P	G2B8A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 7.9 - 7 (% AREA)
5010	5	1P	G2B7A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 6.9 - 6 (% AREA)
5020	5	1P	G2B6A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 5.9 - 5 (% AREA)
5030	5	1P	G2B5A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 4.9 - 4 (% AREA)
5040	5	1P	G2B4A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 3.9 - 3 (% AREA)
5050	5	1P	G2B3A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 2.9 - 2 (% AREA)
5060	5	1P	G2B2A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 1.9 - 1 (% AREA)
5070	5	1P	G2B1A	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT 0.9 - 0 (% AREA)
5080	5	1P	G2BCLNA	4	0	N	% AREA	BOTTOM GROOVE #2 DEPOSIT CLEAN (% AREA)
5090	5	1P	G3THCA	4	0	N	% AREA	TOP GROOVE #3 HEAVY CARBON (% AREA)
5100	5	1P	G3TMCA	4	0	N	% AREA	TOP GROOVE #3 MEDIUM CARBON (% AREA)
5110	5	1P	G3TLCA	4	0	N	% AREA	TOP GROOVE #3 LIGHT CARBON (% AREA)
5120	5	1P	G3T9A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 9 - 8 (% AREA)
5130	5	1P	G3T8A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 7.9 - 7 (% AREA)
5140	5	1P	G3T7A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 6.9 - 6 (% AREA)
5150	5	1P	G3T6A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 5.9 - 5 (% AREA)
5160	5	1P	G3T5A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 4.9 - 4 (% AREA)
5170	5	1P	G3T4A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 3.9 - 3 (% AREA)
5180	5	1P	G3T3A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 2.9 - 2 (% AREA)
5190	5	1P	G3T2A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 1.9 - 1 (% AREA)
5200	5	1P	G3T1A	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT 0.9 - 0 (% AREA)
5210	5	1P	G3TCLNA	4	0	N	% AREA	TOP GROOVE #3 DEPOSIT CLEAN (% AREA)
5220	5	1P	G3BHCA	4	0	N	% AREA	BOTTOM GROOVE #3 HEAVY CARBON (% AREA)
5230	5	1P	G3BMCA	4	0	N	% AREA	BOTTOM GROOVE #3 MEDIUM CARBON (% AREA)
5240	5	1P	G3BLCA	4	0	N	% AREA	BOTTOM GROOVE #3 LIGHT CARBON (% AREA)
5250	5	1P	G3B9A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 9 - 8 (% AREA)
5260	5	1P	G3B8A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 7.9 - 7 (% AREA)
5270	5	1P	G3B7A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 6.9 - 6 (% AREA)
5280	5	1P	G3B6A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 5.9 - 5 (% AREA)
5290	5	1P	G3B5A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 4.9 - 4 (% AREA)
5300	5	1P	G3B4A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 3.9 - 3 (% AREA)
5310	5	1P	G3B3A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 2.9 - 2 (% AREA)
5320	5	1P	G3B2A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 1.9 - 1 (% AREA)
5330	5	1P	G3B1A	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT 0.9 - 0 (% AREA)
5340	5	1P	G3BCLNA	4	0	N	% AREA	BOTTOM GROOVE #3 DEPOSIT CLEAN (% AREA)
5350	5	1P	R1THCA	4	0	N	% AREA	TOP RING #1 HEAVY CARBON (% AREA)
5360	5	1P	R1TMCA	4	0	N	% AREA	TOP RING #1 MEDIUM CARBON (% AREA)
5370	5	1P	R1TLCA	4	0	N	% AREA	TOP RING #1 LIGHT CARBON (% AREA)
5380	5	1P	R1T9A	4	0	N	% AREA	TOP RING #1 DEPOSIT 9 - 8 (% AREA)
5390	5	1P	R1T8A	4	0	N	% AREA	TOP RING #1 DEPOSIT 7.9 - 7 (% AREA)
5400	5	1P	R1T7A	4	0	N	% AREA	TOP RING #1 DEPOSIT 6.9 - 6 (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
5410	5	1P	R1T6A	4	0	N	% AREA	TOP RING #1 DEPOSIT 5.9 - 5 (% AREA)
5420	5	1P	R1T5A	4	0	N	% AREA	TOP RING #1 DEPOSIT 4.9 - 4 (% AREA)
5430	5	1P	R1T4A	4	0	N	% AREA	TOP RING #1 DEPOSIT 3.9 - 3 (% AREA)
5440	5	1P	R1T3A	4	0	N	% AREA	TOP RING #1 DEPOSIT 2.9 - 2 (% AREA)
5450	5	1P	R1T2A	4	0	N	% AREA	TOP RING #1 DEPOSIT 1.9 - 1 (% AREA)
5460	5	1P	R1T1A	4	0	N	% AREA	TOP RING #1 DEPOSIT 0.9 -0 (% AREA)
5470	5	1P	R1TCLNA	4	0	N	% AREA	TOP RING #1 DEPOSIT CLEAN (% AREA)
5480	5	1P	R1BHCA	4	0	N	% AREA	BOTTOM RING #1 HEAVY CARBON (% AREA)
5490	5	1P	R1BMCA	4	0	N	% AREA	BOTTOM RING #1 MEDIUM CARBON (% AREA)
5500	5	1P	R1BLCA	4	0	N	% AREA	BOTTOM RING #1 LIGHT CARBON (% AREA)
5510	5	1P	R1B9A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 9 - 8 (% AREA)
5520	5	1P	R1B8A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 7.9 - 7 (% AREA)
5530	5	1P	R1B7A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 6.9 - 6 (% AREA)
5540	5	1P	R1B6A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 5.9 - 5 (% AREA)
5550	5	1P	R1B5A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 4.9 - 4 (% AREA)
5560	5	1P	R1B4A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 3.9 - 3 (% AREA)
5570	5	1P	R1B3A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 2.9 - 2 (% AREA)
5580	5	1P	R1B2A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 1.9 - 1 (% AREA)
5590	5	1P	R1B1A	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT 0.9 - 0 (% AREA)
5600	5	1P	R1BCLNA	4	0	N	% AREA	BOTTOM RING #1 DEPOSIT CLEAN (% AREA)
5610	5	1P	R1BKHCA	4	0	N	% AREA	BACK RING #1 HEAVY CARBON (% AREA)
5620	5	1P	R1BKMCA	4	0	N	% AREA	BACK RING #1 MEDIUM CARBON (% AREA)
5630	5	1P	R1BKLCA	4	0	N	% AREA	BACK RING #1 LIGHT CARBON (% AREA)
5640	5	1P	R1BK9A	4	0	N	% AREA	BACK RING #1 DEPOSIT 9 - 8 (% AREA)
5650	5	1P	R1BK8A	4	0	N	% AREA	BACK RING #1 DEPOSIT 7.9 - 7 (% AREA)
5660	5	1P	R1BK7A	4	0	N	% AREA	BACK RING #1 DEPOSIT 6.9 - 6 (% AREA)
5670	5	1P	R1BK6A	4	0	N	% AREA	BACK RING #1 DEPOSIT 5.9 - 5 (% AREA)
5680	5	1P	R1BK5A	4	0	N	% AREA	BACK RING #1 DEPOSIT 4.9 - 4 (% AREA)
5690	5	1P	R1BK4A	4	0	N	% AREA	BACK RING #1 DEPOSIT 3.9 - 3 (% AREA)
5700	5	1P	R1BK3A	4	0	N	% AREA	BACK RING #1 DEPOSIT 2.9 - 2 (% AREA)
5710	5	1P	R1BK2A	4	0	N	% AREA	BACK RING #1 DEPOSIT 1.9 - 1 (% AREA)
5720	5	1P	R1BK1A	4	0	N	% AREA	BACK RING #1 DEPOSIT 0.9 - 0 (% AREA)
5730	5	1P	R1BKCLNA	4	0	N	% AREA	BACK RING #1 DEPOSIT CLEAN (% AREA)
5740	5	1P	R2THCA	4	0	N	% AREA	TOP RING #2 HEAVY CARBON (% AREA)
5750	5	1P	R2TMCA	4	0	N	% AREA	TOP RING #2 MEDIUM CARBON (% AREA)
5760	5	1P	R2TLCA	4	0	N	% AREA	TOP RING #2 LIGHT CARBON (% AREA)
5770	5	1P	R2T9A	4	0	N	% AREA	TOP RING #2 DEPOSIT 9 - 8 (% AREA)
5780	5	1P	R2T8A	4	0	N	% AREA	TOP RING #2 DEPOSIT 7.9 - 7 (% AREA)
5790	5	1P	R2T7A	4	0	N	% AREA	TOP RING #2 DEPOSIT 6.9 - 6 (% AREA)
5800	5	1P	R2T6A	4	0	N	% AREA	TOP RING #2 DEPOSIT 5.9 - 5 (% AREA)
5810	5	1P	R2T5A	4	0	N	% AREA	TOP RING #2 DEPOSIT 4.9 - 4 (% AREA)
5820	5	1P	R2T4A	4	0	N	% AREA	TOP RING #2 DEPOSIT 3.9 - 3 (% AREA)
5830	5	1P	R2T3A	4	0	N	% AREA	TOP RING #2 DEPOSIT 2.9 - 2 (% AREA)
5840	5	1P	R2T2A	4	0	N	% AREA	TOP RING #2 DEPOSIT 1.9 - 1 (% AREA)
5850	5	1P	R2T1A	4	0	N	% AREA	TOP RING #2 DEPOSIT 0.9 - 0 (% AREA)
5860	5	1P	R2TCLNA	4	0	N	% AREA	TOP RING #2 DEPOSIT CLEAN (% AREA)
5870	5	1P	R2BHCA	4	0	N	% AREA	BOTTOM RING #2 HEAVY CARBON (% AREA)
5880	5	1P	R2BMCA	4	0	N	% AREA	BOTTOM RING #2 MEDIUM CARBON (% AREA)
5890	5	1P	R2BLCA	4	0	N	% AREA	BOTTOM RING #2 LIGHT CARBON (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
5900	5	1P	R2B9A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 9 - 8 (% AREA)
5910	5	1P	R2B8A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 7.9 - 7 (% AREA)
5920	5	1P	R2B7A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 6.9 - 6 (% AREA)
5930	5	1P	R2B6A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 5.9 - 5 (% AREA)
5940	5	1P	R2B5A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 4.9 - 4 (% AREA)
5950	5	1P	R2B4A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 3.9 - 3 (% AREA)
5960	5	1P	R2B3A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 2.9 - 2 (% AREA)
5970	5	1P	R2B2A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 1.9 - 1 (% AREA)
5980	5	1P	R2B1A	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT 0.9 - 0 (% AREA)
5990	5	1P	R2BCLNA	4	0	N	% AREA	BOTTOM RING #2 DEPOSIT CLEAN (% AREA)
6000	5	1P	R2BKHCA	4	0	N	% AREA	BACK RING #2 HEAVY CARBON (% AREA)
6010	5	1P	R2BKMCA	4	0	N	% AREA	BACK RING #2 MEDIUM CARBON (% AREA)
6020	5	1P	R2BKLCA	4	0	N	% AREA	BACK RING #2 LIGHT CARBON (% AREA)
6030	5	1P	R2BK9A	4	0	N	% AREA	BACK RING #2 DEPOSIT 9 - 8 (% AREA)
6040	5	1P	R2BK8A	4	0	N	% AREA	BACK RING #2 DEPOSIT 7.9 - 7 (% AREA)
6050	5	1P	R2BK7A	4	0	N	% AREA	BACK RING #2 DEPOSIT 6.9 - 6 (% AREA)
6060	5	1P	R2BK6A	4	0	N	% AREA	BACK RING #2 DEPOSIT 5.9 - 5 (% AREA)
6070	5	1P	R2BK5A	4	0	N	% AREA	BACK RING #2 DEPOSIT 4.9 - 4 (% AREA)
6080	5	1P	R2BK4A	4	0	N	% AREA	BACK RING #2 DEPOSIT 3.9 - 3 (% AREA)
6090	5	1P	R2BK3A	4	0	N	% AREA	BACK RING #2 DEPOSIT 2.9 - 2 (% AREA)
6100	5	1P	R2BK2A	4	0	N	% AREA	BACK RING #2 DEPOSIT 1.9 - 1 (% AREA)
6110	5	1P	R2BK1A	4	0	N	% AREA	BACK RING #2 DEPOSIT 0.9 - 0 (% AREA)
6120	5	1P	R2BKCLNA	4	0	N	% AREA	BACK RING #2 DEPOSIT CLEAN (% AREA)
6130	5	1P	R3THCA	4	0	N	% AREA	TOP RING #3 HEAVY CARBON (% AREA)
6140	5	1P	R3TMCA	4	0	N	% AREA	TOP RING #3 MEDIUM CARBON (% AREA)
6150	5	1P	R3TLCA	4	0	N	% AREA	TOP RING #3 LIGHT CARBON (% AREA)
6160	5	1P	R3T9A	4	0	N	% AREA	TOP RING #3 DEPOSIT 9 - 8 (% AREA)
6170	5	1P	R3T8A	4	0	N	% AREA	TOP RING #3 DEPOSIT 7.9 - 7 (% AREA)
6180	5	1P	R3T7A	4	0	N	% AREA	TOP RING #3 DEPOSIT 6.9 - 6 (% AREA)
6190	5	1P	R3T6A	4	0	N	% AREA	TOP RING #3 DEPOSIT 5.9 - 5 (% AREA)
6200	5	1P	R3T5A	4	0	N	% AREA	TOP RING #3 DEPOSIT 4.9 - 4 (% AREA)
6210	5	1P	R3T4A	4	0	N	% AREA	TOP RING #3 DEPOSIT 3.9 - 3 (% AREA)
6220	5	1P	R3T3A	4	0	N	% AREA	TOP RING #3 DEPOSIT 2.9 - 2 (% AREA)
6230	5	1P	R3T2A	4	0	N	% AREA	TOP RING #3 DEPOSIT 1.9 - 1 (% AREA)
6240	5	1P	R3T1A	4	0	N	% AREA	TOP RING #3 DEPOSIT 0.9 - 0 (% AREA)
6250	5	1P	R3TCLNA	4	0	N	% AREA	TOP RING #3 DEPOSIT CLEAN (% AREA)
6260	5	1P	R3BHCA	4	0	N	% AREA	BOTTOM RING #3 HEAVY CARBON (% AREA)
6270	5	1P	R3BMCA	4	0	N	% AREA	BOTTOM RING #3 MEDIUM CARBON (% AREA)
6280	5	1P	R3BLCA	4	0	N	% AREA	BOTTOM RING #3 LIGHT CARBON (% AREA)
6290	5	1P	R3B9A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 9 - 8 (% AREA)
6300	5	1P	R3B8A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 7.9 - 7 (% AREA)
6310	5	1P	R3B7A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 6.9 - 6 (% AREA)
6320	5	1P	R3B6A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 5.9 - 5 (% AREA)
6330	5	1P	R3B5A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 4.9 - 4 (% AREA)
6340	5	1P	R3B4A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 3.9 - 3 (% AREA)
6350	5	1P	R3B3A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 2.9 - 2 (% AREA)
6360	5	1P	R3B2A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 1.9 - 1 (% AREA)
6370	5	1P	R3B1A	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT 0.9 - 0 (% AREA)
6380	5	1P	R3BCLNA	4	0	N	% AREA	BOTTOM RING #3 DEPOSIT CLEAN (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
6390	5	1P	R3BKHCA	4	0	N	% AREA	BACK RING #3 HEAVY CARBON (% AREA)
6400	5	1P	R3BKMCA	4	0	N	% AREA	BACK RING #3 MEDIUM CARBON (% AREA)
6410	5	1P	R3BKLCA	4	0	N	% AREA	BACK RING #3 LIGHT CARBON (% AREA)
6420	5	1P	R3BK9A	4	0	N	% AREA	BACK RING #3 DEPOSIT 9 - 8 (% AREA)
6430	5	1P	R3BK8A	4	0	N	% AREA	BACK RING #3 DEPOSIT 7.9 - 7 (% AREA)
6440	5	1P	R3BK7A	4	0	N	% AREA	BACK RING #3 DEPOSIT 6.9 - 6 (% AREA)
6450	5	1P	R3BK6A	4	0	N	% AREA	BACK RING #3 DEPOSIT 5.9 - 5 (% AREA)
6460	5	1P	R3BK5A	4	0	N	% AREA	BACK RING #3 DEPOSIT 4.9 - 4 (% AREA)
6470	5	1P	R3BK4A	4	0	N	% AREA	BACK RING #3 DEPOSIT 3.9 - 3 (% AREA)
6480	5	1P	R3BK3A	4	0	N	% AREA	BACK RING #3 DEPOSIT 2.9 - 2 (% AREA)
6490	5	1P	R3BK2A	4	0	N	% AREA	BACK RING #3 DEPOSIT 1.9 - 1 (% AREA)
6500	5	1P	R3BK1A	4	0	N	% AREA	BACK RING #3 DEPOSIT 0.9 - 0 (% AREA)
6510	5	1P	R3BKCLNA	4	0	N	% AREA	BACK RING #3 DEPOSIT CLEAN (% AREA)
6520	5	1P	CROWNAD	70	0	C		ADDITIONAL DEPOSIT & CONDITION RATINGS\nPISTON CROWN
6530	5	1P	SKIRTAD	70	0	C		ADDITIONAL DEPOSIT & CONDITION RATINGS PISTON SKIRT
6540	5	1P	LINERAD	70	0	C		ADDITIONAL DEPOSIT & CONDITION RATINGS\nLINER
6550	5	1P	RINGSAD	70	0	C		ADDITIONAL DEPOSIT & CONDITION RATINGS\nRINGS
6560	5a	1P	RRNO	10	0	C		REFEREE RATING NUMBER
6570	5a	1P	RRDATE	8	0	C	YYYYMMDD	REFEREE RATING DATE (YYYYMMDD)
6580	5a	1P	RRINIT	3	0	C		REFEREE RATING INITIALS
6590	5a	1P	RRG1HCA	4	0	N	% AREA	REFEREE GROOVE #1 HC-1.0 CARBON AREA PERCENT (% AREA)
6600	5a	1P	RRG1HCD	7	2	N	DEMERITS	REFEREE GROOVE #1 HC-1.0 CARBON DEMERITS (DEMERITS)
6610	5a	1P	RRG2HCA	4	0	N	% AREA	REFEREE GROOVE #2 HC-1.0 CARBON AREA PERCENT (% AREA)
6620	5a	1P	RRG2HCD	7	2	N	DEMERITS	REFEREE GROOVE #2 HC-1.0 CARBON DEMERITS (DEMERITS)
6630	5a	1P	RRL1HCA	4	0	N	% AREA	REFEREE LAND #1 HC-1.0 CARBON AREA PERCENT (% AREA)
6640	5a	1P	RRL1HCD	7	2	N	DEMERITS	REFEREE LAND #1 HC-1.0 CARBON DEMERITS (DEMERITS)
6650	5a	1P	RRL2HCA	4	0	N	% AREA	REFEREE LAND #2 HC-1.0 CARBON AREA PERCENT (% AREA)
6660	5a	1P	RRL2HCD	7	2	N	DEMERITS	REFEREE LAND #2 HC-1.0 CARBON DEMERITS (DEMERITS)
6670	5a	1P	RRG3HCA	4	0	N	% AREA	REFEREE GROOVE #3 HC-1.0 CARBON AREA PERCENT (% AREA)
6680	5a	1P	RRG3HCD	7	2	N	DEMERITS	REFEREE GROOVE #3 HC-1.0 CARBON DEMERITS (DEMERITS)
6690	5a	1P	RRL3HCA	4	0	N	% AREA	REFEREE LAND #3 HC-1.0 CARBON AREA PERCENT (% AREA)
6700	5a	1P	RRL3HCD	7	2	N	DEMERITS	REFEREE LAND #3 HC-1.0 CARBON DEMERITS (DEMERITS)
6710	5a	1P	RRL4HCA	4	0	N	% AREA	REFEREE RATING LAND #4 HC-1.0 CARBON AREA % (% AREA)
6720	5a	1P	RRL4HCD	7	2	N	DEMERITS	REFEREE RATING LAND #4 HC-1.0 CARBON DEMERITS (DEMERITS)
6730	5a	1P	RRG1MCA	4	0	N	% AREA	REFEREE GROOVE #1 MC-0.5 CARBON AREA PERCENT (% AREA)
6740	5a	1P	RRG1MCD	7	2	N	DEMERITS	REFEREE GROOVE #1 MC-0.5 CARBON DEMERITS (DEMERITS)
6750	5a	1P	RRG3MCA	4	0	N	% AREA	REFEREE GROOVE #3 MC-0.5 CARBON AREA PERCENT (% AREA)
6760	5a	1P	RRG3MCD	7	2	N	DEMERITS	REFEREE GROOVE #3 MC-0.5 CARBON DEMERITS (DEMERITS)
6770	5a	1P	RRG1LCA	4	0	N	% AREA	REFEREE GROOVE #1 LC-.25 CARBON AREA PERCENT (% AREA)
6780	5a	1P	RRG1LCD	7	2	N	DEMERITS	REFEREE GROOVE #1 LC-.25 CARBON DEMERITS (DEMERITS)
6790	5a	1P	RRG2LCA	4	0	N	% AREA	REFEREE GROOVE #2 LC-.25 CARBON AREA PERCENT (% AREA)
6800	5a	1P	RRG2LCD	7	2	N	DEMERITS	REFEREE GROOVE #2 LC-.25 CARBON DEMERITS (DEMERITS)
6810	5a	1P	RRL1LCA	4	0	N	% AREA	REFEREE LAND #1 LC-.25 CARBON AREA PERCENT (% AREA)
6820	5a	1P	RRL1LCD	7	2	N	DEMERITS	REFEREE LAND #1 LC-.25 CARBON DEMERITS (DEMERITS)
6830	5a	1P	RRL2LCA	4	0	N	% AREA	REFEREE LAND #2 LC-.25 CARBON AREA PERCENT (% AREA)
6840	5a	1P	RRL2LCD	7	2	N	DEMERITS	REFEREE LAND #2 LC-.25 CARBON DEMERITS (DEMERITS)
6850	5a	1P	RRG3LCA	4	0	N	% AREA	REFEREE GROOVE #3 LC-.25 CARBON AREA PERCENT (% AREA)
6860	5a	1P	RRG3LCD	7	2	N	DEMERITS	REFEREE GROOVE #3 LC-.25 CARBON DEMERITS (DEMERITS)
6870	5a	1P	RRL3LCA	4	0	N	% AREA	REFEREE LAND #3 LC-.25 CARBON AREA PERCENT (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
6880	5a	1P	RRL3LCD	7	2	N	DEMERITS	REFEREE LAND #3 LC-.25 CARBON DEMERITS (DEMERITS)
6890	5a	1P	RRL4LCA	4	0	N	% AREA	REFEREE RATING LAND #4 LC-.25 CARBON AREA % (% AREA)
6900	5a	1P	RRL4LCD	7	2	N	DEMERITS	REFEREE RATING LAND #4 LC-.25 CARBON DEMERITS (DEMERITS)
6910	5a	1P	RROGLCA	4	0	N	% AREA	REFEREE RATING OIL COOLING GALLERY LC-.25 CARBON (% AREA)
6920	5a	1P	RROGLCD	7	2	N	DEMERITS	REFFEREE RATING OIL COOLING GALLERY LC-.25 CARBON (DEMERITS)
6930	5a	1P	RRUCLCA	4	0	N	% AREA	REFEREE RATING UNDER CROWN LC-.25 CARBON (% AREA)
6940	5a	1P	RRUCLCD	7	2	N	DEMERITS	REFFEREE RATING UNDER CROWN LC-.25 CARBON (DEMERITS)
6950	5a	1P	RG1ACTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #1 CARBON AREA PERCENT (% AREA)
6960	5a	1P	RG1DCTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #1 CARBON DEMERITS (DEMERITS)
6970	5a	1P	RG2ACTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #2 CARBON AREA PERCENT (% AREA)
6980	5a	1P	RG2DCTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #2 CARBON DEMERITS (DEMERITS)
6990	5a	1P	RL1ACTOT	4	0	N	% AREA	REFEREE TOTAL LAND #1 CARBON AREA PERCENT (% AREA)
7000	5a	1P	RL1DCTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #1 CARBON DEMERITS (DEMERITS)
7010	5a	1P	RL2ACTOT	4	0	N	% AREA	REFEREE TOTAL LAND #2 CARBON AREA PERCENT (% AREA)
7020	5a	1P	RL2DCTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #2 CARBON DEMERITS (DEMERITS)
7030	5a	1P	RG3ACTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #3 CARBON AREA PERCENT (% AREA)
7040	5a	1P	RG3DCTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #3 CARBON DEMERITS (DEMERITS)
7050	5a	1P	RL3ACTOT	4	0	N	% AREA	REFEREE TOTAL LAND #3 CARBON AREA PERCENT (% AREA)
7060	5a	1P	RL3DCTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #3 CARBON DEMERITS (DEMERITS)
7070	5a	1P	RL4ACTOT	4	0	N	% AREA	REFEREE TOTAL LAND #3 CARBON AREA PERCENT (% AREA)
7080	5a	1P	RL4DCTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #3 CARBON DEMERITS (DEMERITS)
7090	5a	1P	ROGACTOT	4	0	N	% AREA	REFEREE RATING TOTAL OIL COOLING GALLERY CARBON % (% AREA)
7100	5a	1P	ROGDCTOT	7	2	N	DEMERITS	REF. RATING TOTAL OIL COOLING GALLERY CARBON DEM.(DEMERITS)
7110	5a	1P	RUCACTOT	4	0	N	% AREA	REF. RATING TOTAL UNDER CROWN CARBON AREA PERCENT (% AREA)
7120	5a	1P	RUCDCTOT	7	2	N	DEMERITS	REF. RATING TOTAL UNDER CROWN CARBON DEMERITS (DEMERITS)
7130	5a	1P	RRG1V9A	4	0	N	% AREA	REFEREE GROOVE #1 8-9 VARNISH AREA PERCENT (% AREA)
7140	5a	1P	RRG1V9D	7	2	N	DEMERITS	REFEREE GROOVE #1 8-9 VARNISH DEMERITS (DEMERITS)
7150	5a	1P	RRG2V9A	4	0	N	% AREA	REFEREE GROOVE #2 8-9 VARNISH AREA PERCENT (% AREA)
7160	5a	1P	RRG2V9D	7	2	N	DEMERITS	REFEREE GROOVE #2 8-9 VARNISH DEMERITS (DEMERITS)
7170	5a	1P	RRL1V9A	4	0	N	% AREA	REFEREE LAND #1 8-9 VARNISH AREA PERCENT (% AREA)
7180	5a	1P	RRL1V9D	7	2	N	DEMERITS	REFEREE LAND #1 8-9 VARNISH DEMERITS (DEMERITS)
7190	5a	1P	RRL2V9A	4	0	N	% AREA	REFEREE LAND #2 8-9 VARNISH AREA PERCENT (% AREA)
7200	5a	1P	RRL2V9D	7	2	N	DEMERITS	REFEREE LAND #2 8-9 VARNISH DEMERITS (DEMERITS)
7210	5a	1P	RRG1V8A	4	0	N	% AREA	REFEREE GROOVE #1 7-7.9 VARNISH AREA PERCENT (% AREA)
7220	5a	1P	RRG1V8D	7	2	N	DEMERITS	REFEREE GROOVE #1 7-7.9 VARNISH DEMERITS (DEMERITS)
7230	5a	1P	RRG2V8A	4	0	N	% AREA	REFEREE GROOVE #2 7-7.9 VARNISH AREA PERCENT (% AREA)
7240	5a	1P	RRG2V8D	7	2	N	DEMERITS	REFEREE GROOVE #2 7-7.9 VARNISH DEMERITS (DEMERITS)
7250	5a	1P	RRL1V8A	4	0	N	% AREA	REFEREE LAND #1 7-7.9 VARNISH AREA PERCENT (% AREA)
7260	5a	1P	RRL1V8D	7	2	N	DEMERITS	REFEREE LAND #1 7-7.9 VARNISH DEMERITS (DEMERITS)
7270	5a	1P	RRL2V8A	4	0	N	% AREA	REFEREE LAND #2 7-7.9 VARNISH AREA PERCENT (% AREA)
7280	5a	1P	RRL2V8D	7	2	N	DEMERITS	REFEREE LAND #2 7-7.9 VARNISH DEMERITS (DEMERITS)
7290	5a	1P	RRG3V75A	4	0	N	% AREA	REFEREE GROOVE #3 7.5 VARNISH AREA PERCENT (% AREA)
7300	5a	1P	RRG3V75D	7	2	N	DEMERITS	REFEREE GROOVE #3 7.5 VARNISH DEMERITS (DEMERITS)
7310	5a	1P	RRL3V75A	4	0	N	% AREA	REFEREE LAND #3 7.5 VARNISH AREA PERCENT (% AREA)
7320	5a	1P	RRL3V75D	7	2	N	DEMERITS	REFEREE LAND #3 7.5 VARNISH DEMERITS (DEMERITS)
7330	5a	1P	RRL4V75A	4	0	N	% AREA	REFEREE LAND #4 7.5 VARNISH AREA PERCENT (% AREA)
7340	5a	1P	RRL4V75D	7	2	N	DEMERITS	REFEREE LAND #4 7.5 VARNISH DEMERITS (DEMERITS)
7350	5a	1P	RROGV75A	4	0	N	% AREA	REFEREE LAND OIL COOLING GALLERY 7.5 VARNISH AREA % (% AREA)
7360	5a	1P	RROGV75D	7	2	N	DEMERITS	REFEREE LAND OIL COOLING GALLERY 7.5 VARNISH (DEMERITS)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
7370	5a	1P	RRUCV75A	4	0	N	% AREA	REFEREE LAND UNDER CROWN 7.5 VARNISH AREA % (% AREA)
7380	5a	1P	RRUCV75D	7	2	N	DEMERITS	REFEREE LAND UNDER CROWN 7.5 VARNISH (DEMERITS)
7390	5a	1P	RRG1V7A	4	0	N	% AREA	REFEREE GROOVE #1 6-6.9 VARNISH AREA PERCENT (% AREA)
7400	5a	1P	RRG1V7D	7	2	N	DEMERITS	REFEREE GROOVE #1 6-6.9 VARNISH DEMERITS (DEMERITS)
7410	5a	1P	RRG2V7A	4	0	N	% AREA	REFEREE GROOVE #2 6-6.9 VARNISH AREA PERCENT (% AREA)
7420	5a	1P	RRG2V7D	7	2	N	DEMERITS	REFEREE GROOVE #2 6-6.9 VARNISH DEMERITS (DEMERITS)
7430	5a	1P	RRL1V7A	4	0	N	% AREA	REFEREE LAND #1 6-6.9 VARNISH AREA PERCENT (% AREA)
7440	5a	1P	RRL1V7D	7	2	N	DEMERITS	REFEREE LAND #1 6-6.9 VARNISH DEMERITS (DEMERITS)
7450	5a	1P	RRL2V7A	4	0	N	% AREA	REFEREE LAND #2 6-6.9 VARNISH AREA PERCENT (% AREA)
7460	5a	1P	RRL2V7D	7	2	N	DEMERITS	REFEREE LAND #2 6-6.9 VARNISH DEMERITS (DEMERITS)
7470	5a	1P	RRG1V6A	4	0	N	% AREA	REFEREE GROOVE #1 5-5.9 VARNISH AREA PERCENT (% AREA)
7480	5a	1P	RRG1V6D	7	2	N	DEMERITS	REFEREE GROOVE #1 5-5.9 VARNISH DEMERITS (DEMERITS)
7490	5a	1P	RRG2V6A	4	0	N	% AREA	REFEREE GROOVE #2 5-5.9 VARNISH AREA PERCENT (% AREA)
7500	5a	1P	RRG2V6D	7	2	N	DEMERITS	REFEREE GROOVE #2 5-5.9 VARNISH DEMERITS (DEMERITS)
7510	5a	1P	RRL1V6A	4	0	N	% AREA	REFEREE LAND #1 5-5.9 VARNISH AREA PERCENT (% AREA)
7520	5a	1P	RRL1V6D	7	2	N	DEMERITS	REFEREE LAND #1 5-5.9 VARNISH DEMERITS (DEMERITS)
7530	5a	1P	RRL2V6A	4	0	N	% AREA	REFEREE LAND #2 5-5.9 VARNISH AREA PERCENT (% AREA)
7540	5a	1P	RRL2V6D	7	2	N	DEMERITS	REFEREE LAND #2 5-5.9 VARNISH DEMERITS (DEMERITS)
7550	5a	1P	RRG1V5A	4	0	N	% AREA	REFEREE GROOVE #1 4-4.9 VARNISH AREA PERCENT (% AREA)
7560	5a	1P	RRG1V5D	7	2	N	DEMERITS	REFEREE GROOVE #1 4-4.9 VARNISH DEMERITS (DEMERITS)
7570	5a	1P	RRG2V5A	4	0	N	% AREA	REFEREE GROOVE #2 4-4.9 VARNISH AREA PERCENT (% AREA)
7580	5a	1P	RRG2V5D	7	2	N	DEMERITS	REFEREE GROOVE #2 4-4.9 VARNISH DEMERITS (DEMERITS)
7590	5a	1P	RRL1V5A	4	0	N	% AREA	REFEREE LAND #1 4-4.9 VARNISH AREA PERCENT (% AREA)
7600	5a	1P	RRL1V5D	7	2	N	DEMERITS	REFEREE LAND #1 4-4.9 VARNISH DEMERITS (DEMERITS)
7610	5a	1P	RRL2V5A	4	0	N	% AREA	REFEREE LAND #2 4-4.9 VARNISH AREA PERCENT (% AREA)
7620	5a	1P	RRL2V5D	7	2	N	DEMERITS	REFEREE LAND #2 4-4.9 VARNISH DEMERITS (DEMERITS)
7630	5a	1P	RRG3V45A	4	0	N	% AREA	REFEREE GROOVE #3 4.5 VARNISH AREA PERCENT (% AREA)
7640	5a	1P	RRG3V45D	7	2	N	DEMERITS	REFEREE GROOVE #3 4.5 VARNISH DEMERITS (DEMERITS)
7650	5a	1P	RRL3V45A	4	0	N	% AREA	REFEREE LAND #3 4.5 VARNISH AREA PERCENT (% AREA)
7660	5a	1P	RRL3V45D	7	2	N	DEMERITS	REFEREE LAND #3 4.5 VARNISH DEMERITS (DEMERITS)
7670	5a	1P	RRL4V45A	4	0	N	% AREA	REFEREE LAND #4 4.5 VARNISH AREA PERCENT (% AREA)
7680	5a	1P	RRL4V45D	7	2	N	DEMERITS	REFEREE LAND #4 4.5 VARNISH DEMERITS (DEMERITS)
7690	5a	1P	RROGV45A	4	0	N	% AREA	REFEREE RATING OIL COOLING GALLERY 4.5 VARNISH (% AREA)
7700	5a	1P	RROGV45D	7	2	N	DEMERITS	REFEREE RATING OIL COOLING GALLERY 4.5 VARNISH (DEMERITS)
7710	5a	1P	RRUCV45A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 4.5 VARNISH (% AREA)
7720	5a	1P	RRUCV45D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 4.5 VARNISH (DEMERITS)
7730	5a	1P	RRG1V4A	4	0	N	% AREA	REFEREE GROOVE #1 3-3.9 VARNISH AREA PERCENT (% AREA)
7740	5a	1P	RRG1V4D	7	2	N	DEMERITS	REFEREE GROOVE #1 3-3.9 VARNISH DEMERITS (DEMERITS)
7750	5a	1P	RRG2V4A	4	0	N	% AREA	REFEREE GROOVE #2 3-3.9 VARNISH AREA PERCENT (% AREA)
7760	5a	1P	RRG2V4D	7	2	N	DEMERITS	REFEREE GROOVE #2 3-3.9 VARNISH DEMERITS (DEMERITS)
7770	5a	1P	RRL1V4A	4	0	N	% AREA	REFEREE LAND #1 3-3.9 VARNISH AREA PERCENT (% AREA)
7780	5a	1P	RRL1V4D	7	2	N	DEMERITS	REFEREE LAND #1 3-3.9 VARNISH DEMERITS (DEMERITS)
7790	5a	1P	RRL2V4A	4	0	N	% AREA	REFEREE LAND #2 3-3.9 VARNISH AREA PERCENT (% AREA)
7800	5a	1P	RRL2V4D	7	2	N	DEMERITS	REFEREE LAND #2 3-3.9 VARNISH DEMERITS (DEMERITS)
7810	5a	1P	RRG1V3A	4	0	N	% AREA	REFEREE GROOVE #1 2-2.9 VARNISH AREA PERCENT (% AREA)
7820	5a	1P	RRG1V3D	7	2	N	DEMERITS	REFEREE GROOVE #1 2-2.9 VARNISH DEMERITS (DEMERITS)
7830	5a	1P	RRG2V3A	4	0	N	% AREA	REFEREE GROOVE #2 2-2.9 VARNISH AREA PERCENT (% AREA)
7840	5a	1P	RRG2V3D	7	2	N	DEMERITS	REFEREE GROOVE #2 2-2.9 VARNISH DEMERITS (DEMERITS)
7850	5a	1P	RRL1V3A	4	0	N	% AREA	REFEREE LAND #1 2-2.9 VARNISH AREA PERCENT (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
7860	5a	1P	RRL1V3D	7	2	N	DEMERITS	REFEREE LAND #1 2-2.9 VARNISH DEMERITS (DEMERITS)
7870	5a	1P	RRL2V3A	4	0	N	% AREA	REFEREE LAND #2 2-2.9 VARNISH AREA PERCENT (% AREA)
7880	5a	1P	RRL2V3D	7	2	N	DEMERITS	REFEREE LAND #2 2-2.9 VARNISH DEMERITS (DEMERITS)
7890	5a	1P	RRG1V2A	4	0	N	% AREA	REFEREE GROOVE #1 1-1.9 VARNISH AREA PERCENT (% AREA)
7900	5a	1P	RRG1V2D	7	2	N	DEMERITS	REFEREE GROOVE #1 1-1.9 VARNISH DEMERITS (DEMERITS)
7910	5a	1P	RRG2V2A	4	0	N	% AREA	REFEREE GROOVE #2 1-1.9 VARNISH AREA PERCENT (% AREA)
7920	5a	1P	RRG2V2D	7	2	N	DEMERITS	REFEREE GROOVE #2 1-1.9 VARNISH DEMERITS (DEMERITS)
7930	5a	1P	RRL1V2A	4	0	N	% AREA	REFEREE LAND #1 1-1.9 VARNISH AREA PERCENT (% AREA)
7940	5a	1P	RRL1V2D	7	2	N	DEMERITS	REFEREE LAND #1 1-1.9 VARNISH DEMERITS (DEMERITS)
7950	5a	1P	RRL2V2A	4	0	N	% AREA	REFEREE LAND #2 1-1.9 VARNISH AREA PERCENT (% AREA)
7960	5a	1P	RRL2V2D	7	2	N	DEMERITS	REFEREE LAND #2 1-1.9 VARNISH DEMERITS (DEMERITS)
7970	5a	1P	RRG3V15A	4	0	N	% AREA	REFEREE GROOVE #3 1.5 VARNISH AREA PERCENT (% AREA)
7980	5a	1P	RRG3V15D	7	2	N	DEMERITS	REFEREE GROOVE #3 1.5 VARNISH DEMERITS (DEMERITS)
7990	5a	1P	RRL3V15A	4	0	N	% AREA	REFEREE LAND #3 1.5 VARNISH AREA PERCENT (% AREA)
8000	5a	1P	RRL3V15D	7	2	N	DEMERITS	REFEREE LAND #3 1.5 VARNISH DEMERITS (DEMERITS)
8010	5a	1P	RRL4V15A	4	0	N	% AREA	REFEREE LAND #4 1.5 VARNISH AREA PERCENT (% AREA)
8020	5a	1P	RRL4V15D	7	2	N	DEMERITS	REFEREE LAND #4 1.5 VARNISH DEMERITS (DEMERITS)
8030	5a	1P	RROGV15A	4	0	N	% AREA	REFEREE RATING OIL COOLING GALLERY 1.5 VARNISH (% AREA)
8040	5a	1P	RROGV15D	7	2	N	DEMERITS	REFEREE RATING OIL COOLING GALLERY 1.5 VARNISH (DEMERITS)
8050	5a	1P	RRUCV15A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 1.5 VARNISH (% AREA)
8060	5a	1P	RRUCV15D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 1.5 VARNISH (DEMERITS)
8070	5a	1P	RRG1V1A	4	0	N	% AREA	REFEREE GROOVE #1 0-0.9 VARNISH AREA PERCENT (% AREA)
8080	5a	1P	RRG1V1D	7	2	N	DEMERITS	REFEREE GROOVE #1 0-0.9 VARNISH DEMERITS (DEMERITS)
8090	5a	1P	RRG2V1A	4	0	N	% AREA	REFEREE GROOVE #2 0-0.9 VARNISH AREA PERCENT (% AREA)
8100	5a	1P	RRG2V1D	7	2	N	DEMERITS	REFEREE GROOVE #2 0-0.9 VARNISH DEMERITS (DEMERITS)
8110	5a	1P	RRL1V1A	4	0	N	% AREA	REFEREE LAND #1 0-0.9 VARNISH AREA PERCENT (% AREA)
8120	5a	1P	RRL1V1D	7	2	N	DEMERITS	REFEREE LAND #1 0-0.9 VARNISH DEMERITS (DEMERITS)
8130	5a	1P	RRL2V1A	4	0	N	% AREA	REFEREE LAND #2 0-0.9 VARNISH AREA PERCENT (% AREA)
8140	5a	1P	RRL2V1D	7	2	N	DEMERITS	REFEREE LAND #2 0-0.9 VARNISH DEMERITS (DEMERITS)
8150	5a	1P	RRG1VCLA	4	0	N	% AREA	REFEREE GROOVE #1 CLEAN VARNISH DEMERITS (% AREA)
8160	5a	1P	RRG2VCLA	4	0	N	% AREA	REFEREE GROOVE #2 CLEAN VARNISH DEMERITS (% AREA)
8170	5a	1P	RRL1VCLA	4	0	N	% AREA	REFEREE LAND #1 CLEAN VARNISH DEMERITS (% AREA)
8180	5a	1P	RRL2VCLA	4	0	N	% AREA	REFEREE LAND #2 CLEAN VARNISH DEMERITS (% AREA)
8190	5a	1P	RRG3VCLA	4	0	N	% AREA	REFEREE GROOVE #3 CLEAN VARNISH DEMERITS (% AREA)
8200	5a	1P	RRL3VCLA	4	0	N	% AREA	REFEREE LAND #3 CLEAN VARNISH DEMERITS (% AREA)
8210	5a	1P	RRL4VCLA	4	0	N	% AREA	REFEREE LAND #4 CLEAN VARNISH DEMERITS (% AREA)
8220	5a	1P	RROGVCLA	4	0	N	% AREA	REFEREE OIL COOLING GALLERY CLEAN VARNISH DEMERITS (% AREA)
8230	5a	1P	RRUCVCLA	4	0	N	% AREA	REFEREE UNDER CROWN CLEAN VARNISH DEMERITS (% AREA)
8240	5a	1P	RG1AVTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #1 VARNISH AREA PERCENT (% AREA)
8250	5a	1P	RG1DVTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #1 VARNISH DEMERITS (DEMERITS)
8260	5a	1P	RG2AVTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #2 VARNISH AREA PERCENT (% AREA)
8270	5a	1P	RG2DVTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #2 VARNISH DEMERITS (DEMERITS)
8280	5a	1P	RG3AVTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #3 VARNISH AREA PERCENT (% AREA)
8290	5a	1P	RG3DVTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #3 VARNISH DEMERITS (DEMERITS)
8300	5a	1P	RL1AVTOT	4	0	N	% AREA	REFEREE TOTAL LAND #1 VARNISH AREA PERCENT (% AREA)
8310	5a	1P	RL1DVTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #1 VARNISH DEMERITS (DEMERITS)
8320	5a	1P	RL2AVTOT	4	0	N	% AREA	REFEREE TOTAL LAND #2 VARNISH AREA PERCENT (% AREA)
8330	5a	1P	RL2DVTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #2 VARNISH DEMERITS (DEMERITS)
8340	5a	1P	RL3AVTOT	4	0	N	% AREA	REFEREE TOTAL LAND #3 VARNISH AREA PERCENT (% AREA)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
8350	5a	1P	RL3DVTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #3 VARNISH DEMERITS (DEMERITS)
8360	5a	1P	RL4AVTOT	4	0	N	% AREA	REFEREE TOTAL LAND #3 VARNISH AREA PERCENT (% AREA)
8370	5a	1P	RL4DVTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #3 VARNISH DEMERITS (DEMERITS)
8380	5a	1P	ROGAVTOT	4	0	N	% AREA	REF. RATING TOTAL OIL COOLING GALLERY VARNISH % (% AREA)
8390	5a	1P	ROGDVTOT	7	2	N	DEMERITS	REF. RATING TOTAL OIL COOLING GALLERY VARNISH DEM.(DEMERITS)
8400	5a	1P	RUCAVTOT	4	0	N	% AREA	REF. RATING TOTAL UNDER CROWN VARNISH AREA PERCENT (% AREA)
8410	5a	1P	RUCDVTOT	7	2	N	DEMERITS	REF. RATING TOTAL UNDER CROWN VARNISH DEMERITS (DEMERITS)
8420	5a	1P	RRG1UWD	7	2	N	DEMERITS	REFEREEE GROOVE #1 UNWEIGHTED DEMERITS (DEMERITS)
8430	5a	1P	RRG2UWD	7	2	N	DEMERITS	REFEREE GROOVE #2 UNWEIGHTED DEMERITS (DEMERITS)
8440	5a	1P	RRG3UWD	7	2	N	DEMERITS	REFEREE GROOVE #3 UNWEIGHTED DEMERITS (DEMERITS)
8450	5a	1P	RRL1UWD	7	2	N	DEMERITS	REFEREE LAND #1 UNWEIGHTED DEMERITS (DEMERITS)
8460	5a	1P	RRL2UWD	7	2	N	DEMERITS	REFEREE LAND #2 UNWEIGHTED DEMERITS (DEMERITS)
8470	5a	1P	RRL3UWD	7	2	N	DEMERITS	REFEREE LAND #3 UNWEIGHTED DEMERITS (DEMERITS)
8480	5a	1P	RRL4UWD	7	2	N	DEMERITS	REFEREE LAND #4 UNWEIGHTED DEMERITS (DEMERITS)
8490	5a	1P	RROGUWD	7	2	N	DEMERITS	REFEREE RATING OIL COOLING GALLERY UNWEIGHTED DEM.(DEMERITS)
8500	5a	1P	RRUCUWD	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN UNWEIGHTED DEMERITS (DEMERITS)
8510	5a	1P	RRG1WD	7	2	N	DEMERITS	REFEREE GROOVE #1 WEIGHTED DEMERITS (DEMERITS)
8520	5a	1P	RRG2WD	7	2	N	DEMERITS	REFEREE GROOVE #2 WEIGHTED DEMERITS (DEMERITS)
8530	5a	1P	RRG3WD	7	2	N	DEMERITS	REFEREE GROOVE #3 WEIGHTED DEMERITS (DEMERITS)
8540	5a	1P	RRL1WD	7	2	N	DEMERITS	REFEREE LAND #1 WEIGHTED DEMERITS (DEMERITS)
8550	5a	1P	RRL2WD	7	2	N	DEMERITS	REFEREE LAND #2 WEIGHTED DEMERITS (DEMERITS)
8560	5a	1P	RRL3WD	7	2	N	DEMERITS	REFEREE LAND #3 WEIGHTED DEMERITS (DEMERITS)
8570	5a	1P	RRL4WD	7	2	N	DEMERITS	REFEREE LAND #4 WEIGHTED DEMERITS (DEMERITS)
8580	5a	1P	RROGWD	7	2	N	DEMERITS	REFEREE RATING OIL COOLING GALLERY WEIGHTED DEM.(DEMERITS)
8590	5a	1P	RRUCWD	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN WEIGHTED DEMERITS (DEMERITS)
8600	5a	1P	RRUWD	7	1	N	DEMERITS	REFEREE RATING UNWEIGHTED TOTAL DEMERITS (DEMERITS)
8610	5a	1P	RRTLFC	7	0	N	%	REFEREE RATING T.L. FLAKED CARBON (%)
8620	6	1P	V100Hxxx	7	2	N	cSt	VISC @ 100 øC AT XXX HOURS (cSt)
8630	6	1P	V40_Hxxx	7	2	N	cSt	VISC @ 40 øC AT XXX HOURS (cSt)
8640	6	1P	TBN_Hxxx	7	2	N		TBN D4739 AT XXX HOURS
8650	6	1P	TAN_Hxxx	7	2	N		TAN D664 AT XXX HOURS
8660	6	1P	FEWMHxxx	4	0	A	ppm	FE - WEAR METALS AT XXX HOURS [<] (ppm)
8670	6	1P	ALWMHxxx	4	0	A	ppm	AL - WEAR METALS AT XXX HOURS [<] (ppm)
8680	6	1P	SIWMHxxx	4	0	A	ppm	SI - WEAR METALS AT XXX HOURS [<] (ppm)
8690	6	1P	CUWMHxxx	4	0	A	ppm	CU - WEAR METALS AT XXX HOURS [<] (ppm)
8700	6	1P	CRWMHxxx	4	0	A	ppm	CR - WEAR METALS AT XXX HOURS [<] (ppm)
8710	6	1P	PBWMHxxx	4	0	A	ppm	PB - WEAR METALS AT XXX HOURS [<] (ppm)
8720	6	1P	FDILHxxx	5	1	N	%	FUEL DILUTION ENGINE HOURS AT XXX HOURS (%)
8730	6	1P	BLBYHxxx	6	1	N	L/min	BLOWBY ENGINE HOURS AT XXX HOURS (L/min)
8740	6	1P	OCONHxxx	5	1	N	g/h	OIL CONSUMPTION @ ENGINE HOURS AT XXX HOURS (g/h)
8750	6	1P	OCRRHxxx	5	2	N		OIL CONSUMPTION R SQUARED @ ENGINE HOURS AT XXX HOURS
8760	6	1P	FPOSHxxx	5	1	N	mm	FUEL POSITION AT XXX HOURS (mm)
8770	7	1P	DOWNHxxx	6	0	C	HHH:MM	DOWNTIME TEST HOURS (HHH:MM)
8780	7	1P	DDATHxxx	8	0	C	YYYYMMDD	DOWNTIME DATE (YYYYMMDD)
8790	7	1P	DTIMHxxx	6	0	C	HHH:MM	DOWNTIME TIME (HHH:MM)
8800	7	1P	DREAHxxx	60	0	C		DOWNTIME REASON
8810	7	1P	OCOMHxxx	70	0	C		OTHER DOWNTIME COMMENTS XXX
8820	7	1P	DWNOCR	3	0	Z		NUMBER OF DOWNTIME OCCURENCES
8830	7	1P	TOTLDOWN	6	0	C	HHH:MM	DOWNTIME TIME TOTAL (HHH:MM)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
8840	7	1P	TOTCOM	3	0	Z		TOTAL LINES OF COMMENTS
8850	8	1P	RINGGTE	6	3	N	mm	TOP RING GAP PRE-TEST (mm)
8860	8	1P	RINGGI1E	6	3	N	mm	INTERMEDIATE #1 RING GAP PRE-TEST (mm)
8870	8	1P	RINGGOE	6	3	N	mm	OIL RING GAP PRE-TEST (mm)
8880	8	1P	RINGGTO	6	3	N	mm	TOP RING GAP POST-TEST (mm)
8890	8	1P	RINGGI1O	6	3	N	mm	INTERMEDIATE #1 RING GAP POST-TEST (mm)
8900	8	1P	RINGGOO	6	3	N	mm	OIL RING GAP POST-TEST (mm)
8910	8	1P	SIDETPE1	7	3	A	mm	TOP PRETEST RING SIDE CLEARANCE A [STUCK, <, >] (mm)
8920	8	1P	SIDETPE2	7	3	A	mm	TOP PRETEST RING SIDE CLEARANCE B [STUCK, <, >] (mm)
8930	8	1P	SIDETPE3	7	3	A	mm	TOP PRETEST RING SIDE CLEARANCE C [STUCK, <, >] (mm)
8940	8	1P	SIDETPE4	7	3	A	mm	TOP PRETEST RING SIDE CLEARANCE D [STUCK, <, >] (mm)
8950	8	1P	ASIDETPE	7	3	A	mm	TOP PRETEST RING SIDE CLEARANCE AVG [STUCK, <, >] (mm)
8960	8	1P	ISIDETPE	6	3	A	mm	MINIMUM RING SIDE CLEARANCE -TOP- PRETEST [STUCK, <, >] (mm)
8970	8	1P	SIDETPO1	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST A [STUCK, <, >] (mm)
8980	8	1P	SIDETPO2	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST B [STUCK, <, >] (mm)
8990	8	1P	SIDETPO3	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST C [STUCK, <, >] (mm)
9000	8	1P	SIDETPO4	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST D [STUCK, <, >] (mm)
9010	8	1P	ASIDETPO	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST AVERAGE [STUCK, <, >] (mm)
9020	8	1P	ISIDETPO	6	3	A	mm	MIN. RING SIDE CLEARANCE POSTTEST-0.114-0.185[STUCK,<,>](mm)
9030	8	1P	LSCT1	7	3	A	mm	RING SIDE CLEARANCE TOP LSC A [STUCK, <, >] (mm)
9040	8	1P	LSCT2	7	3	A	mm	RING SIDE CLEARANCE TOP LSC B [STUCK, <, >] (mm)
9050	8	1P	LSCT3	7	3	A	mm	RING SIDE CLEARANCE TOP LSC C [STUCK, <, >] (mm)
9060	8	1P	LSCT4	7	3	A	mm	RING SIDE CLEARANCE TOP LSC D [STUCK, <, >] (mm)
9070	8	1P	ILSCT	7	3	A	mm	RING SIDE CLEARANCE TOP LSC MINIMUM [STUCK, <, >] (mm)
9080	8	1P	ISIDE1PE	6	3	A	mm	MINIMUM RING SIDE CLEARANCE - INT1 PRETEST [STUCK, <, >](mm)
9090	8	1P	SIDE1PE1	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST A [STUCK, <, >] (mm)
9100	8	1P	SIDE1PE2	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST B [STUCK, <, >] (mm)
9110	8	1P	SIDE1PE3	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST C [STUCK, <, >] (mm)
9120	8	1P	SIDE1PE4	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST D [STUCK, <, >] (mm)
9130	8	1P	ASIDE1PE	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST D [STUCK, <, >] (mm)
9140	8	1P	ISIDE1PO	6	3	A	mm	MINIMUM RING SIDE CLEARANCE-INT1-POSTTEST [STUCK, <, >] (mm)
9150	8	1P	SIDE1PO1	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST A [STUCK, <, >] (mm)
9160	8	1P	SIDE1PO2	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST B [STUCK, <, >] (mm)
9170	8	1P	SIDE1PO3	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST C [STUCK, <, >] (mm)
9180	8	1P	SIDE1PO4	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST D [STUCK, <, >] (mm)
9190	8	1P	ASIDE1PO	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST AVG [STUCK, <, >] (mm)
9200	8	1P	LSCI1	7	3	A	mm	RING SIDE CLEARANCE INT. LSC A [STUCK, <, >] (mm)
9210	8	1P	LSCI2	7	3	A	mm	RING SIDE CLEARANCE INT. LSC B [STUCK, <, >] (mm)
9220	8	1P	LSCI3	7	3	A	mm	RING SIDE CLEARANCE INT. LSC C [STUCK, <, >] (mm)
9230	8	1P	LSCI4	7	3	A	mm	RING SIDE CLEARANCE INT. LSC D [STUCK, <, >] (mm)
9240	8	1P	ILSCINT	7	3	A	mm	RING SIDE CLEARANCE INT. LSC MINIMUM [STUCK, <, >] (mm)
9250	8	1P	SIDEOPE1	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST A [STUCK, <, >] (mm)
9260	8	1P	SIDEOPE2	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST B [STUCK, <, >] (mm)
9270	8	1P	SIDEOPE3	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST C [STUCK, <, >] (mm)
9280	8	1P	SIDEOPE4	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST D [STUCK, <, >] (mm)
9290	8	1P	ASIDEOPE	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST AVG [STUCK, <, >] (mm)
9300	8	1P	ISIDEOPE	6	3	A	mm	MINIMUM RING SIDE CLEARANCE-OIL-PRETEST [STUCK, <, >] (mm)
9310	8	1P	SIDEOPO1	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST A [STUCK, <, >] (mm)
9320	8	1P	SIDEOPO2	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST B [STUCK, <, >] (mm)

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
9330	8	1P	SIDEOPO3	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST C [STUCK, <, >] (mm)
9340	8	1P	SIDEOPO4	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST D [STUCK, <, >] (mm)
9350	8	1P	ASIDEOPO	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST AVG [STUCK, <, >] (mm)
9360	8	1P	ISIDEOPO	6	3	A	mm	MINIMUM RING SIDE CLEARANCE-OIL-POSTTEST [STUCK, <, >] (mm)
9370	8	1P	LSCO1	7	3	A	mm	RING SIDE CLEARANCE OIL LSC A [STUCK, <, >] (mm)
9380	8	1P	LSCO2	7	3	A	mm	RING SIDE CLEARANCE OIL LSC B [STUCK, <, >] (mm)
9390	8	1P	LSCO3	7	3	A	mm	RING SIDE CLEARANCE OIL LSC C [STUCK, <, >] (mm)
9400	8	1P	LSCO4	7	3	A	mm	RING SIDE CLEARANCE OIL LSC D [STUCK, <, >] (mm)
9410	8	1P	ILSCO	7	3	A	mm	RING SIDE CLEARANCE OIL LSC MINIMUM [STUCK, <, >] (mm)
9420	9	1P	BBLFINT1	5	2	N	micrometre	LINER BORE SURFACE FINISH - TRANSVERSE - 130 MM (micrometre)
9430	9	1P	BBLFINL1	5	2	N	micrometre	LINER BORE SURFACE FINISH -LONGITUDINAL- 130 MM (micrometre)
9440	9	1P	BBLFINA1	5	2	N	micrometre	LINER BORE SURFACE FINISH - AVERAGE - 130 MM (micrometre)
9450	9	1P	BBLFINT2	5	2	N	micrometre	LINER BORE SURFACE FINISH - TRANSVERSE - 50 MM (micrometre)
9460	9	1P	BBLFINL2	5	2	N	micrometre	LINER BORE SURFACE FINISH -LONGITUDINAL- 50 MM (micrometre)
9470	9	1P	BBLFINA2	5	2	N	micrometre	LINER BORE SURFACE FINISH - AVERAGE - 50 MM (micrometre)
9480	9	1P	BBLFINT3	5	2	N	micrometre	LINER BORE SURFACE FINISH - TRANSVERSE - 25 MM (micrometre)
9490	9	1P	BBLFINL3	5	2	N	micrometre	LINER BORE SURFACE FINISH -LONGITUDINAL- 25 MM (micrometre)
9500	9	1P	BBLFINA3	5	2	N	micrometre	LINER BORE SURFACE FINISH - AVERAGE - 25 MM (micrometre)
9510	9	1P	BBLFIN	5	2	N	micrometre	BEFORE TEST LINER BORE SURFACE FINISH TOTAL AVG (micrometre)
9520	9	1P	BOREPT	6	1	N	%	LINER BORE POLISH - GRID - THRUST (%)
9530	9	1P	BOREPAT	6	1	N	%	LINER BORE POLISH - GRID - ANTI-THRUST (%)
9540	9	1P	BBLONG1	8	3	N	mm	BEFORE TEST LINER BORE MEA.--250 MM HT-LONGITUDINAL (mm)
9550	9	1P	BBTRAN1	8	3	N	mm	BEFORE TEST LINER BORE MEA.--250 MM HT-TRANSVERSE (mm)
9560	9	1P	OOR1	6	3	N	mm	BEFORE TEST LINER BORE MEA.-250 MM HT-OUT OF ROUND (mm)
9570	9	1P	BBLONG2	8	3	N	mm	BEFORE TEST LINER BORE MEA.--210 MM HT-LONGITUDINAL (mm)
9580	9	1P	BBTRAN2	8	3	N	mm	BEFORE TEST LINER BORE MEA.--210 MM HT-TRANSVERSE (mm)
9590	9	1P	OOR2	6	3	N	mm	BEFORE TEST LINER BORE MEA.-210 MM HT-OUT OF ROUND (mm)
9600	9	1P	BBLONG3	8	3	N	mm	BEFORE TEST LINER BORE MEA.--170 MM HT-LONGITUDINAL (mm)
9610	9	1P	BBTRAN3	8	3	N	mm	BEFORE TEST LINER BORE MEA.--170 MM HT-TRANSVERSE (mm)
9620	9	1P	OOR3	6	3	N	mm	BEFORE TEST LINER BORE MEA.-170 MM HT-OUT OF ROUND (mm)
9630	9	1P	BBLONG4	8	3	N	mm	BEFORE TEST LINER BORE MEA.--130 MM HT-LONGITUDINAL (mm)
9640	9	1P	BBTRAN4	8	3	N	mm	BEFORE TEST LINER BORE MEA.--130 MM HT-TRANSVERSE (mm)
9650	9	1P	OOR4	6	3	N	mm	BEFORE TEST LINER BORE MEA.-130 MM HT-OUT OF ROUND (mm)
9660	9	1P	BBLONG5	8	3	N	mm	BEFORE TEST LINER BORE MEA.--50 MM HT-LONGITUDINAL (mm)
9670	9	1P	BBTRAN5	8	3	N	mm	BEFORE TEST LINER BORE MEA.--50 MM HT-TRANSVERSE (mm)
9680	9	1P	OOR5	6	3	N	mm	BEFORE TEST LINER BORE MEA.--50 MM HT-OUT OF ROUND (mm)
9690	9	1P	BBLONG6	8	3	N	mm	BEFORE TEST LINER BORE MEA.--25 MM HT-LONGITUDINAL (mm)
9700	9	1P	BBTRAN6	8	3	N	mm	BEFORE TEST LINER BORE MEA.--25 MM HT-TRANSVERSE (mm)
9710	9	1P	OOR6	6	3	N	mm	BEFORE TEST LINER BORE MEA.-25 MM HT-TRANSVERSE (mm)
9720	9	1P	BBLONG7	8	3	N	mm	BEFORE TEST LINER BORE MEA.--15 MM HT-LONGITUDINAL (mm)
9730	9	1P	BBTRAN7	8	3	N	mm	BEFORE TEST LINER BORE MEA.--15 MM HT-TRANSVERSE (mm)
9740	9	1P	OOR7	6	3	N	mm	BEFORE TEST LINER BORE MEA.-15 MM HT-TRANSVERSE (mm)
9750	9	1P	TAPRLONG	8	3	N	mm	BEFORE TEST LINER BORE MEA.-TAPER -LONGITUDINAL (mm)
9760	9	1P	TAPRTRAN	8	3	N	mm	BEFORE TEST LINER BORE MEA.-TAPER-TRANSVERSE (mm)
9770	9	1P	AWEARLF	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--LONGITUDINAL FRONT (mm)
9780	9	1P	AWEARLR	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--LONGITUDINAL REAR (mm)
9790	9	1P	AWEARTT	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--TRANSVERSE T (mm)
9800	9	1P	AWEARTAT	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--TRANSVERSE AT (mm)
9810	10	1P	RPMSENS	17	0	C		ENGINE SPEED SENSING DEVICE

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
9820	10	1P	RPMCALF	13	0	C		ENGINE SPEED CALIBRATION FREQUENCY
9830	10	1P	RPMRECD	16	0	C		ENGINE SPEED RECORD DEVICE
9840	10	1P	RPMOBSF	12	0	C		ENGINE SPEED OBSERVATION FREQUENCY
9850	10	1P	RPMRECF	12	0	C		ENGINE SPEED RECORD FREQUENCY
9860	10	1P	RPMLOGF	12	0	C		ENGINE SPEED LOG FREQUENCY
9870	10	1P	RPMSYSR	8	0	C		ENGINE SPEED SYSTEM RESPONSE
9880	10	1P	PWRSENS	17	0	C		ENGINE POWER SENSING DEVICE
9890	10	1P	PWRCALF	13	0	C		ENGINE POWER CALIBRATION FREQUENCY
9900	10	1P	PWRRECD	16	0	C		ENGINE POWER RECORD DEVICE
9910	10	1P	PWROBSF	12	0	C		ENGINE POWER OBSERVATION FREQUENCY
9920	10	1P	PWRRECF	12	0	C		ENGINE POWER RECORD FREQUENCY
9930	10	1P	PWRLOGF	12	0	C		ENGINE POWER LOG FREQUENCY
9940	10	1P	PWRSYSR	8	0	C		ENGINE POWER SYSTEM RESPONSE
9950	10	1P	FFLOSENS	17	0	C		FUEL RATE SENSING DEVICE
9960	10	1P	FFLOCALF	13	0	C		FUEL RATE CALIBRATION FREQUENCY
9970	10	1P	FFLORECD	16	0	C		FUEL RATE RECORD DEVICE
9980	10	1P	FFLOOBSF	12	0	C		FUEL RATE OBSERVATION FREQUENCY
9990	10	1P	FFLORECF	12	0	C		FUEL RATE RECORD FREQUENCY
10000	10	1P	FFLOLOGF	12	0	C		FUEL RATE ENGINE SPEED LOG FREQUENCY
10010	10	1P	FFLOSYSR	8	0	C		FUEL RATE SYSTEM RESPONSE
10020	10	1P	HUMSENS	17	0	C		HUMIDITY SENSING DEVICE
10030	10	1P	HUMCALF	13	0	C		HUMIDITY CALIBRATION FREQUENCY
10040	10	1P	HUMRECD	16	0	C		HUMIDITY RECORD DEVICE
10050	10	1P	HUMOBSF	12	0	C		HUMIDITY OBSERVATION FREQUENCY
10060	10	1P	HUMRECF	12	0	C		HUMIDITY RECORD FREQUENCY
10070	10	1P	HUMLOGF	12	0	C		HUMIDITY LOG FREQUENCY
10080	10	1P	HUMSYSR	8	0	C		HUMIDITY SYSTEM RESPONSE
10090	10	1P	COTSENS	17	0	C		COOLANT OUT TEMPERATURE SENSING DEVICE
10100	10	1P	COTCALF	13	0	C		COOLANT OUT TEMPERATURE CALIBRATION FREQUENCY
10110	10	1P	COTRECD	16	0	C		COOLANT OUT TEMPERATURE ENGINE SPEED RECORD DEVICE
10120	10	1P	COTOBSF	12	0	C		COOLANT OUT TEMPERATURE OBSERVATION FREQUENCY
10130	10	1P	COTRECF	12	0	C		COOLANT OUT TEMPERATURE RECORD FREQUENCY
10140	10	1P	COTLOGF	12	0	C		COOLANT OUT TEMPERATURE LOG FREQUENCY
10150	10	1P	COTSYSR	8	0	C		COOLANT OUT TEMPERATURE SYSTEM RESPONSE
10160	10	1P	CONSENS	17	0	C		COOLANT IN TEMPERATURE SENSING DEVICE
10170	10	1P	CONCALF	13	0	C		COOLANT IN TEMPERATURE CALIBRATION FREQUENCY
10180	10	1P	CONRECD	16	0	C		COOLANT IN TEMPERATURE RECORD DEVICE
10190	10	1P	CONOBSF	12	0	C		COOLANT IN TEMPERATURE OBSERVATION FREQUENCY
10200	10	1P	CONRECF	12	0	C		COOLANT IN TEMPERATURE RECORD FREQUENCY
10210	10	1P	CONLOGF	12	0	C		COOLANT IN TEMPERATURE LOG FREQUENCY
10220	10	1P	CONSYSR	8	0	C		COOLANT IN TEMPERATURE SYSTEM RESPONSE
10230	10	1P	OBRGSENS	17	0	C		OIL TO MANIFOLD TEMPERATURE SENSING DEVICE
10240	12	1P	AEXHHxxx	6	1	N	øC	AVERAGE EXHAUST TEMPERATURE FOR LAST 10 TESTS (øC)
10250	10	1P	OBRGCALF	13	0	C		OIL TO MANIFOLD TEMPERATURE CALIBRATION FREQUENCY
10260	12	1P	ATORHxxx	6	1	N	Nm	AVERAGE ENGINE TORQUE FOR LAST 10 TESTS (Nm)
10270	10	1P	OBRGRECD	16	0	C		OIL TO MANIFOLD TEMPERATURE RECORD DEVICE
10280	10	1P	OBRGOBSF	12	0	C		OIL TO MANIFOLD TEMPERATURE OBSERVATION FREQUENCY
10290	10	1P	OBRGRECF	12	0	C		OIL TO MANIFOLD TEMPERATURE RECORD FREQUENCY
10300	10	1P	OBRGLOGF	12	0	C		OIL TO MANIFOLD TEMPERATURE LOG FREQUENCY

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
10310	15	1P	DTSTRxxx	8	0	C	YYYYMMDD	USAGE START DATES (YYYYMMDD)
10320	10	1P	OBRGSYSR	8	0	C		OIL TO MANIFOLD TEMPERATURE SYSTEM RESPONSE
10330	15	1P	DTTMRxxx	6	0	C	HHH:MM	USAGE DATES TIME (HHH:MM)
10340	10	1P	OCOLSENS	17	0	C		OIL COOLER IN TEMPERATURE SENSING DEVICE
10350	15	1P	WDZIRxxx	7	3	N		WEIGHTED TOTAL DEMERITS ZI
10360	10	1P	OCOLCALF	13	0	C		OIL COOLER IN TEMPERATURE CALIBRATION FREQUENCY
10370	15	1P	WDSARxxx	6	1	N		WEIGHTED TOTAL DEMERITS SEVERITY ADJUSTMENT
10380	10	1P	OCOLRECD	16	0	C		OIL COOLER IN TEMPERATURE RECORD DEVICE
10390	15	1P	TGZIRxxx	7	3	N		TOP GROOVE CARBON ZI
10400	10	1P	OCOLOBSF	12	0	C		OIL COOLER IN TEMPERATURE OBSERVATION FREQUENCY
10410	15	1P	TGSARxxx	6	2	N		TOP GROOVE CARBON S.A.
10420	10	1P	OCOLRECF	12	0	C		OIL COOLER IN TEMPERATURE RECORD FREQUENCY
10430	15	1P	TLZIRxxx	7	3	N		TOP LAND CARBON ZI
10440	10	1P	OCOLLOGF	12	0	C		OIL COOLER IN TEMPERTURE LOG FREQUENCY
10450	15	1P	TLSARxxx	6	2	N		TOP LAND CARBON S.A.
10460	10	1P	OCOLSYSR	8	0	C		OIL COOLER IN TEMPERATURE SYSTEM RESPONSE
10470	15	1P	OCZIRxxx	7	3	N		OIL CONSUMPTION ZI
10480	10	1P	AIRTSENS	17	0	C		INLET AIR TEMPERATURE SENSING DEVICE
10490	15	1P	OCSARxxx	5	1	N		OIL CONSUMPTION S.A.
10500	10	1P	AIRTCALF	13	0	C		INLET AIR TEMPERATURE CALIBRATION FREQUENCY
10510	15	1P	ETZIRxxx	7	3	N		EOT OIL CONSUMPTION ZI
10520	10	1P	AIRTRECD	16	0	C		INLET AIR TEMPERATURE RECORD DEVICE
10530	15	1P	ETSARxxx	5	1	N		EOT OIL CONSUMPTION S.A.
10540	10	1P	AIRTOBSF	12	0	C		INLET AIR TEMPERATURE OBSERVATION FREQUENCY
10550	10	1P	AIRTRECF	12	0	C		INLET AIR TEMPERATURE ENGINE SPEED RECORD FREQUENCY
10560	10	1P	AIRTLOGF	12	0	C		INLET AIR TEMPERATURE LOG FREQUENCY
10570	10	1P	AIRTSYSR	8	0	C		INLET AIR TEMPERATURE SYSTEM RESPONSE
10580	10	1P	EXTSENS	17	0	C		EXHAUST TEMPERATURE SENSING DEVICE
10590	10	1P	EXTCALF	13	0	C		EXHAUST TEMPERATURE CALIBRATION FREQUENCY
10600	10	1P	EXTRECD	16	0	C		EXHAUST TEMPERATURE RECORD DEVICE
10610	10	1P	EXTOBSF	12	0	C		EXHAUST TEMPERATURE OBSERVATION FREQUENCY
10620	10	1P	EXTRECF	12	0	C		EXHAUST TEMPERATURE RECORD FREQUENCY
10630	10	1P	EXTLOGF	12	0	C		EXHAUST TEMPERATURE LOG FREQUENCY
10640	10	1P	EXTSYSR	8	0	C		EXHAUST TEMPERATURE SYSTEM RESPONSE
10650	10	1P	FUELSENS	17	0	C		FUEL TO HEAD TEMPERATURE SENSING DEVICE
10660	10	1P	FUELCALF	13	0	C		FUEL TO HEAD TEMPERATURE CALIBRATION FREQUENCY
10670	10	1P	FUELRECD	16	0	C		FUEL TO HEAD TEMPERATURE RECORD DEVICE
10680	10	1P	FUELOBSF	12	0	C		FUEL TO HEAD TEMPERATURE OBSERVATION FREQUENCY
10690	10	1P	FUELRECF	12	0	C		FUEL TO HEAD TEMPERATURE RECORD FREQUENCY
10700	10	1P	FUELLOGF	12	0	C		FUEL TO HEAD TEMPERATURE LOG FREQUENCY
10710	10	1P	FUELSYSR	8	0	C		FUEL TO HEAD TEMPERATURE SYSTEM RESPONSE
10720	10	1P	OBRPSENS	17	0	C		OIL TO MANIFOLD PRESSURE SENSING DEVICE
10730	10	1P	OBRPCALF	13	0	C		OIL TO MANIFOLD PRESSURE CALIBRATION FREQUENCY
10740	10	1P	OBRPRECD	16	0	C		OIL TO MANIFOLD PRESSURE RECORD DEVICE
10750	10	1P	OBRPOBSF	12	0	C		OIL TO MANIFOLD PRESSURE OBSERVATION FREQUENCY
10760	10	1P	OBRPRECF	12	0	C		OIL TO MANIFOLD PRESSURE RECORD FREQUENCY
10770	10	1P	OBRPLOGF	12	0	C		OIL TO MANIFOLD PRESSURE LOG FREQUENCY
10780	10	1P	OBRPSYSR	8	0	C		OIL TO MANIFOLD PRESSURE SYSTEM RESPONSE
10790	10	1P	AIRPSENS	17	0	C		INLET AIR PRESSURE SENSING DEVICE

FIG. A16.1 Data Dictionary *(continued)*

AA16 Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Dec. Size	Data Type	Units/Format	Description
10800	10	1P	AIRPCALF	13	0	C		INLET AIR PRESSURE CALIBRATION FREQUENCY
10810	10	1P	AIRPRECD	16	0	C		INLET AIR PRESSURE RECORD DEVICE
10820	10	1P	AIRPOBSF	12	0	C		INLET AIR PRESSURE OBSERVATION FREQUENCY
10830	10	1P	AIRPRECF	12	0	C		INLET AIR PRESSURE RECORD FREQUENCY
10840	10	1P	AIRPLOGF	12	0	C		INLET AIR PRESSURE LOG FREQUENCY
10850	10	1P	AIRPSYSR	8	0	C		INLET AIR PRESSURE SYSTEM RESPONSE
10860	10	1P	EXPSENS	17	0	C		EXHAUST PRESSURE SENSING DEVICE
10870	10	1P	EXPCALF	13	0	C		EXHAUST PRESSURE CALIBRATION FREQUENCY
10880	10	1P	EXPRECD	16	0	C		EXHAUST PRESSURE RECORD DEVICE
10890	10	1P	EXPOBSF	12	0	C		EXHAUST PRESSURE OBSERVATION FREQUENCY
10900	10	1P	EXPRECF	12	0	C		EXHAUST PRESSURE RECORD FREQUENCY
10910	10	1P	EXPLOGF	12	0	C		EXHAUST PRESSURE LOG FREQUENCY
10920	10	1P	EXPSYSR	8	0	C		EXHAUST PRESSURE SYSTEM RESPONSE
10930	10	1P	FFILSENS	17	0	C		FUEL FROM HEAD PRESSURE SENSING DEVICE
10940	10	1P	FFILCALF	13	0	C		FUEL FROM HEAD PRESSURE CALIBRATION FREQUENCY
10950	10	1P	FFILRECD	16	0	C		FUEL FROM HEAD PRESSURE RECORD DEVICE
10960	10	1P	FFILOBSF	12	0	C		FUEL FROM HEAD PRESSURE OBSERVATION FREQUENCY
10970	10	1P	FFILRECF	12	0	C		FUEL FROM HEAD PRESSURE RECORD FREQUENCY
10980	10	1P	FFILLOGF	12	0	C		FUEL FROM HEAD PRESSURE LOG FREQUENCY
10990	10	1P	FFILSYSR	8	0	C		FUEL FROM HEAD PRESSURE SYSTEM RESPONSE
11000	10	1P	CCVSENS	17	0	C		CRANKCASE SENSING DEVICE
11010	10	1P	CCVCALF	13	0	C		CRANKCASE ENGINE SPEED CALIBRATION FREQUENCY
11020	10	1P	CCVRECD	16	0	C		CRANKCASE RECORD DEVICE
11030	10	1P	CCVOBSF	12	0	C		CRANKCASE OBSERVATION FREQUENCY
11040	10	1P	CCVRECF	12	0	C		CRANKCASE RECORD FREQUENCY
11050	10	1P	CCVLOGF	12	0	C		CRANKCASE LOG FREQUENCY
11060	10	1P	CCVSYSR	8	0	C		CRANKCASE SYSTEM RESPONSE
11070	10	1P	BLBYSENS	17	0	C		BLOWBY SENSING DEVICE
11080	10	1P	BLBYCALF	13	0	C		BLOWBY ENGINE SPEED CALIBRATION FREQUENCY
11090	10	1P	BLBYRECD	16	0	C		BLOWBY RECORD DEVICE
11100	10	1P	BLBYOBSF	12	0	C		BLOWBY OBSERVATION FREQUENCY
11110	10	1P	BLBYRECF	12	0	C		BLOWBY RECORD FREQUENCY
11120	10	1P	BLBYLOGF	12	0	C		BLOWBY LOG FREQUENCY
11130	10	1P	BLBYSYSR	8	0	C		BLOWBY SYSTEM RESPONSE
11140	10	1P	CFLWSENS	17	0	C		COOLANT FLOW SENSING DEVICE
11150	10	1P	CFLWCALF	13	0	C		COOLANT FLOW CALIBRATION FREQUENCY
11160	10	1P	CFLWRECD	16	0	C		COOLANT FLOW RECORD DEVICE
11170	10	1P	CFLWOBSF	12	0	C		COOLANT FLOW OBSERVATION FREQUENCY
11180	10	1P	CFLWRECF	12	0	C		COOLANT FLOW ENGINE SPEED RECORD FREQUENCY
11190	10	1P	CFLWLOGF	12	0	C		COOLANT FLOW LOG FREQUENCY
11200	10	1P	CFLWSYSR	8	0	C		COOLANT FLOW SYSTEM RESPONSE
11210	13	1P	BOTOC	5	1	N	g/h	0 - 48 OIL CONSUMPTION (g/h)
11220	13	1P	OCPIM	70	0	C		OIL CONSUMPTION PLOT IMAGE
11230	14	1P	PRLIM	70	0	C		PISTON RING AND LINER PHOTOGRAPHS PLOT IMAGE
11240	16	1P	FUELIM	70	0	C		FUEL BATCH ANALYSIS PLOT IMAGE
11250	17	1P	CCHIM	70	0	C		TMC CONTROL CHART ANALYSIS PLOT IMAGE

FIG. A16.1 Data Dictionary *(continued)*

APPENDIXES

(Nonmandatory Information)

X1. VARIOUS EXAMPLES FOR REFERENCE PURPOSES

X1.1 See Figs. X1.1-X1.8.

	GROOVE 1			GROOVE 2			GROOVE 3			COOLING GALLERY			UNDER CROWN		
	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM
CARBON	5	1.00	5.00	5	1.00	5.00	5	1.00	5.00						
	5	0.50	2.50				5	0.50	2.50						
	5	0.25	1.25	5	0.25	1.25	5	0.25	1.25	5	0.25	1.25	5	0.25	1.25
	SUBTOTAL		8.75	SUBTOTAL		6.25	SUBTOTAL		8.75	SUBTOTAL		1.25	SUBTOTAL		1.25
VARNISH	9	8.5	0.76	9	8.5	0.76	11	8.5	0.82	7	7.5	0.52	7	7.5	0.52
	7	7.5	0.52	7	7.5	0.52	7	7.5	0.52	9	4.5	0.40	9	4.5	0.40
	9	6.5	0.58	9	6.5	0.58	3	6.5	0.22	7	1.5	0.10	7	1.5	0.10
	7	5.5	0.38	7	5.5	0.38	13	5.5	0.58						
	9	4.5	0.40	9	4.5	0.40	9	4.5	0.40						
	7	3.5	0.24	7	3.5	0.24	5	3.5	0.22						
	9	2.5	0.22	9	2.5	0.22	11	2.5	0.16						
	7	1.5	0.10	7	1.5	0.10	7	1.5	0.10						
	9	0.5	0.04	9	0.5	0.04	3	0.5	0.04						
	SUBTOTAL		3.24	SUBTOTAL		3.24	SUBTOTAL		3.06	SUBTOTAL		1.02	SUBTOTAL		1.02
	TOTAL		11.99	TOTAL		9.49	TOTAL		11.81	TOTAL		2.27	TOTAL		2.27
	LOC FCT		2	LOC FCT		3	LOC FCT		20	LOC FCT		0.50	LOC FCT		1
	WTD		23.98	WTD		28.47	WTD		236.20	WTD		1.14	WTD		2.27

	LAND 1			LAND 2			LAND 3			LAND 4		
	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM
CARBON	5	1.00	5.00	5	1.00	5.00	5	1.00	5.00	5	1.00	5.00
	5	0.25	1.25	5	0.25	1.25	5	0.25	1.25	5	0.25	1.25
	SUBTOTAL		6.25	SUBTOTAL		6.25	SUBTOTAL		6.25	SUBTOTAL		6.25
VARNISH	9	8.5	0.76	9	8.5	0.76	11	8.5	0.82	11	8.5	0.82
	7	7.5	0.52	7	7.5	0.52	7	7.5	0.52	7	7.5	0.52
	9	6.5	0.58	9	6.5	0.58	3	6.5	0.22	3	6.5	0.22
	7	5.5	0.38	7	5.5	0.38	13	5.5	0.58	13	5.5	0.58
	9	4.5	0.40	9	4.5	0.40	9	4.5	0.40	9	4.5	0.40
	7	3.5	0.24	7	3.5	0.24	5	3.5	0.22	5	3.5	0.22
	9	2.5	0.22	9	2.5	0.22	11	2.5	0.16	11	2.5	0.16
	7	1.5	0.10	7	1.5	0.10	7	1.5	0.10	7	1.5	0.10
	9	0.5	0.04	9	0.5	0.04	3	0.5	0.04	3	0.5	0.04
	SUBTOTAL		3.24	SUBTOTAL		3.24	SUBTOTAL		3.06	SUBTOTAL		3.06
	TOTAL		9.49	TOTAL		9.49	TOTAL		9.31	TOTAL		9.31
	LOC FCT		1	LOC FCT		3	LOC FCT		20	LOC FCT		60
	WTD		9.49	WTD		28.47	WTD		186.20	WTD		558.60

WDP	1074.8
TGC	8.75
TLC	6.25

PISTON NO. 1	RING STUCK	SCUFFED AREA %
TOP RING		
INT. RING		
OIL RING		
PISTON		
CYLINDER LINER		

TLFC	

FIG. X1.1 Rating Worksheet Example

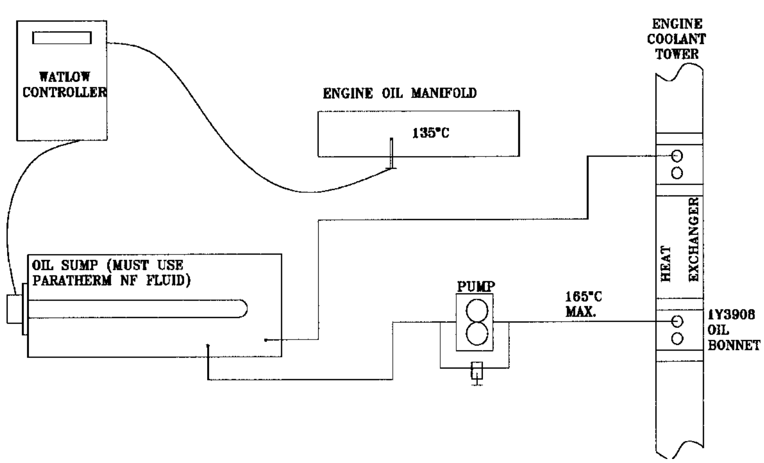
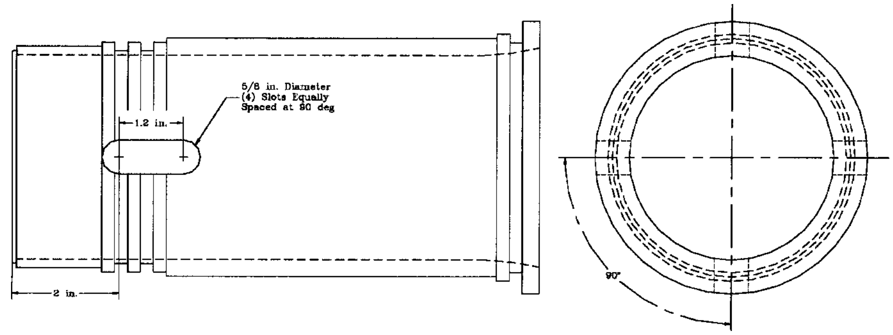


FIG. X1.2 Engine Oil Heating System



NOTE—Use a 1Y3555 liner from the 1K/1N test. The liner shall be free of I.D. distortion or surface distress.

FIG. X1.3 Ring Side Clearance Measurement Fixture

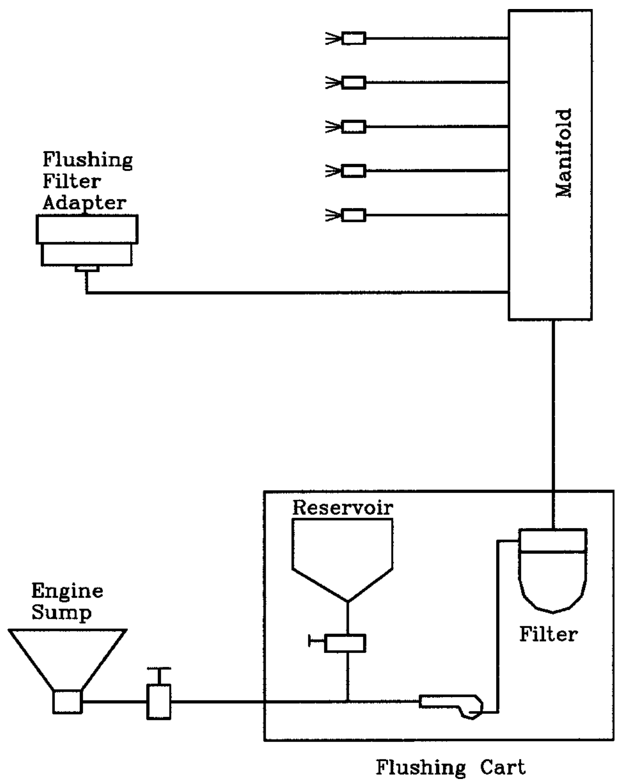


FIG. X1.4 Flushing Cart Flow Schematic

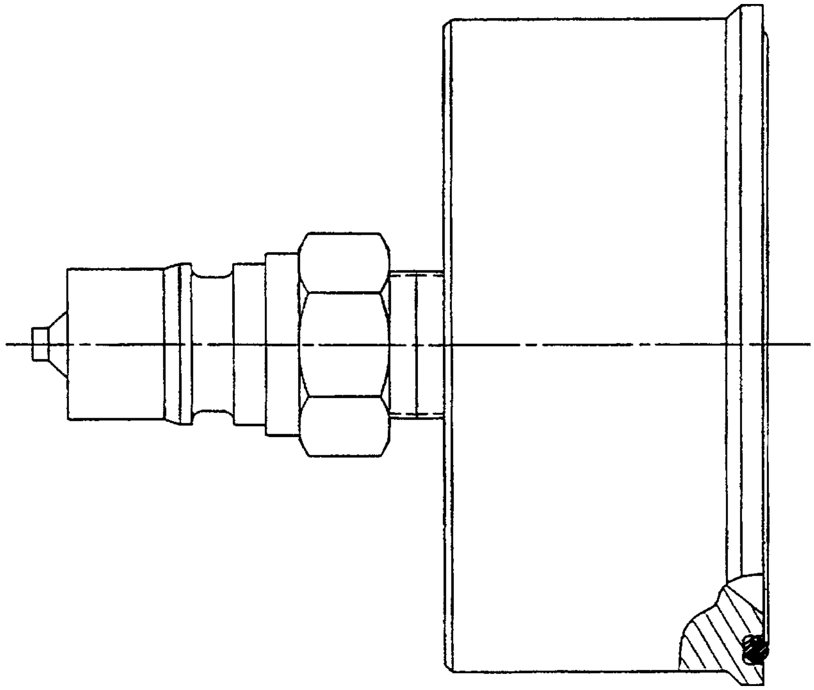
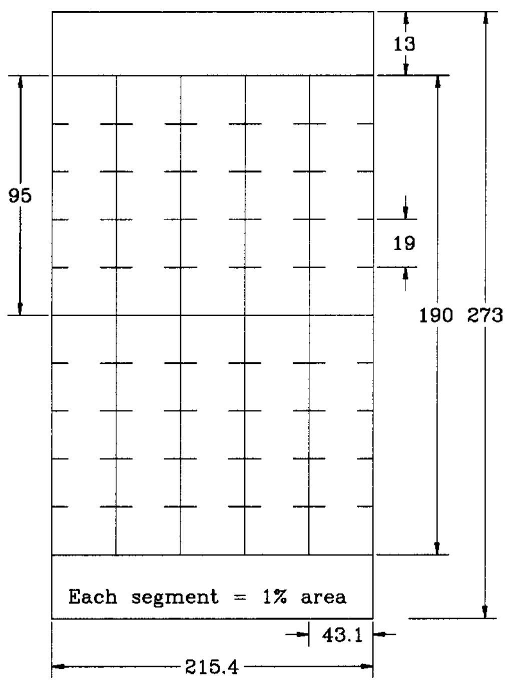


FIG. X1.5 Oil Filter Flushing Adapter Example



NOTE—Material is clear plastic; dimensions are in mm.

FIG. X1.6 Bore Polish Grid

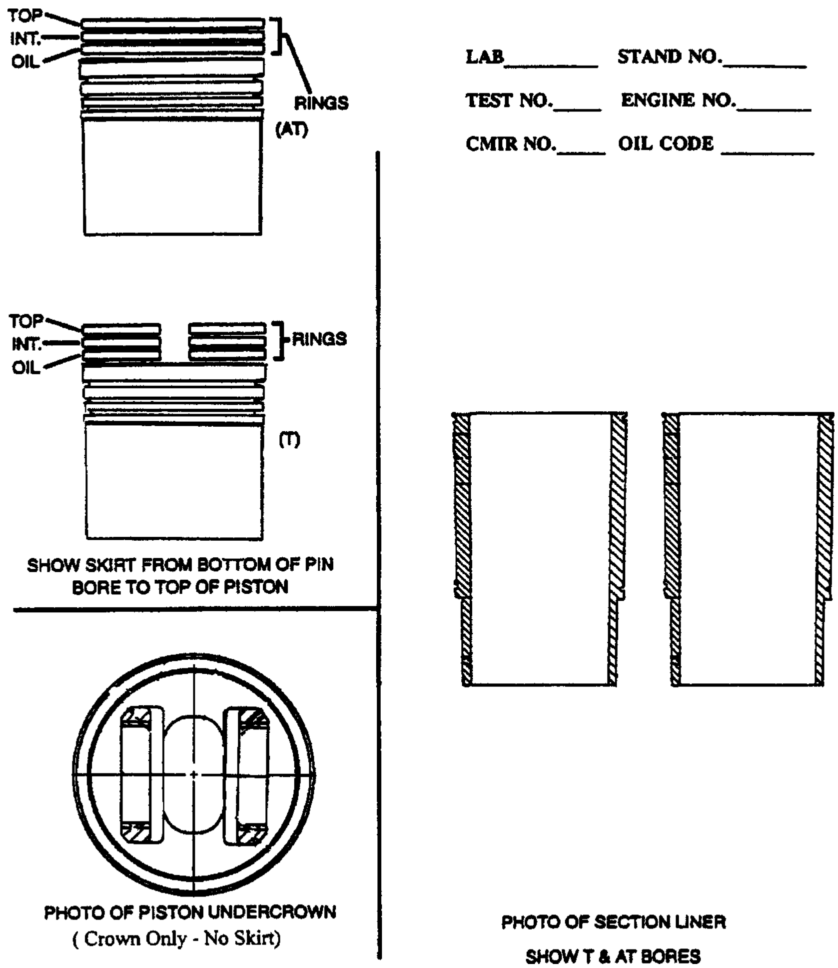


FIG. X1.7 Example of Piston, Rings and Liner Photograph Layout

1P TEST SUMMARY SHEET

OIL CODE NO.________________________________

TEST NO.	DATE TEST COMP	OIL CODE NO.	TEST LAB	ENGINE STAND NO.	ENGINE RUN NO.	WDP	TGC	TLC	BSOC g/h 0 - 360	BSOC g/h 0 - 48	BSOC g/h 336-360
TEST DATA											
1ST											
2											
3											
4											
TEST AVG											
1ST											
2											
3											
OUTLIER MIN. LEVEL						(1)	(2)	(4)			
2 TEST AVG. WITH OUTLIER REMOVED											
3 TEST AVG. WITH OUTLIER REMOVED											
ACCEPTANCE LIMITS											
1ST TEST PASS											
2 TEST PASS											
3 TEST PASS											

NOTES:

(1) WDP 3 TEST AVG + ____

(2) TGF 3 TEST AVG + ____

(3) IGF 3 TEST AVG + ____

(4) TLHC 3 TEST AVG + ____

NOTE—If testing candidate lubricants in accordance with Specification D 4485, the results of multiple testing should be reported on this form.

FIG. X1.8 Example of Multiple Test Summary Sheet

X2. SAFETY

X2.1 The operating of engine tests can expose personnel and facilities to a number of safety hazards. It is recommended that only personnel who are thoroughly trained and experienced in engine testing should undertake the design, installation, and operation of engine test stands. Each laboratory conducting engine tests should have their test installation inspected and approved by their Safety Department. Personnel working on the engines should be provided with the proper tools, be alert to common sense safety practices and avoid contact with external moving or hot parts. When engines are operating at high speeds, heavy duty guards are required and personnel should be cautioned against working alongside the engine and coupling shaft. Barrier protection should be provided for personnel. All fuel, oil lines, and electrical wiring should be properly routed, guarded, and kept in good order. Scraped knuckles, minor burns, and cuts are common if proper safety precautions are not taken. Safety masks or glasses should always be worn by personnel working on the engines and no loose or flowing clothing should be worn near running engines. The external parts of the engine and the floor area around the engines should be kept clean and free of oil and fuel spills. In addition, working areas should be free of all tripping hazards. In case of injury, no matter how slight, first aid attention should be applied at once and the incident reported. Leaking fuel represents a fire hazard and exhaust gas fumes are noxious. Do not allow containers of oil or fuel to accumulate in the testing area. 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: the engine dynamometer loses field current, engine over-speeds, low oil pressure, high water temperature, exhaust system fails, room ventilation fails, or the fire protection system is activated. Consider an excessive vibration pickup interlock if equipment operates unattended. Fixed fire protection equipment should be provided and dry chemical fire extinguishers should be available at the test stands.