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An American National Standard

Standard Test Methods for Evaluation of Engine Oils in A High-Speed, Single-Cylinder Diesel Engine —1K Procedure (0.4 % Fuel Sulfur) and 1N Procedure (0.04 % Fuel Sulfur)[1]

This standard is issued under the fixed designation D 6750; 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

The test methods described in this standard can be used by any properly equipped laboratory without outside assistance. However, the ASTM Test Monitoring Center (TCM)[2] provides reference oils and an assessment of the test results obtained on those oils by the laboratory (see Annex A16). By this means, the laboratory will know whether its use of the test methods gives results statistically similar to those obtained by other laboratories. Furthermore, various agencies require that a laboratory utilizes 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, these test methods are written for those laboratories that use the TMC services. Laboratories that choose not to use these services may ignore those portions of the test methods that refer to the TMC.

These test methods may be modified by Information Letters issued periodically by the TMC after the publication of this edition of the standard to become part of it. These letters are obtainable from the TMC. In addition, the TMC may issue supplementary memoranda related to the test methods, also obtainable from the TMC.

1. Scope

1.1 These test methods cover the performance of engine oils intended for use in certain diesel engines. They are performed in a standardized high-speed, single-cylinder diesel engine by either the 1K (0.4 % fuel sulfur) or 1N (0.04 % fuel sulfur) procedure.[3] *The only difference in the two test methods is the fuel used*. Piston and ring groove deposit-forming tendency and oil consumption are measured. Also, the piston, the rings, and the liner are examined for distress and the rings for mobility. These test methods are required to evaluate oils intended to satisfy API service categories CF-4 and CH-4 for 1K, and CG-4 for 1N of Specification D 4485.

1.2 These test methods, although based on the original Caterpillar 1K/1N procedures,[3] also embody TMC information letters issued before these test methods were first published. These test methods are subject to frequent change. Until the next revision of these test methods, TMC will update changes in these test methods by the issuance of information letters which shall be obtained from TMC (see Annex A16).

1.3 The values stated in inch-pound units or SI units are to be regarded separately as standard. When inch-pound units are standard, the SI units are shown in parenthesis. The values stated in each system are not necessarily exact equivalents. Because of this, combining values from the two systems may be incompatible. Therefore, use either system independently of the other.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given within the text. Being engine tests, these test methods do have definite hazards which shall be met by safe practices (see Annex A17 on Safety).

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[1] These test methods are under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.B0.02 on Automotive Lubricants.

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[2] ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206-4489.

[3] These 1K/1N test procedures were developed by Caterpillar Inc., P.O. Box 610, Mossville, IL 61552-0610.

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2. Referenced Documents

2.1 *ASTM Standards:*

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

D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester[4]

D 97 Test Method for Pour Point of Petroleum Products[4]

D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[4]

D 235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Drycleaning Solvent)[5]

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

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

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

D 524 Test Method for Ramsbottom Carbon Residue of Petroleum Products[4]

D 613 Test Method for Cetane Number of Diesel Fuel Oil[6]

D 664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration[4]

D 976 Test Methods for Calculated Cetane Index of Distillate Fuels[4]

D 1298 Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method[4]

D 1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption[4]

D 1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)[4]

D 2425 Test Method for Hydrocarbon Types in Middle Distillates by Mass Spectrometry[4]

D 2500 Test Method for Cloud Point of Petroleum Products[4]

D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry[7]

D 2709 Test Method for Water and Sediment in Distillate Fuels by Centrifuge[7]

D 3117 Test Method for Wax Appearance Point of Distillate Fuels[7]

D 3524 Test Method for Diesel Fuel Diluent in Used Diesel Engine Oils by Gas Chromatography[7]

D 4485 Specification for Performance of Engine Oils[7]

D 4737 Test Method for Calculated Cetane Index by Four Variable Equation[7]

D 4739 Test Method for Base Number Determination by Potentiometric Titration[7]

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

[4] *Annual Book of ASTM Standards*, Vol 05.01.
[5] *Annual Book of ASTM Standards*, Vol 06.04.
[6] *Annual Book of ASTM Standards*, Vol 05.05.
[7] *Annual Book of ASTM Standards*, Vol 05.02.

by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES)[8]

D 5186 Test Method for Determination of Aromatic Content and Polynuclear Aromatic Content of Diesel Fuels and Aviation Turbine Fuels by Supercritical Fluid Chromatography[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)[8]

D 5862 Test Method for Evaluation of Engine Oils in Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine[8]

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]

D 6594 Test Method for Evaluation of Corrosiveness of Diesel Engine Oil at 135°C[9]

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

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System[11]

2.2 *SAE Standard:*

SAE J183 Engine Oil Performance and Engine Service Classification[12]

2.3 *API Standard:*

API 1509 Engine Service Classification and Guide to Crankcase Oil Selection[13]

3. Terminology

3.1 *Definitions:*

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

3.1.1.1 *Discussion*—This is a coded reference oil that is submitted by a source independent from the test facility. **D 5844**

3.1.2 *calibration test*, *n*—an engine test conducted on a reference oil under carefully prescribed conditions, the results of which are used to determine the suitability of the engine stand/laboratory for such tests on non-reference oils.

3.1.2.1 *Discussion*—A calibration test also includes tests conducted on parts to ensure their suitability for use in reference and non-reference tests.

3.1.3 *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.

3.1.3.1 *Discussion*—In several automotive lubricant standard test methods, the TMC provides testing guidance and determines acceptability. **Sub. B Glossary[2]**

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

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

3.1.6 *double-blind test*, *n*—a standard test performed on a double-blind reference oil.

3.1.7 *double-blind reference oil*, *n*—a reference oil, the identity of which is unknown by either the submitting source or the test facility and is not known to be a reference oil by the test facility.

3.1.7.1 *Discussion*—This is a coded reference oil that is supplied by an independent source to a second party, who applies their own coded designation to the oil (and if necessary, repackages it to preserve its anonymity), and submits it to a third party for testing. **Sub. B Glossary**

3.1.8 *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 the pistons; and serves as a combustion gas sealant for the piston rings.

3.1.8.1 *Discussion*—It may contain additives to enhance properties. Inhibition of engine rusting, deposit formation, valve train wear, oil oxidation, and foaming are examples. **D 5862**

3.1.9 *erosion*, *n*—wearing away gradually, especially by rubbing or corroding.

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

3.1.11 *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**

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

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

3.1.13.1 *Discussion*—The preferred term is *purchaser*. Deprecated terms that have been used are *client*, *requestor*, *sponsor*, and *customer*. **D 6202**

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

3.1.14.1 *Discussion*—Reference oils are used to calibrate testing facilities, to compare the performance of other oils, or to evaluate other materials (such as seals) that interact with oils. **D 5844**

3.1.15 *soot*, *n—in internal combustion engines*, submicron size particles, primarily carbon, created in the combustion chamber as products of incomplete combustion. **D 5862**

3.1.16 *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.

[8] *Annual Book of ASTM Standards*, Vol 05.03.
[9] *Annual Book of ASTM Standards*, Vol 05.04.
[10] *Annual Book of ASTM Standards*, Vol 14.02.
[11] *Annual Book of ASTM Standards*, Vol 14.04.
[12] Available from the Society of Automotive Engineers Inc., 400 Commonwealth Dr., Warrendale, PA 15096. Order *SAE Handbook*, Vol 3; the standard is not available separately.
[13] Available from the American Petroleum Institute, 1220 L St., NW, Washington, DC 20005.

3.1.16.1 *Discussion*—In some instances, such as a test method for chemical analysis, an ASTM working group can be the *sponsor* of a 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 test method, but is the *sponsor*, of the test method **D 6594**

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

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

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

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *heavy land carbon*, *n*—see CRC Manual 18.[14]

3.2.2 *Keystone ring*, *n*—a compression ring with both sides tapered.

3.2.3 *liner bore polishing*, *n*—see CRC Manual 18.

3.2.4 *new laboratory*, *n*—a laboratory that has not had two acceptable reference oil test results on approved reference oils (see special circumstances in 3.2.5.1).

3.2.4.1 *Discussion*—A laboratory not running either a 1K or 1N test for 24 months from the start of the last test is considered a new laboratory. Under special circumstances (such as extended downtime due to industry-wide parts shortage or fuel outages), the TMC may extend the lapsed time requirement. Non-reference oil tests conducted during an extended time allowance shall be annotated on the comment form.

3.2.5 *new test stand*, *n*—a test engine and support hardware that has never been calibrated under this test procedure.

3.2.6 *scratching*, *n*—see CRC Manual 18.

3.2.7 *scuffing*, *n—in lubrication*, see CRC Manual 18.

3.2.8 *test time*, *n—in this test method*, all engine test time accumulated when carrying out this test procedure.

3.2.9 *varnish*, *n—in internal combustion engines*, see CRC Manual 18.

3.3 *Abbreviations:*

3.3.1 *BDC*—bottom dead center.

3.3.2 *BSOC*—break specific oil comsumption.

3.3.3 *EOT*—end of test.

3.3.4 *EOTOC*—end of test oil consumption.

3.3.5 *EWMA*—exponentially weighted moving average.

3.3.6 *LTMS*—TMC Lubrication Test Monitoring System.

3.3.7 *SA*—severity adjustment.

3.3.8 *TDC*—top dead center.

3.3.9 *TGF*—top groove fill.

3.3.10 *TLHC*—top land heavy carbon.

3.3.11 *WDK*—weighted demerits (1K).

3.3.12 *WDN*—weighted demerits (1N).

4. Summary of Test Method

4.1 A Caterpillar 1Y540 diesel engine, or a 1Y73 diesel engine with a 1Y541 conversion arrangement (see 6.2), is built up prior to test (either 1K or 1N test procedure) in accordance with the accompanied directions using a special parts kit. These include disassembly, solvent cleaning, measurement, and rebuild of the power section in strict accordance with specifications. The parts comprise a new piston, ring assembly, and cylinder liner which are measured and installed prior to test. The engine crankcase is solvent cleaned and worn or defective parts replaced. The test stand is equipped with appropriate accessories for controlling speed, load, and various other engine operating conditions. Suitable systems are provided for treating the inlet air and controlling the exhaust gases. Using the test oil as the engine lubricating oil, the single cylinder, calibrated diesel engine is run for a total of 252 h under the prescribed test conditions. A specified break-in procedure precedes each test and whenever the engine needs to be restarted. During the test, engine oil consumption is periodically measured. At the end of the test (either 1K or 1N), the engine is disassembled and the piston, liner, and rings photographed, inspected, and measured. Average oil consumption and used oil condition data are also recorded.

5. Significance and Use

5.1 These are accelerated engine oil tests (known as the 1K and 1N test procedures), performed in a standardized, calibrated, stationary single-cylinder diesel engine using either 0.4 % sulfur fuel (1K test) or 0.04 % sulfur fuel (1N test), that give a measure of (*1*) piston and ring groove deposit forming tendency, (*2*) piston, ring and liner scuffing and (*3*) oil consumption. Test results from these procedures have been correlated with test results from field engines; that is, certain multi-cylinder direct ignition engines under heavy duty service prior to 1990. Correlation was particularly good with regard to piston and ring groove deposits.[15] These test methods are used in the establishment of diesel engine oil specification requirements as cited in Test Method D 4485 for appropriate API Performance Category C oils (API 1509). These test methods can also be used in diesel engine oil development.

6. Apparatus

6.1 *General Laboratory Requirements*:

6.1.1 *Engine Operation and Buildup Area*—Keep the ambient air free from gross dirt, dust, and other contamination, especially in the build-up area, following accepted engine test laboratory practice.

[14] Available from the Co-ordinating Research Council Inc., 219 Perimeter Center Pkwy., Atlanta, GA 30346.

[15] ASTM Research Reports RR:D02:1273 and RR:D02-1321 on the Caterpillar 1K/1N procedures are available from ASTM International Headquarters.

6.1.2 *Measurement Area*—As good practice, maintain this area at about 50 to 75°F (10 to 25°C). The actual air temperature is not critical within this range, but maintain it within ± 5°F (3°C) to achieve acceptable repeatability in the measurement of dimensions of parts. Filter the air supply to the area to remove particles larger than about 400 µin. (10 µm) and maintain at 45 to 65 % relative humidity. If unable to do this, keep the air free from gross particulate contamination as indicated in 6.1.1.

6.1.3 *Parts Rating Area*—Maintain as specified in the Appendix of CRC Manual No. 18.

6.1.4 *Parts Cleaning Area*—(**Warning**: Provide adequate ventilation and fire protection in areas where solvents are used (see Annex A17).

6.2 *Test Engine*—The test engine for these 1K and 1N test procedures is either (*a*) a Caterpillar 1Y540 engine[16] or (*b*) a Caterpillar 1Y73 engine with a 1Y541 conversion arrangement[16]. Details are given in the Caterpillar Service Manual.[16] Each test engine (*a*) is a direct injection, single-cylinder diesel engine with a four-valve arrangement, (*b*) has a 137.2 mm (5.4 in.) bore and a 165.1 mm (6.5 in.) stroke resulting in a 2.4 L (148.8 in.^{3}) displacement and (*c*) is equipped with a number of modified and unmodified accessories which are described in 6.3. See Annex A1 for specifications for engine build.

6.3 *Test Engine Accessories and Parts*—Many of the accessories of the assembled Caterpillar engines (see 6.2) require modifications for these test methods. These modifications are described herewith.

6.3.1 *Intake Air System*—The system comprises an air heater chamber, isolation hose and appropriate piping. Construction details are given in Annex A2. To ensure good precision, the system shall be uniform within a laboratory and among laboratories. The system shall be capable of filtering, heating, compressing, and humidifying the inlet air in accordance with the specified engine operating conditions in Annex A10.

6.3.1.1 *Filtering*—Use an air filter capable of 10µm (or smaller) filtration.

6.3.1.2 *Heating*—Heating shall be provided to heat the intake air to the specified temperature. Locate the air temperature measurement tap at the P/N 1Y632 adapter (see Annex A2). For air barrels mounted horizontally, the location of the pressure tap and air outlet pipe may be interchanged (see Annex A2).

6.3.1.3 *Compressing*—Provide air compression capability. Locate the intake air pressure measurement tap at the air barrel (see Annex A2). When air barrels are mounted horizontally, the locations of the pressure tap and air outlet pipe may be interchanged (see 6.3.1.2).

6.3.1.4 *Humidifying*—The equipment shall be capable of humidifying compressed air to 17.8 g H_2O/kg (125 grains/lb) of dry air and maintaining the humidified inlet air at a specified temperature. See Annex A2 for location of humidity measurement tap.

6.3.1.5 *Inspection of Air Intake Barrel*—Prior to each stand calibration test, inspect the intake air barrel for rust and debris. Perform the inspection through either of the pipe flanges using a borescope or other optical means.

6.3.2 *Exhaust System*—The exhaust system comprises an exhaust elbow, a welded 45 ° pipe nipple, a bellows assembly, an exhaust barrel, and exhaust piping downstream of the barrel that contains a restriction valve to maintain the exhaust gases at back pressures up to 64 ± 0.3 in. Hg (216 ± 1 kPa). Drawings of the component parts, dimensions, and instrument locations are given in Annex A3. The exhaust system shall also provide for exhaust gas temperature measurement and exhaust gas sampling, the exhaust gas temperature range being 550 ± 30°C.

6.3.2.1 *Exhaust Barrel*—The exhaust barrel may be insulated or water-cooled. Place the new exhaust elbow P/N 1Y631-2 (see Annex A3) at the rear side or front of the engine. The volume of the exhaust barrel and the dimensions and distance of the exhaust piping from the exhaust elbow to the barrel are specified in Figs. A3.1 to A3.4. The downstream distance of the restriction valve from the exhaust barrel is not specified.

6.3.2.2 *Exhaust Probe*—Use an exhaust probe to sample exhaust gases for air/fuel ratio determinations. Install the probe using a suitable reducer and compression fitting within 1.2 m (4 ft) downstream of the exhaust restriction valve. Locate the probe in mid-stream and parallel to the exhaust flow as shown in Fig. A3.5.

6.3.2.3 *Exhaust Temperature*—Measure the exhaust temperature with thermocouple P/N 1Y467 or equivalent located as shown in Fig. A3.4.

6.3.2.4 *Exhaust Pressure*—Measure the exhaust pressure in the exhaust barrel as shown in Fig. A3.2. Set the pressure at the conditions specified in Table A10.1 by adjusting the restriction valve.

6.3.3 *Cooling System*—Provide a closed circulating cooling system with an engine-driven centrifugal water pump. System details as given in Figs. A4.1 to A4.4 show (*a*) cooling system modifications; (*b*) coolant temperature, flow and pressure measurement locations; and (*c*) a water pump bypass arrangement. See 6.3.3.5 regarding system cleaning.

6.3.3.1 *Cooling System Modification*—Modify the cooling system as shown in Fig A4.4.

6.3.3.2 *Coolant Flow, Control and Measurement*—Modify the engine coolant lines from the cylinder head to the standpipe in accordance with Fig. A4.1. As shown, the coolant line contains (*a*) a calibrated, 25.4 mm (1.0 in.) Barco flowmeter, P/N BR 12705-16-31[17] to measure the coolant flow and (*b*) a P/N 1Y496 orifice, 15.797 mm (0.618 in.) in diameter before the flowmeter to develop cooling system pressure and thereby to eliminate coolant cavitation. Control coolant flow at 65 ±

[16] Available from Caterpillar Inc., Engine System Technology Development, P.O. Box 610, Mossville, Il 61552-0610. Service and parts manuals available are (*1*) Caterpillar Service Manual for Single Cylinder Oil Test Engine for Diesel Lubricants, Form No. SENR2856 and (*2*) Caterpillar Parts Book, Form No. SEBP1408.

[17] The Barco flowmeter (Venturi Meter) is available as P/N No. BR12705-16-31 from Aeroquip Co., Maddock Mechanical Industries, 833 N. Orleans, Chicago, IL 60610.

2.0 L/min (17.3 gal/min) at Step 5 (see Table A10.1) by a 3/4 in. bypass valve down-stream of the water pump. Replace the production hose and the restrictive 90° elbows that connect the bypass valve to the cylinder block by a Gates 20777 hose[18] or equivalent (see Fig. A4.3). Measure the coolant pressure at the block to ensure that proper cooling system operation has been attained (see Fig. A4.2).

6.3.3.3 *Engine Temperature Differential*—As an indicator of coolant system performance, maintain the engine temperature differential (ΔT) (coolant temperature out of the cylinder head minus coolant temperature into the block) at 5.0 ± 1.0° C (9.0 ± 1.8 °F). Also control the coolant temperature out at 93± 2.5 °C (199.4 ± 4.5 °F).

6.3.3.4 *Engine Coolant*—The engine coolant is a mixture of 50/50 volume ratio of coolant (Caterpillar brand P/N 8C3684 in a gallon container or P/N 8C3686 in a 55-gal drum)[19] to mineral-free water, the mineral content being ≤34.2 ppm (2 grains/gal) of total solids in water. This coolant mixture may be used for up to six tests or three months, whichever comes first. Maintain the mixture at a 50/50 ratio of coolant to water and verify periodically with either a Caterpillar tester P/N 5P3514 or P/N 590957 or equivalent commercial tester. Keep the coolant mixture substantially free from solids contamination (total solids <5000 ppm) and at the correct additive level by checking with test kit P/N 8T5296.

6.3.3.5 *Cooling System Cleaning Procedure, General*—Clean the system when visual inspection shows the presence of (*a*) oil or grease (see 6.3.3.6), (*b*) mineral deposits or rust, or both (see 6.3.3.7). *When the cooling system is contaminated by both oil and scale, first remove the oil, then remove the scale.* Cylinder head coolant passages also may be cleaned after the head is removed.

6.3.3.6 *Removal of Oil and Grease from Cooling System*—Follow these steps:

(*1*) Operate the engine until the engine oil and coolant water reach operating temperatures and then shut down the engine and drain the coolant from the cooling system.

(*2*) Fill the cooling system with oil/grease cleaning solution comprising 454 g (1 lb) of trisodium phosphate (Na_3PO_4) dissolved in 38 L (10 gal) of water. Run the engine for 5 min to ensure complete solution with any engine coolant left in the cooling system from (*1*).

(*3*) Shut down the engine, drain the oil/grease cleaning solution and flush the cooling system with fresh water. Drain the water from the system.

6.3.3.7 *Removal of Scale from Cooling System*—Follow these steps:

(*1*) Operate the engine until the engine oil and coolant water reach operating temperatures and then shut down the engine and drain the coolant from the cooling system.

(*2*) Fill the cooling system with scale cleaning solution comprising 454 g (1 lb) of commercial sodium bisulfate ($NaHSO_4$) dissolved in 38 L (10 gal) of water. Run the engine at operating temperatures for 30 min.

(*3*) Shut down the engine, drain the scale cleaning solution, and flush the cooling system with fresh water. Drain the water from the system.

(*4*) Fill the system with oil/grease cleaning solution comprising 454 g (1 lb) of trisodium phosphate (Na_3PO_4) dissolved in 38 L (10 gal) of water. Run the engine for 5 min to ensure complete solution with any water left in the cooling system from (*3*).

(*5*) Shut down the engine, drain the oil/grease cleaning solution and flush the cooling system with clear water. Drain the water from the system.

(*6*) Disassemble the engine and prepare for the next test.

6.3.4 *Dynamometer*—Use a dynamometer or other suitable loading device to maintain and control engine load and speed.

6.3.5 *Engine Starting System*—Use an engine starting system capable of delivering to the engine 136 N.m (100 lbf-ft) breakaway and 102 N.m (75 lbf-ft) sustained torque at 200 r/min.

6.3.6 *Engine Instrumentation*—Locations of the various measurement sensors and taps, and installation details and calibration requirements are given as follows: (*1*) for intake air system (see 6.3.1 and Annex A2); (*2*) for exhaust system (see 6.3.2 and Annex A3); (*3*) for cooling system (see 6.3.3 and Annex A4); (*4*) for oil system modifications, see Annex A5; and (*5*) for other locations, see Annex A6.

6.3.6.1 *Thermocouples*—Install the thermocouples or equivalents to a depth such that the sensor tip rests in the middle of the fluid stream at the following specified temperature measurement locations:

air-to-engine – P/N 1Y468 (see Annex A2)
engine exhaust – P/N 1Y467 (see Annex A3)
fluids, water, oil, fuel – P/N 1Y466 (see Annexes A5 and A6)

6.3.6.2 Locate the instruments for measuring fuel pressure and fuel temperature as shown in Fig. A6.1.

6.3.6.3 Locate the instrument for measuring crankcase pressure to the crankcase as shown in Fig. A6.2.

6.3.6.4 *Calibration of Instruments*—Calibrate all facility read-out instrumentation used for the test immediately prior to commencing a test stand calibration sequence. The test laboratory may, at its own discretion, carry out instrumentation calibrations prior to subsequent stand calibration tests, that is, those that follow a failed or invalid first attempt. Refer to Annex A12 for calibration tolerances and allowable time constants.

6.3.6.5 *Calibration of Instrument Measurement Standards*—Calibrate, annually, all temperature, pressure, and speed measurement standards themselves against *recognized national standards*. Maintain a record of these calibrations for at least two years.

6.3.7 *Standardized Fuel System and Fuels*—To ensure that fuel line pressure transients are held to acceptable conditions, install the fuel system components as specified in the service manual accompanying the diesel engine, taking especial care to use the high pressure fuel lines and fuel pump components described therein. In addition, the system shall have a fuel consumption measuring device (see 6.3.7.1), a fuel return line with a check valve (see 6.3.7.2) or shut-of solenoid (see 6.3.7.3). Install instruments for measuring fuel pressure and

[18] The Gates hose, P/N 20777, is available from The Gates Rubber Co., 900 S. Broadway, Denver, CO 80217-5887.

[19] Available from Caterpillar Inc. , Caterpillar Brand antifreeze, P/N 8C3684 (1-gal) or P/N 8C3686 (55-gal drum).

temperature in the locations shown in Fig. A6.1. Control fuel pressure and temperature in accordance with the requirements for engine operating conditions in Table A10.1. Change the fuel filter when the pressure deviates from specification requirements.

6.3.7.1 *Fuel Consumption Measuring Device*—Install a suitable fuel consumption measuring device to keep fuel consumption rates within required tolerances. Maintain the fuel flow transducer filter time constant at 73 s max. There shall be no variation in fuel transfer pump pressure or exhaust temperature when switching from the engine operating fuel system to the fuel rate measuring system.

6.3.7.2 *Fuel Return Line*—The fuel return line runs from the 1.19 mm (0.047 in.) D orificed tap, through the P/N 307946 elbow at the fuel pump, to the fuel scale. This line provides fuel temperature stabilization at the pump and also allows entrained air to be expelled from the system. Place a check valve or shut-off solenoid in the return line to prevent fuel from backing into the pump during engine shutdown.

6.3.7.3 *Shut-off Solenoid*—A P/N 9L8791 solenoid or equivalent should be placed at the pump housing fuel inlet to control the fuel flow. Location of the solenoid near the fuel pump decreases the fuel volume available to the pump and can reduce shut-down time if the solenoid is activated by the engine oil/water pressure safety circuit.

6.3.7.4 *Fuels*—The test fuels are obtainable from Haltermann Products[20] as LLC 0.4 % sulfur diesel test fuel (see 7.2.1) for the 1K test and LLC low sulfur research diesel fuel (LSRD-4, 0.04 % sulfur) (see 7.2.2) for the 1N test. The fuels are essentially the same in properties (although specification limits show minor variations (compare Tables A8.1 and A8.2)), except, as shown, for the marked difference in sulfur contents. Use the high heating value to calculate the fuel rate as specified in Annex A10 and Table A12.2. Include the fuel analysis for the last batch used for the test in the final report form (Fig. A13.20, Form 17). The fuel analysis is provided by the fuel supplier. If more than one batch is used, this shall be noted in the comments section of the report with appropriate percentages of run time. Take a sample of the fuel used in the stands calibrated for both 1K and 1N tests prior to each test and have it analyzed for sulfur. Report the results of this analysis in the comment section.

6.3.8 *Engine Lubrication System*—Use the lubrication system of the engine (see 6.2), but make modifications as shown in Annex A5 to the (*a*) remote mount oil pump relief valve (see Fig. A5.1), (*b*) oil pump relief valve plug (see Fig. A5.2), (*c*) oil pump accessory drive drain (see Fig. A5.3) and (*d*) oil filter housing assembly (see Fig. A5.4). The engine lubrication system itself is shown in Fig. A9.1.

6.3.8.1 *Engine Oil Temperature and Pressure Measurement Locations, and Operating Conditions*—Locations of the measurement points are shown in Figs. A5.5 through A5.7. The oil cooling jet pressure and the oil to manifold temperature limits are given in Table A10.1. Record other oil pressure and temperature readings, as necessary, to monitor the operational conditions of the engine and its lubrication system.

6.3.8.2 *Engine Oil Scale System*—Install an engine oil scale system to measure accurately engine oil consumption (see Fig. A5.8). The system shall have a capacity to measure about 6 L (5 kg (11 lbs)) of engine oil to within 4.5 g (0.01 lb). The hoses[21] to and from the oil scale reservoir shall be of sufficient flexibility to eliminate measurement errors. Hose length to and from the oil scale cart shall be 2.7 m (9 ft) max.

6.3.8.3 *Oil Filter Replacement*—Replace the P/N 1Y636 factory oil/filter group by the new P/N 1Y0699 filter group. Fit the original oil lines directly into the mounting bracket as on the P/N 1Y7277 bracket. Attach the oil line from the oil cooler, to the lower oil hole, and the line to the oil manifold to the upper hole. The base assembly includes a pressure sensitive bypass around the filter. Install the last chance screen P/N 1Y3549. Disassemble and clean the oil filter bypass valve before each test.

6.3.8.4 *Oil Pump Modifications*—Modify the oil pump (see Fig. A5.1) by (*a*) adding an external oil pump bypass to safely and conveniently adjust oil pressure on engine break-in and warm-up; (*b*) routing directly the oil pump drive housing drain line to the oil pan to ensure proper drainage of the housing; and (*c*) tapping deeper the oil bypass port and installing a bolt to fill the dead oil space (see Fig. A5.2).

6.3.9 *Gas Meter for Measuring Engine Blowby*—Measure the engine blowby with a displacement type gas meter or equivalent fitted with an oil separator and surge chamber. Attach the meter to the engine in two steps. First, attach the fitting on the P/N 1Y479 valve (see Table A15.1) to the crankcase breather; then attach the meter by way of this fitting to the engine by using appropriate length of hose and pipe. When switching from a normal operating system to the blowby measuring system, allow no more than a minimal increase in crankcase pressure for a period not exceeding 4 min.

6.3.10 *Procurement of Parts and Warranty*—Obtain information concerning the test engine, new engine parts, replacement parts and permissible substitution of replacement parts from Caterpillar, Inc. (see A15). Table A15.1 shows a listing of parts by part numbers (P/N) referenced in these 1K/1N standard methods, while A15.2 provides information on parts warranty.

7. Reagents and Materials

7.1 *Engine Coolant*—A mixture of equal volumes of mineral-free [total dissolved solids, ≤ (34.2 ppm) (2 grains/gal) (0.03 g/L) max.] water and Caterpillar brand antifreeze, P/N 8C3684 (see Table A15.1) in a 1-gal container, or P/N 8C3686 (see A15) in a 55-gal drum. (**Warning**—Combustible. Health hazard.)

7.2 *Test Fuels*:

7.2.1 *Test Fuel for 1K Test*—Diesel test fuel containing 0.4 mass % natural sulfur known as 0.4 % sulfur diesel test fuel (SDTF)[20]. The specification for this fuel is given in Table A8.1. (**Warning**—Combustible. Health hazard.)

[20] Available from Haltermann Products, Ten Lamar, Ste. 1800, Houston, TX 77002.

[21] Gould/Imperial Eastman flexible hoses, P/N C405-100 or equivalent are suitable.

7.2.2 *Test Fuel for 1N Test*—Diesel test fuel containing 0.04 mass % natural sulfur known as low sulfur diesel test fuel (LSRD-4)[20]. The specification for this fuel is given in Table A8.2. (**Warning**—Combustible. Health hazard.)

7.3 *Stoddard Solvent*, Specification D 235, Part 1. (**Warning**—Combustible. Health hazard.)

7.4 *Dispersant Engine Cleaner*—[22] (**Warning**—Use with adequate safety precautions.)

7.5 *Aqueous Detergent Solution*, prepared from a commercial laundry detergent.

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

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

7.8 *Pentane*—Any mixture of branched and normal aliphatic hydrocarbons containing at least 95 volume % of pentanes and not more than a total of 0.5 volume % hydrocarbons $< C_4$ and $> C_6$. (**Warning**—Flammable. Health hazard.)

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

7.10 *Test Oil*—See test oil sample requirements (see Section 8).

7.11 *Engine Oil*, for shakedown run, use REO 217 available from CRC.

7.11.1 *Engine Oil, Substitute*, for oiling cylinder liner and when test oil unavailable at assembly, use Exxon-Mobil EF-411 oil.[23]

7.12 *Lead Shot*, [24]approximately 5 mm (0.2 in) in diameter.

7.13 *Light Grease*. [25]

7.14 *Diesel Piston Rating Equipment*.

7.14.1 *Diesel Piston Rating Lamp*—See A11.5.

7.14.2 *Diesel Piston Rating Booth*, of plywood, 1200 mm × 775 mm × 648 mm (see A11.6).

7.15 *Valve Guide Honing Equipment*—see A1.2.

7.15.1 *Sunnen P-300 Dial Bore Gage.*[26]

7.15.2 *Sunnen P-375 Probe*.

7.15.3 *Ralmike's Ringmaster Set*, to set P-300 gage.[27]

7.15.4 *Stanley Model D-30LR-4 Air Drill*, 400 r/min.[28]

7.15.5 *Sunnen Honall P-180 Hone Head and Driver Group*.

7.15.6 *JK-12-370AS Mandrell*. [26]

7.15.7 *PK-12A Adapter*. [26]

7.15.8 *LN-3702A Stone Retainer*. [26]

7.15.9 *K-12-J68 Stones*. [26]

7.15.10 *S-370 Truing Sleeve*. [26]

7.15.11 *MAN-845-5 Sunnen Hone Oil*, 5 gal.

7.15.12 *LBN-700 Stone Dresser*. [26]

7.15.13 *VST-2012 Perfect Circle Seal Groove Tool*. [16]

7.15.14 *Sunnen P-180 Head and Driver*.

7.15.15 *Sunnen B-L-12-370AS Mandrell*.

7.15.16 *L-12-J68 Stones*. [26]

7.15.17 *LN-3167A Stone Retainer*. [26]

7.16 *Gages*—One Ring, Four Feelers and One Taper (optional, see 9.3.3).[28]

8. Test Oil Sample Requirements

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

8.2 *Inspection*—New oil baseline inspection requirements are described in Fig. A13.9 (Form 6).

8.3 *Quantity*—A total of approximately 10 US gal (38 L) of test oil are required to run the test.

9. Preparation of Apparatus

9.1 *Engine Inspection*:

9.1.1 *General*—Completely inspect the engine at an interval of every second test stand calibration run or 18 months, whichever comes first, the aim being to 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, are within manufacturer's specifications. Refer to the 1Y540 Service Manual for engine disassembly, assembly, inspections, and specifications requirements [16]. This inspection shall terminate the stand's current calibration (see Section 10), if any. Re-calibrate whenever the crankshaft is removed for any purpose other than bearing replacement.

9.1.2 *Engine Instrumentation*—Inspect and recalibrate periodically instruments (with their accompanying probes or sensors) of the engine, including those of the fuel and cooling systems (see 6.3.3, 6.3.6 and 6.3.7).

9.1.3 *New and Converted Engine Crankcases*—Inspect new and converted engine crankcases to ensure the presence of a proper paint coating. Coat crankcases, as needed, with either of the two approved paints.[29]

9.1.4 *Cooling Jets*—Measure the internal diameters of cooling jet tubes. Reject tubes that do not meet specification requirements.

9.1.5 *Shakedown Run After Rebuild*—Perform a shakedown run after rebuild using REO 217 engine oil obtainable from CRC (see 7.11). Continue with the run until two consecutive 12-h periods show a stable copper level in the engine oil. Ensure that the valve opening and closing tolerance on the camshaft is ± 4 crankshaft degrees.

9.2 *Engine Pre-Test Lubrication System Flush*:

9.2.1 *Preparation*—To ensure proper flushing and draining, drill a hole in the oil pump accessory drive housing and install a plug (see Fig. A5.3).

9.2.2 *Flushing/Cleaning Summary*—Flush and clean the lubrication system before each test so as to remove deposits

[22] Dispersant engine cleaner may be ordered from The Lubrizol Corp., 29400 Lakeland Blvd., Cleveland, OH 44092.

[23] A suitable engine oil is Exxon-Mobil EF411. It is available from Exxon-Mobil Oil Corp., Att: Illinois Order Board, P.O. Box 66940, AMF-O'Hare, IL 60666. Request P/N 47503-8.

[24] Lead shot is available as 375 DIABOLO, 22 cal (5.5 mm) 14.3 gr. pellets from Benjamin Sheridan, Racine WI 53403.

[25] Light grease is available as AMOCO, RYKON Premium Grease from Eddins-Walcher Co., 9421 Andrews Highway, Odessa, TX 79765.

[26] Available from Sunnen Products Co., 7910 Manchester Road, St. Louis, MO 63143.

[27] Available from Ralmike Tool-A-Rama, 4505 S. Clinton Ave., South Plainfield, NJ 07080.

[28] Available from Stanley Tool Div., 700 Beta Dr., Cleveland, OH 44143.

[29] Either of the following two paints is acceptable: (*1*) In one gallon cans, Yellow Primer Paint Cat Part No. IE2083A, Primer No. A123590, Serial No. BIMO115877, B.A.S.F. Part No. U27YD005, obtainable from B.A.S.F. Coating and Colorant Div., P.O. Box 1297, Morganton, NC 28655 and (*2*) Glyptal 1201 Red Enamel, obtainable from Brownell Outlet, 84 Executive Avenue, Edison, NJ 08817.

from surfaces of all engine cavities. To achieve this, flush the crankcase of used oil by a series of liquid flushes in eleven steps as follows (see Fig. A9.2): (*1*), with Stoddard solvent (Step 1), (*2*), with a mixture of Stoddard solvent and a dispersant engine cleaner (Step 2), (*3*) with additional repeated flushes with Stoddard solvent until the solvent remains clean (Steps 3 to 6 or 7 as necessary) and (*4*) a flush of the lubrication system and crankcase with the test oil to remove the solvent before it is drained (see 9.2.3 on cooling jet alignment). This test oil flush is also used to check alignment of the piston cooling jet (see 9.2.3). Finally, double flush the engine crankcase with test oil before starting the test (see Fig. A9.2, Steps 9 to 11). If the test oil is not available at engine assembly use Exxon-Mobil EF411 engine oil.

9.2.3 *Cooling Jet Alignment*—Use the final test oil flush (see Fig. A9.2) that removes the remaining solvent to check alignment of the piston cooling jet by using a poly(methyl methacrylate) top piston. Alignment may be done with either the jug assembly or the alignment fixture (see Figs. A9.10, A9.11 and A9.12).

9.2.4 *Cleaning of Some Other Components*—Before each test clean the oil weigh system. Also disassemble and clean the engine oil bypass valve. On occasion extra cleaning may be required.

9.2.5 *Additional Oil Filter*—Install a full-flow paper element filter in the flushing unit to remove engine wear particles during the engine flush. TEI CLR engine oil filter housing No. 2418 and filter element No. 3105[30] have been found satisfactory for this purpose. These particles have been known to cause piston scuffing during subsequent tests.

9.2.6 *Flushing Procedure Components*—Use the components shown in Figs A9.3 through A9.12 to conduct the engine flushing procedure. (See Fig. A9.8 (Views A and B) of flushing component location). A dummy engine oil filter may be used during the flush sequence.

9.2.7 *Flushing Procedures*—(See, also, Fig. A9.2):

9.2.7.1 With the crankcase breather secured to the side of the crankcase and the connecting rod assembled on the crankshaft, rotate the crankshaft until the top end of the connecting rod is below the cylinder block bore in the top of the crankcase.

9.2.7.2 Install the poly(methyl methacrylate) or clear plastic cover (see Fig. A9.3) on the top surface of the crankcase as shown in Fig. A9.8 (View A).

9.2.7.3 Install a new P/N 8N9586 (see Annex A15) engine oil filter and a clean P/N 1Y5700 (see Annex A15) element in the flushing pump oil filter housings. Change both oil flush cart filters after each engine flush.

9.2.7.4 Connect the flushing pump outlet hose to the engine oil cooler drain location.

9.2.7.5 Remove breather assembly P/N 1Y2592 (see Annex A15) (top portion of the side assembly) and clean separately by soaking in Stoddard solvent. Air dry.

9.2.7.6 Insert the P/N 1Y653 (Annex A15) rocker shaft oil line in the center opening of the clear plastic cover (see Fig. A9.3).

9.2.7.7 Place the flushing pump inlet in a clean supply tank containing 7.6 L (2 gal) of Stoddard solvent. Open the crankcase drain, start the flushing pump and oil scale pumps and run this material once through the engine into a drain pan. Do not recirculate. Drain oil scale reservoir.

9.2.7.8 Close the crankcase drain and connect the flushing pump inlet line to the crankcase drain. Add to the crankcase 7.6 L (2 gal) of a flushing mixture comprising 1.9 L (0.5 gal) of dispersant engine cleaner and 5.7 L (1.5 gal) of Stoddard solvent.

9.2.7.9 Connect the flushing pump outlet line to the engine oil cooler drain location. Open the crankcase drain valve, start the flushing pump and oil scale pumps and circulate the flushing mixture through the engine for approximately 15 min. Turn off the pumps, but do not drain the flushing mixture from the crankcase. Open completely the oil pressure regulator during flushing.

9.2.7.10 Close the oil cooler drain valve, disconnect the flushing pump outlet hose from the oil cooler drain location and connect to the crankcase sprayer (see Fig. A9.5).

9.2.7.11 Remove the P/N 1Y653 (see Annex A15) oil line from the poly(methyl methacrylate) coverhole and insert the crankcase sprayer through the opening in the poly(methyl methacrylate) cover. Start the flushing pump and oil scale pumps and spray the interior of the crankcase by slowly moving the sprayer around and into all accessible areas of the crankcase (see Fig. A9.8, View A) for approximately 10 min. Turn off the pumps, but do not drain the flushing mixture from the crankcase. Insert the crankcase sprayer into the oil scale reservoir and start the flush pump and oil scale pumps. Spray the reservoir for 10 min. Turn off the pumps, but do not drain the flushing solution from the crankcase.

9.2.7.12 Remove the one-half in. pipe plug from the modified 1Y1990 governor housing cover (see Fig. A9.6). Insert the crankcase sprayer (see Fig. A9.5) through the opening in the governor housing cover. Start the pumps and spray the interior governor housing for about 10 min. Turn off the pumps, but do not drain the flushing solution from the crankcase.

9.2.7.13 Remove the oil spout assembly from the front of the crankcase and install the front cover sprayer (see Fig. A9.7) as shown in Fig. A9.8.

9.2.7.14 Connect the flushing pump outlet to the 0.64 cm (1/3 in.) × 12.7 cm (5 in.) fitting. Start the flushing pump and oil scale pumps and spray the interior of the front cover for about 10 min. Drain the crankcase, governor housing, engine and flushing pump unit filters, oil cooler and oil pump accessory drive housing, and oil scale reservoir. Discard the drained flushing mixture.

9.2.7.15 Using Stoddard solvent, repeat steps 9.2.7.9-9.2.7.14 until the Stoddard solvent discharge is clean. Three to four flushes with Stoddard solvent are usually sufficient to remove all traces of the flushing mixture from the engine.

[30] The oil filter, P/N 2418 and filter element, P/N 3105 are available from Test Engineering, Inc., 12718 Cimarron Path, San Antonio, TX 78249.

9.2.7.16 Drain the Stoddard solvent from the crankcase, governor housing, engine and flushing pump unit filters, oil cooler, oil pump accessory drive housing, and oil scale reservoir.

9.2.7.17 Prepare the flush with test oil by blocking off the 1Y653 oil line to the rocker arm shaft and installing the 1/4 in. (0.635 cm) fitting (see Fig. A9.9) on the open end of the line. Close all drain openings.

9.2.7.18 Using the flushing pump, add 4.7 L (5 qt) of test oil to the engine crankcase through the engine oil cooler.

9.2.7.19 Connect the flushing pump outlet to the engine oil cooler drain location. Start the flushing pump and oil scale pumps and force any Stoddard solvent left in the system out through the crankcase drain. After the Stoddard solvent has been forced out of the system, connect the inlet line of the flushing pump to the crankcase drain. Install the *dummy* piston and the assembled cylinder block and liner. The *dummy* piston with a poly(methyl methacrylate) top is shown in Figs. A9.10 and A9.11. Re-install the oil filler spout and 1.27 cm (1/2 in.) pipe plug in the modified governor housing cover (see A9.6).

9.2.7.20 Open the crankcase drain and start the flushing pump and oil scale pumps. Set and maintain the oil pressure at 359 kPa (52 psi). With the starter or dynamometer, turn the engine over at a speed of 200 r/min for one minute. Turn off the pumps and drain all of the oil from the engine crankcase, governor housing, engine and flushing pump unit filters, oil cooler, oil pump accessory drive housing, and oil scale reservoir. Discard the drained oil.

9.2.7.21 Again add 4.7 L (5 qt) of test oil to the engine crankcase through the engine oil cooler. Repeat the flushing procedure in 9.2.7.20. During this flush, check the alignment of the piston cooling nozzle and adjust, if necessary, being certain that oil condition has stabilized before adjustment. Drain the oil and install a new P/N 8N9586 oil filter (see Annex A15). Re-install crankcase breather assembly P/N 1Y2592 (see Annex A15).

9.3 *Engine Pre-Test Measurements and Inspections*—Measure and inspect the engine components prior to each test. Information on component reusability and assembly is found, herein, and in the P/N 1Y540 Service Manual[16]. Part numbers for replacement parts are also given in this manual.

9.3.1 *Crankshaft Angles*—Record the crankshaft angles at the specified exhaust and intake cam lift before each test and show a full lift profile before each reference test. See 1Y540 Service Manual.

9.3.2 *Cylinder Head and Specification for Valves*—Use a new or reconditioned head for each test. Ensure that measurements after reconditioning are within specification requirements as shown in Fig. A1.1. Also measure valve head projection and ensure that it meets specification requirements. Record the measurement. Conduct non-reference tests using cylinder head/jug assemblies that during their laboratory histories had been subjected to at least one complete and acceptable calibration test.

9.3.2.1 *Valve Guide Bushings*—The valve guide bushings have threaded bores and are machined to close fit tolerances to the valve stem. See A1.2 for the reconditioning method. Use a short arbor and a long stone for valve guide honing, the final valve guide sizing operation.

9.3.2.2 *Fuel Nozzle*—Remove the fuel nozzle from the cylinder head before commencing reconditioning. Use either Service Kit P/N 6V7020 (see Annex A15) to pull the nozzle or a suitable adapter that is threaded on the nozzle head. Replace the P/N 9L9098 seal and P/N 2W6163 (see Annex A15) fiber washer as needed. Inspect the nozzle tip for carbon build-up and deformed surfaces. Replace questionable nozzles. Check the valve opening pressure (V.O.P.) before each test using any commercially available nozzle testing tool or a P/N 5P4150 (see Annex A15) nozzle tester group. A V.O.P. equal to or greater than 10 342 kPa (1500 psi) is satisfactory. Remove the P/N 2W1230 screw (see Annex A15) only during this check. See the Caterpillar Service Manual for additional information. Fuel injection housing bolts may be standardized to the hex head type of Grade 8 quality.

9.3.3 *Piston and Rings*—Use a new piston (P/N 1Y0727) and new rings (P/N 1Y0728) for each test recording measurements before and after each test (see Annex A15 for all P/Ns). The measurements before the test ensure that good parts are evaluated and are compared to measurements after the test to determine the amount of wear. Before the test clean all three rings using pentane and a lint-free cotton cloth. Measure the ring side clearances and ring end gaps of all three rings in accordance with the procedure in Fig. A1.2. For Keystone ring side clearance measurements, the ring shall be confined in a dedicated slotted liner (see Fig. A1.2) or a ring gage 137.16 mm (5.400 in.) in size (see Fig. A1.2). Obtain the average side clearances with four feeler gages of equal width and 0.01 mm thickness increments at 90° spacing around the piston. Similarly, measure the rectangular side clearance. Measure minimum side clearance in accordance with directions in CRC Manual 18. Measurement may also be made using taper gages.

9.3.4 *Cylinder Liner*—For each test, select a new cylinder liner (P/N 1Y3555) having a surface finish of 0.4 to 0.8 µm. First remove the protective grease with Stoddard solvent, then clean the liner bore with a hot water/detergent solution (see 7.5) and rinse with hot water. Measure the surface finish and record the results on Fig. A13.12 (Form 9). Oil the liner bore with Exxon-Mobil EF-411 oil. Assemble the cylinder liner, block and head, torquing the stud nuts as shown in Fig. A1.5. Measure the liner with a dial bore gage to ensure that the out-of-round and taper conditions are within specified tolerances measured at five intervals as shown in Figs. A1.3 and A1.5. Torquing increases the cylinder liner outside diameter at the o-flange necessitating machining of the 1Y544 cylinder block. Machine the block inside diameter as shown in Fig A1.6.

9.3.5 *Compression Ratio*—Before starting each test, ensure that the engine has the specified compression ratio of 14.5 to 1 by measuring the piston-to-head clearance. For this measurement use lead shot[24] approximately 5 mm (0.2 in.) in diameter. Place four lead shots on top of the piston at 90° intervals on the major and minor piston diameters, holding them in position with light grease. With the piston near the top of the stroke, install and torque to specifications the head and block assembly. Then in succession, turn the engine over top center by

hand, remove the head and block assembly and measure the thickness of the lead shot to obtain the average piston-to-head clearance. The piston-to-head clearance shall measure 3.556 ± 0.076 mm (0.140± 0.003 in.). Use multiple block gaskets (P/N 1Y3698) (see Annex A15) to adjust the clearance. If the piston-to-head clearance still exceeds the requirement, check the crankshaft main and rod journals, connecting rod main bearings and piston pin and rod bushings for excessive wear. Also, check the piston cooling jet-to-piston skirt clearance to ensure that no contact is made.

9.3.6 *Fuel Timing*—Before each test, ensure that the engine fuel timing is set at 31.5 ± 0.5° before top center (BTC) of the piston travel. Set the engine flywheel which has 2° marked intervals to coincide with the piston travel. Make a final check to ensure that the fuel timing is set correctly. The fuel flow timing method (described in A1.6) is the preferred method for assessing quickly timing settings. Alternatively, use an electronic fuel timing instrument before each test, provided that it is equivalent in accuracy to the Caterpillar or AVL device. The electronic instrument shall be calibrated to give the same timing values as the fuel flow timing method. Refer to Service Manual SENR2856[16] for instructions and fuel timing dimensions for major rebuilds or fuel pump disassemblies.

9.3.7 *Pre-Test Component Inspections*—For future reference, inspect all components and assemblies that are exposed when the engine is disassembled and record the observations. These include valve train components, bearings, journals, housings, seals, and gaskets as well as those items noted in 9.3.1-9.3.3. Replace those that fail to meet requirements.

9.3.7.1 Inspect the special fuel plunger for erosion as noted in A1.8.

9.3.7.2 Ensure that the valve camshaft timing meets the requirements as listed in Service Manual SENR2856 (that is, ±4° tolerance).

9.4 *Engine Assembly*—Assemble the engine with components and bolt torques as specified in Engine Service Manual P/N 1Y540 (see Annex A15), aiming for the mean of the specified values. In keeping with good assembly practices, ensure that (*a*) the components are clean and lubricated, (*b*) airborne dirt and debris are kept to a minimum in the assembly area (see 6.1), and (*c*) standard assembly techniques such as staggered piston ring gap positions are maintained.

9.5 *Pressure Testing of Fuel System Assembly*—Pressure test the fuel system assembly, notably the high pressure fuel line and components at 20 000 kPa (3000 psi), to ensure that it is leak-proof. Because the fuel line connections are routed under the valve cover, fuel leakage can lead to undesirable fuel dilution of the engine oil. A fuel dilution greater than 2.0 % volume at 24 h will render the test operationally invalid. The pressure test will also show if the P/N 7W8629 line assembly needs to be replaced.

9.5.1 *Pressure Testing Procedure*—After engine assembly, connect a high pressure fuel line to the external rocker arm housing fitting where the P/N 1Y648 line assembly connects. Using a P/N 5P4150 CAT nozzle tester pump, pressurize the system to 20 000 kPa (3000 psi). Close the back bleed valve of the pump to check pressure leak-off rates. Hereafter, the fuel system should maintain pressure with little or no pressure leak-off.

10. Calibration of Engine Test Stand

10.1 *General Requirements and Frequency of Calibration*:

10.1.1 To maintain test consistency and severity levels, calibrate the engine test stand at regular intervals in accordance with the requirements of the TMC using TMC reference oils.

10.1.2 TMC shall establish frequency of calibration testing.

10.1.2.1 Based on whichever occurs first, run a calibration test on a reference oil assigned by TMC either 12 months from the start of date of the last acceptable calibration test, or after 15 test starts run under the test type for which the test stand was calibrated (1K or 1N). A test stand can be calibrated as both a 1K and 1N test stand and failure to calibrate under one test shall not invalidate the calibration for the other.

10.1.2.2 To enhance reference oil test program design and test severity monitoring, the TMC may move up or extend reference oil tests.

10.1.2.3 If a reference test calibration period is extended beyond the normal duration, any subsequent non-standard reference tests shall include a notation of this fact in the comments section. Additionally, written confirmation from the TMC shall be attached to the report.

10.1.3 Complete any non-reference oil tests before the expiration of the current calibration. If a test does not complete when expected due to unscheduled shutdowns, continue the calibration to the end of the test.

10.2 *Runs*:

10.2.1 *Double Blind Runs*—TMC shall administer double blind tests on a maximum of every third engine in each laboratory annually.

10.2.2 *Runs on REO 810 and Subsequent Reblends*—Once per calendar year, the Surveillance Panel shall solicit calibrated laboratories for a volunteer to run one 1K and one 1N calibration test on Oil 810 (or a subsequent reblend). The 0.5 g/kWh maximum BSOC limit shall not be applied to these tests. Instead, BSOC shall be treated in the same manner as the other control charted parameters. For this BSOC shall have a calculated mean and standard deviation that shall be used in conjunction with the lambda and *k* values specified by the LTMS system. Theses tests shall be treated in every other respect as any other calibration tests.

10.3 *Specified Test Parameters*—The specified test parameters for determination of test acceptance are as follows:

10.3.1 Top groove fill, percent area (critical parameter).

10.3.2 Weighted total deposits, demerits (critical parameter).

10.3.3 Transformed top land heavy carbon, transformed units, percent area (non-critical parameter).

10.3.4 Brake specific oil consumption (BSOC), g/kW-h (non-critical parameter).

10.4 *Calibration Test Acceptance Criteria*—See TMC Lubrication Test Monitoring System (LTMS) for calibration test targets and acceptance criteria.

10.5 *Failing Calibration Test*:

10.5.1 *Failure of a Reference Oil Test*—Failure of a calibration test to meet test acceptance criteria can indicate (*a*) a

testing stand problem, (*b*) a testing laboratory problem, (*c*) an industry-wide problem or (*d*) a false alarm. When failure occurs, the laboratory in conjunction with the TMC shall attempt to determine the cause.

10.5.2 *Action to Determine Cause of Problem*—First, TMC shall decide, with advice from industry specialists (testing laboratories, test procedure developer, ASTM Technical Guidance Committee, Surveillance Panel, and so forth), if the cause of any unacceptable blind reference oil test is isolated to one particular stand or is related to other stands as well. Second, if the problem is isolated to an individual stand, calibrated testing on other stands can continue throughout the laboratory. Third, if it is decided that more than one stand may be involved, the involved stands shall be considered not calibrated until the problem is identified, corrected, and an acceptable reference oil test completed in one of the involved stands.

10.5.3 *Non-standard Tests*—If non-standard tests are conducted on the calibrated test stand, at the discretion of TMC, the test stand may be required to be recalibrated prior to running standard tests.

10.6 *Test Numbering*—Each 1K/1N test shall be identified by a test stand number and test run number. All runs shall be numbered sequentially. All repeat calibration runs shall be appended with a letter (also sequentially). The letter suffix sequencing for each test type calibration shall be maintained until the calibration is accepted. Any test start, regardless of type, shall increment the run number. Test start is the start of accumulation of any engine test time by this test procedure.

10.6.1 *Example of Test Numbering*—See Table 1.

10.7 *Reference Oils*—The reference oils used to calibrate the 1K and 1N test stands are formulated or selected to represent specific chemical types or specific performance levels or both. The TMC assigns the reference oils for calibration tests. The oils are available from the TMC and are supplied under code numbers (blind reference oils).

10.7.1 *Banning Extra Analysis/Testing of Reference Oils*—Reference oils shall not be identified by chemical analysis and laboratory bench testing of physical properties. Such analysis and testing would undermine the confidentiality required to operate an effective blind reference oil system. Only those chemical analyses and physical tests specified within this procedure shall be performed. However, the TMC may authorize analyses and bench testing under special circumstances. When authorized, written confirmation of the circumstances involved, data obtained, and the name of the person authorizing such analyses and bench testing shall be supplied to TMC.

TABLE 1 Example of Test Numbering

Test			Run No.
	1K	1N	
1st	Reference Fail		1
2nd	Reference Fail		2A
3rd	Reference Fail		3B
4th		Reference Fail	4
5th		Shakedown	5
6th		Reference Pass	6A
7th	Reference Pass		7C
8th	Non-reference		8
9th		Non-reference	9

10.8 *Severity Adjustments*:

10.8.1 *Non-Reference Oil* —Non-reference oil test results may be adjusted to maintain intended severity levels.

NOTE 1—See fixed candidate oil test pass criteria in Specification D 4485.

10.8.2 *Severity Adjustments*—Use a method accepted by the Surveillance Panel for calculating a severity adjustment (SA) for non-reference test results. When a significant bias is identified according to the control chart technique (10.8.3), apply a severity adjustment (SA) to non-reference oil test results. The SA remains in effect until subsequent calibration test results indicate that the bias is no longer significant. SA's are calculated and applied on a laboratory basis.

10.8.3 *Control Chart Techniques for Severity Adjustment (SA)*—Apply standardized calibration oil test results to an exponentially weighted moving average (EWMA) technique. Standardize the values using the following ratio: Delta/SD ((result — target)/standard deviation). The target and standard deviation values are available from the TMC. Include all operationally valid calibration test results on a laboratory control chart. Record the test results on the chart in order of completion. Completion of tests shall be recorded by EOT date and time. EOT time shall be reported as hour and minute according to the 24 h clock (1 a.m. = 1:00, 1 p.m. = 13:00). Reporting test completion time enables the TMC to order tests that are completed on the same day for industry plotting purposes. Report calibration test results to the TMC in order of test completion. Results from at least two tests are required to start a control chart. Calculate EWMA values using the following equation:

$$Z_i = \text{Lambda} \times Y_i + (1 - \text{Lambda}) \times Z_{i-1} \quad (1)$$

where:

Z_0 = 0,
Y_i = standardized test result,
Z_i = EWMA of the standarized test result at test order *i*, and
Lambda = the appropriate lambda from the LTMS document.

10.8.3.1 If the absolute value of EWMA, rounded to three decimal places, exceeds the alarm limit in the LTMS document, apply an SA to subsequent non-reference oil results.

10.8.4 *Example of Calculation of Severity Adjustment*—This example shows how to calculate and apply EWMA and SA values (test targets being examples only).

10.8.4.1 *TGF Severity Adjustment*:

(1) Applicable test targets: Mean, 40.8; standard deviation (SD), 15.9; TGF, 55; Z_i, 0.897.

(2) Standard test result: Y_2 = (TGF – Mean)/SD = (55 – 40.8)/15.9 = 0.893.

(3) Alarm limit: 0.653.

(4) EWMA: $Z_2 = 0.2 \times Y_2 + 0.8 \times Z_1 + 0.896$.

10.8.4.2 Since | 0.896 | > 0.653, an SA shall be applied as follows: SA = –1 ×EWMA ×SD (in the example, SA = –14). For TGF, round off the SA to a whole percent; for WDK/WDN, round off to one decimal place; and for TTLHC, round off to three decimal places. Do not adjust BSOC and EOTOC for severity. Enter this number on Fig. A13.2 (Form 1) in the

appropriate laboratory severity adjustment box and add to it the test result. An SA shall remain in effect until the next calibration test. At that time, calculate a new EWMA and SA.

11. Engine Operating Procedure

11.1 *Engine Run-In*—After the engine components have been prepared and assembled as described in Section 9, perform the final engine preparations and the 60-min run-in itself as follows:

11.1.1 Fill the crankcase with 6 L of fresh test oil.

11.1.2 Install a new P/N 8N9586 oil filter.

11.1.3 Fill the cooling system with specified coolant and ensure that the facility coolant to the engine heat exchanger is operational.

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

11.1.5 Finally, ensure that all other systems and facilities are operational.

11.1.6 Obtain familiarity with the engine run-in operating conditions (see Table A10.1), and note the five time-related steps.

11.1.7 Start the engine run-in by turning the engine on and then ensuring that the operating conditions of Table A10.1 are strictly followed, and the rated load condition observed as shown under Step No. 5 of Table A10.1.

11.1.8 During the 5-step run-in period measured in minutes (5 + 5 + 10 + 20 + 20 = 60 min) check and correct for leakage, and make adjustments as necessary to meet the engine operating requirements in A10.1.

11.2 *Cool-Down Procedure*—Except for emergencies or uncontrolled stops, at the end of the 60-min run-in period start a 20-min cool-down period by following the run-in period in partial reverse order as follows: Step No. 3 (10 min), Step No. 2 (5 min) and Step No. 1 (5 min) and including the observance of the test parameters in Table A10.1, finally turning the engine off.

11.3 *Warm-Up Procedure*—For all subsequent starts throughout the test, warm up the engine in accordance with the run-in directions in 11.1.1-11.1.8.

11.4 *Operating Conditions and Oil Additions*:

11.4.1 After the run-in (60 min) and cool-down (20 min) periods of 11.1 and 11.2 and while the engine is hot, drain the oil for 30 min from the crankcase, governor housing, oil cooler, engine oil filter, oil pump accessory drive housing, and weigh scale.

11.4.2 Charge the engine with 4.95 ± 0.11 kg (10.9± 0.24 1b) of test oil (reference or non-reference, as required).

11.4.3 Start and warm-up the engine for the 252 h test in accordance with 11.1.1-11.1.8, observing the test conditions in Table A10.1. Turn on the oil scale pumps when the engine reaches operating temperatures at the start of Step No. 5 in Table A10.1. Record the full oil scale pump mark at the end of this step.

11.4.4 Throughout the test, record the oil scale reading at least every hour. Add oil to the full mark (initial fill level) every 12 h, but *do not overfill*, recording the weight of oil added.

11.4.5 Measure oil consumption in accordance with 11.5 and take used oil samples for analysis in accordance with 11.6.

11.4.6 During the test hold all control parameters within the specified tolerance range in Table A10.1. *Failure to do so affects the validity of the test*.

11.4.7 *Test Duration*—The test duration is 252 h. It is counted from the moment that stabilized conditions are attained, a maximum of 30 min being allowed to attain stabilization.

11.4.8 *Calculation of Offset from Mean and of Deviation*—At the end of the test, calculate the offset from the mean (in percent) and deviation (in percent) outside of the specification tolerance (see Annex A12). Report on Fig. A13.4 (Form 3).

11.5 *Measurement of Oil Consumption*:

11.5.1 Use linear regression to calculate oil consumption (see Annex A7).

11.5.2 Plot graphically the oil scale readings taken hourly over a 12-h period versus time at which the reading was taken (see Annex A7). Delete the first reading after the oil addition from the linear regression.

11.5.3 Derive 12-h oil consumption data points for plotting on Fig A13.16 (Form 13) and reporting (see 13.2.4.1).

11.5.3.1 For a 12-h period, including a shutdown, calculate the BSOC from linear regression as follows (excluding the first oil weigh reading after shutdown in the linear regression): (*a*) calculate the linear regression for the periods before and after shutdown and (*b*) average the two linear regressions to obtain the oil consumption for the 12-h period. Base the BSOC calculations on actual average engine horsepower over the 12-h period.

11.5.4 Derive average values of oil consumption for recording on Fig. A13.9 (Form 6). Also derive and record average oil consumptions between 0 to 24 h and 0 to 252 h.

11.5.4.1 Derive the end of test oil consumption (EOTOC) from the average of the last two 12-h (BSOC) figures. For a normal, completed test, this number is the same as the 252-h BSOC number.

11.6 *Sampling Used Oil*:

11.6.1 Obtain samples of new oil and used oil after run-in and at 24, 72, 156, 204 and 252 h. The quantity of each sample shall be 237 mL (8 oz).

11.6.2 See 12.4.2 for tests required on the used oil.

11.6.2.1 Testing of the used oil samples taken at 72 and 156 h is optional.

11.6.3 After the used oil samples are taken, fill the oil system to the initial level.

11.7 *Shutdowns, Lost Time, and Off Tolerance Conditions*—Report on Fig. A13.10 (Form 7) the test hours, date, and length of off-test conditions for all occurrences. Also, record when the engine is off-test conditions, 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. Always pump the oil from the scale cart to the engine crankcase to ensure adequate oil volume for engine restarting. In the event of an emergency shutdown, a 2-h engine off-condition shall be maintained to allow complete engine cooldown before restarting. To limit the ingress of foreign

matter into the combustion chamber and to protect the deposits, rotate the engine to top dead center of the compression stroke during downtime.

11.7.1 Always pump the oil from the scale cart to the engine crankcase to ensure an adequate oil volume for engine restarting.

11.7.2 In the event of an emergency shutdown, maintain a 2-h engine off condition before restarting to allow complete engine cool-down.

11.8 *Recording of Exhaust Temperature*—An exhaust temperature recorder may be used to track all regular starts, run-ins, and shut-downs and as well all exhaust temperature excursions that occur from speed and load changes during run-in, warm-up and cool-down procedures. Examine all exhaust temperature excursions for possible effects on test results. Operate the engine so as to minimize exhaust temperature excursions from speed, load, and air pressure variations or adjustments.

11.9 *Air-Fuel Ratio Measurement*—Calculate the air-to-fuel ratio within 24 h of test hour 24 and test hour 252. Use either an orifice air flow meter and fuel flow measuring device or exhaust gas analysis. Draw gas samples by way of the exhaust pressure probe, its location being shown in Fig. A3.5. Tables and formulae for deriving air-fuel ratios are shown in Table A10.2.

11.9.1 *Air-Fuel Ratio Report*—The report shall include the following three entries:

11.9.1.1 Observed measurement data comprising either (*a*) percent CO_2 and percent O_2 or (*b*) air flow and fuel flow.

11.9.1.2 Calculated air-fuel ratio from Table A10.2.

11.9.1.3 Date and test hours observed.

11.10 *Recording of Engine Conditions*—Note the engine conditions listed in Table A10.1 at least once per hour, recording data before adjustments are made. These data show the actual engine conditions at each hour of test; they should not be averages of data logged during the test hour. Record in the test report all observed readings that exceed the limits.

11.11 *Humidity Requirements/Calibration/Measurement*:

11.11.1 *Humidity Measurement*—Record humidity readings each test hour using the laboratory's primary humidity measuring system. This system shall be accurate to within ± 0.648 g (± 10 grains) of the humidity measuring chilled mirror dew point hygrometer (see 11.11.2). Make corrections to each hourly reading for non-standard barometric conditions using factors either taken directly from Tables X1.1 to X1.8 or derived from the perfect gas law equation in X1.2.

11.11.2 *Calibration of Primary Humidity Measuring System*—Calibrate the primary humidity measuring system during the first 24 h of each stand calibration test with a chilled mirror dew point hygrometer having an accuracy of ± 0.55 °C at 24 °C (± 1 °F at 75 °F) dew point and moisture content of ± 0.6 g/kg (± 4 grains/lb) of dry air. Perform additional stand calibrations when ambient temperature and ambient humidity conditions differ from the last semi-annual ambient test condition to ensure that the stand humidity remains within test requirements.

11.11.2.1 The humidity (hygrometer) tap is located on the air inlet tube leading to the air heater chamber (see Fig. A2.1). The sample line shall not be hygroscopic and may require insulation to prevent a temperature decrease to below the dew point.

11.11.2.2 *Calibration Procedure*—Make a series of paired comparison measurements between the primary system and the chilled mirror dew point hygrometer. The comparison period lasts for 20 min to 2 h, measurements being taken at 1 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. Check the flow rate to ensure that it is within the equipment manufacturer's requirements.

11.11.2.3 *Calibration Measurements and Calculations*—Take all measurements with the dew point hygrometer at atmospheric pressure and correct to standard conditions (101.12 kPa (29.92 in. Hg)) using the perfect gas law equation (see X1.2) or from humidity correction factors taken from Tables X1.1 to X1.8. From the differences between the results of each pairs of measurements, calculate the mean and standard deviation (see Appendix X2). The absolute value of the mean difference of humidity shall not exceed 0.648 g (10 grains) and the standard deviation shall be ≤ 0.324 g (≤ 5 grains). Both requirements shall be met when calibrating the primary humidity measurement. If one or both requirements are not met, investigate the cause, make repairs, and recalibrate. Maintain calibration records for two years.

11.11.3 *Combustion Air System Drain Taps*—Drain taps may be installed at low points of the combustion air system. Keep them open during shut-down and warm-up.

12. Engine and Parts Inspections, Photographs and Measurements

12.1 Refer to the appropriate reporting forms (see Annex A13) before doing the inspections and recording the data. Also when recording data, clearly indicate under which procedure (1K or 1N) the data where obtained.

12.2 *Pre-Test Measurements of Engine Parts*—See 9.3.

12.3 *Post-Test Information*—At the completion of the engine test inspect for deposits and measure the wear of piston, rings, and liner as described herewith. Photograph the piston/ring assembly and section the cylinder liner (see Fig. A13.17, Form 14).

12.3.1 *Deposit Ratings, Photographs, Measurements*—Remove the piston and ring assembly from the engine. Examine the assembly and measure the components in accordance with the CRC Diesel Piston Rating System Manual No. 18 that utilizes the varnish scale (see A11.1). Photograph the pistons and rings, and perform deposit ratings as follows:

12.3.1.1 Photograph the piston and rings with the rings placed on top of the piston to show the ring gaps (thrust view) and 180° from the gaps (anti-thrust view). Ensure that the photographs of the pistons show the piston from the crown down to at least the bottom of the pin bore.

12.3.1.2 When rating second groove and land deposits only two levels of carbon (light and heavy) are applicable.

12.3.1.3 Define and break down the undercrown rating area as shown in Fig. A11.1.

12.3.1.4 Use a piston deposit demerit rating as specified in CRC Manual 18.[14]

12.3.1.5 Rate the top land heavy carbon piston deposits within 15 min after the power unit or piston assembly is removed from the engine.

12.3.1.6 After the crownland (topland) heavy deposits are rated, wash the crownland in solvent and wipe dry before continuing with the rating.

12.3.1.7 *Training of Piston Deposit Rating Specialist (Rater)*—Piston deposit raters shall be trained by the CRC Rating Task Force. They shall maintain rating expertise by attending rating seminars or workshops annually. The rater shall attend either the CRC Task Force seminar held each spring or the expanded CRC Heavy Duty Piston Rating Workshop held each autumn, or both. The rater shall rate a minimum of six diesel pistons at the seminar or workshop. If the rater is unable to attend either session, the rater shall make alternative arrangements at the earliest opportunity. In applying these seminar attendance requirements to a laboratory having more than one rater, the laboratory shall be expected to send at least one heavy duty diesel piston rater annually.

12.3.1.8 *Referee Ratings*—To detect quickly and correct any shifts in rater severity, all operationally valid calibration tests shall be refereed. Also, any test reviewed by the test procedure developer shall be referee-rated. Test laboratories shall supply the entire rating breakdown for land No. 1 to the referee laboratory. The referee rater shall use the test laboratory results for land No. 1 when computing WDK/WDN. All pistons to be referee-rated shall be wrapped in paper and placed in plastic with the CRC approved dessicant chips and sealed before being shipped to the referee laboratory. Refereed results shall be reported to TMC on Fig. A13.8 (Form 5A) within ten working days of test completion.

12.3.2 *Piston/Ring Side Clearances*—Determine the level of deposit formation in the piston/ring area by measuring the piston/ring side clearance. Substantially follow the procedure as shown in Fig. A1.2 for pre-treatment measurement. Insert the feeler gage between the ring and groove carefully so as not to disturb or remove the deposit. Do *not* force the gage as this could dislodge the deposit. Record clearances on all rings as shown in Fig A13.2 (Form 1) and Fig. A13.11 (Form 8).

12.3.3 *Ring End Gap Increase*—Measure the ring gap according to Fig. A1.2. Post-test, clean the rings to remove carbon. If scraping the rings is required, use an instrument made from soft material, such as, wood. Measure and record the end gap in accordance with 9.3.3 and Fig. A13.11 (Form 8).

12.3.4 *Liner Wear/Bore Polishing Measurements& Photographs*—Carry out liner preparation and measurements in accordance with the CRC Diesel Liner Rating Method (May 1985) as given in A11.3.

12.3.4.1 First remove the deposits on the liner above the piston ring travel.

12.3.4.2 Then, to determine the liner wear step, measure the surface profile at the wear step location transversely and longitudinally relative to the crankshaft at four locations about 15 mm from the top of the liner.

12.3.4.3 Record the measurements as liner wear on the report sheet as shown in Fig. A13.12 (Form 9).

12.3.4.4 Section the cylinder liner for measurement of the amount of bore polishing and for photographing. The sectioned liner shall show the thrust and anti-thrust sides (see Annex A11, Fig A13.17 (Form 14), and Fig. X3.2). Use the proposed CRC Diesel Liner Rating Method (May 1985) (see A11.3).

12.4 *Oil Inspections*:

12.4.1 *New Oil Inspections*—Perform the following tests on the new oil (see Fig A13.9 (Form 6)):

12.4.1.1 Kinematic Viscosity at 100 °C by Test Method D 445.

12.4.1.2 Base number by Test Method D 4739.

12.4.1.3 For reference against used oil tests, wear metals, that is, iron, aluminum, copper, chromium, and lead, and air-borne particle contamination element, silicon by Test Method D 5185.

12.4.2 *Used Oil Inspections*—Perform the following tests on the used oil at 24, 204 and 252 h:

12.4.2.1 Same tests as for new oil (see 12.4.1).

12.4.2.2 Fuel dilution by Test Method D 3524.

12.5 *Oil Consumption*—Calculate and record the average oil consumption for each 12-h period and between 0 to 24 and 0 to 252 h periods (see Fig. A13.16, Form 13).

12.5.1 For a 12-h period including a shutdown, calculate the BSOC as follows:

12.5.1.1 Do not include the first oil weigh reading after the shutdown in the linear regression.

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

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

12.5.1.4 Average both regressions to obtain the oil consumption for the 12-h period.

12.5.2 Derive BSOC calculations from actual engine horsepower over the 12-h period.

12.5.3 Record average oil consumptions between 0 to 24 h and 0 to 252 h.

12.5.4 Record oil consumptions on the Summary Sheet (Fig. A13.9 (Form 6)).

12.6 *Unscheduled Shutdowns and Off-Limit Operation*—During the 252-h test, if the engine is shut down or operated out of test limits, report the engine hours, and time and date of these occurrences. Also report the time that the engine is off-test limit condition, has early test termination, and the reasons for the occurrences. Report, in addition, all prior reference test events that were deemed operationally and statistically invalid or aborted (see 11.7 and Fig. A13.10 (Form 7)). Account for all runs during the calibration sequence.

12.6.1 *Missing or Bad test Data*—Observe the following:

12.6.1.1 If the engine is shut down or operated out-of-test limits during the 252-h test, record the engine hours, time and date.

12.6.1.2 Record the time the engine is off-test conditions, has early test inspections or test terminations, and note the reasons for the occurrences.

12.6.1.3 Record missing or bad test data in Fig. A13.18 (Form 15).

12.6.1.4 Consider the test operationally invalid if it has greater than four consecutive hours without data acquisition on any controlled parameter.

12.6.1.5 If any alternative data acquisition method is used, record in the comment section.

12.6.1.6 If any prior reference test reports were deemed operationally invalid, statistically invalid or aborted, record in the comment section.

13. Report

13.1 *General Directions*:

13.1.1 Use the test report forms (see Annex A13) and the data dictionary (see Annex A14) for the 1K/1N final report. *Clearly show under which procedure, 1K or 1N,* the data were obtained.

13.1.1.1 Report data to the precision and format given in the data dictionary (see Annex A14).

13.1.2 Attach to each calibration report:

13.1.2.1 The control chart summary page sent to the laboratory from TMC,

13.1.2.2 The fuel batch analysis page received from the fuel supplier, Haltermann Products, and

13.1.2.3 The parts photographs.

13.2 *Specific Directions*:

13.2.1 Report all deposits, wear and engine operational data as required by the forms in Annex A13 (Forms 1 to 17).

13.2.2 Report a summary of the overall test results on Fig. A13.2 (Form 1) and of the engine minimum, maximum, and average operational data on Fig. A13.3 (Form 2).

13.2.3 Show the 1K or 1N engine operating conditions by plotting hourly data points on Fig. A13.14 (Form 11) and Fig. A13.15 (Form 12).

13.2.3.1 The graphs may be formatted as one per page or any combination that the laboratory desires so long as the parameters are plotted in the same sequence with adequate resolution.

13.2.4 *Oil Consumption*:

13.2.4.1 Calculate average oil consumption for each 12-h period and record on Fig. A13.16 (Form 13).

13.2.4.2 Report on Fig. A13.2 (Form 1) end of test oil consumption (EOTOC) as the average of the last two 12-h BSOC figures. For a normally completed test, this number is the same as the 252-h BSOC number.

13.2.5 *Ring and Liner Wear Measurements*:

13.2.5.1 Report on Fig. A13.11 (Form 8) and Fig. A13.12 (Form 9) the ring and liner wear measurements respectively.

13.2.6 *Reporting of Unusual Conditions on Fig. A13.10 (Form 7)*:

13.2.6.1 Record any missing or bad test data.

13.2.6.2 If a test has more than four consecutive hours without data acquisition, it shall be considered operationally invalid.

13.2.7 Include in the report photographs of the pistons, rings and sectioned liner showing the thrust and anti-thrust sides (Fig. A13.17 (Form 14)) and Fig. X3.2 (an example of a completed form).

13.3 *Electronic Transmission of Test Results (Optional)*:

13.3.1 Transmit test results electronically using the ASTM Data Communications Committee Test Report Transmission Model (see Section 2 – Flat File Transmission Format) available from TMC. Refer to the data dictionary in A14 for use with this test.

13.4 *Reporting Calibration Test Results*

13.4.1 Transmit calibration test results by facsimile to TMC immediately after completion of the test using the cover sheet (Fig. A13.1), Fig. A13.2 (Form 1), Fig. A13.3 (Form 2), Fig. A13.4 (Form 3), and Fig. A13.10 (Form 7). For the test to be considered valid, the laboratories shall transmit data to TMC within seven days of end of test (EOT).

13.4.2 Test results may be transmitted electronically (see 13.3) if approved by TMC.

13.4.3 TMC shall review all calibration test results to determine test acceptability.

13.4.3.1 If the calibration test results are judged acceptable, the reference oil code and the industry average results for the reference oil shall be disclosed by TMC.

13.4.3.2 If the calibration test results are judged not acceptable, the test laboratory shall offer an explanation. If an explanation is not readily available, all test related equipment shall be checked. If a fault is still not identifed, it shall be assumed that the problem is related to the laboratory and another reference oil shall be assigned.

13.4.4 Forward one copy of the standard final test report with photographs for each 1K and 1N reference oil test to each of the following:

13.4.4.1 Caterpillar Inc., Tech Center, Bldg. L, 100 N.E. Adams St., Peoria, IL 61629.

13.4.4.2 ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206-4489.

13.4.5 For the test to be valid, send the completed final test report to TMC within 30 days of the end of test (EOT).

14. Precision and Bias

14.1 Test precision is established on the basis of reference oil test results (for operationally valid tests) monitored by the ASTM Test Monitoring Center. The data are reviewed semi-annually by the Single-Cylinder Diesel Surveillance Panel. Contact the ASTM TMC for current industry data.

14.1.1 Table 2 and Table 3 summarize reference oil intermediate precision and reproducibility of the test as of July 10, 1998.

14.1.2 Intermediate Precision (I.P.) is defined as the difference between two results obtained by the same operator or laboratory under constant operating conditions on the same oil that would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in Table 2 and Table 3 in only one case in twenty.

14.1.3 Reproducibility (R) is defined as the difference between two single and independent results obtained by different operators working in different laboratories on the same oil that would, in the long run, in the normal and correct

TABLE 2 1K Reference Oil Precision Data

NOTE 1—These statistics are based on results obtained on Test Monitoring Center Reference Oils 809, 809-1, 811 and 811-1.

Variable	$S_{I.P.}$	I.P.	S_R	R
Weighted total deposits, demerits	67.27	188.36	68.73	192.44
Top groove fill, %	12.2	34.2	12.4	34.7
Top land heavy carbon, ln (TLHC + 1)	0.918	2.570	0.932	2.610
Average oil consumption, g/Kw-h	0.086	0.241	0.089	0.249

TABLE 3 1N Reference Oil Precision Data

NOTE 1—These statistics are based on results obtained on Test Monitoring Center Reference Oils 809-1, 811-1, 1004, 1004-1 and 1004-2.

Variable	$S_{I.P.}$	*I.P.*	S_R	*R*
Weighted total deposits, demerits	28.77	80.56	30.80	86.24
Top groove fill, %	16.5	46.2	16.5	46.2
Top land heavy carbon, ln (TLHC + 1)	0.838	2.346	0.846	2.369
Average oil consumption, g/Kw-h	0.084	0.235	0.085	0.238

Legend:
$S_{I.P.}$ = intermediate precision standard deviation.
I.P. = intermediate precision.
S_R = reproducibility standard deviation.
R = reproducibility.

conduct of the test method, exceed the values shown in Table 2 and Table 3 in only one case in twenty.

14.1.4 Bias is determined by applying an acceptable statistical technique to reference oil test results and when a significant bias is determined, a severity adjustment is permitted for non-reference oil test results (see TMC Memo 94-200, Lubricant Test Monitoring System document for details).

15. Keywords

15.1 deposits; engine oil; engine wear;1K test;1N test; piston-ring-liner scuffing; piston ring sticking; top land heavy carbon

ANNEXES

(Mandatory Information)

A1. SPECIFICATIONS FOR TEST ENGINE AND ENGINE BUILD

A1.1 See Fig. A1.1 for the specification for valves.

A1.2 *Procedure for Honing Valve Guides*:

A1.2.1 Use equipment shown in parts list (see 7.15).

A1.2.2 Clean valves with a clean cloth and Stoddard solvent.

A1.2.3 Measure valve stems with a micrometer, 25.4 mm (1 in.).

A1.2.4 If required, install new valve guides into the cylinder head. Either press or drive the valve guides into the head using the tool specified in the service manual.

A1.2.5 Before honing, cut a groove in the top of the intake guides for the P.C. seals using the Perfect Circle tool VST-2012.

A1.2.6 Hone the guides with a P-180 Honal. Measure the guides with a Sunnen P-300 bore gage and a P-375 probe. Hone the intake valves to a clearance of 0.0254 mm (0.0010 in.) and the exhaust valves to 0.0508 mm (0.0020 in.), the tolerance of the clearance being + 0.005 mm (0.0002 in.).

A1.2.7 After honing, clean the guides with a nylon tooth brush.

A1.2.8 Machine the intake valve seat inserts into the head as specified to 30.25 + 0.25 ° and the exhaust valves to 45.25 + 0.25 °.

A1.2.9 Clean the head and guides with Stoddard solvent and blow dry.

A1.2.10 Lubricate the valves and guides with engine oil (API service CD) and assemble into the head.

A1.2.11 Additional valve clearance (0.0127 mm (0.0005 in.)) is allowed after test, giving a maximum for the intake valve of 0.038 mm (0.0015 in.) and for the exhaust valve of 0.0635 mm (0.0025 in.).

A1.2.12 Reuse, provided the requirements in A1.2.11 are met.

A1.2.13 The intake valves guides may be pre-cut for the valve guide seals before insertion into the head. A go-no-go gage may be used for valve depth measurements.

A1.3 *Piston Specifications*—See Fig. A1.2.

A1.4 *Details of Cylinder Liner*:

A1.4.1 *Liner Specifications 1Y3555 Cylinder Liner*—Surface finish shall be 0.4 to 0.8 µm (R_a). See Figs. A1.3-A1.6.

A1.5 *Cylinder Head Torquing Procedure*:

A1.5.1 Disassemble the rocker box and inspect before each test. (See Fig. A1.7).

A1.5.2 Put clean engine oil on all stud threads and tighten the nuts to the correct torque in the following sequence.

A1.5.3 Rocker arm shaft group is not assembled for initial head torque. Use separate 1Y609 pedestal under No. 6 nut.

A1.5.4 *Step 1*—Tighten nuts 1 to 6 in number sequence to 270 ± 25 N·m (200 ± 18 lbf·ft).

A1.5.5 *Step 2*—Tighten nuts 1 to 6 in number sequence to 450 ± 20 N·m (330 ± 15 lbf·ft).

A1.5.6 *Step 3*—Tighten nuts 1 to 6 in number sequence, again 450 ± 20 N·m (330 ± 15 lbf·ft) *Cylinder liner inside diameter is measured at end of Step No. 3.*

A1.5.7 *Step 4*— Loosen No. 6 nut and install the rocker arm shaft group.

A1.5.8 *Step 5*—Tighten nut 6 to a torque of 270 ± 25 N-m (200 ± 18 lbf-ft).

A1.5.9 *Step 6*—Tighten nut 6 to a torque of 450 ± 20 N-m (330 ± 15 lbf-ft).

A1.5.10 *Step 7*—Tighten nut 6 again to a torque of 450 ± 20 N-m (330 ± 15 lbf-ft).

A1.5.11 Height of dowel for the rocker arm pedestal from the cylinder head is 3.25 ± 0.25 mm (0.128 ± 0.010 in.)

A1.5.12 Torque for exhaust manifold studs is 27 ± 4 N-m (20 ± 3 lbf-ft).

VALVES

..... Height of valve guides from top of cylinder
..... head ..... 32.3 ± 0.8 mm (1.27 ± 0.03 in.)

..... Diameter of valve stems (new)
....9.441 ± 0.008 mm (0.3717 ± 0.0003 in)

..... Maximum bore in valve guide after assembled in the head and reamed to fit valve. (See valve fit procedure at the end of the section) ... 9.472 mm (0.3729 in.)

..... Diameter of valve head:
..... Exhaust valve.....41.81±0.13 mm (1.646±.005 in)
..... Intake valve.....44.96±0.13 mm (1.771±.005 in)

..... Angle of intake valve face .... 29 1/4° ± 1/4°
..... Angle of exhaust valve face.... ..... 44 1/4° ± 1/4°

..... Depth of bore in head for valve seat inserts, exhaust and
..... intake..... .....13.01 ± 0.35 mm (.512±.014 in)

..... Diameter of valve seat insert for exhaust valve

..... Bore in head for valve seat insert for exhaust valve
....2.774±0.025 mm (1.6840±.001 in)

..... Diameter of valve seat inset for intake valve
....46.025 ± 0.013 mm (1.8120±.0005 in)

..... Bore in head for valve seat insert for intake valve
....45.949 ± 0.025 mm (1.809±.001 in)

..... Outside diameter of the face of the valve seat insert:
..... Exhaust seat .....40.41±0.13 mm (1.591±.005 in)
..... Intake seat 44.04±0.13 mm (1.734±.005 in)

..... Valve seat width:
..... Exhaust seat .....1.524±0.508 mm (.060±.020 in)
..... Intake seat 2.286±0.635 mm (.090±.025 in)

..... Angle of face of intake valve seat insert:
.... 30 1/4°± 1/4°
..... Angle of face of exhaust valve seat insert:
....45 1/4°± 1/2°

) ..... "Use again" thickness of valve lip:
..... Exhaust valve..... .....2.03 mm (0.080 in)
..... Intake valve..... .....2.51 mm (0.099 in)

) ..... Dimension from top of closed valve to face of head:
..... Maximum permissible dimension for intake and exhaust: 1.07 mm (0.042 in)

..... Minimum permissible dimension for intake and exhaust: 0.05 mm (0.002 in)

) ..... Umbrella 6N7174

) ..... Perfect Circle Seal VS-4
..... Perfect Circle Tool.... .....VST2012

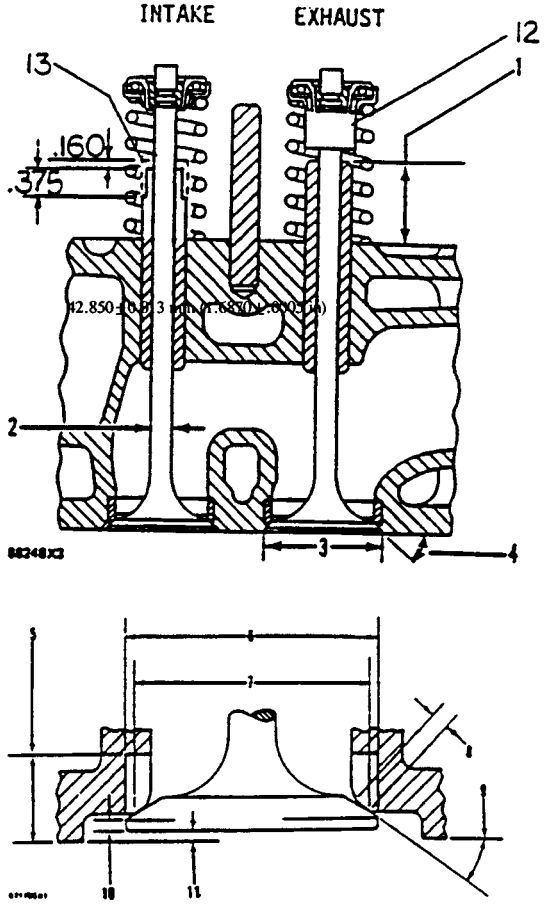


FIG. A1.1 Specification for Valves

A1.6 *Fuel Flow Timing Dimension Check (Bubble Method)*:

A1.6.1 *Procedure for Checking Timing*:

A1.6.1.1 Check flywheel point setting (see SENR2856 Sevice Manual, p 147).

A1.6.1.2 Pressurize air into the fuel system at 7 ± 1.2 kPa (28 ± 7 in. H_2O). Remove the fuel rack pin and rotate the fuel rack clockwise to the full *on* position.

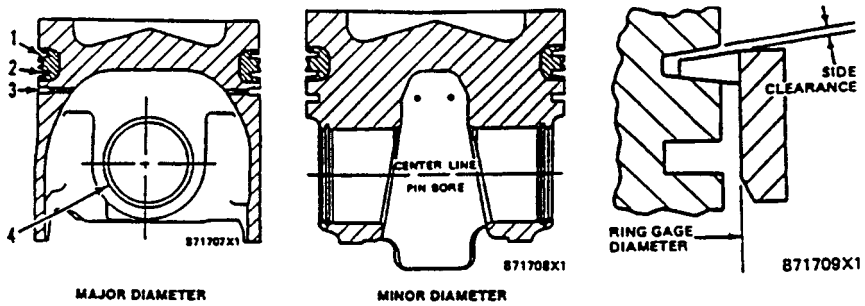
A1.6.1.3 Turn the crankshaft by hand in normal rotation (counter-clockwise rotation from the flywheel end) starting at 90° BTC on the compression stroke.

A1.6.1.4 The air at 90° BTC should flow from the adapter bleed line.

A1.6.1.5 Bleed the fuel using air pressure until a constant stream of bubbles is achieved.

A1.6.1.6 Slowly rotate the crankshaft (counter-clockwise from the flywheel end) until the bubbles stop, *stopping rotation immediately after the bubbles stop flowing*. This step is known as bypass closing. Failure to observe it by continued crank rotation will cause incorrect timing values. (*a*) Place the Vernier on top of the flywheel. Put the 32.0° line of the Vernier at the flywheel pointer. Ensure that the 30° line of the Vernier is in the direction of the 30° mark of the flywheel. See Fig. A1.8. (*b*) Read down on the Vernier to the location where a line on the Vernier directly matches up with a timing line on the flywheel. Read the Vernier value at the location where the lines match up. This is the fuel timing ° BTDC.

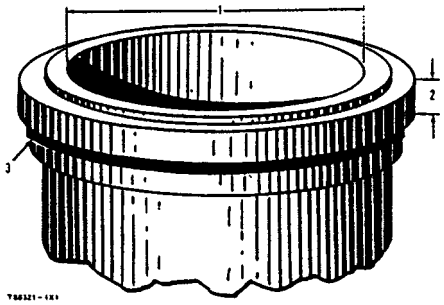
1Y0727 Piston And 1Y0728 Rings



	TOP RING[A]	INTERMEDIATE RING[A]	OIL CONTROL RING[A]
Width of groove in piston for piston ring (new)	—	2.455 ± 0.01 mm	3.21 ± 0.01 mm
Thickness of piston ring (new)	—	2.365 ± 0.01 mm	3.137 ± 0.006 mm
Side Clearance between groove and piston ring (new)	0.193± 0.032 mm	0.090 ± 0.02 mm	0.073 ± 0.016 mm
End gap clearance between end of ring (new) installed in 137.160 mm (5.4 in.) diameter gage.	0.724 ± 0.76 mm	0.673 ± 0.076 mm	0.572 ± 0.190 mm

[A] This engine uses Keystone style piston rings and grooves int the piston for top rings. The piston ring lands are also elliptically ground. therefore measure top and ringside 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 137.160 mm (5.4000 in.) diameter ring gage.
(*c*) Push piston and ring until ring to be measured is at the top of the gage as shown. Keep the piston in the center of the gage.
(*d*) Measure the side clearance with a feeler gage at both major diameter (90° from the centerline of the pin bore) and minor diameter. Either measurement should be within specifications shown.
Install the oil control ring with gap in the sprint 180° away from the gap in the ring.
(*1*) Top ring groove.
(*2*) Intermediate ring groove.
(*3*) Oil control ring groove.
(*4*) Bore in piston for pin. . . . . 50.815 ± 0.008 mm (2.006 ± 0.003 in)
Piston pin diameter 50.795 ± 0.005 mm (1.9996 ± 0.002 in.)
Clearance between pin and bore in piston . . . . . 0.020 ± 0.013 mm (0.008 ± 0.0005 in.)

FIG. A1.2 Piston Specifications



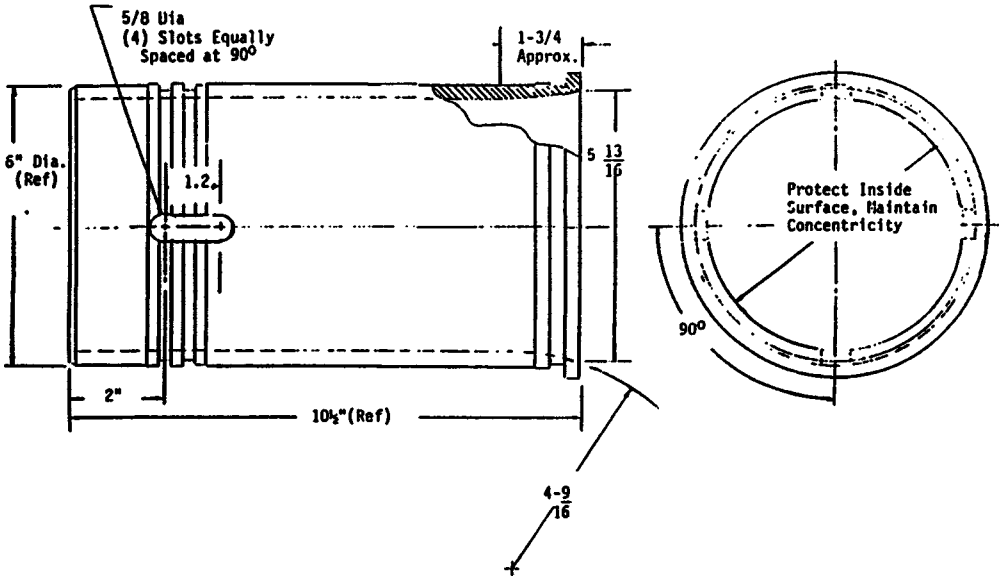
NOTE 1—Legend:
(*1*) Bore in liner (new) 137.185± 0.025 mm (5.401 ± 0.001 in.). With head torqued to block, assembled liner diameter is measured at 15 mm (0.6 in.) 25.4 mm (1.0 in.) 50.8 mm (2.0 in.) 130. mm (5.1 in.) 230. mm (9.0 in.) from top of liner. Out of round (difference of transverse and longitudinal diameters at each vertical height level). Max.–0.038 mm (0.0015 in.) Taper (Difference of all vertical height diameters in either the transverse or longitudinal direction). Max.–0.050 mm (0.0020 in.) Minimum assembled liner diameter–137.154 mm (5.3998 in.)
(*2*) Thickness of flange on liner–8.89± 0.02 mm (.350 ± .0008 in.)
(*3*) Filler band.

FIG. A1.3 Details of Cylinder Liner

A1.6.1.7 The air flow at the timing setting (bypass closing and start of fuel injection) should stop and occur at 31.5° ± 0.5 BTC. Measure the position by the Vernier.

A1.6.1.8 Continue rotation with the crankshaft past the timing setting and air flow should return.

A1.6.1.9 Further crankshaft rotation within 180° of the timing setting should approach another point where the air does not flow. This step ensures that the fuel timing is set on the correct side of the fuel cam. Fig. A1.9 is a diagram of the bubble method apparatus.



NOTE 1—Retrofit not to distort inside diameter or surface.

FIG. A1.4 Front and Side Views of Cylinder Liner

Cyl. No.	Serial No.	VERTICAL LOCATION OF MEASUREMENT									
		A		B		C		D		E	
		LONG.	TRANS.	LONG.	TRANS.	LONG.	TRANS.	LONG.	TRANS.	LONG.	TRANS
1											
2											
3											
4											
5											
6											

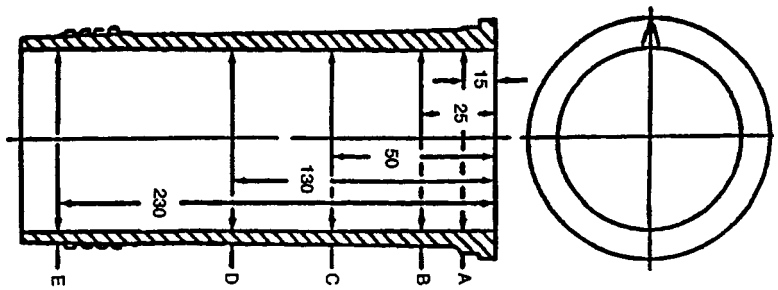
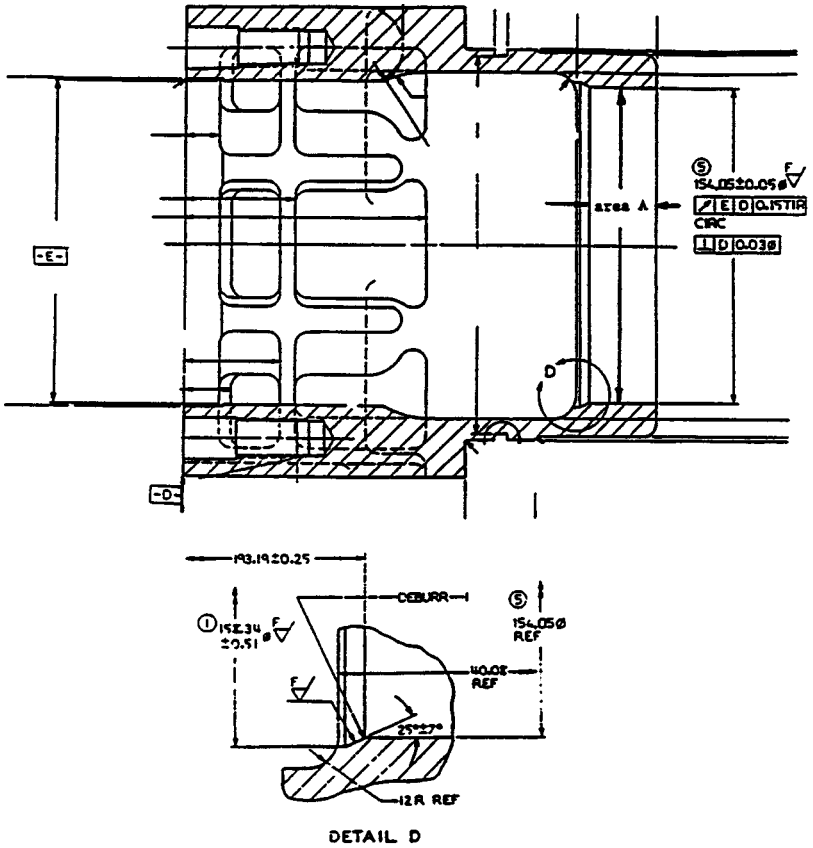


FIG. A1.5 Measurements of Cylinder Liner

A1.7 *1Y615 Cooling Jet I.D. Verification and Alignment*—See Fig. A1.10.

A1.8 *Fuel Pump Plunger Erosion*—See Fig. A1.11.



NOTE 1—1Y544 Cylinder Block (modifications required for product type cylinder liners)

NOTE 2—Machine o-ring area bore to 154.05 mm and tolerance shown.

NOTE 3—During assembly the cyl. liner o-ring flange must not touch the block in area A (liner distortion may occur). Use feeler gage to check clearances.

FIG. A1.6 Cylinder Block Modifications

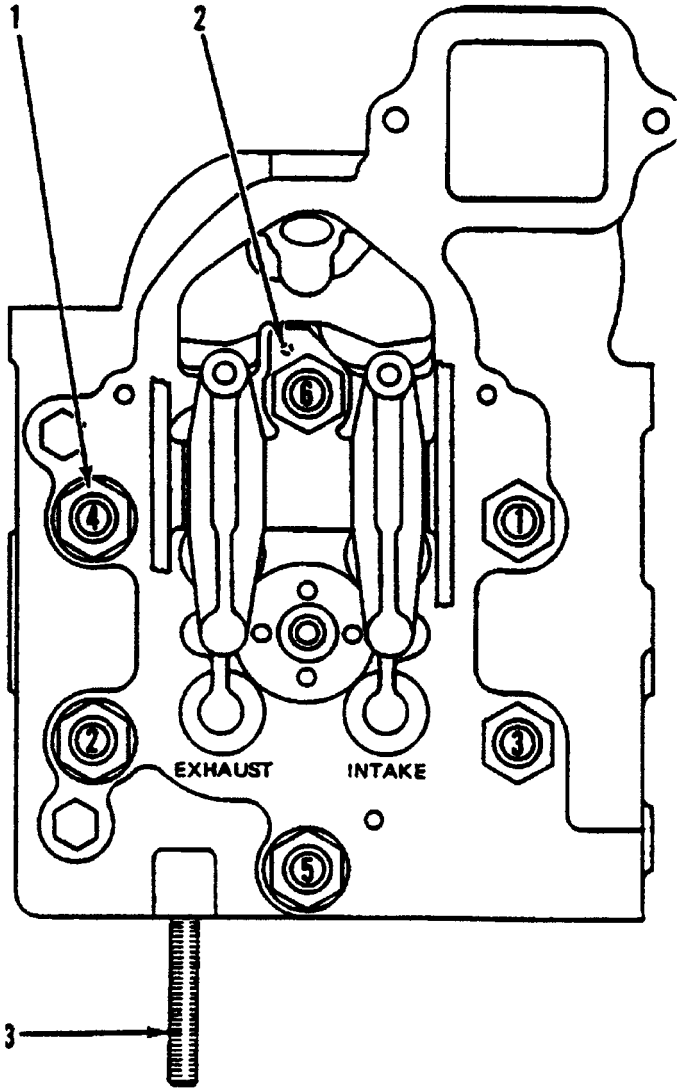
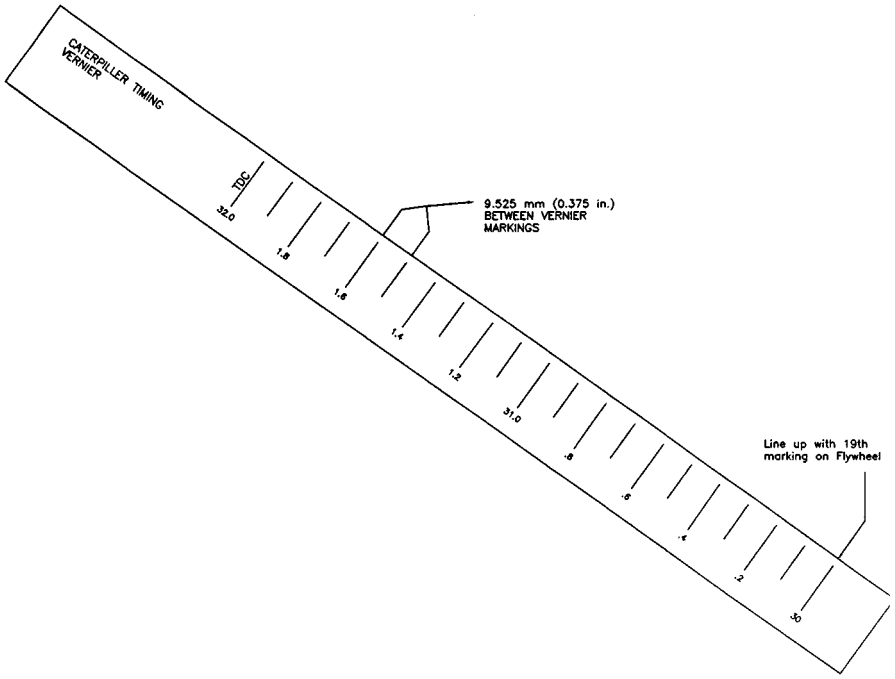


FIG. A1.7 Cylinder Head



NOTE 1—Vernier Information

(*1*) Make certain distance between the lines of the Vernier are 9.525 mm (0.375 in.).

(*2*) Slowly rotate crankshaft (CCW from flywheel end) until bubbles stop. **STOP ROTATION IMMEDIATELY AFTER THE BUBBLES STOP FLOWING**. This is by-pass closing. Continued crank rotation will cause incorrect timing values.

(*3*) Place the Vernier on top of the flywheel. Put the 32.0° line of the Vernier at the flywheel pointer with 30° line in the direction of 30° mark of the flywheel.

(*4*) Read down on the Vernier to the location where a line on the Vernier directly matches up with a timing line on the flywheel. Read the Vernier °TDC value at the location where the lines match up.

(*5*) Method to determine Vernier length:

20 flywheel division (40°) = 195 mm

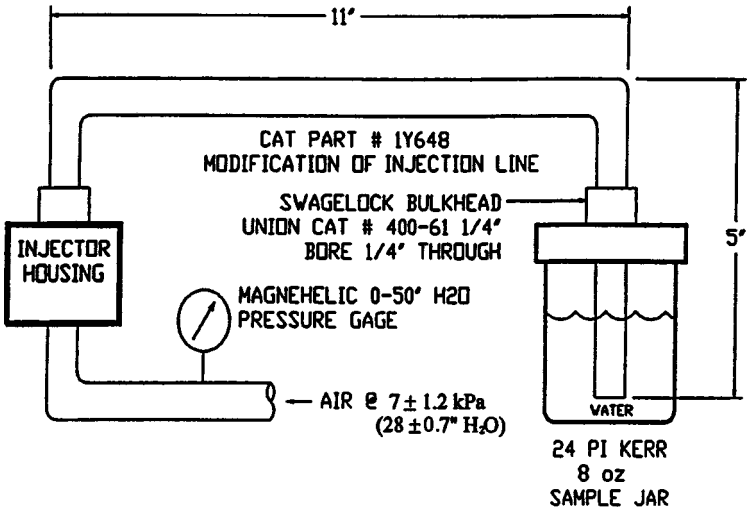
Length of Vernier scale $= \frac{195 \times 19}{20}$

$= 185.25$ mm

Length of 0.1° on vernier $= \frac{185.25}{20}$

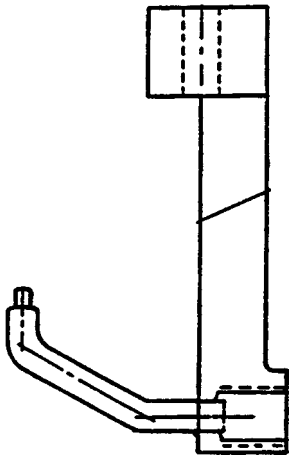
$= 9.2625$ mm

FIG. A1.8 Vernier for Measuring Flywheel Position



NOTE 1—Use Vernier to measure flywheel position.

FIG. A1.9 Diagram of Bubble Method Apparatus



NOTE 1—Ensure jet tube I.D. at threaded end (opposite end of orifice) is 0.135± 0.005 in. diameter.
NOTE 2—Tube can be inspected with:
No. 29 drill (0.1360 in.) nominal size.
No. 28 Drill (0.1405 in.). Drill should not fit in tube.
No. 3.3 mm drill (0.1299 in.). Drill should fit in tube.
NOTE 3—Replace 1Y615 cooling jet if not within specifications.
NOTE 4—When aligning the P tube (piston cooling jet tube), use an oil pressure of 358 kPa (52 psi) (system pressure).

FIG. A1.10 1Y615 Cooling, Jet I.D. Verification and Alignment

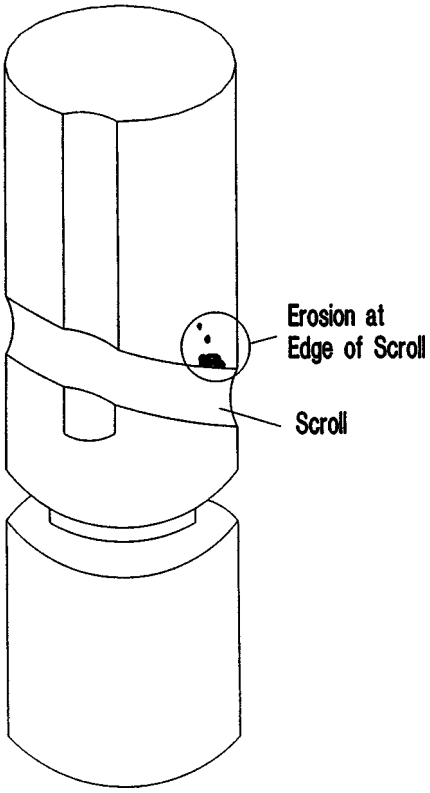


FIG. A1.11 Fuel Pump Plunger Erosion

A2. INTAKE AIR SYSTEM DETAILS

A2.1 See Fig. A2.1 and Fig. A2.2.

A2.2 *1Y38 Surge Chamber and Heater Assembly*:

A2.2.1 *General Dimensions*—This assembly is essentially a pressure vessel with internal electrical heating elements. The general dimensions of the surge chamber are: (*1*) volume, 204 L (7.37 ft^3); (*2*) inside diameter, 533 mm (21.00 in.); and (*3*) inside height, 933 mm (36.75 in.). See Table A2.1.

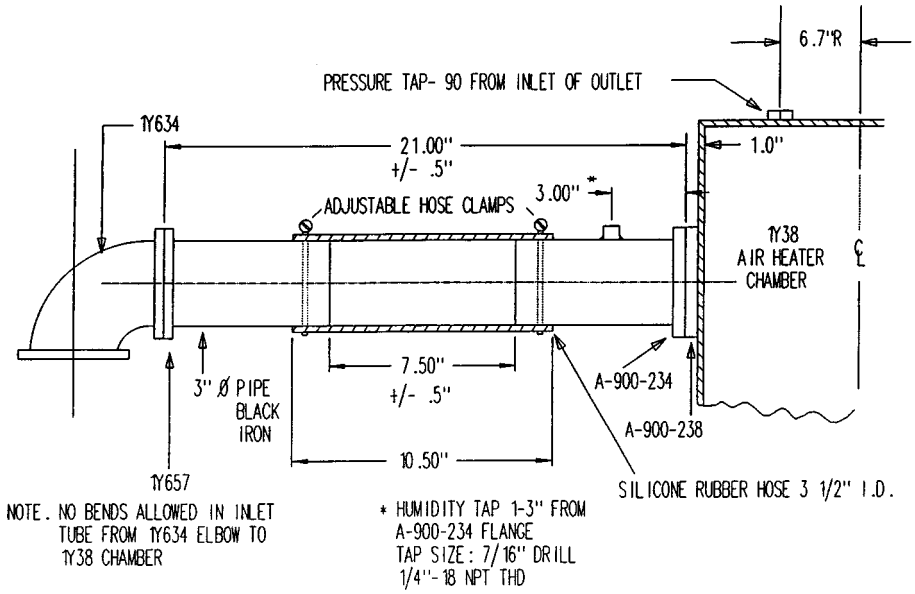


FIG. A2.1 Inlet Air Piping Arrangement

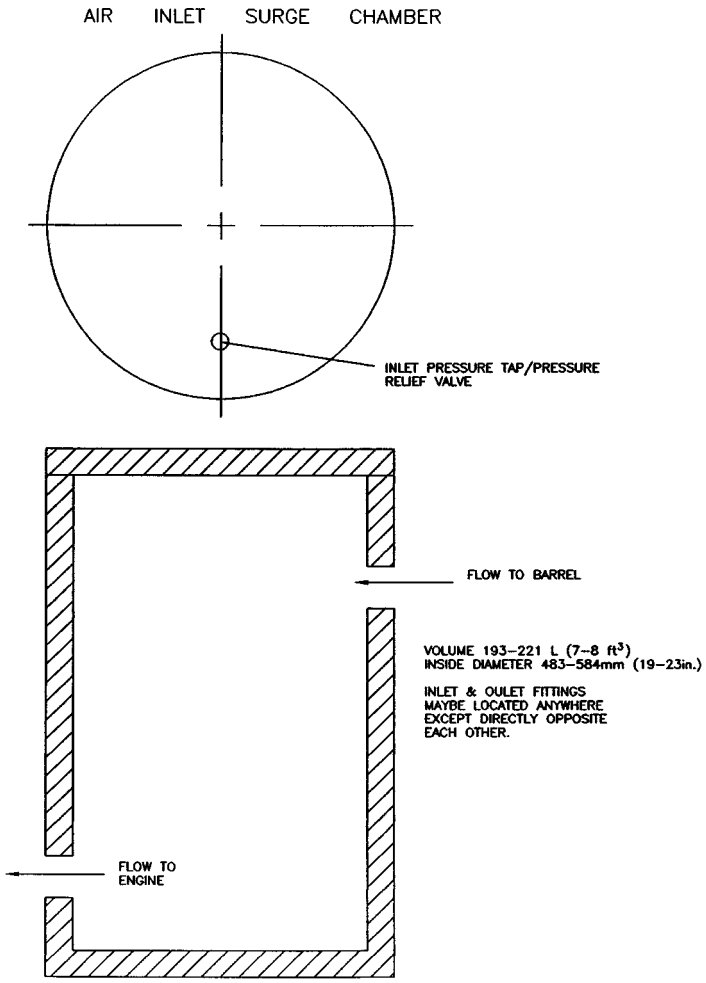


FIG. A2.2 Air Inlet Surge Chamber

A2.2.2 *Permissible Changes in Design*—If individual requirements or local building codes necessitate changes in the design, the following modifications are permissible:

A2.2.2.1 Volume may vary from 193 to 221 L (7 to 8 ft^3).

A2.2.2.2 Inside diameter may vary from 483 to 584 mm (19 to 23 in.).

A2.2.2.3 Inside height is a function of the volume and inside diameter.

A2.2.2.4 Inlet and outlet fittings may be anywhere except opposite one another.

A2.2.2.5 The type and arrangement of heating controls may be determined by local conditions.

A2.2.2.6 The chamber may be located in any position relative to the engine so long as (*a*) the length of the air transfer pipe is 533.4 ± 12.7 mm (21.0 ± 0.5 in.) from the face of the surge chamber mounting pad to the face of the 1Y634 elbow; and (*b*) the air transfer pipe contains no bends between the surge chamber and the 1Y634 elbow.

A2.2.2.7 A stand may be constructed to raise the chamber to the proper height to fit the engine arrangement and mounting.

A2.3 See Fig. A2.3 for intake air temperature location and Fig. A2.4 for horizontal air barrel pressure tap location.

TABLE A2.1 Bill of Material, Surge Chamber and Heater Assembly

NOTE 1—Dimensions are in inches unless otherwise specified.
NOTE 2—Drawings are available from Caterpillar.

Item No.	Name	Caterpillar Part No.	Description	No. Required
1-1	Surge chamber and Heater Assembly			1
1-2	Bolt	L1648	3/8–24thd 2.50 long[A]	1
1-4	Thermostatic switch			2
1-5	Lockwasher	3B4506	Std. for .375 diameter bolt	20
1-6	Bolt	2A4996	3/8–24thd 1.375 long	20
1-7	Pressure relief valve		[B]	1
1-8	Gasket		0.0312 thick[C]	1
1-9	Mounting plate		20×12×.0625 thick SAE 1020 steel	1
1-10	Spacer	8B7430	0.750 OD 0.359 ID .532 thick SAE 1020 steel	4
1-11	Bolt	L1590	1/4-28thd 1.125 long	4
1-12	Lockwasher	3B4504	Std. for 0.250 diameter bolt	4
1-13	Nut	1B4201	1/4-28thd	4
1-14	Electrical junction box		12×18×4 std pull box w/hinged cover	1
1-15	Strip heater		[D]	24
1-16	Gasket		0.0312 thick[C]	1
2-1	Assembly			1
2-2	Top ring			1
2-3	Bottom plate			1
2-4	Strap-surge chamber			1
2-5	Hook			1
2-6	Pad			1
3-1	Assembly			1
3-2	Top cover			1
3-3	Inner bracket			1
3-4	Outer bracket			1
4-1	Terminal assembly			5
4-2	Nut		7/16–14thd SAE 73 brass	29
4-3	Washer		Std. for .437 dia. bolt	10
4-4	Insulator		1.250 OD, .453 ID, .187 thick Synthane	5
4-5	Stud		7/16-14thd 3 long brass	5
4-6	Collar			5
4-7	Insulator assembly			48
4-8	Washer		.750 OD, .265 ID, .125 thick Mica	48
4-9	Insulator		.500 OD .265 ID	48
4-10	Insulator		1.687×1×.0625 w/.265 hole Mica	
4-11	Bolt		1/4-20thd 1 long	48
4-12	Washer		Std. for .250 diameter bolt	48
4-13	Nut		Std. for 1/4 20thd	48
4-14	Electric cable cover			1
4-15	Terminal connector			[E]
4-16	Lower bracket assembly			1

[A] 40 °F per turn-normally closed-contacts open with increase of temperature. Turning screw counter-clockwise causes contacts to open at a higher temperature.
[B] Set to pop off at 137.9 ± 3.4 kPa (20 ± 0.5 psi).
[C] Make gaskets to fit top ring (2-2) and pad (2-6).
[D] Terminal on element goes to inside of barrel on inner rings and to outside of barrel on outer rings.
[E] As required.

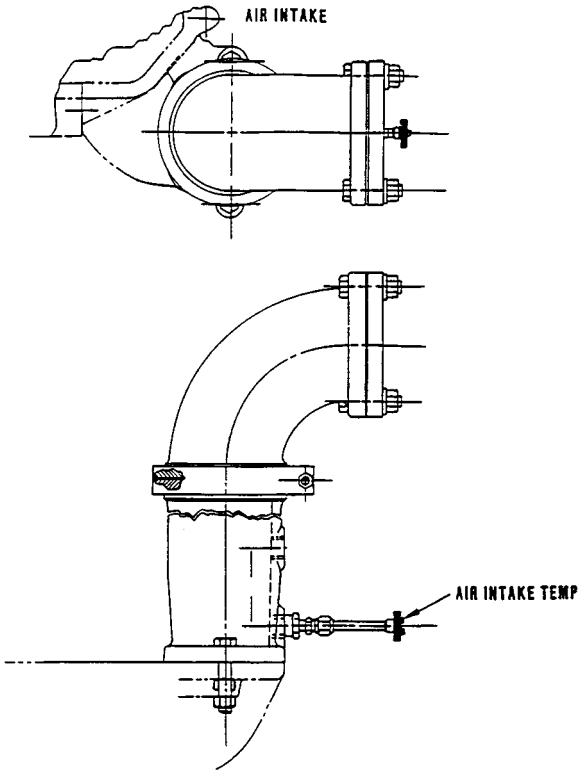
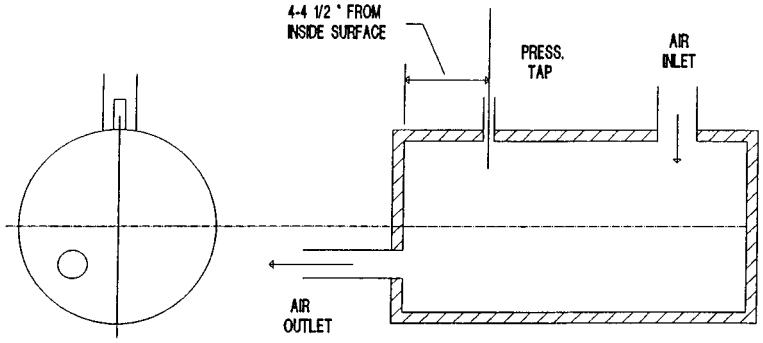


FIG. A2.3 Intake Air Temperature Location



NOTE 1—Air outlet should be 90° or greater from the air pressure tap.

FIG. A2.4 Horizontal Air Barrel Pressure Tap Location

A3. EXHAUST SYSTEM DETAILS

A3.1 See Figs. A3.1-A3.5.

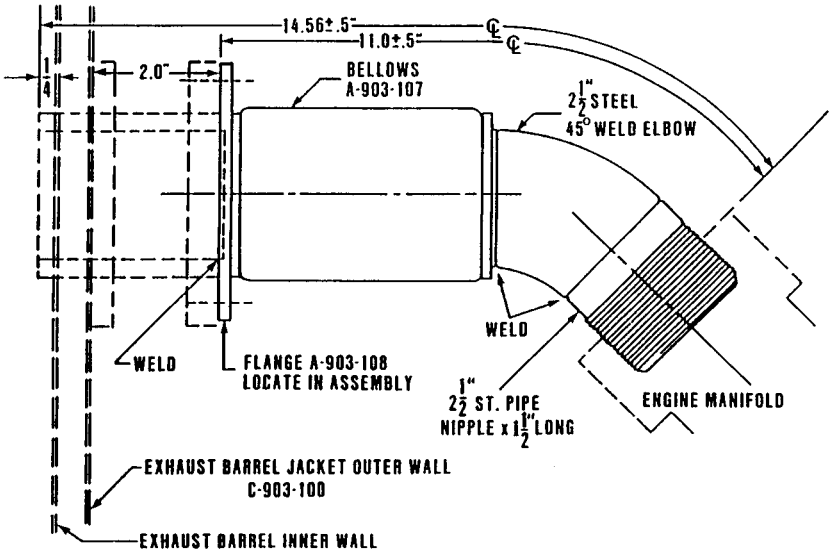


FIG. A3.1 Exhaust Piping Arrangement

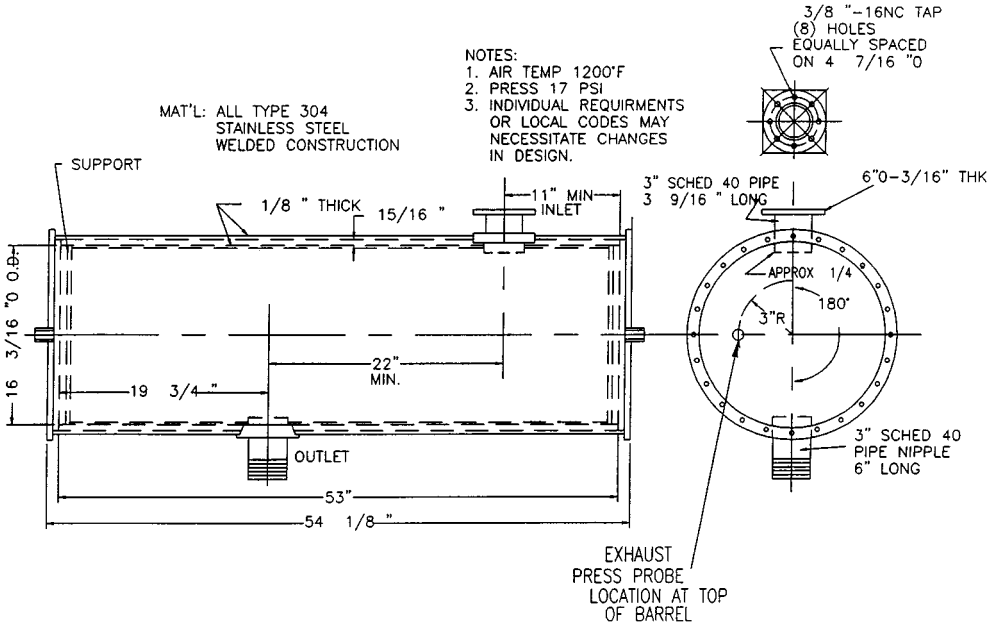


FIG. A3.2 Exhaust Barrel Diagram

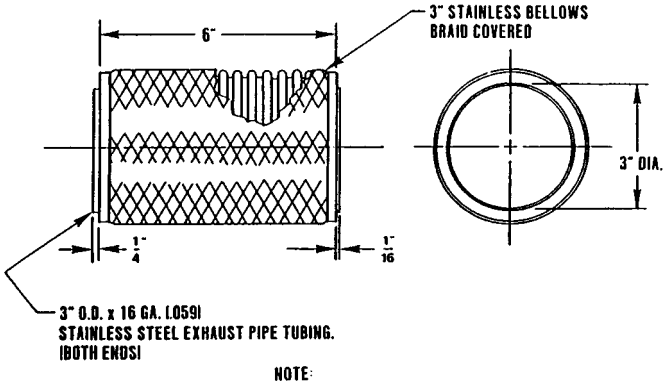
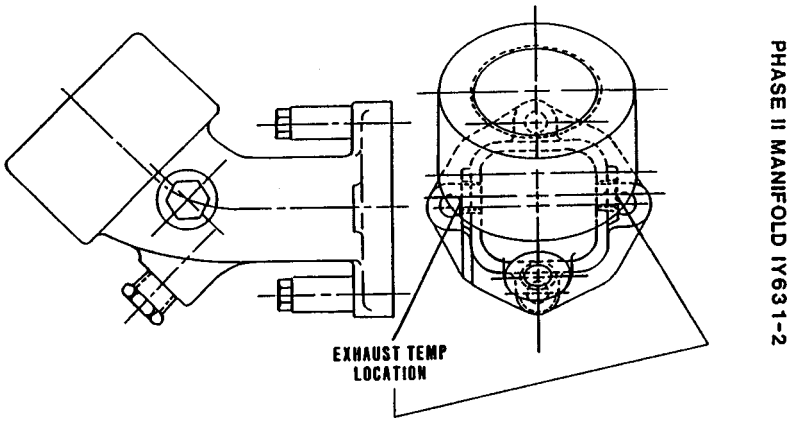
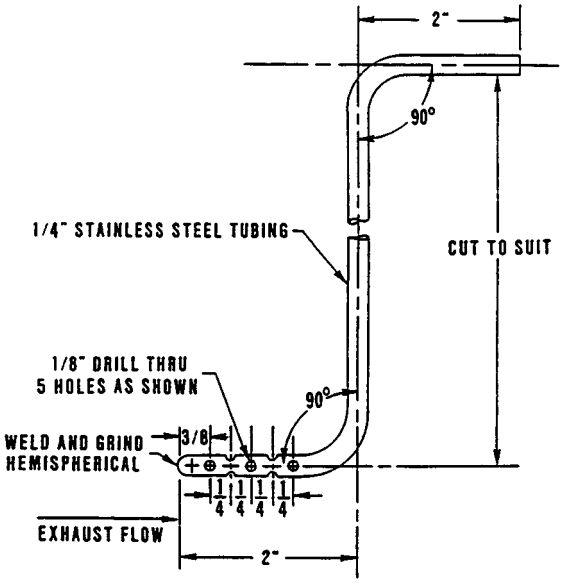


FIG. A3.3 Exhaust Bellows



Either location is acceptable.

FIG. A3.4 Thermocouple Location in Exhaust Manifold



NOTE. WALL THICKNESS .03 IN.

FIG. A3.5 Exhaust Gas Sample Probe

A4. COOLING SYSTEM DETAILS

A4.1 See Figs. A4.1-A4.4.

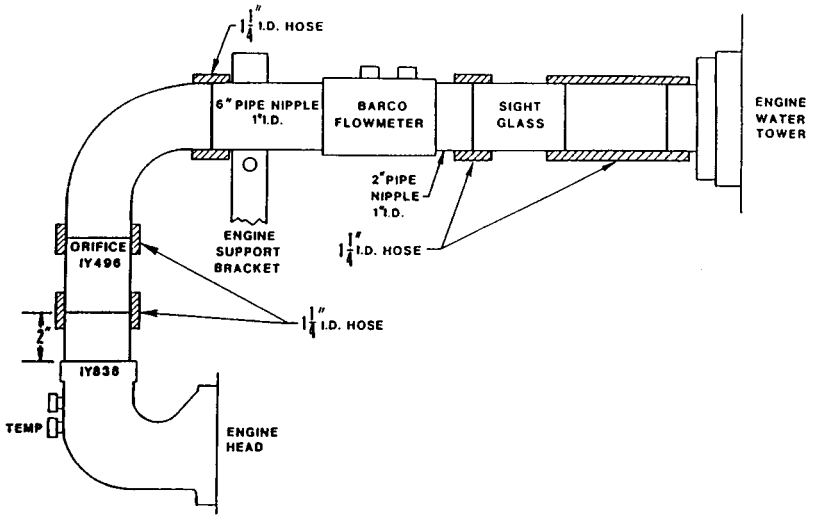


FIG. A4.1 Piping Arrangement and Instrument Locations

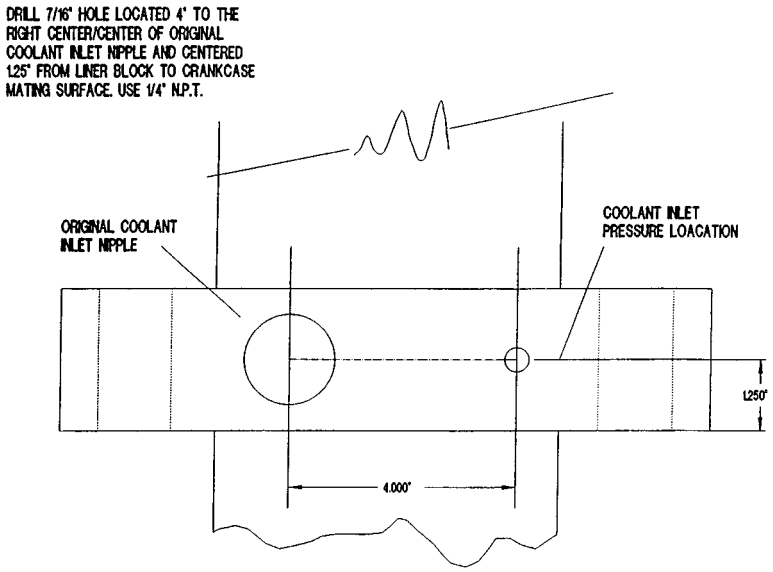
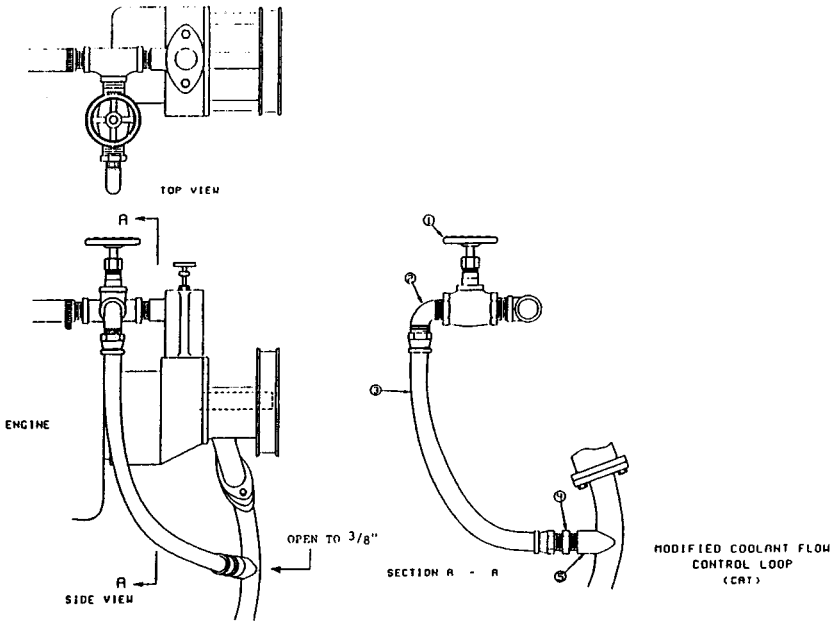
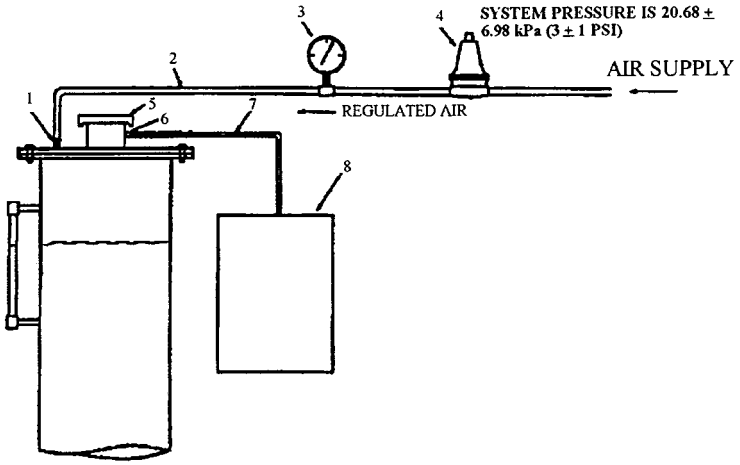


FIG. A4.2 Block Coolant Pressure Tap Location



NOTE 1—¾ in. valve
NOTE 2—90° elbow ¾ in. MNPT - TO No. 10AN.
NOTE 3—No. 10 hose with swivels.
NOTE 4—Connector ⅜ in. MNPT - TO No. 10AN. Drill to 7⁄16 in. inside diameter.
NOTE 5—Modify existing boss on the water pump intake. Drill and tap to ⅜ in. NPT.

FIG. A4.3 Water Pump Bypass Arrangement



Pressurized Coolant System

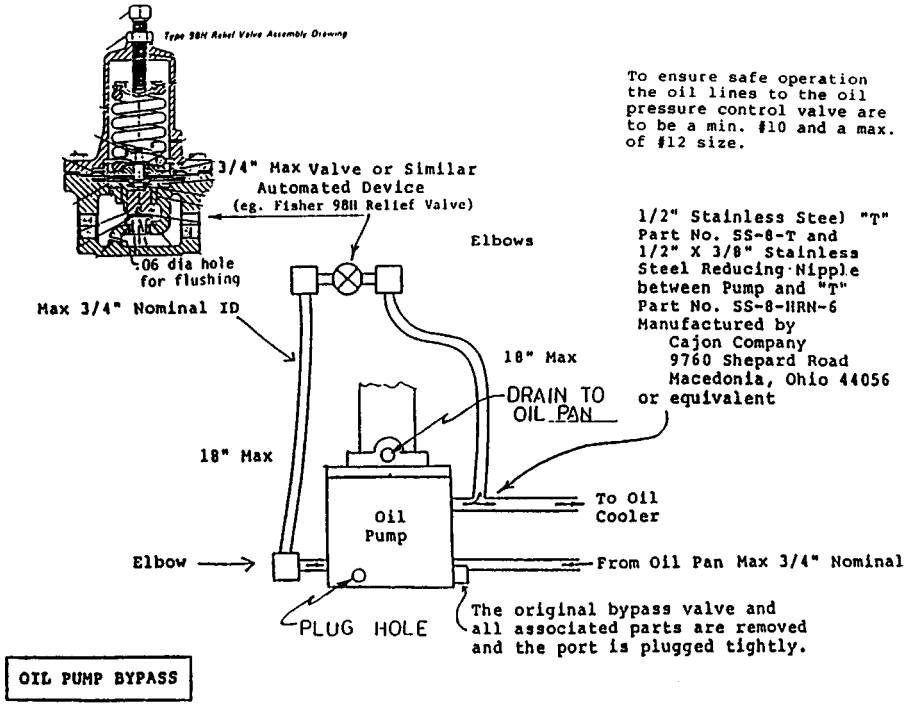
NOTE 1—Legend:
1. ¼ in. NPT-to No. 4AN (male connector)
2. No. 4 hose
3. Pressure gage 0-15 PSIG
4. Pressure regulator (self bleeding)
5. Radiator cap 15-16 PSIG
6. Radiator filler neck
7. Overflow tube
8. Overflow tank

NOTE 2—If the system builds to greater than regulator setting, then condensate will back-flow through regulator.

FIG. A4.4 Cooling System Modification

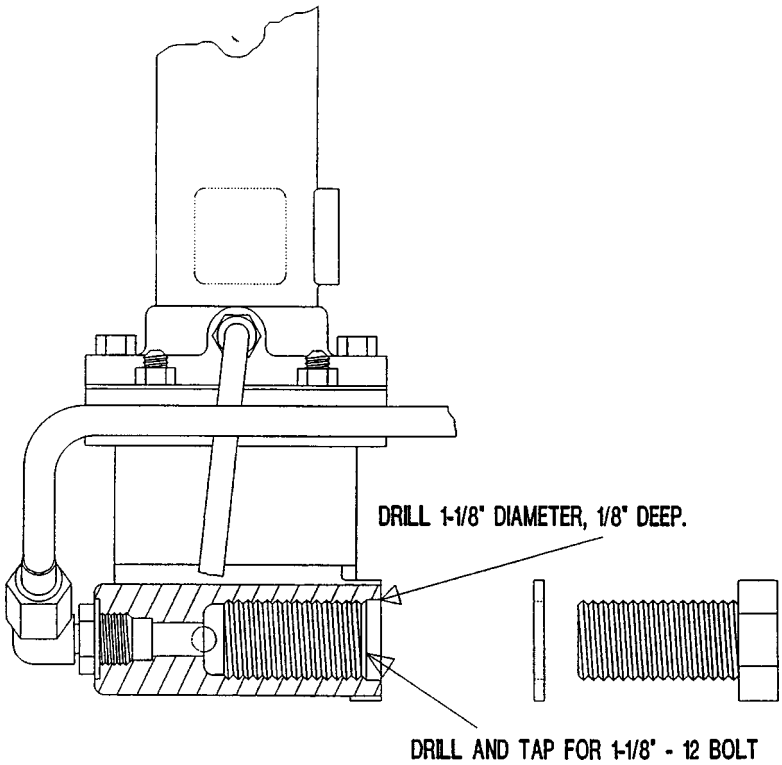
A5. OIL SYSTEM MODIFICATIONS AND INSTRUMENT LOCATIONS

A5.1 See Figs. A5.1-A5.8.



NOTE 1—Available from General Meters and Controls, 1776 Commerce Drive, Bos 625, Elk Grove, Village, IL 60007 as Oil Pressure External Relief Valve Fisher 98H-17 ½ in. Cast Iron Body, S.S. Diaphragm.

FIG. A5.1 Remote Mount Oil Pump Relief Valve



NOTE 1—Install: 1-2H3751 bolt (1-1/8-12 × 2-1/2"); 1–5B3265 gasket. If desired, bolt thread may be sealed with 7M7456 bearing mount.

FIG. A5.2 Oil Pump Relief Valve Plug

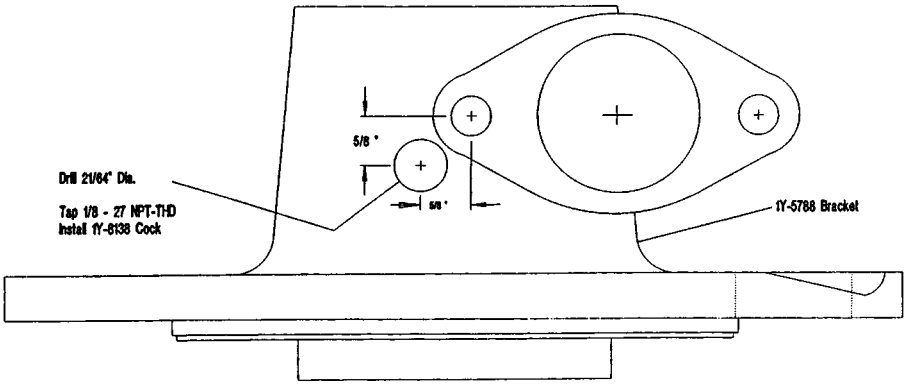
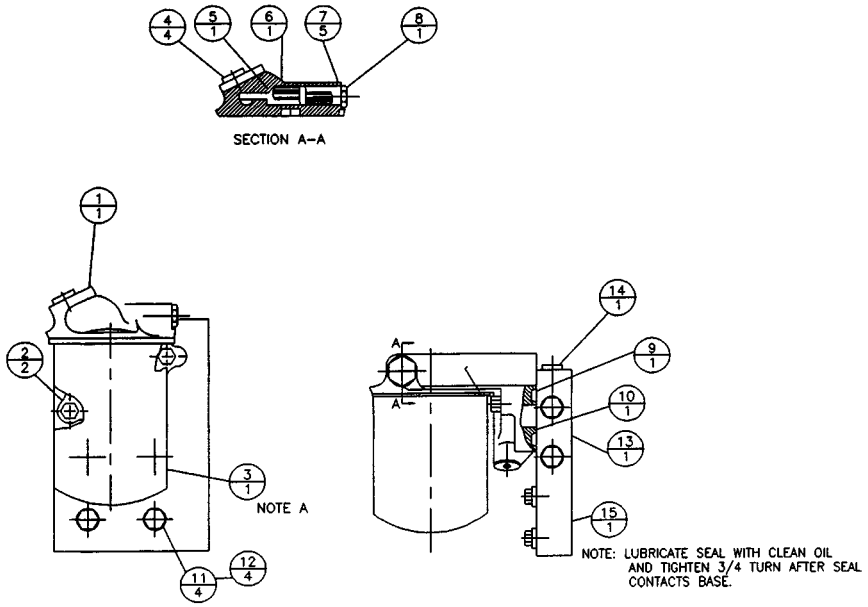


FIG. A5.3 Oil Pump Accessory Drive Housing Drain



NOTE 1—Legend:

Quantity	PART NO.	NAME
1	IN4426	Base AS.
2	OS1571	Bolt
1	8N9586	Filter AS.
4	9S8005	Plug
1	IN4424	Valve
1	IN4425	Spring
5	SK0360	Seal
1	IN4423	Plug
1	6J2244	Seal
1	5P7530	Seal
4	OS1590	Bolt
4	5M2894	Washer
1	7M7410	Plug
1	5B8994	Gasket
1	1Y0698	Bracket

FIG. A5.4 Oil Filter Housing Assembly

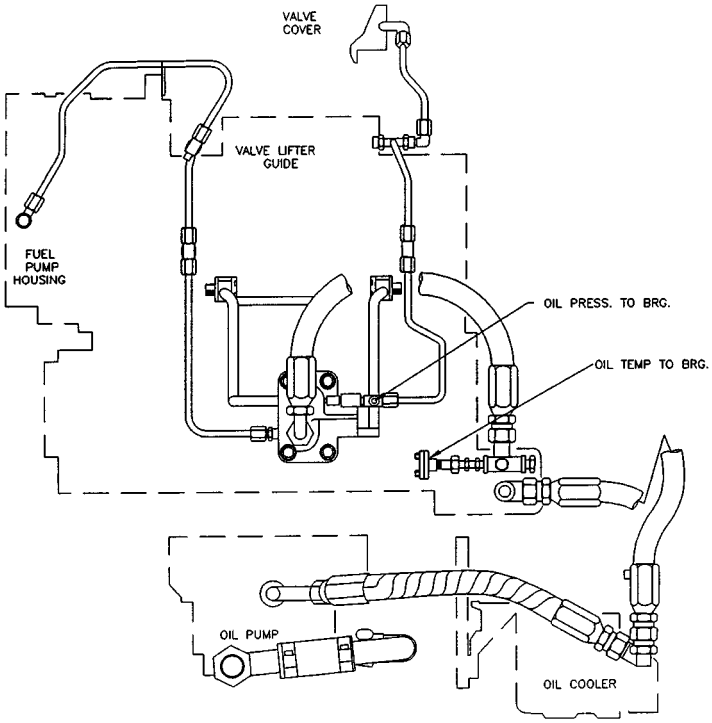


FIG. A5.5 1Y580 Engine Oil Lines Group – Part 1

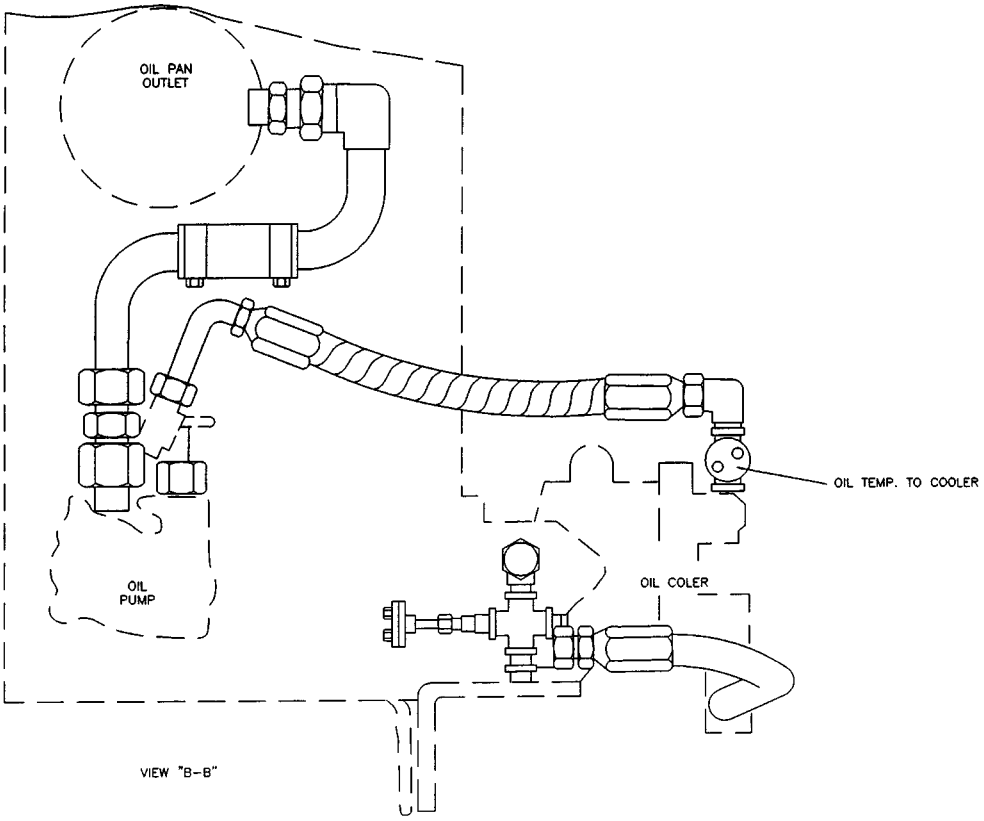


FIG. A5.6 1Y580 Engine Oil Lines Group – Part 2

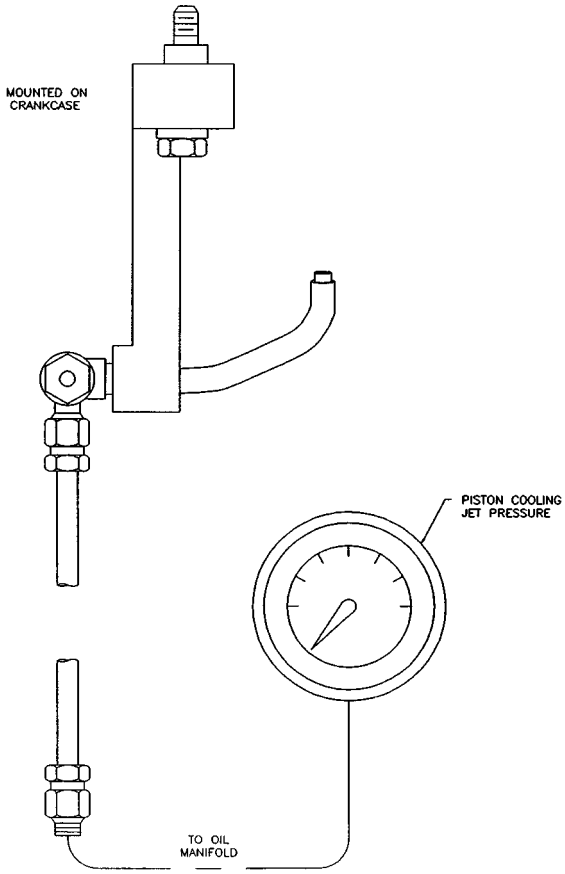
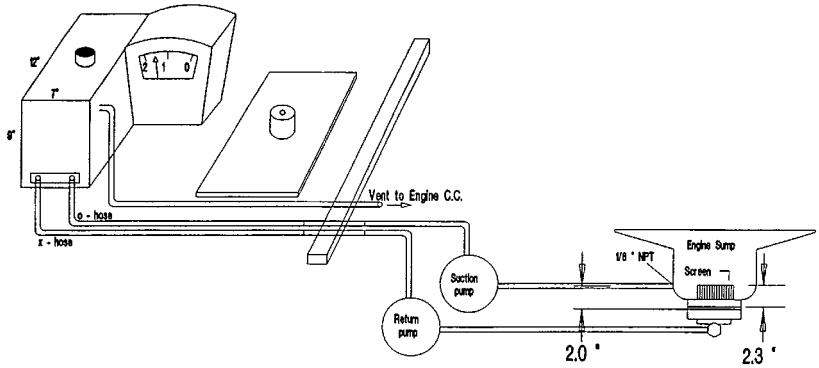


FIG. A5.7 1Y616 Piston Cooling Jet Group

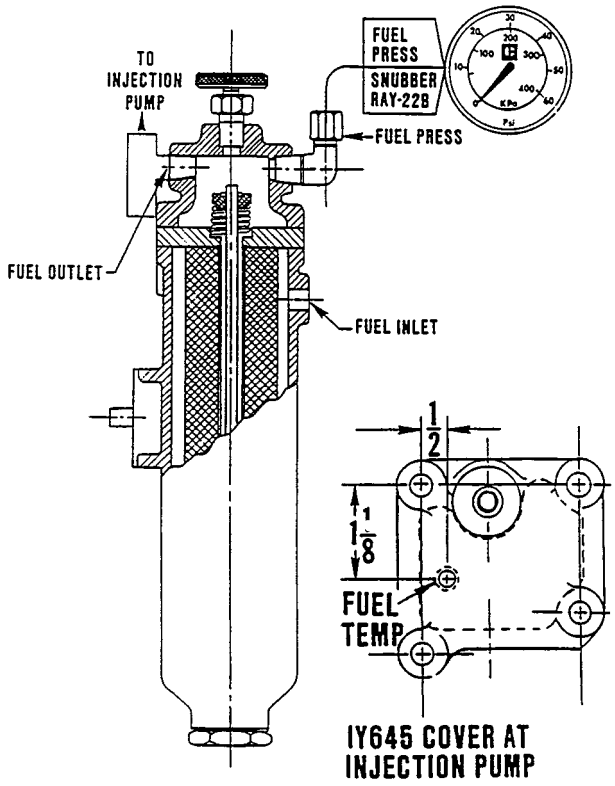


NOTE 1—Requirements:
(*1*) Suction pump and hose
Type – Viking C-90 pump or equivalent
Flow – 6 GPH/ – 1.5 GPH
Speed – 285 R/min
Hose – 0.25″ ID; 9′ total length (max.)
Pulley – 4.95″ OD
(*2*) Return pump and hose
Type – Viking C-92 pump or equivalent
Flow Differential – 3 GPH /– 1 GPH
Speed – 163 R/min
Hose – 0.25″ ID; 9′ total length (max.)
Pulley – 8″ OD
(*3*) Pump motor (both pumps)
Type – 56 Nema Grainger 6K949 or equivalent
Speed – 1140 R/min
H.P. – 3/4
Pulley – 1.5″ OD
Vent line – 0.25″ OD hose
(*4*) Oil in reservoir – 2 qt
(*5*) Scale precision – 0.01 (properly damped)
(*6*) Flexible hose – To/from reservoir from fixed cart support – Gould/Imperial catalog C405-100

FIG. A5.8 Low Flow Oil Scale System

A6. OTHER PRESSURE AND TEMPERATURE MEASUREMENT LOCATIONS

A6.1 See Figs. A6.1 and A6.2.



NOTE 1—Fuel gage snubber available from Operating and Maintenance Specialities, Charlotte, NC: As Ray Snubber, Model 22B.

FIG. A6.1 Fuel Pressure and Temperature Measurement Locations

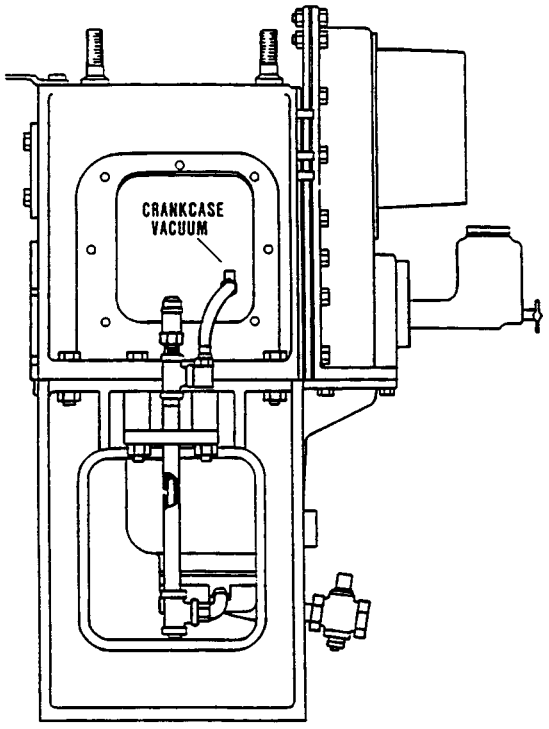


FIG. A6.2 Crankcase Pressure Measurement Location

A7. OIL CONSUMPTION LINEAR REGRESSION METHOD

A7.1 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: Eq A7.1 and A7.2. Also, see Figs. A7.1 and A7.2.

$$b = \frac{\Sigma x_i y_i - \frac{\Sigma x_i \, \Sigma y_i}{n}}{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}} \quad \text{(A7.1)}$$

$$a = \left[\frac{\Sigma y_i}{n} - b\frac{\Sigma x_i}{n}\right] \quad \text{(A7.2)}$$

$$r^2 = \frac{\left[\Sigma x_i y_i - \frac{\Sigma x_i \Sigma y_i}{n}\right]^2}{\left[\Sigma (x_i)^2 - \frac{(\Sigma x_i)^2}{n}\right]\left[\Sigma (y_i)^2 - \frac{(\Sigma y_i)^2}{n}\right]} \quad \text{(A7.3)}$$

where:

Y_i points = oil weights taken at time X,
X_i points = times at which oil weight observation X are made (that is, hours 1,2,....n),
b = slope of best-fit line = oil consumption,
a = Y–intercept, and
r^2 = goodness of fit (if 1, perfect; if 0, no fit at all).

A7.2 *Methods of Computation of Oil Consumption Using Linear Regression*:

A7.2.1 Oil consumption may be calculated during any period by performing a linear regression on Y_i and X_i data points where:

Y_i = oil weight taken at time X (from digital readout, strip chart, or as recorded by a computer), and
X_i = time at which oil observation Y is taken (from manual log or computer memory).

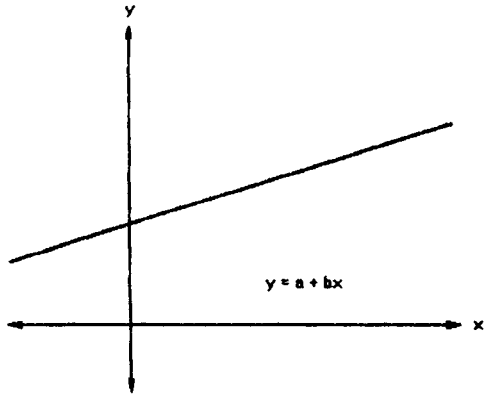


FIG. A7.1 Oil Consumption Linear Regression Graph

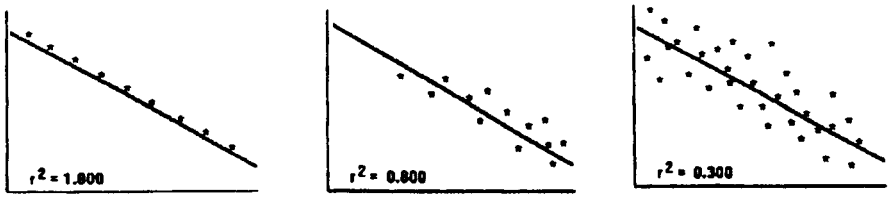


FIG. A7.2 Examples of Goodness of Fit

A8. TEST FUEL SPECIFICATIONS

A8.1 See Tables A8.1-A8.3.

TABLE A8.1 Specification for 1K Test Fuel

Test	ASTM Method	Requirement	
Flash point	D 93	140°F (60.0°C) min. or legal	
Pour point	D 97	20°F (–7°C) max.	
Cloud point	D 2500 OR D 3117	Report	
Water and sediment	D 1796	0.05 volume % max.	
Ramsbottom carbon residue on 10% residuum	D 524	0.20 mass % max.	
Ash	D 482	0.01 mass % max.	
Distillation	D 86	IBP Report	
		10 % Report	
		50 % 500-530°F (260-277°C)	
		90 % 590-620°F (310-327°C)	
		EP 659-690°F (343-366°C)	
Kinematic viscosity At 104°F (40.0°C)	D 445	2.0-4.0 cSt (2.0-4.0 mm^2/s)	
Total sulfur (must be natural)	D 2622	0.380-0.420 mass %	
Copper corrosion (122°F, 50°C, 3 h)	D 130	no. 2 max.	
Acid No. (an-E)	D 664	0.15 mg KOH/g max.	
Cetane No.	D 613	47.0-53.0	
Density	D 287 OR D 1298	report	
API gravity	D 287 OR D 1298	33-35°API	
Cracked stocks		none	
Hydrocarbon types	D 1319	report	
Hydrocarbon Types	D 2425	Component	Mass %
		Aliphatic paraffins	45.0-65.0
		Monocycloparaffins	report
		Dicycloparaffins	0.0-15.0
		Tricycloparaffins	report
		Alkybenzenes	5.0-10.0
		Indans/Tetralins	report
		Indenes	report
		Napthalene	report
		Napthalenes	5.0-15.0
		Acenaphthenes	report
		Acenaphthylenes	report
		Tricyclic aromatics	report

TABLE A8.2 Specification for 1N Test Fuel

Test	ASTM Method	Requirement	
Flash point	D 93	54°C min.	
Pour point	D 97	–18°C max.	
Cloud point	D 2500	–12°C max.	
Water and sediment	D 2709	0.05 volume % max.	
Ramsbottom carbon residue on 10% residuum	D 524	0.35 mass % max.	
Ash	D 482	0.01 mass % max.	
Distillation	D 86	IBP 177-199°C	
		10 % 210-232°C	
		50 % 249-277°C	
		50 % 299-327°C	
		EP 327-360°C	
Kinematic viscosity At 40°C	D 445	2.0-3.2 cSt	
Total sulfur (must be natural)	D 2622	0.03-0.05 mass %	
Copper corrosion	D 130	no. 3 max.	
Cetane index	D 4737	42-48	
Cetane number	D 613	42-48	
API gravity	D 287	32-36°API	
Hydrocarbon Types		Component	
	D 5186	Aromatics % volume	28-35
	D 1319	Olefin	report
	D 1319	Saturates	report

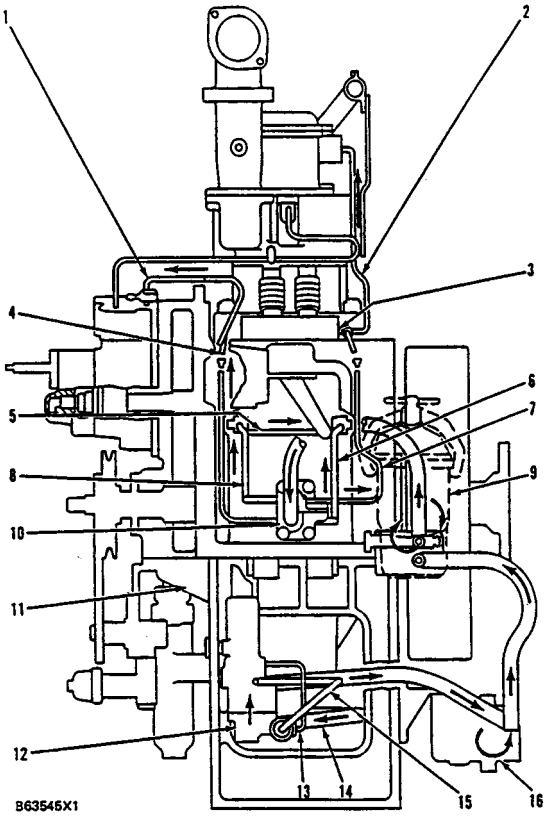
TABLE A8.3 Estimation of High Heating Value of Fuel from API Gravity

NOTE 1—For calculating heat input, use the high heating value (gross heat of combustion) estimated from the API gravity of the fuel. The relationship between gross heat of combustion and API gravity figures in this table was obtained from NIST Miscellaneous Publication No. 97.

Gravity	Gross Heat of Combustion	
Degrees, A.P.I., 15.6°C (60°F)	kJ/kg	(BTU/lb)
30	45 155	(19 420)
31	45 225	(19 450)
32	45 318	(19 490)
33	45 388	(19 520)
34	45 481	(19 560)
35	45 551	(19 590)

A9. LUBRICATION SYSTEM, FLUSH APPARATUS, AND PROCEDURE

A9.1 See Figs. A9.1-A9.12.



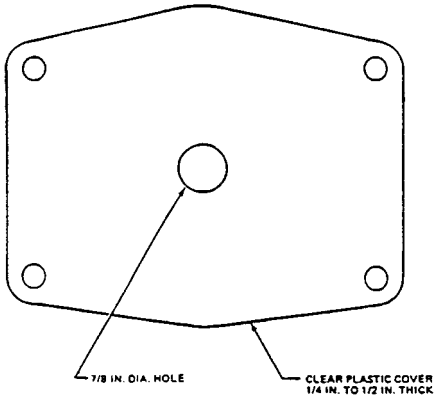
NOTE 1—B63545X1 Legend
1. Line to fuel cam
2. Line to rocker arm shaft.
3. Line to lifter.
4. Line to accessory shaft.
5. Line to piston cooling jet.
6. Line to rear main bearing.
7. Line to rear cam bearing.
8. Line to front main bearing.
9. Oil filter.
10. Manifold.
11. Oil pan.
12. Oil pump.
13. Drain line.
14. Oil pump supply line.
15. Bypass line.
16. Oil cooler assembly.

FIG. A9.1 Lubrication System

PROCEDURE	FLUSH FLUID	PUMP CONNECTION		FLUSHING TIME (min)			
		Inlet	Outlet	Engine Oil Line	Crank case	Governor Housing	Front Cover
1. Install a new 8N9586 oil filter and a clean 1Y5700 element in the flushing pump unit. Remove crankcase breather 1Y2592 from engine and wash in solvent until clean. Air dry.	7.6 L (2 U.S.gal) Stoddard solvent No recirculation; Crankase drain open.	Solvent tank	Oil cooler drain	5			
*2. Recirculate cleaning mixture. Turn on oil scale pumps.	Cleaning mixture: 1.9 L (0.5 U.S.gal) engine cleaner 5.7 L (1.5 U.S.gal) Stoddard solvent	Crankacase drain	Oil cooler drain	15			
		Crankacase drain	Crankcase sprayer		10	10	
		Crankacase drain	Front cover sprayer				10
*3. Drain mixture from crankcase, governor housing, drive housing, oil cooler, oil scale reservoir, and engine and flushing pump filters. Recirculate using C.	Solvent flush A 7.6 L (2 U.S. gal) Stoddard solvent	Crankacase drain	Oil cooler drain	15			
		Crankacase drain	Crankcase sprayer		10	10	
		Crankacase drain	Front cover sprayer				10
*4. Drain Stoddard solvent from crankcase, governor housing, oil cooler, oil scale reservoir, and engine and flushing pump filters. Recirculate using B.	Solvent flush B 7.6 L (2 U.S. gal) Stoddard solvent	Crankacase drain	Oil cooler drain	15			
		Crankacase drain	Crankcase sprayer		10	10	
		Crankacase drain	Front cover sprayer				10
*5. Drain Stoddard solvent from crankcase, governor housing, oil cooler, oil scale reservoir, and engine and flushing pump filters. Recirculate using C.	Solvent flush C 7.6 L (2 U.S. gal) Stoddard solvent	Crankacase drain	Oil cooler drain				
		Crankacase drain	Crankcase sprayer		10	10	
		Crankacase drain	Front cover sprayer				10
*6. Drain Stoddard solvent from crankcase, governor housing, oil cooler, oil scale reservoir, and engine and flushing pump filters. If solvent clean, go to step. Otherwise, recirculate with extra solvent.	Extra solvent flushes: 7.6 L (2 U.S. gal) Stoddard solvent	Crankacase drain	Oil cooler drain	15			
		Crankacase drain	Crankcase sprayer		10	10	
		Crankacase drain	Front cover sprayer				10
7. Repeat step 6							
*8. Drain Stoddard solvent from crankcase, governor housing, oil cooler, oil scale reservoir, and engine and flushing pump filters. Close drain & 1Y653 line. Install dummy piston, cylinder block, liner, oil filler spout, governor housing cover.	4.7 L (5 U.S.qt.) test oil						
9. Add test oil. Recirculate at 359 kPa (52 psi)	4.7 L (5 U.S.qt.) test oil	Crankacase drain	Oil cooler drain	5 Motor engine @ 400r/min at least 1 min			
*10. Drain test oil from crankcase, governor housing, accumulator drive housing, oil cooler, and oil scale reservoir, engine and flushing pump filters.							
11. Add test oil. Recirculate at 359 kPa (52 psi). Align piston jet. Drain and build for test.	4.7 L (5 U.S.qt.) test oil	Crankacase drain	Oil cooler drain	Recirculate 5 min			

* Low flow oil scale pumps should be turned on during each step.

FIG. A9.2 Flushing Instruction Sheet



NOTE 1—Use 1 Y3698 gasket as pattern for bolt hole locations.

FIG. A9.3 Clear Plastic Cover

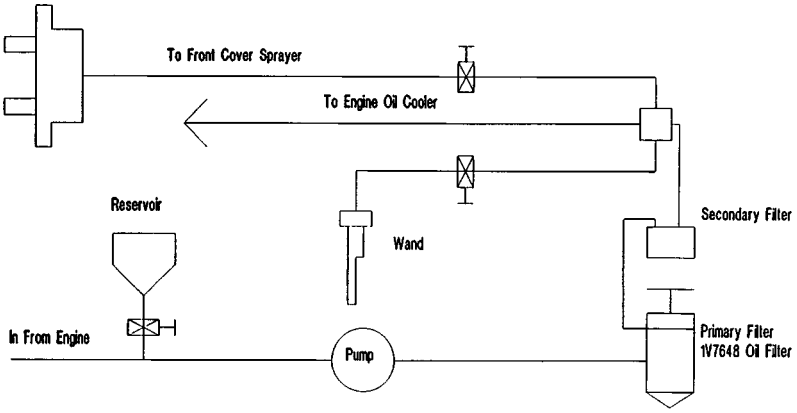


FIG. A9.4 Flushing Cart Flow Schematic

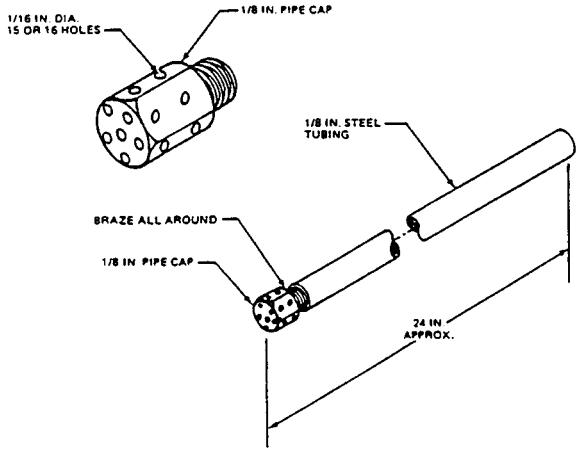


FIG. A9.5 Crankcase/Governor Housing Sprayer

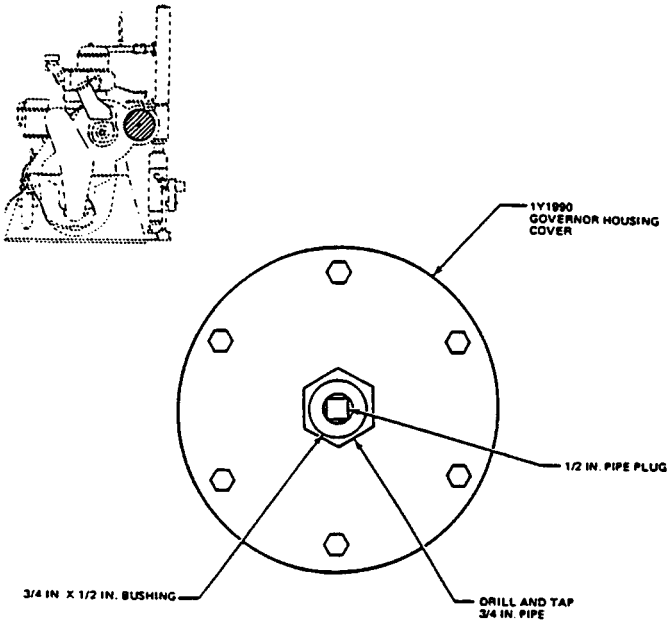


FIG. A9.6 Governor Housing Cover Modification

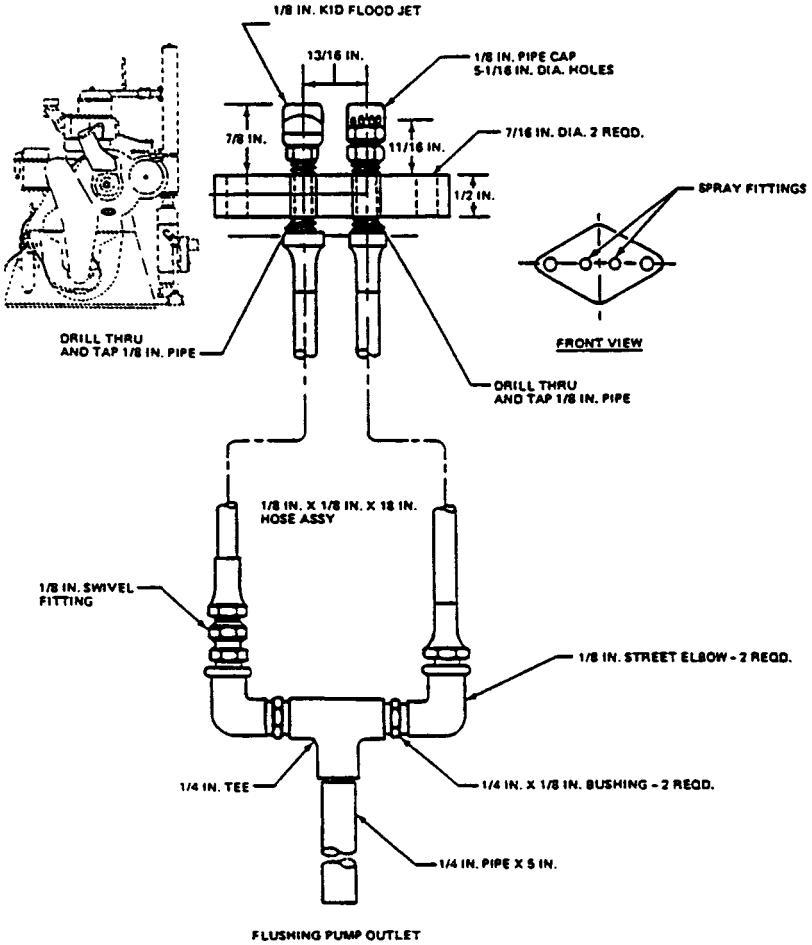


FIG. A9.7 Front Cover Sprayer

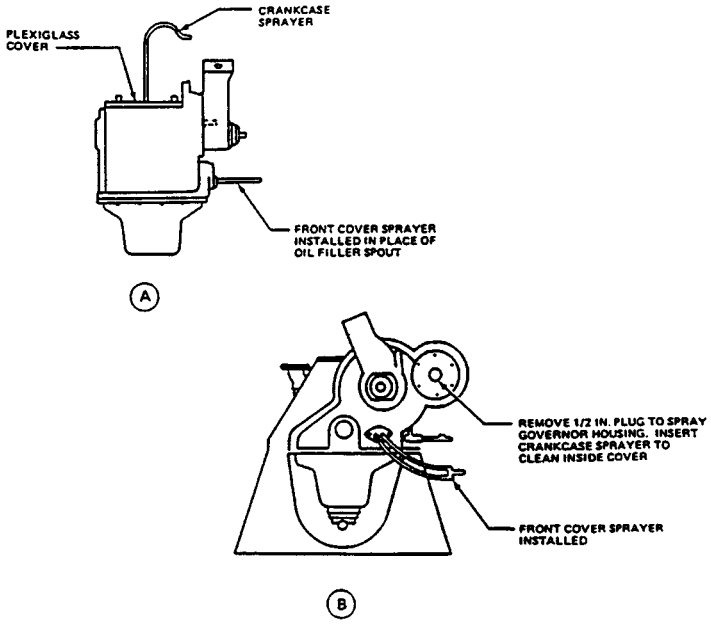
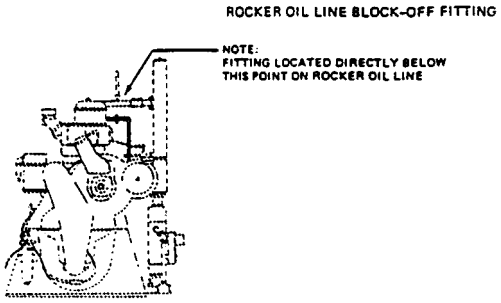


FIG. A9.8 Flushing Component Location



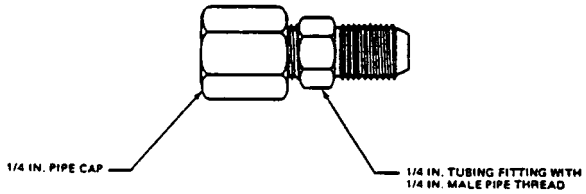


FIG. A9.9 Rocker Oil Line Block-off Fitting

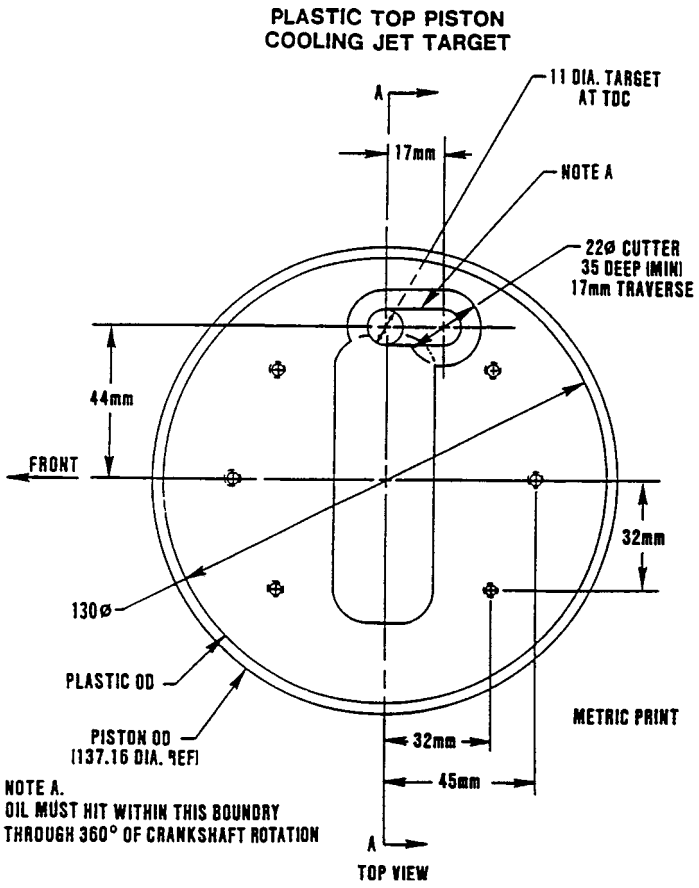


FIG. A9.10 Plastic Top Piston Cooling Jet Target

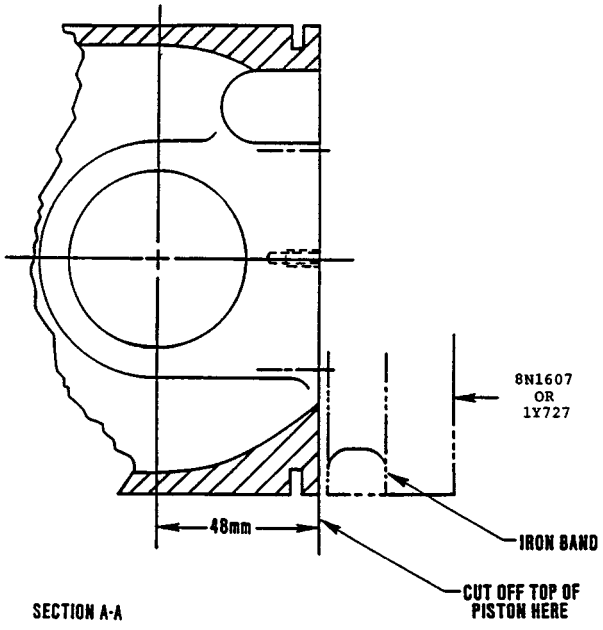


FIG. A9.11 Plastic Top Piston Cooling Jet Target, Section A-A

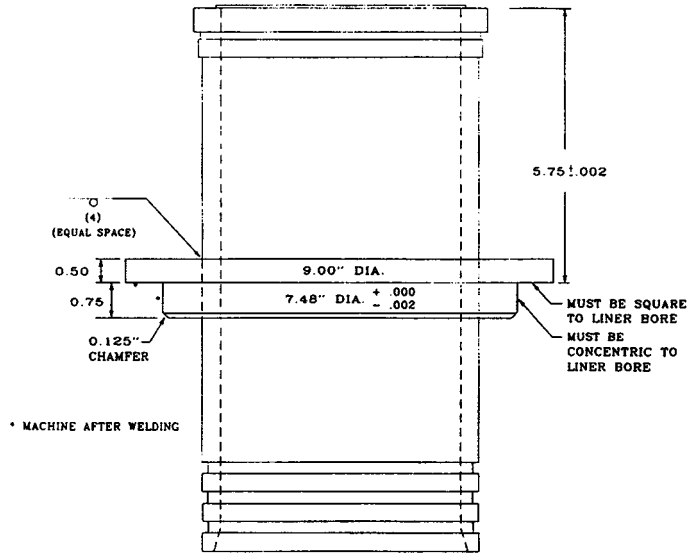


FIG. A9.12 Jet Alignment Fixture (2W6000 Liner)

A10. ENGINE OPERATING CONDITIONS

A10.1 See Tables A10.1 and A10.2.

TABLE A10.1 Engine Run-in, Warm-up, Cool-down, and Test Conditions

Step No.	Range	Unit	1	2	3	4	5	Step 5 equivalent in inch-lb. units
Test Time		min	5	5	10	20	20	
Engine speed	± 10	r/min	1000	1000	1800	2100	2100	
Engine power		kW	idle	12	26	38	52	70 bbp
BMEP		kPa		586	690	855	1240	180 psi
Fuel Rate	± 53	kJ/min		2160	4250	6250	8430	7990 Btu/min
Fuel flow		g/min		48	94	137	185	0.408 lb/min
B.S.F.C.		kg/kW·h				0.222	0.213	0.355 lb/bhp·h
Humidity	± 1.7	g/kg				17.8	17.8	125 grains/lb
			Temperatures					
Coolant out	± 2.5	°C			84	90	93	200°F
Coolant in		°C				86	88	192°F
Coolant ΔT	± 1	°C				4	5	9 °F
Oil to bearing	± 2.5	°C			76	93	107	225°F
Oil cooler in		°C				96	110	232°F
Inlet air	± 2.5	°C			93	93	127	260°F
Exhaust	± 30	°C				405	550	1020°F
Fuel injector housing	± 3	°C				57	57	135°F
			Pressures					
Oil to bearing		Max. kPa				440	482	70 psi
Oil to jet	± 13	kPa			410	370	360	52 psi
Inlet air (ABS)	± 1	kPa	120	120	160	220	240	71 in. Hg
Exhaust (ABS)	±1	kPa		104	140	180	216	64 in. Hg
Fuel filter housing	± 20	kPa				210	210	31 psi
Crankcase vacuum	± 0.1	kPa					0.7	3 in. H_2O
Coolant jug		kPa					50	7 psi
			Flows					
Blowby		L/min					23	50 ft^3/hr
Coolant flow	± 2.0	L/min					65	17.3 gal/min
Air/Fuel ratio							29	

TABLE A10.2 Air-Fuel Ratios

NOTE 1—

$$A/F_{O_2} = 14.33786\left(\frac{100 - 0.064355(\%\ O_2)}{100 - 4.7619(\%\ O_2)}\right)$$

$$A/F_{CO_2} = \left(\frac{208.8367}{\%CO_2}\right) + 0.9227$$

% CO_2	A/F CO_2	% CO_2	A/F CO_2	% O_2	A/F O_2	% O_2	A/F O_2
6.5	33.05	10.5	20.81	6.5	20.68	10.5	28.48
6.6	32.56	10.6	20.62	6.6	20.82	10.6	28.75
6.7	32.09	10.7	20.44	6.7	20.96	10.7	29.03
6.8	31.63	10.8	20.26	6.8	21.11	10.8	29.31
6.9	31.19	10.9	20.08	6.9	21.26	10.9	29.60
7.0	30.76	11.0	19.91	7.0	21.41	11.0	29.90
7.1	30.34	11.1	19.74	7.1	21.56	11.1	30.20
7.2	29.93	11.2	19.57	7.2	21.72	11.2	30.50
7.3	29.53	11.3	19.40	7.3	21.87	11.3	30.81
7.4	29.14	11.4	19.24	7.4	22.03	11.4	31.13
7.5	28.77	11.5	19.08	7.5	22.20	11.5	31.46
7.6	28.40			7.6	22.36		
7.7	28.04			7.7	22.53		
7.8	27.70			7.8	22.70		
7.9	27.36			7.9	22.87		
8.0	27.03			8.0	23.04		
8.1	26.71			8.1	23.22		
8.2	26.39			8.2	23.40		
8.3	26.08			8.3	23.58		
8.4	25.78			8.4	23.77		
8.5	25.49			8.5	23.96		
8.6	25.21			8.6	24.15		
8.7	24.93			8.7	24.34		
8.8	24.65			8.8	24.54		
8.9	24.39			8.9	24.74		
9.0	24.13			9.0	24.95		
9.1	23.87			9.1	25.15		
9.2	23.62			9.2	25.37		
9.3	23.38			9.3	25.58		
9.4	23.14			9.4	25.80		
9.5	22.19			9.5	26.02		
9.6	22.68			9.6	26.25		
9.7	22.45			9.7	26.48		
9.8	22.23			9.8	26.71		
9.9	22.02			9.9	26.95		
10.0	21.81			10.0	27.20		
10.1	21.60			10.1	27.44		
10.2	21.40			10.2	27.20		
10.3	21.20			10.3	27.95		
10.4	21.00			10.4	28.22		

A11. PROCEDURE FOR RATING PISTON AND LINER

A11.1 *Manual for Rating Piston and Liner*—Rate piston and liner in accordance with CRC Manual No. 18, Modified CRC Diesel Piston Rating Method, and A13.1 and A13.6. This includes rating the varnish deposit and utilizing the varnish scale described in the manual. Carbon deposit factors range from 1.000 to 0.250 and varnish deposits range from 9.0 to 0.0. Convert varnish scale values to demerit values in accordance with the technique described in the updated 1G2 method.

A11.2 Fig. A11.1 is a diagram of the procedure for rating undercrown deposits.

A11.3 *Procedure for Rating Liner*—Carry out the rating of the liner in sequence as follows:

A11.3.1 Evaluate deposits above ring travel immediately upon the completion of the test or disassembly.

A11.3.2 *Liner Preparation*:

A11.3.2.1 *Marking*—Draw a straight line on the front and rear of the liner from the top to the bottom. Then mark the thrust and anti-thrust sides as *T* and *AT* respectively. See Fig. A11.2. Finally place on the liner appropriate test identification (for example, run number, and so forth).

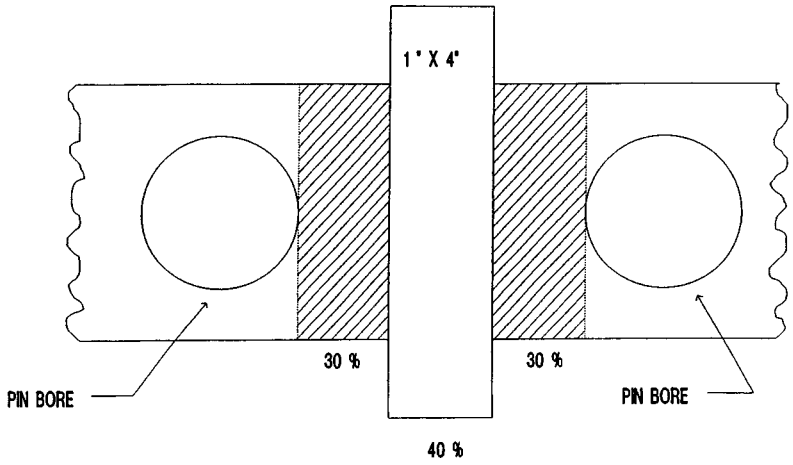


FIG. A11.1 Procedure for Rating Undercrown Deposits

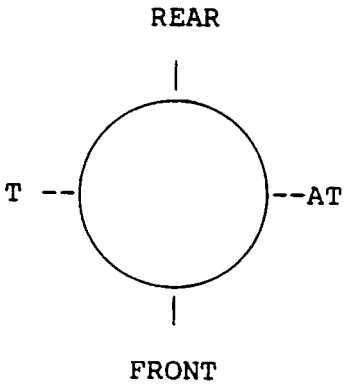


FIG. A11.2 Rating Liner Marking

A11.3.2.2 *Cutting*—Cut the liner on a vertical line *fore* and *aft*.

A11.3.2.3 *Liner Handling and Surface Preparation*—Handle the liner with care to avoid injury from the sharply cut edges. Wipe both halves of the liner first with a soft cloth dampened with Stoddard solvent and then with a soft, clean, dry cloth.

A11.3.3 *Liner Rating*:

A11.3.3.1 *Rating Environment*—Rate the liners in the existing CRC rating booth using the same light as specified for piston rating or a two-bulb fluorescent desk lamp.

A11.3.3.2 *Bore Polishing Rating*—Outline the bore polished area of the liner with a black magic marker. Insert the overlay in the liner half and use the 10 % segments with 1 % indicators as a guide in estimating the amount of polishing. Record the percent polish for each segment and then summarize the ten areas or equivalent for a permanent recording of the liner polishing. The rating area is defined as the area swept by the rings from the top of the first ring at TDC to the bottom of the ring at BDC. Occasionally, the rating area may include the area above top ring travel.

A11.3.3.3 *Liner Scuffing Rating*—Identical to bore polishing rating (see A11.3.3.2).

A11.3.3.4 *Above Top Ring Travel Conditions*—For multicylinder engines, check the above top ring travel conditions before piston removal. Use the 20-segmented template to determine area percentages in the liner. Rate carbon deposits in two levels. If required, report polishing and scratching/scuffing in the area covered.

A11.4 *Bore Polishing Grid*—See Fig. A11.3.

A11.5 *Rating Lamp*:

A11.5.1 *Source and Description*—A suitable lamp is the diesel piston rating lamp obtainable from Newark Electronics Corp.[31] described Model No., LFM-1; Stock No., 99F 1100; Mounting Bracket Stock No., 99F 1114; and bulb designation, 20W cool white.

[31] Available from Newark Electronics Corporation, 500 N Pulaski Road, Chicago, IL 60624.

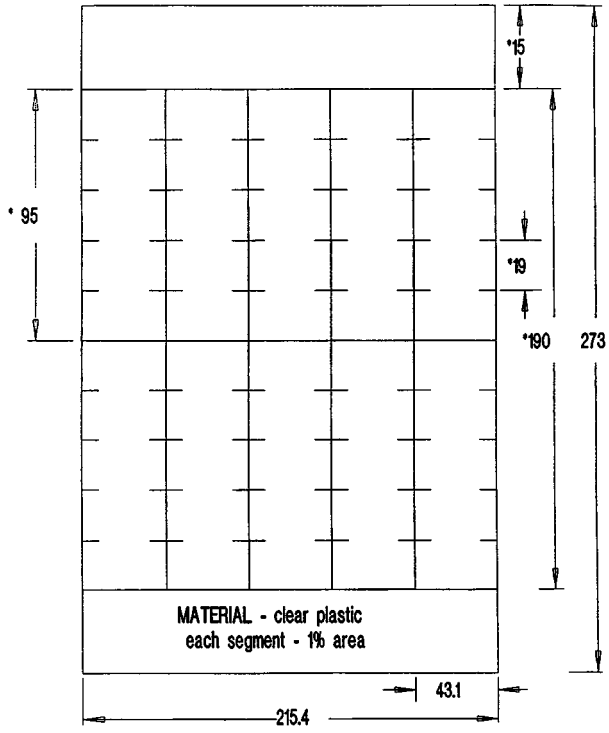


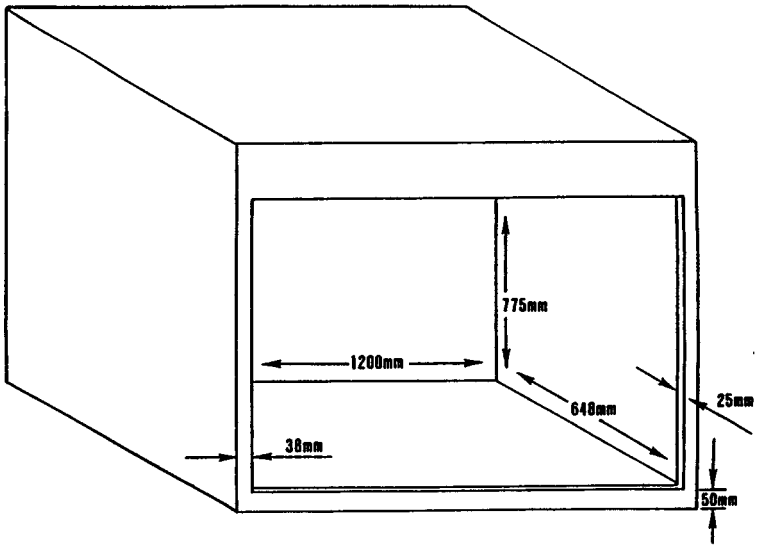
FIG. A11.3 Bore Polishing Grid

A11.5.2 *Mounting*—Mount the lamp in any convenient position such that the liner may be placed and manipulated in the rating booth (see A11.6) while being viewed through the lamp.

A11.5.3 *Bulb Replacement*—Replace the bulb annually or when burned out. After replacement, stabilize the bulb by turning it on for 24 h before using it for rating.

A11.5.4 Use the lamp without the accompanying magnifying lens.

A11.6 *Rating Booth*—See Fig. A11.4.



NOTE 1—Materials–Plywood/13mm internal bracing can be made of strips of wood.

FIG. A11.4 Rating Booth

A12. CALCULATION OF PERCENT OFFSET AND PERCENT DEVIATION

A12.1 See Tables A12.1-A12.4.

A12.2 *Instructions for Calculation of Percent Out/Percent Off*:

A12.2.1 If needed, round off recorded values in accordance with the foot-pound (English) and SI (metric) specifications sheet.

A12.2.2 For the percent calculations use (optional) the test specifications and tolerances listed on the foot-pound (English) and SI (metric) specifications sheet.

A12.2.3 Calculate the percent out and percent off using the same units as in the recorded data. For example, if the test is operated in foot-pound units, calculate the percentages in foot-pound units. *Do not convert the units and then calculate the percentages*.

A12.2.4 The logging frequency used for calculating the percentages shall be at the discretion of the laboratory and shall be at least hourly.

A12.2.5 Any data used in the calculation of the percentages that are edited should include an explanation. List the data

TABLE A12.1 Calibration Tolerance

Parameter	Tolerance	
Speed, r/min	2	
Load	Not applicable due to differences within industry. TMC to verify each laboratory during visits.	
Fuel Flow	Not applicable due to differences within industry. TMC to verify each laboratory during visits.	
Humidity	Not applicable. Already specified. Checked during running conditions as outlined in the test procedure (see form attached).	
Oil Weight	Not applicable because relative difference is the only item that matters. Measurement resolution must be met as defined in the test procedure.	
Temperatures	°F	°C
Coolant out	0.5	0.25
Coolant in	0.5	0.25
Oil to bearing	1.0	0.5
Intake air	1.0	0.5
Exhaust	2.0	1.0
Fuel at injector housing	1.0	0.5
Pressures		
Oil to bearing, psig	0.1	0.7 kPa
Oil to jet, psig	0.1	0.7 kPa
Inlet air, in. Hg	0.1	0.3 kPa
Exhaust, in. Hg	0.1	0.3 kPa
Fuel at filter, housing, psig	0.1	0.7 kPa
Crankcase vacuum, in. H_2O	0.1	0.02 kPa

TABLE A12.2 Operational Specifications, Measurement Resolution and Rounding

CAT-1K/IN	Inch-Pound Specification				SI Specification			
Parameter	Units	Specified Range	Minimum Measurement Resolution	Round Value to the Nearest	Units	Specified Range	Minimum Measurement Resolution	Round Values to the Nearest
Speed	rpm	2100 ± 10	1	whole number	rpm	2100 ± 10	1	whole number
Power	bhp	70			kW	52		
BMEP	psig	180			kPa	1240		
Fuel rate	Btu/min	7990 ± 50			kJ/min	8430 ± 53		
Fuel flow[A]	lb/h	24.47 ± 0.15	0.01	hundredth	g/min	185 ± 1	0.1	tenth
BSFC	lb/bhp·h	0.355			kg/kW	0.213		
Humidity	grains/lb	125 ± 12	1	whole number	g/Kg	17.8 ± 1.7	0.1	tenth
Oil weight	lb	N/A	0.01	hundredth	g	N/A	1	whole number
				Temperatures				
Coolant out	°F	200 ± 5	0.1	tenth	°C	93 ± 2.5	0.1	tenth
Coolant in	°F	191	0.1	tenth	°C	88	0.1	tenth
Coolant Δ	°F	9 ± 2	0.1	tenth	°C	5 ± 1	0.1	tenth
Oil to bearing	°F	225 ± 5	0.1	tenth	°C	107 ± 2.5	0.1	tenth
Oil cooler inlet	°F	230	0.1	tenth	°C	110	0.1	tenth
Inlet air	°F	260 ± 5	0.1	tenth	°C	127 ± 2.5	0.1	tenth
Exhaust	°F	1020 ± 50	0.1	whole number	°C	550 ± 30	1	whole number
Fuel at injector housing	°F	135 ± 5	0.1	tenth	°C	57 ± 3	0.1	tenth
				Pressures				
Oil to bearing	psig	70 Max.			kPa	482 max.		
Oil to jet	psig	52 ± 2	0.1	tenth	kPa	360 ± 13	0.1	tenth
Inlet air (ABS)	in. Hg	70.9 ± 0.3	0.1	tenth	kPa	240 ± 1	0.1	tenth
Exhaust (ABS)	in. Hg	63.8 ± 0.3	0.1	tenth	kPa	216 ± 1	0.1	tenth
Fuel at filter	psig	30.5 ± 2.9	0.1	tenth	kPa	210 ± 20	0.1	tenth
Crankcase vacuum	in. H_2O	2.8 ± 0.4	0.1	tenth	kPa	0.7 ± 0.1	0.01	hundredth
Coolant at jug	psig	7			kPa	50		
				Flows				
Blowby	ft^3/hr	50			L/min	23		
Coolant flow	gpm	17.2 ± 0.6	0.1	tenth	L/min	65 ± 2	0.1	tenth
Air/fuel ratio		29				29		

[A] The fuel flow specified range is based on the high heating value of 19,590 btu/lb at an API Gravity of 35. The fuel specification range is 33 to 35 API Gravity.

TABLE A12.3 Conversion Factors, Foot-Pound to Metric

NOTE 1—Based on Practice E 380-91 (Practice for Use of the International System of Units (SI) (the Modernized Metric System) which has been replaced by IEEE/ASTM SI-10.

Foot-Pound	Conversion Factor	Metric	No. of Decimal Places to Report
°F	5/9 (°F-32)	°C	1
$lbf/in.^2$	psi×6.895	kPa	1
in. Hg	in. Hg×3.386	kPa	1
in. H_2O	in. H_2O×0.2491	kPa	2
lbf/bhp•hr	(lbf/bhp•hr)×0.6080	kg/kW•h	6
inch	in.×25.4	mm	1
lbf•ft	lbf•ft×1.3558	N•m	1
Hp	Hp•0.746	kW	1
BTU/min	(BTU/min)×1.0551	kJ/min	0
grains/lb_m	(grains/lb_m)×0.1429	g/kg	1
gal/min	(gallons/min)×3.7854	L/min	1
ft^3/hr	(ft^3/hr)×0.47195	L/min	1
Δ°F	5/9×°F	Δ°C	1
lb_f	lb_f×453.6	g	0

TABLE A12.4 System Time Constants, Maximum Allowable Caterpillar 1K/1N Industry Wide System Time Constant Survey (time, s)

Measurements	
Speed	3.0
Fuel flow	73.0
Temperatures	
Coolant out	3.0
Coolant in	3.0
Oil to bearings	3.0
Intake air	3.0
Exhaust	3.0
Fuel at injection	3.0
Pressures	
Oil to bearings	3.0
Oil to jet	3.0
Intake air	3.0
Exhaust	3.0
Fuel at filter	3.0
Crankcase vacuum	3.0

before they are edited, the new value, and the explanation for the change in comments or outlier section of the test report.

A12.2.6 Include these percent calculations within each test report on Form 3 (see Fig. A13.4).

A12.2.7 Calculate each percent out to three significant digits using ASTM E29, Rounding Off Method.

A12.2.8 Round off the calculated average used in the percent off calculation to 0.1 using the rounding off method of Practice E29.

A12.2.9 Round off the percent out summation and percent off results to 0.1 using the rounding off method of Practice E29.

A12.2.10 Use the following formula to calculate percent out:

$$\text{percent out} = \frac{\frac{|A-B|}{C} \times \frac{D}{60} \times 100}{252} \quad \text{(A12.1)}$$

where:

A = recorded test measurement of parameter that is beyond test limits prior to any corrective action,
B = upper test specification if the measured parameter is out on the high side or the lower test specification if it is out on the low side,
C = specification tolerance of the measured parameter,
D = length of deviation in minutes (it cannot be less than the logging frequency),
60 = conversion factor for min/h, and
100 = conversion to percent.

A12.2.11 Calculate the percent out for each measured parameter based on its logging frequency. Sum the individual percent outs to arrive at the final percent out for judging test validity. See Table A12.5.

A12.2.12 Use the following formula to calculate the percent off (see Table A12.5):

$$\text{percent off} = \frac{|\,X - \text{Specification}\,| \times 100}{\text{specification range}} \qquad \text{(A12.2)}$$

where:

X = average of all readings of the parameter for the entire test duration, and
specification range = the upper specification limit minus the lower specification limit, or two times the specification tolerance.

A12.3 *Allowable Limits for Percent Out and Percent Off*—

A12.3.1 Use the parameters in Table A12.6 to judge test validity based on their operational control. Any parameter for a given test with a percent out or percent off that is *greater than* the specifications listed in the table shall be considered to be operated in an invalid manner.

TABLE A12.5 Example of Calculation of Percent Out and Percent Off

NOTE 1—This example is for 21 test hours using humidity measured in g/kg.

NOTE 2—Percent out for test hour 11:

$$\%\ \text{out} = \frac{\frac{|16.0 - 16.1|}{1.7} \cdot \frac{60}{60} \cdot 100}{252} = 0.023$$

NOTE 3—At 21 test hours:
Percent out summation = 1.1 (round to 0.1)
Average of the rounded values = 128.6 (round to 0.1)
Percent offset = 15.0 (round to 0.1)

Test Hours	Raw Value, grains/lb	Rounded Value, grains/lb	% Out for Each Value, Rounded to 0.001
1	18.65	18.7	
2	18.65	18.7	
3	18.55	18.6	
4	17.96	18.0	
5	18.28	18.3	
6	17.96	18.0	
7	18.00	18.0	
8	17.73	17.7	
9	17.59	17.6	
10	16.90	16.9	
11	15.99	16.0	0.023
12	15.21	15.2	0.210
13	18.28	18.3	
14	18.93	19.0	
15	19.27	19.3	
16	19.64	19.6	0.023
17	19.95	20.0	0.117
18	19.67	19.7	0.047
19	19.64	19.6	0.023
20	19.95	20.0	0.117
21	18.06	18.1	

TABLE A12.6 Allowable Limits for Percent Out and Percent Off

Controlled parameter	Allowable % Out	Allowable % Off
Speed	5	20
Fuel flow	10	25
Humidity	10	25
Coolant Flow	5	25
Temperatures		
Coolant Out	5	20
Oil to Bearing	5	20
Intake air	5	20
Fuel at injector housing	5	20
Pressures		
Oil jet	5	25
Intake air	10	25
Exhaust	10	25
Fuel at filter housing	5	20
Crankcase vacuum	10	20

A13. 1K/1N TEST REPORTING

A13.1 Examples of all forms necessary for test reporting are provided in Figs. A13.1-A13.18.

1K/1N
FINAL REPORT COVER

METHOD *METHOD*

CHECK ONE	
1K	1N

VERSION *20020107 BETA*

CONDUCTED FOR

TSTSPON1

TSTSPON2

LABVALID	V =VALID
	I = INVALID
	N = RESULTS CANNOT 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 #: *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* has been conducted in accordance with the 1K/1N Test Procedure (Research Report RR:D02-1273/RR:D02-1321) and the appropriate amendments through the information letter system. The remarks included in the report describe the anomalies associated with this test.

[A] *CMIR* or Non-Reference Oil Code

SUBMITTED BY:

SUBLAB
Testing Laboratory

SUBSIGIM
Signature

SUBNAME
Typed Name

SUBTITLE
Title

FIG. A13.1 Final Report Cover Sheet

1K/1N
FORM 1
TEST REPORT SUMMARY

LAB: *LAB*	EOT DATE: *DTCOMP*	END TIME: *EOTTIME*	METHOD: *METHOD*
STAND: *STAND*	RUN NUMBER: *ENRUN*		
FORMULATION/STAND CODE: *FORM*			
OILCODE/CMIR: *OILCODE/CMIR*			
START DATE: *DTSTRT*	TOTAL TEST LENGTH: *TESTLEN*	TMC OIL TYPE: *IND*	
LABORATORY INTERNAL OIL CODE: *LABOCODE*			

	CORRECTION EFFECTIVE DATE	WDK/WDN	TGF %	TLHC %	TRANSFORMED TLHC %	BSOC g/kW-h	EOTOC g/kW-h
UNADJUSTED LAB RATING		*WD*	*TGF*	*TLHC*	*TTLHC*	*BSOC*	*EOTOC*
INDUSTRY CORRECTION (IF ANY)	*DATECF*	*WDCF*	*TGFCF*	*TLHCCF*	*TTLHCCF*	*BSOCCF*	*EOTOCCF*
SUBTOTAL		*WDCOR*	*TGFCOR*	*TLHCCOR*	*TTLHCCOR*	*BSOCCOR*	*EOTOCCOR*
LAB SEVERITY ADJUSTMENT (IF ANY) [A]	*DATESA*	*WDSA*	*TGFSA*	*TLHCSA*	*TTLHCSA*	*BSOCSA*	*EOTOCSA*
TOTAL		*WDFNL*	*TGFFNL*	*TLHCFNL*	*TTLHCFNL*	*BSOCFNL*	*EOTOCFNL*

	EFFECTIVE DATE	WDK/WDN	TGF %	TLHC %	TRANSFORMED TLHC %	BSOC g/kW-h	EOTOC g/kW-h
TEST TARGET MEAN [B]	*EFFDATE*	*WDM*	*TGFM*		*TTLHCM*	*BSOCM*	*EOTOCM*
TEST TARGET STD [B]	*EFFDATE*	*WDS*	*TGFS*		*TTLHCS*	*BSOCS*	*EOTOCS*
LDESC [A,C]	*DTCEFF*	*WDPL*	*TGFPL*	*TLHCPL*		*BSOCPL*	*EOTOCPL*

	REFEREE LAB	WDK/WDN	TGF %	
REFEREE RATINGS	*RRLAB*	*RRWD*	*RRTGF*	

	TOP	INT. 1	OIL	PISTON	LINER
RING LOSS OF SIDE CLEARANCE (mm)	*LSCTOP*	*LSCINT1*	*LSCOIL*		
RING END GAP INCREASE (mm)	*RINGGTI*	*RINGGI11*	*RINGGOI*		
IS THE RING STUCK?	*STUCKTOP*	*STUCKIN1*	*STUCKOIL*		
SCUFFED AREA %	*SCUFFTOP*	*SCUFFIN1*	*SCUFFOIL*	*SCUFFPIS*	*SCUFFLIN*
AVERAGE WEAR STEP (mm)					*AWEARST*
% BORE POLISH					*BOREPOL*

Notes: [A] Non-reference tests only [C] See Appendix X4
[B] Reference tests only

FIG. A13.2 1K/1N Test Report Summary

1K/1N

FORM 2

OPERATIONAL SUMMARY

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

OPERATING CONDITION		MINIMUM	MAXIMUM	AVERAGE	SPECIFICATION
ENGINE SPEED	r/min	*IRPM*	*XRPM*	*ARPM*	2100 ± 10
ENGINE POWER	kW	*IPWR*	*XPWR*	*APWR*	REPORT
FUEL FLOW	g/min	*IFFLO*	*XFFLO*	*AFFLO*	185 ± 1
HUMIDITY	g/kg	*IHUMID*	*XHUMID*	*AHUMID*	17.8 ± 1.7
TEMPERATURE °C					
COOLANT OUT	°C	*ICOLOUT*	*XCOLOUT*	*ACOLOUT*	93 ± 2.5
COOLANT IN	°C	*ICOLIN*	*XCOLIN*	*ACOLIN*	REPORT
COOLANT delta T	°C	*ICOLDT*	*XCOLDT*	*ACOLDT*	5 ±1.0
OIL TO BRG	°C	*IOBRGTMP*	*XOBRGTMP*	*AOBRGTMP*	107 ± 2.5
OIL COOLER IN	°C	*IOCOOLIN*	*XOCOOLIN*	*AOCOOLIN*	REPORT
INLET AIR	°C	*IINAIRT*	*XINAIRT*	*AINAIRT*	127 ± 2.5
EXHAUST	°C	*IEXHTMP*	*XEXHTMP*	*AEXHTMP*	550 ± 30
FUEL @ INJECTOR HOUSING	°C	*IFUELTMP*	*XFUELTMP*	*AFUELTMP*	57 ± 3
PRESSURES					
OIL TO BRG	kPa	*IOBRGPR*	*XOBRGPR*	*AOBRGPR*	482 MAX
OIL TO JET	kPa	*IOJETPR*	*XOJETPR*	*AOJETPR*	360 ± 13
INLET AIR	kPa	*IINAIRP*	*XINAIRP*	*AINAIRP*	240 ± 1
EXHAUST (ABS)	kPa	*IEBP*	*XEBP*	*AEBP*	216 ±1
FUEL @ FILTER HSG	kPa	*IFUELPR*	*XFUELPR*	*AFUELPR*	210 ± 20
CRANKCASE VACUUM	kPa	*ICCV*	*XCCV*	*ACCV*	0.7 ± 0.1
COOLANT JUG PRESSURE	kPa	*IJUGPR*	*XJUGPR*	*AJUGPR*	REPORT
FLOWS					
BLOWBY	L/min	*IBLOBY*	*XBLOBY*	*ABLOBY*	REPORT
COOLANT FLOW	L/min	*ICOLFLO*	*XCOLFLO*	*ACOLFLO*	65 ± 2

AIR/FUEL RATIO: 24 HR	*AFR24*	AIR/FUEL RATIO: 252 HR	*AFR252*

ASSEMBLY MEASUREMENTS AND PARTS RECORD

PISTON/HEAD CLEARANCE mm	*PISTONCL*	INTAKE VALVE OPEN °ATC	*INVALOPN*
		FUEL TIMING °BTC	*FUELTIM*

	PART NO. (1)	SERIAL NO. (2)	DATE CODE		INSPECTION CODE	
LINER	*LINERPN*	*LINERSN*	*LINERDC*	F	*LINERIC*	G
RING SET (1)	*RINGPN*		*RINGDC*	I	*RINGIC*	H
PISTON	*PISTPN*	*PISTSN*	*PISTDC*	D	*PISTIC*	E

[D] Number below"E" located on top of piston
[E] Number on top of "E" located on top of piston
[F] Four alphanumeric characters (NNAN) on liner O.D.
[G] Four digit number on liner O.D.
[H] Three or four digit number on white label on ring set box
[I] NN-NN from part number label on ring set box

(1) AND (2) NUMBER ON PARTS BOX YELLOW LABEL

FIG. A13.3 1K/1N Operational Summary

1K/1N

FORM 3
OPERATIONAL SUMMARY - OFFSET AND DEVIATION

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

CONTROLLED PARAMETER	ALLOWABLE % OUT	THIS TEST % OUT	ALLOWABLE % OFF	THIS TEST % OFF
SPEED	5	*RPMOUT*	20	*RPMOFF*
FUEL FLOW	10	*FFLOOUT*	25	*FFLOOFF*
HUMIDITY	10	*HUMOUT*	25	*HUMOFF*
COOLANT FLOW	5	*COLFOUT*	25	*COLFOFF*
TEMPERATURES				
COOLANT OUT	5	*COTOUT*	20	*COTOFF*
OIL TO BEARING	5	*OBRGOUT*	20	*OBRGOFF*
INTAKE AIR	5	*AIRTOUT*	20	*AIRTOFF*
FUEL AT INJECTOR HOUSING	5	*FIHTOUT*	20	*FIHTOFF*
PRESSURES				
OIL JET	5	*OJETOUT*	25	*OJETOFF*
INTAKE AIR	10	*AIRPOUT*	25	*AIRPOFF*
EXHAUST	10	*EXPOUT*	25	*EXPOFF*
FUEL AT FILTER HOUSING	5	*FFILOUT*	20	*FFILOFF*
CRANKCASE VACUUM	10	*CCVOUT*	20	*CCVOFF*

FIG. A13.4 1K/1N Operational Summary – Offset and Deviation

FORM 4
PISTON RATING SUMMARY

TEST	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*	RATING NUMBER: *RNO*	RATER: *RINIT*		
LAST STAND REFERENCE INFORMATION	DATE COMPLETED: *LRDTCOMP*	STAND #: *STAND*	RUN #: *LRENRUN*	TMC OIL CODE: *LIND*		

	WDK/WDN	TGF	TLHC	TRANSFORMED TLHC	BSOC	EOTOC
LAST REF. THIS STAND	*LRWD*	*LRTGF*	*LRTLHC*	*LRTTLHC*	*LRBSOC*	*LREOTOC*
INDUSTRY AVERAGE	*LRAWD*	*LRATGF*		*LRATTLHC*	*LRABSOC*	*LRAEOTOC*
INDUSTRY STD	*LRSWD*	*LRSTGF*		*LRSTTLHC*	*LRSBSOC*	*LRSEOTOC*

TOTAL PISTON RATINGS SUMMARY

		GROOVES						LANDS						UPPER SKIRT		UNDER CROWN		PIN BORES			
	DEP. FACTOR	NO. 1		NO. 2		NO. 3		NO. 1		NO. 2		NO. 3						FRONT		REAR	
		A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.	A,%	DEM.
CARBON	HC-1.0	*G1HCA*	*G1HCD*	*G2HCA*	*G2HCD*	*G3HCA*	*G3HCD*	*L1HCA*	*L1HCD*	*L2HCA*	*L2HCD*	*L3HCA*	*L3HCD*	*USHCA*	*USHCD*	*UCHCA*	*UCHCD*	*PFHCA*	*PFHCD*	*PRHCA*	*PRHCD*
	MC-0.5	*G1MCA*	*G1MCD*			*G3MCA*	*G3MCD*														
	LC-.25	*G1LCA*	*G1LCD*	*G2LCA*	*G2LCD*	*G3LCA*	*G3LCD*	*L1LCA*	*L1LCD*	*L2LCA*	*L2LCD*	*L3LCA*	*L3LCD*	*USLCA*	*USLCD*	*UCLCA*	*UCLCD*	*PFLCA*	*PFLCD*	*PRLCA*	*PRLCD*
	TOTAL	*G1ACTOT*	*G1DCTOT*	*G2ACTOT*	*G2DCTOT*	*G3ACTOT*	*G3DCTOT*	*L1ACTOT*	*L1DCTOT*	*L2ACTOT*	*L2DCTOT*	*L3ACTOT*	*L3DCTOT*	*USACTOT*	*USDCTOT*	*UCACTOT*	*UCDCTOT*	*PFACTOT*	*PFDCTOT*	*PRACTOT*	*PRDCTOT*
LACQUER	8 - 9	*G1L9A*	*G1L9D*	*G2L9A*	*G2L9D*	*G3L9A*	*G3L9D*	*L1L9A*	*L1L9D*	*L2L9A*	*L2L9D*	*L3L9A*	*L3L9D*	*USV9A*	*USV9D*	*UCV9A*	*UCV9D*	*PFV9A*	*PFV9D*	*PRV9A*	*PRV9D*
	7 - 7.9	*G1L8A*	*G1L8D*	*G2L8A*	*G2L8D*	*G3L8A*	*G3L8D*	*L1L8A*	*L1L8D*	*L2L8A*	*L2L8D*	*L3L8A*	*L3L8D*	*USV8A*	*USV8D*	*UCV8A*	*UCV8D*	*PFV8A*	*PFV8D*	*PRV8A*	*PRV8D*
	6 - 6.9	*G1L7A*	*G1L7D*	*G2L7A*	*G2L7D*	*G3L7A*	*G3L7D*	*L1L7A*	*L1L7D*	*L2L7A*	*L2L7D*	*L3L7A*	*L3L7D*	*USV7A*	*USV7D*	*UCV7A*	*UCV7D*	*PFV7A*	*PFV7D*	*PRV7A*	*PRV7D*
	5 - 5.9	*G1L6A*	*G1L6D*	*G2L6A*	*G2L6D*	*G3L6A*	*G3L6D*	*L1L6A*	*L1L6D*	*L2L6A*	*L2L6D*	*L3L6A*	*L3L6D*	*USV6A*	*USV6D*	*UCV6A*	*UCV6D*	*PFV6A*	*PFV6D*	*PRV6A*	*PRV6D*
	4 - 4.9	*G1L5A*	*G1L5D*	*G2L5A*	*G2L5D*	*G3L5A*	*G3L5D*	*L1L5A*	*L1L5D*	*L2L5A*	*L2L5D*	*L3L5A*	*L3L5D*	*USV5A*	*USV5D*	*UCV5A*	*UCV5D*	*PFV5A*	*PFV5D*	*PRV5A*	*PRV5D*
	3 - 3.9	*G1L4A*	*G1L4D*	*G2L4A*	*G2L4D*	*G3L4A*	*G3L4D*	*L1L4A*	*L1L4D*	*L2L4A*	*L2L4D*	*L3L4A*	*L3L4D*	*USV4A*	*USV4D*	*UCV4A*	*UCV4D*	*PFV4A*	*PFV4D*	*PRV4A*	*PRV4D*
	2 - 2.9	*G1L3A*	*G1L3D*	*G2L3A*	*G2L3D*	*G3L3A*	*G3L3D*	*L1L3A*	*L1L3D*	*L2L3A*	*L2L3D*	*L3L3A*	*L3L3D*	*USV3A*	*USV3D*	*UCV3A*	*UCV3D*	*PFV3A*	*PFV3D*	*PRV3A*	*PRV3D*
	1 - 1.9	*G1L2A*	*G1L2D*	*G2L2A*	*G2L2D*	*G3L2A*	*G3L2D*	*L1L2A*	*L1L2D*	*L2L2A*	*L2L2D*	*L3L2A*	*L3L2D*	*USV2A*	*USV2D*	*UCV2A*	*UCV2D*	*PFV2A*	*PFV2D*	*PRV2A*	*PRV2D*
	>0 - 0.9	*G1L1A*	*G1L1D*	*G2L1A*	*G2L1D*	*G3L1A*	*G3L1D*	*L1L1A*	*L1L1D*	*L2L1A*	*L2L1D*	*L3L1A*	*L3L1D*	*USV1A*	*USV1D*	*UCV1A*	*UCV1D*	*PFV1A*	*PFV1D*	*PRV1A*	*PRV1D*
	CLEAN	*G1LCLNA*	0	*G2LCLNA*	0	*G3LCLNA*	0	*L1LCLNA*	0	*L2LCLNA*	0	*L3LCLNA*	0	*USVCLNA*	0	*UCVCLNA*	0	*PFVCLNA*	0	*PRVCLNA*	0
	TOTAL	*G1ALTOT*	*G1DLTOT*	*G2ALTOT*	*G2DLTOT*	*G3ALTOT*	*G3DLTOT*	*L1ALTOT*	*L1DLTOT*	*L2ALTOT*	*L2DLTOT*	*L3ALTOT*	*L3DLTOT*	*USALTOT*	*USDLTOT*	*UCALTOT*	*UCDLTOT*	*PFALTOT*	*PFDLTOT*	*PRALTOT*	*PRDLTOT*
RATING		*G1UWD*		*G2UWD*		*G3UWD*		*L1UWD*		*L2UWD*		*L3UWD*		*USUWD*		*UCUWD*		*PFUWD*		*PRUWD*	
LOCATION FACTOR		1.5		1.5		25		1		1		25		50		20		0		0	
IND RATING		*G1WD*		*G2WD*		*G3WD*		*L1WD*		*L2WD*		*L3WD*		*USWD*		*UCWD*		*PFWD*		*PRWD*	

TGF %	INT. GR. FILL %	WDK/WDN	UNWEIGHTED DEP.	T.L. HVY. CARBON %	T.L. FLAKED CARBON %
TGF	*IGF*	*WD*	*UWD*	*TLHC*	*TLFC*

FIG. A13.5 1K/1N Piston Rating Summary

1K/1N
Form 4A
PISTON RATING WORKSHEET

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

RATEWSIM

NOTE 1—Refer to Fig. X3.1 for example of piston rating worksheet

FIG. A13.6 1K/1N Piston Rating Worksheet

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*
LINER	*LINERAD*
RINGS	*RINGSAD*

FIG. A13.7 1K/1N Supplemental Piston Deposits (Groove Sides and Rings)

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						UPPER SKIRT		UNDER CROWN		PIN BORES			
		NO. 1		NO. 2		NO. 3		NO. 1		NO. 2		NO. 3						FRONT		REAR	
	DEP. FACTOR	A,%	DEM.	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*	*RRG3HCA*	*RRG3HCD*	*RRL1HCA*	*RRL1HCD*	*RRL2HCA*	*RRL2HCD*	*RRL3HCA*	*RRL3HCD*	*RRUSHCA*	*RRUSHCD*	*RRUCHCA*	*RRUCHCD*	*RRPFHCA*	*RRPFHCD*	*RRPRHCA*	*RRPRHCD*
	MC-0.5	*RRG1MCA*	*RRG1MCD*			*RRG3MCA*	*RRG3MCD*														
	LC-.25	*RRG1LCA*	*RRG1LCD*	*RRG2LCA*	*RRG2LCD*	*RRG3LCA*	*RRG3LCD*	*RRL1LCA*	*RRL1LCD*	*RRL2LCA*	*RRL2LCD*	*RRL3LCA*	*RRL3LCD*	*RRUSLCA*	*RRUSLCD*	*RRUCLCA*	*RRUCLCD*	*RRPFLCA*	*RRPFLCD*	*RRPRLCA*	*RRPRLCD*
	TOTAL	*RG1ACTOT*	*RG1DCTOT*	*RG2ACTOT*	*RG2DCTOT*	*RG3ACTOT*	*RG3DCTOT*	*RL1ACTOT*	*RL1DCTOT*	*RL2ACTOT*	*RL2DCTOT*	*RL3ACTOT*	*RL3DCTOT*	*RUSACTOT*	*RUSDCTOT*	*RUCACTOT*	*RUCDCTOT*	*RPFACTOT*	*RPFDCTOT*	*RPRACTOT*	*RPRDCTOT*
LACQUER	8 - 9	*RRG1L9A*	*RRG1L9D*	*RRG2L9A*	*RRG2L9D*	*RRG3L9A*	*RRG3L9D*	*RRL1L9A*	*RRL1L9D*	*RRL2L9A*	*RRL2L9D*	*RRL3L9A*	*RRL3L9D*	*RRUSV9A*	*RRUSV9D*	*RRUCV9A*	*RRUCV9D*	*RRPFV9A*	*RRPFV9D*	*RRPRV9A*	*RRPRV9D*
	7 - 7.9	*RRG1L8A*	*RRG1L8D*	*RRG2L8A*	*RRG2L8D*	*RRG3L8A*	*RRG3L8D*	*RRL1L8A*	*RRL1L8D*	*RRL2L8A*	*RRL2L8D*	*RRL3L8A*	*RRL3L8D*	*RRUSV8A*	*RRUSV8D*	*RRUCV8A*	*RRUCV8D*	*RRPFV8A*	*RRPFV8D*	*RRPRV8A*	*RRPRV8D*
	6 - 6.9	*RRG1L7A*	*RRG1L7D*	*RRG2L7A*	*RRG2L7D*	*RRG3L7A*	*RRG3L7D*	*RRL1L7A*	*RRL1L7D*	*RRL2L7A*	*RRL2L7D*	*RRL3L7A*	*RRL3L7D*	*RRUSV7A*	*RRUSV7D*	*RRUCV7A*	*RRUCV7D*	*RRPFV7A*	*RRPFV7D*	*RRPRV7A*	*RRPRV7D*
	5 - 5.9	*RRG1L6A*	*RRG1L6D*	*RRG2L6A*	*RRG2L6D*	*RRG3L6A*	*RRG3L6D*	*RRL1L6A*	*RRL1L6D*	*RRL2L6A*	*RRL2L6D*	*RRL3L6A*	*RRL3L6D*	*RRUSV6A*	*RRUSV6D*	*RRUCV6A*	*RRUCV6D*	*RRPFV6A*	*RRPFV6D*	*RRPRV6A*	*RRPRV6D*
	4 - 4.9	*RRG1L5A*	*RRG1L5D*	*RRG2L5A*	*RRG2L5D*	*RRG3L5A*	*RRG3L5D*	*RRL1L5A*	*RRL1L5D*	*RRL2L5A*	*RRL2L5D*	*RRL3L5A*	*RRL3L5D*	*RRUSV5A*	*RRUSV5D*	*RRUCV5A*	*RRUCV5D*	*RRPFV5A*	*RRPFV5D*	*RRPRV5A*	*RRPRV5D*
	3 - 3.9	*RRG1L4A*	*RRG1L4D*	*RRG2L4A*	*RRG2L4D*	*RRG3L4A*	*RRG3L4D*	*RRL1L4A*	*RRL1L4D*	*RRL2L4A*	*RRL2L4D*	*RRL3L4A*	*RRL3L4D*	*RRUSV4A*	*RRUSV4D*	*RRUCV4A*	*RRUCV4D*	*RRPFV4A*	*RRPFV4D*	*RRPRV4A*	*RRPRV4D*
	2 - 2.9	*RRG1L3A*	*RRG1L3D*	*RRG2L3A*	*RRG2L3D*	*RRG3L3A*	*RRG3L3D*	*RRL1L3A*	*RRL1L3D*	*RRL2L3A*	*RRL2L3D*	*RRL3L3A*	*RRL3L3D*	*RRUSV3A*	*RRUSV3D*	*RRUCV3A*	*RRUCV3D*	*RRPFV3A*	*RRPFV3D*	*RRPRV3A*	*RRPRV3D*
	1 - 1.9	*RRG1L2A*	*RRG1L2D*	*RRG2L2A*	*RRG2L2D*	*RRG3L2A*	*RRG3L2D*	*RRL1L2A*	*RRL1L2D*	*RRL2L2A*	*RRL2L2D*	*RRL3L2A*	*RRL3L2D*	*RRUSV2A*	*RRUSV2D*	*RRUCV2A*	*RRUCV2D*	*RRPFV2A*	*RRPFV2D*	*RRPRV2A*	*RRPRV2D*
	>0 - 0.9	*RRG1L1A*	*RRG1L1D*	*RRG2L1A*	*RRG2L1D*	*RRG3L1A*	*RRG3L1D*	*RRL1L1A*	*RRL1L1D*	*RRL2L1A*	*RRL2L1D*	*RRL3L1A*	*RRL3L1D*	*RRUSV1A*	*RRUSV1D*	*RRUCV1A*	*RRUCV1D*	*RRPFV1A*	*RRPFV1D*	*RRPRV1A*	*RRPRV1D*
	CLEAN	*RRG1LCLA*	0	*RRG2LCLA*	0	*RRG3LCLA*	0	*RRL1LCLA*	0	*RRL2LCLA*	0	*RRL3LCLA*	0	*RRUSVCLA*	0	*RRUCVCLA*	0	*RRPFVCLA*	0	*RRPRVCLA*	0
	TOTAL	*RG1ALTOT*	*RG1DLTOT*	*RG2ALTOT*	*RG2DLTOT*	*RG3ALTOT*	*RG3DLTOT*	*RL1ALTOT*	*RL1DLTOT*	*RL2ALTOT*	*RL2DLTOT*	*RL3ALTOT*	*RL3DLTOT*	*RUSALTOT*	*RUSDLTOT*	*RUCALTOT*	*RUCDLTOT*	*RPFALTOT*	*RPFDLTOT*	*RPRALTOT*	*RPRDLTOT*
RATING		*RRG1UWD*		*RRG2UWD*		*RRG3UWD*		*RRL1UWD*		*RRL2UWD*		*RRL3UWD*		*RRUSUWD*		*RRUCUWD*		*RRPFUWD*		*RRPRUWD*	
LOCATION FACTOR		1.5		1.5		25		1		1		25		50		20		0		0	
IND RATING		*RRG1WD*		*RRG2WD*		*RRG3WD*		*RRL1WD*		*RRL2WD*		*RRL3WD*		*RRUSWD*		*RRUCWD*		*RRPFWD*		*RRPRWD*	

TGF %	INT. GR. FILL %	WDK/WDN	UNWEIGHTED DEP.	TEST LAB TLHC %	TEST LAB TLFC %
RRTGF	*RRIGF*	*RRWD*	*RRUWD*	*TLHC*	*TLFC*

FIG. A13.8 1K/1N Referee Rating

1K/1N

FORM 6

OIL ANALYSIS AND RESULTS SUMMARY

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 ANAL./ENG. HRS.		NEW / 0		24		204		252	
VISC @ 100°C		*V100HNEW*		*V100H024*		*V100H204*		*V100H252*	
TBN D4739		*TBN_HNEW*		*TBN_H024*		*TBN_H204*		*TBN_H252*	
WEAR METALS:	Fe/Al	*FEWMHNEW*	*ALWMHNEW*	*FEWMH024*	*ALWMH024*	*FEWMH204*	*ALWMH204*	*FEWMH252*	*ALWMH252*
	Si/Cu	*SIWMHNEW*	*CUWMHNEW*	*SIWMH024*	*CUWMH024*	*SIWMH204*	*CUWMH204*	*SIWMH252*	*CUWMH252*
	Cr/Pb	*CRWMHNEW*	*PBWMHNEW*	*CRWMH024*	*PBWMH024*	*CRWMH204*	*PBWMH204*	*CRWMH252*	*PBWMH252*
FUEL DILUTION				*FDILH024*		*FDILH204*		*FDILH252*	
BLOWBY (L/min)				*BLBYH024*		*BLBYH204*		*BLBYH252*	
24 HR. AVG. BSOC (g/kW-h) FOR HRS. END				0-252 HR. AVG. BSOC (g/kW-h): *BSOC*		EOT Oil Consumption(g/kW-h): *EOTOC*			

24	48	72	108	132	156	180	204	228	252
BSOCH024	*BSOCH048*	*BSOCH072*	*BSOCH108*	*BSOCH132*	*BSOCH156*	*BSOCH180*	*BSOCH204*	*BSOCH228*	*BSOCH252*

INSPECTION AND MEAS. SUMMARY	RING GAP INCR (mm)	SIDE CL. LOSS (mm)	RING STUCK (1)	SCUFFED AREA % (2)	% BORE POLISH (WITH GRID)	AVERAGE WEAR STEP (mm)
TOP RING	*RINGGTI*	*LSCTOP*	*STUCKTOP*	*SCUFFTOP*		
INT. RING	*RINGGI1I*	*LSCINT1*	*STUCKIN1*	*SCUFFIN1*		
OIL RING	*RINGGOI*	*LSCOIL*	*STUCKOIL*	*SCUFFOIL*		
PISTON				*SCUFFPIS*		
CYLINDER LINER				*SCUFFLIN*	*BOREPOL*	*AWEARST*

PISTON DEPOSIT SUMMARY	TGF %	INT GR. F.%	WDK/WDN	UN WT DEP	T.L. HVY CARB %	T.L. FLAKED CARB %
	TGF	*IGF*	*WD*	*UWD*	*TLHC*	*TLFC*

UNWEIGHTED PISTON DEPOSITS

GROOVES			LANDS			UPPER SKIRT	UNDER CROWN	PIN BORES	
1	2	3	1	2	3			FRONT	REAR
G1UWD	*G2UWD*	*G3UWD*	*L1UWD*	*L2UWD*	*L3UWD*	*USUWD*	*UCUWD*	*PFUWD*	*PRUWD*

FIG. A13.9 1K/1N Oil Analysis and Results Summary

1K/1N
FORM 7
UNSCHEDULED DOWNTIME & MAINTENANCE 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**
DOWNR001	*DDATR001*	*DTIMR001*	*DREAR001*
		TOTLDOWN	TOTAL DOWNTIME (125 HR. MAX)

Out-of-Limits Data and Comments		
Number of Comment Lines	*TOTCOM*	
OCOMR001		

(Rev. 5/94)

FIG. A13.10 1K/1N Unscheduled Downtime and Maintenance Summary

1K/1N

FORM 8

RING MEASUREMENTS

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

RING GAPS (mm)	TOP	INTERMEDIATE	OIL
SPECIFICATIONS	0.724 ± 0.076 mm	0.673 ± 0.076 mm	0.572 ± 0.190 mm
PRE-TEST	*RINGGTE*	*RINGGI1E*	*RINGGOE*
POST-TEST	*RINGGTO*	*RINGGI1O*	*RINGGOO*
INCREASE	*RINGGTI*	*RINGGI1I*	*RINGGOI*

RING SIDE CLEARANCE		A	B	C	D	AVG.	MIN.	SPECIFICATION
TOP	PRE-TEST	*SIDETPE1*	*SIDETPE2*	*SIDETPE3*	*SIDETPE4*	*ASIDETPE*	*ISIDETPE*	0.193±0.032 mm
	POST-TEST	*SIDETPO1*	*SIDETPO2*	*SIDETPO3*	*SIDETPO4*	*ASIDETPO*	*ISIDETPO*	
	LSC	*LSCT1*	*LSCT2*	*LSCT3*	*LSCT4*	*LSCTOP*	*ILSCT*	
INT.	PRE-TEST	*SIDE1PE1*	*SIDE1PE2*	*SIDE1PE3*	*SIDE1PE4*	*ASIDE1PE*	*ISIDE1PE*	0.090±0.020 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*	0.073 ±0.016 mm
	POST-TEST	*SIDEOPO1*	*SIDEOPO2*	*SIDEOPO3*	*SIDEOPO4*	*ASIDEOPO*	*ISIDEOPO*	
	LSC	*LSCO1*	*LSCO2*	*LSCO3*	*LSCO4*	*LSCOIL*	*ILSCO*	

NOTE 1—Write “stuck” in place of dimension when applicable.
NOTE 2—Write “<0.038 mm” for clearance when applicable.
NOTE 3—Write “>” before calculated decrease or average decrease values that incorporate a “<0.038 mm” in calculation.
NOTE 4—LSC: loss of side clearance.
NOTE 5—Min: intermediate and oil ring minimum side clearance is measured 360° around piston.

FIG. A13.11 1K/1N Ring Measurements

1K/1N
FORM 9
LINER MEASUREMENTS

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

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

LINER BORE MEASUREMENT (mm)				
BEFORE TEST - DIAMETER (DIAL BORE GAGE)				
BORE HEIGHT	**LONGITUDINAL**		**TRANSVERSE**	
230 mm	*BBLONG1*		*BBTRAN1*	
130 mm	*BBLONG2*		*BBTRAN2*	
50 mm	*BBLONG3*		*BBTRAN3*	
25 mm	*BBLONG4*		*BBTRAN4*	
15 mm	*BBLONG5*		*BBTRAN5*	
AFTER TEST - (SURFACE PROFILE)				
	LONGITUDINAL		**TRANSVERSE**	
	FRONT	**REAR**	**T**	**AT**
WEAR STEP @ 15mm	*AWEARLF*	*AWEARLR*	*AWEARTT*	*AWEARTAT*

FIG. A13.12 1K/1N Liner Measurements

1K/1N

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 BRG.	*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	*FUELSENS*	*FUELCALF*	*FUELRECD*	*FUELOBSF*	*FUELRECF*	*FUELLOGF*	*FUELSYSR*
PRESSURES (kPa)							
OIL TO BRG.	*OBRPSENS*	*OBRPCALF*	*OBRPRECD*	*OBRPOBSF*	*OBRPRECF*	*OBRPLOGF*	*OBRPSYSR*
OIL TO JET	*OJETSENS*	*OJETCALF*	*OJETRECD*	*OJETOBSF*	*OJETRECF*	*OJETLOGF*	*OJETSYSR*
INLET AIR	*AIRPSENS*	*AIRPCALF*	*AIRPRECD*	*AIRPOBSF*	*AIRPRECF*	*AIRPLOGF*	*AIRPSYSR*
EXHAUST	*EXPSENS*	*EXPCALF*	*EXPRECD*	*EXPOBSF*	*EXPRECF*	*EXPLOGF*	*EXPSYSR*
FUEL @ FILTER HSG	*FFILSENS*	*FFILCALF*	*FFILRECD*	*FFILOBSF*	*FFILRECF*	*FFILLOGF*	*FFILSYSR*
CRANKCASE VAC	*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. A13.13 Characteristics of the Data Acquisition System

1K/1N
FORM 11

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

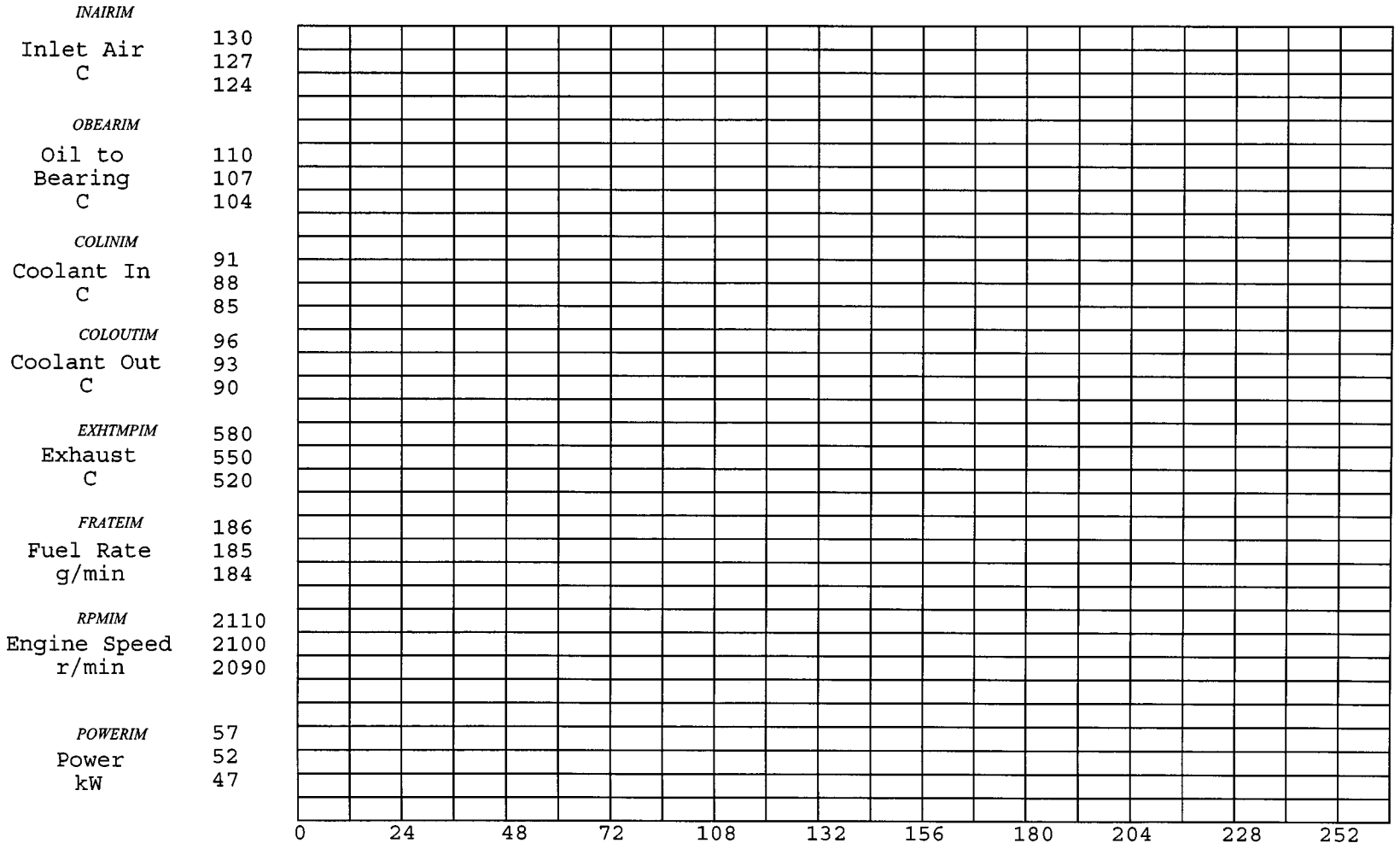


FIG. A13.14 1K/1N Engine Operating Conditions (Form 11)

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

OBEARPIM

Oil to Bearing kPa
482
441
400

OJETPIM

Oil to Jet kPa
375
360
345

INAIRPIM

Inlet Air kPa
241
240
239

EXHPIM

Exhaust kPa
217
216
215

HUMIDIM

Humidity grams/kg
19.5
17.8
16.1

COLFLOIM

Coolant Flow L/min
67
65
63

CCVACIM

Crankcase Vacuum kPa
0.8
0.7
0.6

BLOBYIM

Blowby L/min
30
20
10

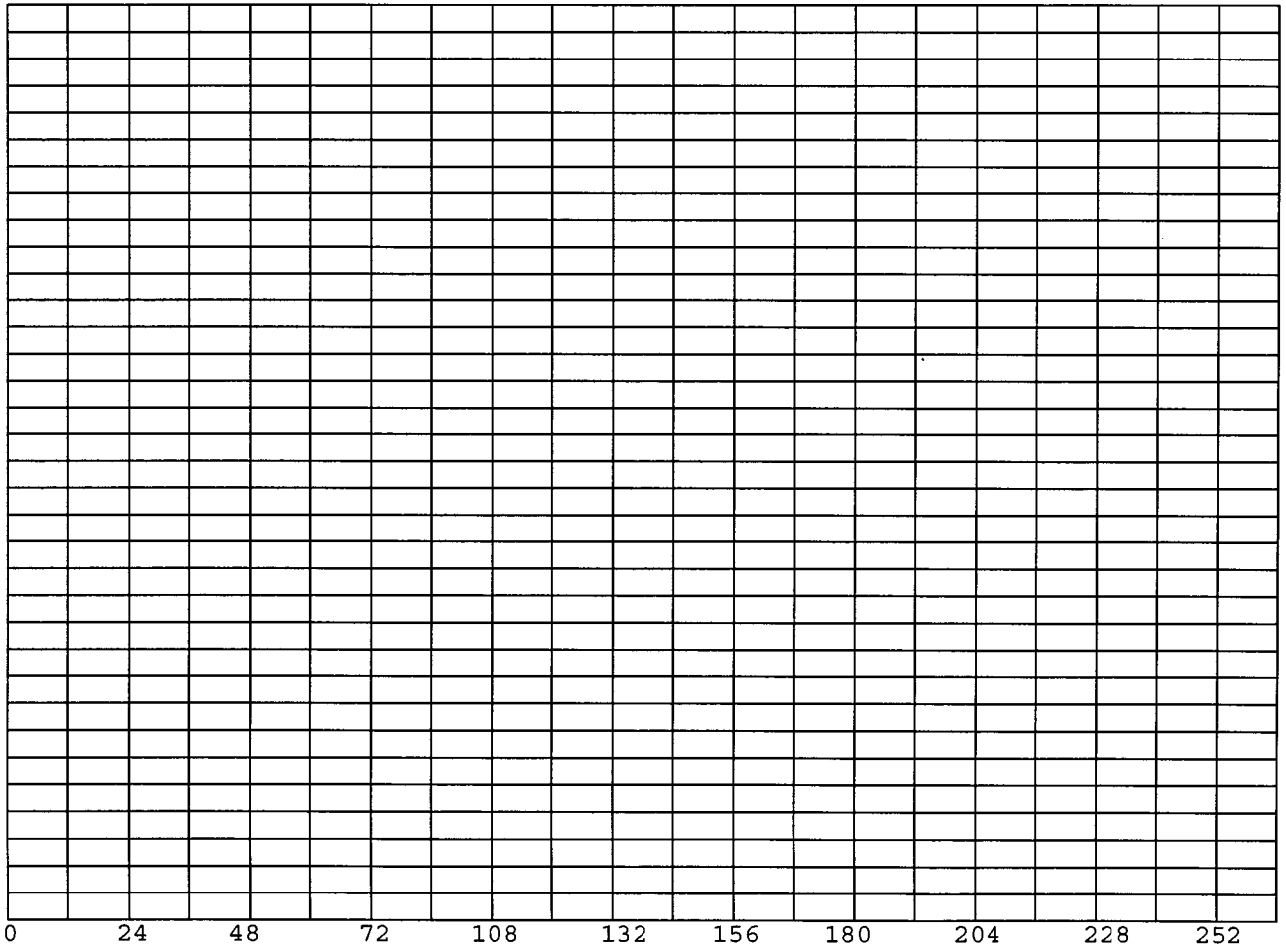


FIG. A13.15 1K/1N Engine Operating Conditions (Form 12)

1K/1N

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*			

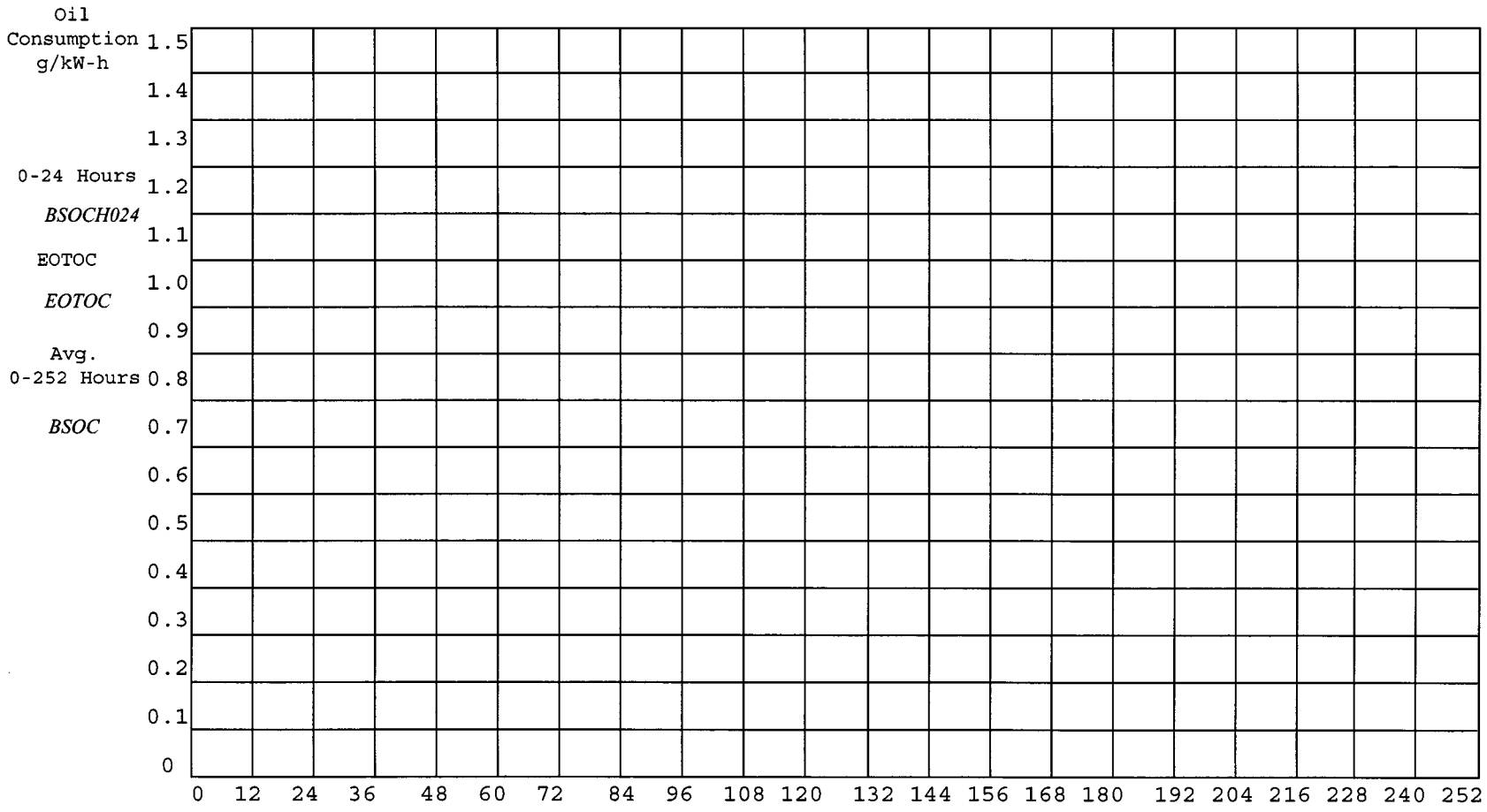


FIG. A13.16 1K/1N Oil Consumption Plot

1K/1N
Form 14
PISTON, RING AND LINER PHOTOGRAPHS

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

PRLIM

NOTE 1—Refer to Appendix X3.2 for example of photo layout.

FIG. A13.17 1K/1N Piston, Ring and Liner Photographs

1K/1N
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		WDK/WDN		TGF %		TRANSFORMED TLHC %	
START	TIME	Zi	S.A.	Zi	S.A.	Zi	S.A.
DTSTR001	*DTTMR001*	*WDZIR001*	*WDSAR001*	*TGZIR001*	*TGSAR001*	*TLZIR001*	*TLSAR001*

FIG. A13.18 1K/1N Severity Adjustment History

1K/1N
Form 16
TMC CONTROL CHART ANALYSIS

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

CCHIM

NOTE 1—Refer to Appendix X3.3 for example of control chart analysis
FIG. A13.19 1K/1N TMC Control Chart Analysis

1K/1N
Form 17
FUEL BATCH ANALYSIS

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

FUELIM

NOTE 1—Refer to Appendix X3.4 for examples of appropriate fuel batch analysis pages.
FIG. A13.20 1K/1N Fuel Batch Analysis

A14. DATA DICTIONARY

A14.1 The data dictionary and repeating field specifications are provided as Fig. A14.1 and Fig. A14.2.

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Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
10	0	1K1N	VERSION	8	0	C	YYYYMMDD	1K1N VERSION 20020107 BETA
20	0	1K1N	METHOD	2	0	C		METHOD
30	0	1K1N	TSTSPON1	40	0	C		CONDUCTED FOR, FIRST LINE
40	0	1K1N	TSTSPON2	40	0	C		CONDUCTED FOR, SECOND LINE
50	0	1K1N	LABVALID	1	0	C	V, I OR N	TEST LAB VALIDATION
60	0	1K1N	STAND	5	0	C		STAND
70	0	1K1N	ENRUN	4	0	C		ENGINE RUN
80	0	1K1N	EOTTIME	5	0	C	HH:MM	END OF TEST TIME
90	0	1K1N	DTCOMP	8	0	C	YYYYMMDD	COMPLETED DATE
100	0	1K1N	OILCODE	38	0	C		OIL CODE
110	0	1K1N	CMIR	6	0	C		CMIR
120	0	1K1N	FORM	38	0	C		FORMULATION/STAND CODE
130	0	1K1N	ALTCODE1	15	0	C		ALTERNATE OIL CODE 1
140	0	1K1N	ALTCODE2	15	0	C		ALTERNATE OIL CODE 2
150	0	1K1N	ALTCODE3	15	0	C		ALTERNATE OIL CODE 3
160	0	1K1N	OPVALID	8	0	C		OPERATIONAL VALIDITY -- HAS/HAS NOT
170	0	1K1N	SUBLAB	40	0	C		SUBMITTED BY: TESTING LABORATORY
180	0	1K1N	SUBSIGIM	70	0	C		SUBMITTED BY: SIGNATURE IMAGE
190	0	1K1N	SUBNAME	40	0	C		SUBMITTED BY: SIGNATURE TYPED NAME
200	0	1K1N	SUBTITLE	40	0	C		SUBMITTED BY: TITLE
210	1	1K1N	LAB	2	0	C		LAB CODE
220	1	1K1N	DTSTRT	8	0	C	YYYYMMDD	STARTING DATE
230	1	1K1N	TESTLEN	5	0	Z	HOURS	TOTAL TEST LENGTH
240	1	1K1N	IND	6	0	C		TMC OIL CODE
250	1	1K1N	LABOCODE	20	0	C		LABORATORY INTERNAL OIL CODE
260	1	1K1N	WD	7	1	N	DEMERITS	WEIGHTED TOTAL DEMERITS UNADJUSTED LAB RATING
270	1	1K1N	TGF	4	0	N	%	TOP GROOVE FILLING UNADJUSTED LAB RATING
280	1	1K1N	TLHC	4	0	N	%	T.L. HVY. CARBON
290	1	1K1N	TTLHC	7	3	N	TRANS UNITS	TRANSFORMED TOP LAND HEAVY CARBON
300	1	1K1N	BSOC	5	2	N	g/kW-h	UNADJUSTED LAB RATING BSOC
310	1	1K1N	EOTOC	5	2	N	g/kW-h	UNADJUSTED LAB RATING EOTOC
320	1	1K1N	DATECF	8	0	C	YYYYMMDD	INDUSTRY CORRECTION DATE
330	1	1K1N	WDCF	7	1	N	DEMERITS	INDUSTRY CORRECTION TOTAL WEIGHTED DEMERITS
340	1	1K1N	TGFCF	4	0	N	%	INDUSTRY CORRECTION TOP GROOVE FILLING
350	1	1K1N	TLHCCF	4	0	N	%	INDUSTRY CORRECTION TL HEAVY CARBON
360	1	1K1N	TTLHCCF	7	3	N	TRANS UNITS	INDUSTRY CORRECTION TRANSFORMED TOP LAND HEAVY CARBON
370	1	1K1N	BSOCCF	5	2	N	g/kW-h	INDUSTRY CORRECTION BSOC
380	1	1K1N	EOTOCCF	5	2	N	g/kW-h	INDUSTRY CORRECTION EOTOC
390	1	1K1N	WDCOR	7	1	N	DEMERITS	CORRECTED WEIGHTED TOTAL DEMERITS
400	1	1K1N	TGFCOR	4	0	N	%	CORRECTED TOP GROOVE FILLING
410	1	1K1N	TLHCCOR	4	0	N	%	CORRECTED TL HEAVY CARBON
420	1	1K1N	TTLHCCOR	7	3	N	TRANS UNITS	CORRECTED TRANSFORMED TOP LAND HEAVY CARBON
430	1	1K1N	BSOCCOR	5	2	N	g/kW-h	CORRECTED BSOC
440	1	1K1N	EOTOCCOR	5	2	N	g/kW-h	CORRECTED EOTOC
450	1	1K1N	DATESA	8	0	C	YYYYMMDD	LAB SEVERITY ADJUSTMENT DATE
460	1	1K1N	WDSA	7	1	N	DEMERITS	LAB SEVERITY ADJUSTMENT WEIGHTED TOTAL DEMERITS
470	1	1K1N	TGFSA	4	0	N	%	LAB SEVERITY ADJUSTMENT TOP GROOVE FILLING
480	1	1K1N	TLHCSA	4	0	N	%	LAB SEVERITY ADJUSTMENT TL HEAVY CARBON
490	1	1K1N	TTLHCSA	7	3	N	TRANS UNITS	LAB SEVERITY ADJUSTMENT TRANSFORMED TOP LAND HEAVY CARBON
500	1	1K1N	BSOCSA	5	2	N	g/kW-h	LAB SEVERITY ADJUSTMENT BSOC
510	1	1K1N	EOTOCSA	5	2	N	g/kW-h	LAB SEVERITY ADJUSTMENT EOTOC
520	1	1K1N	WDFNL	7	1	N	DEMERITS	FINAL WEIGHTED TOTAL DEMERITS
530	1	1K1N	TGFFNL	4	0	N	%	FINAL TOP GROOVE FILLING

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FIG. A14.1 Data Dictionary

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
540	1	1K1N	TLHCFNL	4	0	N	%	FINAL TL HEAVY CARBON
550	1	1K1N	TTLHCFNL	7	3	N	TRANS UNITS	FINAL TRANSFORMED TOP LAND HEAVY CARBON
560	1	1K1N	BSOCFNL	5	2	N	g/kW-h	FINAL BSOC
570	1	1K1N	EOTOCFNL	5	2	N	g/kW-h	FINAL EOTOC
580	1	1K1N	EFFDATE	8	0	C	YYYYMMDD	TEST TARGET EFFECTIVE DATE
590	1	1K1N	WDM	7	1	N	DEMERITS	TEST TARGET MEAN WEIGHTED TOTAL DEMERITS
600	1	1K1N	TGFM	6	1	N	%	TEST TARGET MEAN TOP GROOVE FILLING
610	1	1K1N	TTLHCM	7	3	N	TRANS UNITS	TEST TARGET MEAN TRANSFORMED TOP LAND HEAVY CARBON
620	1	1K1N	BSOCM	5	2	N	g/kW-h	TEST TARGET MEAN BSOC
630	1	1K1N	EOTOCM	5	2	N	g/kW-h	TEST TARGET MEAN EOTOC
640	1	1K1N	WDS	7	1	N	DEMERITS	TEST TARGET STD WEIGHTED TOTAL DEMERITS
650	1	1K1N	TGFS	6	1	N	%	TEST TARGET STD TOP GROOVE FILLING
660	1	1K1N	TTLHCS	5	1	N	TRANS UNITS	TEST TARGET STD TRANSFORMED TOP LAND HEAVY CARBON
670	1	1K1N	BSOCS	5	2	N	g/kW-h	TEST TARGET STD BSOC
680	1	1K1N	EOTOCS	5	2	N	g/kW-h	TEST TARGET STD EOTOC
685	1	1K1N	LDESC	40	0	C		LIMIT DESCRIPTION
690	1	1K1N	DTCEFF	8	0	C	YYYYMMDD	LIMIT EFFECTIVE DATE
700	1	1K1N	WDPL	7	1	N	DEMERITS	LIMIT WEIGHTED TOTAL DEMERITS
710	1	1K1N	TGFPL	6	1	N	%	LIMIT TOP GROOVE FILLING
720	1	1K1N	TLHCPL	6	1	N	%	LIMIT TOP LAND HEAVY CARBON
730	1	1K1N	BSOCPL	5	2	N	g/kW-h	LIMIT BSOC
740	1	1K1N	EOTOCPL	5	2	N	g/kW-h	LIMIT EOTOC
750	1	1K1N	RRLAB	2	0	C		REFEREE LAB CODE
760	1	1K1N	RRWD	7	1	N	DEMERITS	REFEREE RATING WEIGHTED TOTAL DEMERITS
770	1	1K1N	RRTGF	4	0	N	%	REFEREE RATING TOP GROOVE FILLING
780	1	1K1N	LSCTOP	6	3	N	mm	TOP RING SIDE CLEARANCE LSC
790	1	1K1N	LSCINT1	6	3	N	mm	INT. 1 RING SIDE CLEARANCE LSC
800	1	1K1N	LSCOIL	6	3	N	mm	OIL RING SIDE CLEARANCE LSC
810	1	1K1N	RINGGTI	6	3	N	mm	TOP RING END GAP INCREASE
820	1	1K1N	RINGGI1I	6	3	N	mm	INTERMEDIATE 1 RING END GAP INCREASE
830	1	1K1N	RINGGOI	6	3	N	mm	OIL RING END GAP INCREASE
840	1	1K1N	STUCKTOP	3	0	C		IS THE TOP RING STUCK? YES OR NO!!
850	1	1K1N	STUCKIN1	3	0	C		IS THE INT. 1 RING STUCK? YES OR NO!!
860	1	1K1N	STUCKOIL	3	0	C		IS THE OIL RING STUCK? YES OR NO!!
870	1	1K1N	SCUFFTOP	4	0	N	%	SCUFFED AREA TOP
880	1	1K1N	SCUFFIN1	4	0	N	%	SCUFFED AREA INT. 1
890	1	1K1N	SCUFFOIL	4	0	N	%	SCUFFED AREA OIL
900	1	1K1N	SCUFFPIS	4	0	N	%	SCUFFED AREA PISTON
910	1	1K1N	SCUFFLIN	4	0	N	%	SCUFFED AREA LINER
920	1	1K1N	AWEARST	6	3	N	mm	AVERAGE WEAR STEP LINER
930	1	1K1N	BOREPOL	6	1	N	%	LINER BORE POLISH
940	2	1K1N	IRPM	7	1	N	r/min	MIN ENGINE SPEED
950	2	1K1N	XRPM	7	1	N	r/min	MAX ENGINE SPEED
960	2	1K1N	ARPM	7	1	N	r/min	AVG ENGINE SPEED
970	2	1K1N	IPWR	6	1	N	kW	MIN ENGINE POWER
980	2	1K1N	XPWR	6	1	N	kW	MAX ENGINE POWER
990	2	1K1N	APWR	6	1	N	kW	AVG ENGINE POWER
1000	2	1K1N	IFFLO	6	1	N	g/min	MIN FUEL FLOW
1010	2	1K1N	XFFLO	6	1	N	g/min	MAX FUEL FLOW
1020	2	1K1N	AFFLO	6	1	N	g/min	AVG FUEL FLOW
1030	2	1K1N	IHUMID	5	1	N	g/kg	MIN HUMIDITY
1040	2	1K1N	XHUMID	5	1	N	g/kg	MAX HUMIDITY
1050	2	1K1N	AHUMID	5	1	N	g/kg	AVG HUMIDITY
1060	2	1K1N	ICOLOUT	5	1	N	°C	MIN COOLANT OUT

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
1070	2	1K1N	XCOLOUT	5	1	N	°C	MAX COOLANT OUT
1080	2	1K1N	ACOLOUT	5	1	N	°C	AVG COOLANT OUT
1090	2	1K1N	ICOLIN	5	1	N	°C	MIN COOLANT IN
1100	2	1K1N	XCOLIN	5	1	N	°C	MAX COOLANT IN
1110	2	1K1N	ACOLIN	5	1	N	°C	AVG COOLANT IN
1120	2	1K1N	ICOLDT	5	1	N	°C	MIN COOLANT DELTA
1130	2	1K1N	XCOLDT	5	1	N	°C	MAX COOLANT DELTA
1140	2	1K1N	ACOLDT	5	1	N	°C	AVG COOLANT DELTA
1150	2	1K1N	IOBRGTMP	6	1	N	°C	MIN OIL TO BEARING TEMPERATURE
1160	2	1K1N	XOBRGTMP	6	1	N	°C	MAX OIL TO BEARING TEMPERATURE
1170	2	1K1N	AOBRGTMP	6	1	N	°C	AVG OIL TO BEARING TEMPERATURE
1180	2	1K1N	IOCOOLIN	6	1	N	°C	MIN OIL COOLER IN TEMPERATURE
1190	2	1K1N	XOCOOLIN	6	1	N	°C	MAX OIL COOLER IN TEMPERATURE
1200	2	1K1N	AOCOOLIN	6	1	N	°C	AVG OIL COOLER IN TEMPERATURE
1210	2	1K1N	IINAIRT	6	1	N	°C	MIN INLET AIR TEMPERATURE
1220	2	1K1N	XINAIRT	6	1	N	°C	MAX INLET AIR TEMPERATURE
1230	2	1K1N	AINAIRT	6	1	N	°C	AVG INLET AIR TEMPERATURE
1240	2	1K1N	IEXHTMP	6	1	N	°C	MIN EXHAUST TEMPERATURE
1250	2	1K1N	XEXHTMP	6	1	N	°C	MAX EXHAUST TEMPERATURE
1260	2	1K1N	AEXHTMP	6	1	N	°C	AVG EXHAUST TEMPERATURE
1270	2	1K1N	IFUELTMP	6	1	N	°C	MINIMUM FUEL @ INJECTOR HOUSING TEMP
1280	2	1K1N	XFUELTMP	6	1	N	°C	MAXIMUM FUEL @ INJECTOR HOUSING TEMP
1290	2	1K1N	AFUELTMP	6	1	N	°C	AVERAGE FUEL @ INJECTOR HOUSING TEMP
1300	2	1K1N	IOBRGPR	6	1	N	kPa	MIN OIL TO BEARING PRESSURE
1310	2	1K1N	XOBRGPR	6	1	N	kPa	MAX OIL TO BEARING PRESSURE
1320	2	1K1N	AOBRGPR	6	1	N	kPa	AVG OIL TO BEARING PRESSURE
1330	2	1K1N	IOJETPR	6	1	N	kPa	MIN OIL TO JET PRESSURE
1340	2	1K1N	XOJETPR	6	1	N	kPa	MAX OIL TO JET PRESSURE
1350	2	1K1N	AOJETPR	6	1	N	kPa	AVG OIL TO JET PRESSURE
1360	2	1K1N	IINAIRP	6	1	N	kPa	MIN INLET AIR PRESSURE
1370	2	1K1N	XINAIRP	6	1	N	kPa	MAX INLET AIR PRESSURE
1380	2	1K1N	AINAIRP	6	1	N	kPa	AVG INLET AIR PRESSURE
1390	2	1K1N	IEBP	6	1	N	kPa	MIN EXHAUST PRESSURE
1400	2	1K1N	XEBP	6	1	N	kPa	MAX EXHAUST PRESSURE
1410	2	1K1N	AEBP	6	1	N	kPa	AVG EXHAUST PRESSURE
1420	2	1K1N	IFUELPR	6	1	N	kPa	MIN FUEL @ FILTER HOUSING PRESSURE
1430	2	1K1N	XFUELPR	6	1	N	kPa	MAX FUEL @ FILTER HOUSING PRESSURE
1440	2	1K1N	AFUELPR	6	1	N	kPa	AVG FUEL @ FILTER HOUSING PRESSURE
1450	2	1K1N	ICCV	5	2	N	kPa	MIN CRANKCASE VACUUM PRESSURE
1460	2	1K1N	XCCV	5	2	N	kPa	MAX CRANKCASE VACUUM PRESSURE
1470	2	1K1N	ACCV	5	2	N	kPa	AVG CRANKCASE VACUUM PRESSURE
1480	2	1K1N	IJUGPR	6	1	N	kPa	MIN COOLANT JUG PRESSURE
1490	2	1K1N	XJUGPR	6	1	N	kPa	MAX COOLANT JUG PRESSURE
1500	2	1K1N	AJUGPR	6	1	N	kPa	AVG COOLANT JUG PRESSURE
1510	2	1K1N	IBLOBY	6	1	N	L/min	MIN BLOWBY
1520	2	1K1N	XBLOBY	6	1	N	L/min	MAX BLOWBY
1530	2	1K1N	ABLOBY	6	1	N	L/min	AVG BLOWBY
1540	2	1K1N	ICOLFLO	7	1	N	L/min	MIN COOLANT FLOW
1550	2	1K1N	XCOLFLO	7	1	N	L/min	MAX COOLANT FLOW
1560	2	1K1N	ACOLFLO	7	1	N	L/min	AVG COOLANT FLOW
1570	2	1K1N	AFR24	6	1	N		AIR/FUEL RATIO - 24 HOUR
1580	2	1K1N	AFR252	6	1	N		AIR/FUEL RATIO - 252 HOUR
1590	2	1K1N	PISTONCL	6	3	N	mm	PISTON/HEAD CLEAR ASSEM. MEASUREMENT
1600	2	1K1N	INVALOPN	7	1	N	° ATC	INTAKE VALVE OPEN

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
1610	2	1K1N	FUELTIM	7	1	N	° BTC	FUEL TIMING
1620	2	1K1N	LINERPN	12	0	C		LINER PART NUMBER
1630	2	1K1N	LINERSN	12	0	C		LINER SERIAL NUMBER
1640	2	1K1N	LINERDC	12	0	C		LINER DATE CODE
1650	2	1K1N	LINERIC	12	0	C		LINER INSPECTION CODE
1660	2	1K1N	RINGPN	12	0	C		RING SET PART NUMBER
1670	2	1K1N	RINGDC	12	0	C		RING SET DATE CODE
1680	2	1K1N	RINGIC	12	0	C		RING SET INSPECTION CODE
1690	2	1K1N	PISTPN	12	0	C		PISTON PART NUMBER
1700	2	1K1N	PISTSN	12	0	C		PISTON SERIAL NUMBER
1710	2	1K1N	PISTDC	12	0	C		PISTON DATE CODE
1720	2	1K1N	PISTIC	12	0	C		PISTON INSPECTION CODE
1730	3	1K1N	RPMOUT	6	1	N	%	OFFSET & DEV SPEED TEST % OUT
1740	3	1K1N	RPMOFF	6	1	N	%	OFFSET & DEV SPEED TEST % OFF
1750	3	1K1N	FFLOOUT	6	1	N	%	OFFSET & DEV FUEL FLOW TEST % OUT
1760	3	1K1N	FFLOOFF	6	1	N	%	OFFSET & DEV FUEL FLOW TEST % OFF
1770	3	1K1N	HUMOUT	6	1	N	%	OFFSET & DEV HUMIDITY TEST % OUT
1780	3	1K1N	HUMOFF	6	1	N	%	OFFSET & DEV HUMIDITY TEST % OFF
1790	3	1K1N	COLFOUT	6	1	N	%	OFFSET & DEV COOLANT FLOW TEST % OUT
1800	3	1K1N	COLFOFF	6	1	N	%	OFFSET & DEV COOLANT FLOW TEST % OFF
1810	3	1K1N	COTOUT	6	1	N	%	OFFSET & DEV COOLANT OUT TEST % OUT
1820	3	1K1N	COTOFF	6	1	N	%	OFFSET & DEV COOLANT OUT TEST % OFF
1830	3	1K1N	OBRGOUT	6	1	N	%	OFFSET & DEV OIL TO BEARING TEST % OUT
1840	3	1K1N	OBRGOFF	6	1	N	%	OFFSET & DEV OIL TO BEARING TEST % OFF
1850	3	1K1N	AIRTOUT	6	1	N	%	OFFSET & DEV INTAKE AIR TEMP TEST % OUT
1860	3	1K1N	AIRTOFF	6	1	N	%	OFFSET & DEV INTAKE AIR TEMP TEST % OFF
1870	3	1K1N	FIHTOUT	6	1	N	%	FUEL TEMPERATURE AT INJECTOR HOUSING % OUT
1880	3	1K1N	FIHTOFF	6	1	N	%	FUEL TEMPERATURE AT INJECTOR HOUSING % OFF
1890	3	1K1N	OJETOUT	6	1	N	%	OFFSET & DEV OIL JET TEST % OUT
1900	3	1K1N	OJETOFF	6	1	N	%	OFFSET & DEV OIL JET TEST % OFF
1910	3	1K1N	AIRPOUT	6	1	N	%	OFFSET & DEV INLET AIR PRESSURE TEST % OUT
1920	3	1K1N	AIRPOFF	6	1	N	%	OFFSET & DEV INLET AIR PRESSURE TEST % OFF
1930	3	1K1N	EXPOUT	6	1	N	%	OFFSET & DEV EXHAUST PRESSURE TEST % OUT
1940	3	1K1N	EXPOFF	6	1	N	%	OFFSET & DEV EXHAUST PRESSURE TEST % OFF
1950	3	1K1N	FFILOUT	6	1	N	%	OFFSET & DEV FUEL AT FILTER HOUSING PRESSURE TEST % OUT
1960	3	1K1N	FFILOFF	6	1	N	%	OFFSET & DEV FUEL AT FILTER HOUSING PRESSURE TEST % OFF
1970	3	1K1N	CCVOUT	6	1	N	%	OFFSET & DEV CRANKCASE VACUUM PRESSURE TEST % OUT
1980	3	1K1N	CCVOFF	6	1	N	%	OFFSET & DEV CRANKCASE VACUUM PRESSURE TEST % OFF
1990	4	1K1N	TESTFUEL	10	0	C		TEST FUEL
2000	4	1K1N	FUELBTID	10	0	C		FUEL BATCH ID NUMBER
2010	4	1K1N	DTRATE	8	0	C	YYYYMMDD	RATING DATE
2020	4	1K1N	RNO	10	0	C		RATING NUMBER
2030	4	1K1N	RINIT	3	0	C		RATERS INITIALS
2040	4	1K1N	LRDTCOMP	8	0	C	YYYYMMDD	LAST STAND REFERENCE DATE COMPLETED
2050	4	1K1N	LRENRUN	4	0	C		LAST STAND REFERENCE RUN NUMBER
2060	4	1K1N	LIND	6	0	C		LAST STAND REFERENCE OIL CODE
2070	4	1K1N	LRWD	6	1	N	DEMERITS	LAST STAND REFERENCE TOTAL WEIGHTED DEMERITS
2080	4	1K1N	LRTGF	4	0	N	%	LAST STAND REFERENCE TOP GROOVE FILLING
2090	4	1K1N	LRTLHC	4	0	N	%	LAST STAND REFERENCE TL HEAVY CARBON
2100	4	1K1N	LRTTLHC	7	3	N	TRANS UNITS	LAST STAND REFERENCE TRANSFORMED TL HEAVY CARBON
2110	4	1K1N	LRBSOC	5	2	N	g/kW-h	LAST STAND REFERENCE BSOC
2120	4	1K1N	LREOTOC	5	2	N	g/kW-h	LAST STAND REFERENCE EOTOC
2130	4	1K1N	LRAWD	6	1	N	DEMERITS	LAST STAND REFERENCE INDUSTRY AVG WDK
2140	4	1K1N	LRATGF	5	1	N	%	LAST STAND REFERENCE INDUSTRY AVG TGF

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
2150	4	1K1N	LRATTLHC	7	3	N	TRANS UNITS	LAST STAND REF. INDUSTRY AVG. TRANSFORMED TLHC
2160	4	1K1N	LRABSOC	5	2	N	g/kW-h	LAST STAND REFERENCE INDUSTRY AVG BSOC
2170	4	1K1N	LRAEOTOC	5	2	N	g/kW-h	LAST STAND REFERENCE INDUSTRY AVG EOTOC
2180	4	1K1N	LRSWD	6	1	N	DEMERITS	LAST STAND REFERENCE INDUSTRY STD WDK
2190	4	1K1N	LRSTGF	6	1	N	%	LAST STAND REFERENCE INDUSTRY STD TGF
2200	4	1K1N	LRSTTLHC	7	3	N	TRANS UNITS	LAST STAND REF. INDUSTRY STD. TRANSFORMED TLHC
2210	4	1K1N	LRSBSOC	5	2	N	g/kW-h	LAST STAND REFERENCE INDUSTRY STD. BSOC
2220	4	1K1N	LRSEOTOC	5	2	N	g/kW-h	LAST STAND REFERENCE INDUSTRY STD EOTOC
2230	4	1K1N	G1HCA	4	0	N	% AREA	GROOVE #1 HC-1.0 CARBON AREA PERCENT
2240	4	1K1N	G1HCD	7	2	N	DEMERITS	GROOVE #1 HC-1.0 CARBON DEMERITS
2250	4	1K1N	G2HCA	4	0	N	% AREA	GROOVE #2 HC-1.0 CARBON AREA PERCENT
2260	4	1K1N	G2HCD	7	2	N	DEMERITS	GROOVE #2 HC-1.0 CARBON DEMERITS
2270	4	1K1N	G3HCA	4	0	N	% AREA	GROOVE #3 HC-1.0 CARBON AREA PERCENT
2280	4	1K1N	G3HCD	7	2	N	DEMERITS	GROOVE #3 HC-1.0 CARBON DEMERITS
2290	4	1K1N	L1HCA	4	0	N	% AREA	LAND #1 HC-1.0 CARBON AREA PERCENT
2300	4	1K1N	L1HCD	7	2	N	DEMERITS	LAND #1 HC-1.0 CARBON DEMERITS
2310	4	1K1N	L2HCA	4	0	N	% AREA	LAND #2 HC-1.0 CARBON AREA PERCENT
2320	4	1K1N	L2HCD	7	2	N	DEMERITS	LAND #2 HC-1.0 CARBON DEMERITS
2330	4	1K1N	L3HCA	4	0	N	% AREA	LAND #3 HC-1.0 CARBON AREA PERCENT
2340	4	1K1N	L3HCD	7	2	N	DEMERITS	LAND #3 HC-1.0 CARBON DEMERITS
2350	4	1K1N	USHCA	4	0	N	% AREA	UPPER SKIRT HC-1.0 CARBON AREA PERCENT
2360	4	1K1N	USHCD	7	2	N	DEMERITS	UPPER SKIRT HC-1.0 CARBON DEMERITS
2370	4	1K1N	UCHCA	4	0	N	% AREA	UNDER CROWN HC-1.0 CARBON AREA PERCENT
2380	4	1K1N	UCHCD	7	2	N	DEMERITS	UNDER CROWN HC-1.0 CARBON DEMERITS
2390	4	1K1N	PFHCA	4	0	N	% AREA	PIN BORE FRONT HC-1.0 CARBON AREA PERCENT
2400	4	1K1N	PFHCD	7	2	N	DEMERITS	PIN BORE FRONT HC-1.0 CARBON DEMERITS
2410	4	1K1N	PRHCA	4	0	N	% AREA	PIN BORE REAR HC-1.0 CARBON AREA PERCENT
2420	4	1K1N	PRHCD	7	2	N	DEMERITS	PIN BORE REAR HC-1.0 CARBON DEMERITS
2430	4	1K1N	G1MCA	4	0	N	% AREA	GROOVE #1 MC-1.0 CARBON AREA PERCENT
2440	4	1K1N	G1MCD	7	2	N	DEMERITS	GROOVE #1 MC-1.0 CARBON DEMERITS
2450	4	1K1N	G3MCA	4	0	N	% AREA	GROOVE #3 MC-1.0 CARBON AREA PERCENT
2460	4	1K1N	G3MCD	7	2	N	DEMERITS	GROOVE #3 MC-1.0 CARBON DEMERITS
2470	4	1K1N	G1LCA	4	0	N	% AREA	GROOVE #1 LC-1.0 CARBON AREA PERCENT
2480	4	1K1N	G1LCD	7	2	N	DEMERITS	GROOVE #1 LC-1.0 CARBON DEMERITS
2490	4	1K1N	G2LCA	4	0	N	% AREA	GROOVE #2 LC-1.0 CARBON AREA PERCENT
2500	4	1K1N	G2LCD	7	2	N	DEMERITS	GROOVE #2 LC-1.0 CARBON DEMERITS
2510	4	1K1N	G3LCA	4	0	N	% AREA	GROOVE #3 LC-1.0 CARBON AREA PERCENT
2520	4	1K1N	G3LCD	7	2	N	DEMERITS	GROOVE #3 LC-1.0 CARBON DEMERITS
2530	4	1K1N	L1LCA	4	0	N	% AREA	LAND #1 LC-1.0 CARBON AREA PERCENT
2540	4	1K1N	L1LCD	7	2	N	DEMERITS	LAND #1 LC-1.0 CARBON DEMERITS
2550	4	1K1N	L2LCA	4	0	N	% AREA	LAND #2 LC-1.0 CARBON AREA PERCENT
2560	4	1K1N	L2LCD	7	2	N	DEMERITS	LAND #2 LC-1.0 CARBON DEMERITS
2570	4	1K1N	L3LCA	4	0	N	% AREA	LAND #3 LC-1.0 CARBON AREA PERCENT
2580	4	1K1N	L3LCD	7	2	N	DEMERITS	LAND #3 LC-1.0 CARBON DEMERITS
2590	4	1K1N	USLCA	4	0	N	% AREA	UPPER SKIRT LC-1.0 CARBON AREA PERCENT
2600	4	1K1N	USLCD	7	2	N	DEMERITS	UPPER SKIRT LC-1.0 CARBON DEMERITS
2610	4	1K1N	UCLCA	4	0	N	% AREA	UNDER CROWN LC-1.0 CARBON AREA PERCENT
2620	4	1K1N	UCLCD	7	2	N	DEMERITS	UNDER CROWN LC-1.0 CARBON DEMERITS
2630	4	1K1N	PFLCA	4	0	N	% AREA	PISTON BORE FRONT LC-1.0 CARBON AREA PERCENT
2640	4	1K1N	PFLCD	7	2	N	DEMERITS	PISTON BORE FRONT LC-1.0 CARBON DEMERITS
2650	4	1K1N	PRLCA	4	0	N	% AREA	PISTON BORE REAR LC-1.0 CARBON AREA PERCENT
2660	4	1K1N	PRLCD	7	2	N	DEMERITS	PISTON BORE REAR LC-1.0 CARBON DEMERITS
2670	4	1K1N	G1ACTOT	4	0	N	% AREA	TOTAL GROOVE #1 CARBON AREA PERCENT
2680	4	1K1N	G1DCTOT	7	2	N	DEMERITS	TOTAL GROOVE #1 CARBON DEMERITS

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
2690	4	1K1N	G2ACTOT	4	0	N	% AREA	TOTAL GROOVE #2 CARBON AREA PERCENT
2700	4	1K1N	G2DCTOT	7	2	N	DEMERITS	TOTAL GROOVE #2 CARBON DEMERITS
2710	4	1K1N	G3ACTOT	4	0	N	% AREA	TOTAL GROOVE #3 CARBON AREA PERCENT
2720	4	1K1N	G3DCTOT	7	2	N	DEMERITS	TOTAL GROOVE #3 CARBON DEMERITS
2730	4	1K1N	L1ACTOT	4	0	N	% AREA	TOTAL LAND #1 CARBON AREA PERCENT
2740	4	1K1N	L1DCTOT	7	2	N	DEMERITS	TOTAL LAND #1 CARBON DEMERITS
2750	4	1K1N	L2ACTOT	4	0	N	% AREA	TOTAL LAND #2 CARBON AREA PERCENT
2760	4	1K1N	L2DCTOT	7	2	N	DEMERITS	TOTAL LAND #2 CARBON DEMERITS
2770	4	1K1N	L3ACTOT	4	0	N	% AREA	TOTAL LAND #3 CARBON AREA PERCENT
2780	4	1K1N	L3DCTOT	7	2	N	DEMERITS	TOTAL LAND #3 CARBON DEMERITS
2790	4	1K1N	USACTOT	4	0	N	% AREA	TOTAL UPPER SKIRT CARBON AREA PERCENT
2800	4	1K1N	USDCTOT	7	2	N	DEMERITS	TOTAL UPPER SKIRT CARBON DEMERITS
2810	4	1K1N	UCACTOT	4	0	N	% AREA	TOTAL UNDER CROWN CARBON AREA PERCENT
2820	4	1K1N	UCDCTOT	7	2	N	DEMERITS	TOTAL UNDER CROWN CARBON DEMERITS
2830	4	1K1N	PFACTOT	4	0	N	% AREA	TOTAL PIN BORE FRONT CARBON AREA PERCENT
2840	4	1K1N	PFDCTOT	7	2	N	DEMERITS	TOTAL PIN BORE FRONT CARBON DEMERITS
2850	4	1K1N	PRACTOT	4	0	N	% AREA	TOTAL PIN BORE REAR CARBON AREA PERCENT
2860	4	1K1N	PRDCTOT	7	2	N	DEMERITS	TOTAL PIN BORE REAR CARBON DEMERITS
2870	4	1K1N	G1L9A	4	0	N	% AREA	GROOVE #1 8-9 LACQUER AREA PERCENT
2880	4	1K1N	G1L9D	7	2	N	DEMERITS	GROOVE #1 8-9 LACQUER DEMERITS
2890	4	1K1N	G2L9A	4	0	N	% AREA	GROOVE #2 8-9 LACQUER AREA PERCENT
2900	4	1K1N	G2L9D	7	2	N	DEMERITS	GROOVE #2 8-9 LACQUER DEMERITS
2910	4	1K1N	G3L9A	4	0	N	% AREA	GROOVE #3 8-9 LACQUER AREA PERCENT
2920	4	1K1N	G3L9D	7	2	N	DEMERITS	GROOVE #3 8-9 LACQUER DEMERITS
2930	4	1K1N	L1L9A	4	0	N	% AREA	LAND #1 8-9 LACQUER AREA PERCENT
2940	4	1K1N	L1L9D	7	2	N	DEMERITS	LAND #1 8-9 LACQUER DEMERITS
2950	4	1K1N	L2L9A	4	0	N	% AREA	LAND #2 8-9 LACQUER AREA PERCENT
2960	4	1K1N	L2L9D	7	2	N	DEMERITS	LAND #2 8-9 LACQUER DEMERITS
2970	4	1K1N	L3L9A	4	0	N	% AREA	LAND #3 8-9 LACQUER AREA PERCENT
2980	4	1K1N	L3L9D	7	2	N	DEMERITS	LAND #3 8-9 LACQUER DEMERITS
2990	4	1K1N	USV9A	4	0	N	% AREA	UPPER SKIRT 8-9 LACQUER AREA PERCENT
3000	4	1K1N	USV9D	7	2	N	DEMERITS	UPPER SKIRT 8-9 LACQUER DEMERITS
3010	4	1K1N	UCV9A	4	0	N	% AREA	UNDER CROWN 8-9 LACQUER AREA PERCENT
3020	4	1K1N	UCV9D	7	2	N	DEMERITS	UNDER CROWN 8-9 LACQUER DEMERITS
3030	4	1K1N	PFV9A	4	0	N	% AREA	PIN BORE FRONT 8-9 LACQUER AREA PERCENT
3040	4	1K1N	PFV9D	7	2	N	DEMERITS	PIN BORE FRONT 8-9 LACQUER DEMERITS
3050	4	1K1N	PRV9A	4	0	N	% AREA	PIN BORE REAR 8-9 LACQUER AREA PERCENT
3060	4	1K1N	PRV9D	7	2	N	DEMERITS	PIN BORE REAR 8-9 LACQUER DEMERITS
3070	4	1K1N	G1L8A	4	0	N	% AREA	GROOVE #1 7-7.9 LACQUER AREA PERCENT
3080	4	1K1N	G1L8D	7	2	N	DEMERITS	GROOVE #1 7-7.9 LACQUER DEMERITS
3090	4	1K1N	G2L8A	4	0	N	% AREA	GROOVE #2 7-7.9 LACQUER AREA PERCENT
3100	4	1K1N	G2L8D	7	2	N	DEMERITS	GROOVE #2 7-7.9 LACQUER DEMERITS
3110	4	1K1N	G3L8A	4	0	N	% AREA	GROOVE #3 7-7.9 LACQUER AREA PERCENT
3120	4	1K1N	G3L8D	7	2	N	DEMERITS	GROOVE #3 7-7.9 LACQUER DEMERITS
3130	4	1K1N	L1L8A	4	0	N	% AREA	LAND #1 7-7.9 LACQUER AREA PERCENT
3140	4	1K1N	L1L8D	7	2	N	DEMERITS	LAND #1 7-7.9 LACQUER DEMERITS
3150	4	1K1N	L2L8A	4	0	N	% AREA	LAND #2 7-7.9 LACQUER AREA PERCENT
3160	4	1K1N	L2L8D	7	2	N	DEMERITS	LAND #2 7-7.9 LACQUER DEMERITS
3170	4	1K1N	L3L8A	4	0	N	% AREA	LAND #3 7-7.9 LACQUER AREA PERCENT
3180	4	1K1N	L3L8D	7	2	N	DEMERITS	LAND #3 7-7.9 LACQUER DEMERITS
3190	4	1K1N	USV8A	4	0	N	% AREA	UPPER SKIRT 7-7.9 LACQUER AREA PERCENT
3200	4	1K1N	USV8D	7	2	N	DEMERITS	UPPER SKIRT 7-7.9 LACQUER DEMERITS
3210	4	1K1N	UCV8A	4	0	N	% AREA	UNDER CROWN 7-7.9 LACQUER AREA PERCENT
3220	4	1K1N	UCV8D	7	2	N	DEMERITS	UNDER CROWN 7-7.9 LACQUER DEMERITS

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
3230	4	1K1N	PFV8A	4	0	N	% AREA	PIN BORE FRONT 7-7.9 LACQUER AREA PERCENT
3240	4	1K1N	PFV8D	7	2	N	DEMERITS	PIN BORE FRONT 7-7.9 LACQUER DEMERITS
3250	4	1K1N	PRV8A	4	0	N	% AREA	PIN BORE REAR 7-7.9 LACQUER AREA PERCENT
3260	4	1K1N	PRV8D	7	2	N	DEMERITS	PIN BORE REAR 7-7.9 LACQUER DEMERITS
3270	4	1K1N	G1L7A	4	0	N	% AREA	GROOVE #1 6-6.9 LACQUER AREA PERCENT
3280	4	1K1N	G1L7D	7	2	N	DEMERITS	GROOVE #1 6-6.9 LACQUER DEMERITS
3290	4	1K1N	G2L7A	4	0	N	% AREA	GROOVE #2 6-6.9 LACQUER AREA PERCENT
3300	4	1K1N	G2L7D	7	2	N	DEMERITS	GROOVE #2 6-6.9 LACQUER DEMERITS
3310	4	1K1N	G3L7A	4	0	N	% AREA	GROOVE #3 6-6.9 LACQUER AREA PERCENT
3320	4	1K1N	G3L7D	7	2	N	DEMERITS	GROOVE #3 6-6.9 LACQUER DEMERITS
3330	4	1K1N	L1L7A	4	0	N	% AREA	LAND #1 6-6.9 LACQUER AREA PERCENT
3340	4	1K1N	L1L7D	7	2	N	DEMERITS	LAND #1 6-6.9 LACQUER DEMERITS
3350	4	1K1N	L2L7A	4	0	N	% AREA	LAND #2 6-6.9 LACQUER AREA PERCENT
3360	4	1K1N	L2L7D	7	2	N	DEMERITS	LAND #2 6-6.9 LACQUER DEMERITS
3370	4	1K1N	L3L7A	4	0	N	% AREA	LAND #3 6-6.9 LACQUER AREA PERCENT
3380	4	1K1N	L3L7D	7	2	N	DEMERITS	LAND #3 6-6.9 LACQUER DEMERITS
3390	4	1K1N	USV7A	4	0	N	% AREA	UPPER SKIRT 6-6.9 LACQUER AREA PERCENT
3400	4	1K1N	USV7D	7	2	N	DEMERITS	UPPER SKIRT 6-6.9 LACQUER DEMERITS
3410	4	1K1N	UCV7A	4	0	N	% AREA	UNDER CROWN 6-6.9 LACQUER AREA PERCENT
3420	4	1K1N	UCV7D	7	2	N	DEMERITS	UNDER CROWN 6-6.9 LACQUER DEMERITS
3430	4	1K1N	PFV7A	4	0	N	% AREA	PIN BORE FRONT 6-6.9 LACQUER AREA PERCENT
3440	4	1K1N	PFV7D	7	2	N	DEMERITS	PIN BORE FRONT 6-6.9 LACQUER DEMERITS
3450	4	1K1N	PRV7A	4	0	N	% AREA	PIN BORE REAR 6-6.9 LACQUER AREA PERCENT
3460	4	1K1N	PRV7D	7	2	N	DEMERITS	PIN BORE REAR 6-6.9 LACQUER DEMERITS
3470	4	1K1N	G1L6A	4	0	N	% AREA	GROOVE #1 5-5.9 LACQUER AREA PERCENT
3480	4	1K1N	G1L6D	7	2	N	DEMERITS	GROOVE #1 5-5.9 LACQUER DEMERITS
3490	4	1K1N	G2L6A	4	0	N	% AREA	GROOVE #2 5-5.9 LACQUER AREA PERCENT
3500	4	1K1N	G2L6D	7	2	N	DEMERITS	GROOVE #2 5-5.9 LACQUER DEMERITS
3510	4	1K1N	G3L6A	4	0	N	% AREA	GROOVE #3 5-5.9 LACQUER AREA PERCENT
3520	4	1K1N	G3L6D	7	2	N	DEMERITS	GROOVE #3 5-5.9 LACQUER DEMERITS
3530	4	1K1N	L1L6A	4	0	N	% AREA	LAND #1 5-5.9 LACQUER AREA PERCENT
3540	4	1K1N	L1L6D	7	2	N	DEMERITS	LAND #1 5-5.9 LACQUER DEMERITS
3550	4	1K1N	L2L6A	4	0	N	% AREA	LAND #2 5-5.9 LACQUER AREA PERCENT
3560	4	1K1N	L2L6D	7	2	N	DEMERITS	LAND #2 5-5.9 LACQUER DEMERITS
3570	4	1K1N	L3L6A	4	0	N	% AREA	LAND #3 5-5.9 LACQUER AREA PERCENT
3580	4	1K1N	L3L6D	7	2	N	DEMERITS	LAND #3 5-5.9 LACQUER DEMERITS
3590	4	1K1N	USV6A	4	0	N	% AREA	UPPER SKIRT 5-5.9 LACQUER AREA PERCENT
3600	4	1K1N	USV6D	7	2	N	DEMERITS	UPPER SKIRT 5-5.9 LACQUER DEMERITS
3610	4	1K1N	UCV6A	4	0	N	% AREA	UNDER CROWN 5-5.9 LACQUER AREA PERCENT
3620	4	1K1N	UCV6D	7	2	N	DEMERITS	UNDER CROWN 5-5.9 LACQUER DEMERITS
3630	4	1K1N	PFV6A	4	0	N	% AREA	PISTON BORE FRONT 5-5.9 LACQUER AREA PERCENT
3640	4	1K1N	PFV6D	7	2	N	DEMERITS	PISTON BORE FRONT 5-5.9 LACQUER DEMERITS
3650	4	1K1N	PRV6A	4	0	N	% AREA	PISTON BORE REAR 5-5.9 LACQUER AREA PERCENT
3660	4	1K1N	PRV6D	7	2	N	DEMERITS	PISTON BORE REAR 5-5.9 LACQUER DEMERITS
3670	4	1K1N	G1L5A	4	0	N	% AREA	GROOVE #1 4-4.9 LACQUER AREA PERCENT
3680	4	1K1N	G1L5D	7	2	N	DEMERITS	GROOVE #1 4-4.9 LACQUER DEMERITS
3690	4	1K1N	G2L5A	4	0	N	% AREA	GROOVE #2 4-4.9 LACQUER AREA PERCENT
3700	4	1K1N	G2L5D	7	2	N	DEMERITS	GROOVE #2 4-4.9 LACQUER DEMERITS
3710	4	1K1N	G3L5A	4	0	N	% AREA	GROOVE #3 4-4.9 LACQUER AREA PERCENT
3720	4	1K1N	G3L5D	7	2	N	DEMERITS	GROOVE #3 4-4.9 LACQUER DEMERITS
3730	4	1K1N	L1L5A	4	0	N	% AREA	GROOVE #3 4-4.9 LACQUER AREA PERCENT
3740	4	1K1N	L1L5D	7	2	N	DEMERITS	LAND #1 4-4.9 LACQUER DEMERITS
3750	4	1K1N	L2L5A	4	0	N	% AREA	LAND #2 4-4.9 LACQUER AREA PERCENT
3760	4	1K1N	L2L5D	7	2	N	DEMERITS	LAND #2 4-4.9 LACQUER DEMERITS

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
3770	4	1K1N	L3L5A	4	0	N	% AREA	LAND #3 4-4.9 LACQUER AREA PERCENT
3780	4	1K1N	L3L5D	7	2	N	DEMERITS	LAND #3 4-4.9 LACQUER DEMERITS
3790	4	1K1N	USV5A	4	0	N	% AREA	UPPER SKIRT 4-4.9 LACQUER AREA PERCENT
3800	4	1K1N	USV5D	7	2	N	DEMERITS	UPPER SKIRT 4-4.9 LACQUER DEMERITS
3810	4	1K1N	UCV5A	4	0	N	% AREA	UNDER CROWN 4-4.9 LACQUER AREA PERCENT
3820	4	1K1N	UCV5D	7	2	N	DEMERITS	UNDER CROWN 4-4.9 LACQUER DEMERITS
3830	4	1K1N	PFV5A	4	0	N	% AREA	PIN BORE FRONT 4-4.9 LACQUER AREA PERCENT
3840	4	1K1N	PFV5D	7	2	N	DEMERITS	PIN BORE FRONT 4-4.9 LACQUER DEMERITS
3850	4	1K1N	PRV5A	4	0	N	% AREA	PIN BORE REAR 4-4.9 LACQUER AREA PERCENT
3860	4	1K1N	PRV5D	7	2	N	DEMERITS	PIN BORE REAR 4-4.9 LACQUER DEMERITS
3870	4	1K1N	G1L4A	4	0	N	% AREA	GROOVE #1 3-3.9 LACQUER AREA PERCENT
3880	4	1K1N	G1L4D	7	2	N	DEMERITS	GROOVE #1 3-3.9 LACQUER DEMERITS
3890	4	1K1N	G2L4A	4	0	N	% AREA	GROOVE #2 3-3.9 LACQUER AREA PERCENT
3900	4	1K1N	G2L4D	7	2	N	DEMERITS	GROOVE #2 3-3.9 LACQUER DEMERITS
3910	4	1K1N	G3L4A	4	0	N	% AREA	GROOVE #3 3-3.9 LACQUER AREA PERCENT
3920	4	1K1N	G3L4D	7	2	N	DEMERITS	GROOVE #3 3-3.9 LACQUER DEMERITS
3930	4	1K1N	L1L4A	4	0	N	% AREA	LAND #1 3-3.9 LACQUER AREA PERCENT
3940	4	1K1N	L1L4D	7	2	N	DEMERITS	LAND #1 3-3.9 LACQUER DEMERITS
3950	4	1K1N	L2L4A	4	0	N	% AREA	LAND #2 3-3.9 LACQUER AREA PERCENT
3960	4	1K1N	L2L4D	7	2	N	DEMERITS	LAND #2 3-3.9 LACQUER DEMERITS
3970	4	1K1N	L3L4A	4	0	N	% AREA	LAND #3 3-3.9 LACQUER AREA PERCENT
3980	4	1K1N	L3L4D	7	2	N	DEMERITS	LAND #3 3-3.9 LACQUER DEMERITS
3990	4	1K1N	USV4A	4	0	N	% AREA	UPPER SKIRT 3-3.9 LACQUER AREA PERCENT
4000	4	1K1N	USV4D	7	2	N	DEMERITS	UPPER SKIRT 3-3.9 LACQUER DEMERITS
4010	4	1K1N	UCV4A	4	0	N	% AREA	UNDER CROWN 3-3.9 LACQUER AREA PERCENT
4020	4	1K1N	UCV4D	7	2	N	DEMERITS	UNDER CROWN 3-3.9 LACQUER DEMERITS
4030	4	1K1N	PFV4A	4	0	N	% AREA	PIN BORE FRONT 3-3.9 LACQUER AREA PERCENT
4040	4	1K1N	PFV4D	7	2	N	DEMERITS	PIN BORE FRONT 3-3.9 LACQUER DEMERITS
4050	4	1K1N	PRV4A	4	0	N	% AREA	PIN BORE REAR 3-3.9 LACQUER AREA PERCENT
4060	4	1K1N	PRV4D	7	2	N	DEMERITS	PIN BORE REAR 3-3.9 LACQUER DEMERITS
4070	4	1K1N	G1L3A	4	0	N	% AREA	GROOVE #1 2-2.9 LACQUER AREA PERCENT
4080	4	1K1N	G1L3D	7	2	N	DEMERITS	GROOVE #1 2-2.9 LACQUER DEMERITS
4090	4	1K1N	G2L3A	4	0	N	% AREA	GROOVE #2 2-2.9 LACQUER AREA PERCENT
4100	4	1K1N	G2L3D	7	2	N	DEMERITS	GROOVE #2 2-2.9 LACQUER DEMERITS
4110	4	1K1N	G3L3A	4	0	N	% AREA	GROOVE #3 2-2.9 LACQUER AREA PERCENT
4120	4	1K1N	G3L3D	7	2	N	DEMERITS	GROOVE #3 2-2.9 LACQUER DEMERITS
4130	4	1K1N	L1L3A	4	0	N	% AREA	LAND #1 2-2.9 LACQUER AREA PERCENT
4140	4	1K1N	L1L3D	7	2	N	DEMERITS	LAND #1 2-2.9 LACQUER DEMERITS
4150	4	1K1N	L2L3A	4	0	N	% AREA	LAND #2 2-2.9 LACQUER AREA PERCENT
4160	4	1K1N	L2L3D	7	2	N	DEMERITS	LAND #2 2-2.9 LACQUER DEMERITS
4170	4	1K1N	L3L3A	4	0	N	% AREA	LAND #3 2-2.9 LACQUER AREA PERCENT
4180	4	1K1N	L3L3D	7	2	N	DEMERITS	LAND #3 2-2.9 LACQUER DEMERITS
4190	4	1K1N	USV3A	4	0	N	% AREA	UPPER SKIRT 2-2.9 LACQUER AREA PERCENT
4200	4	1K1N	USV3D	7	2	N	DEMERITS	UPPER SKIRT 2-2.9 LACQUER DEMERITS
4210	4	1K1N	UCV3A	4	0	N	% AREA	UNDER CROWN 2-2.9 LACQUER AREA PERCENT
4220	4	1K1N	UCV3D	7	2	N	DEMERITS	UNDER CROWN 2-2.9 LACQUER DEMERITS
4230	4	1K1N	PFV3A	4	0	N	% AREA	PIN BORE FRONT 2-2.9 LACQUER AREA PERCENT
4240	4	1K1N	PFV3D	7	2	N	DEMERITS	PIN BORE FRONT 2-2.9 LACQUER DEMERITS
4250	4	1K1N	PRV3A	4	0	N	% AREA	PIN BORE REAR 2-2.9 LACQUER AREA PERCENT
4260	4	1K1N	PRV3D	7	2	N	DEMERITS	PIN BORE REAR 2-2.9 LACQUER DEMERITS
4270	4	1K1N	G1L2A	4	0	N	% AREA	GROOVE #1 1-1.9 LACQUER AREA PERCENT
4280	4	1K1N	G1L2D	7	2	N	DEMERITS	GROOVE #1 1-1.9 LACQUER DEMERITS
4290	4	1K1N	G2L2A	4	0	N	% AREA	GROOVE #2 1-1.9 LACQUER AREA PERCENT
4300	4	1K1N	G2L2D	7	2	N	DEMERITS	GROOVE #2 1-1.9 LACQUER DEMERITS

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
4310	4	1K1N	G3L2A	4	0	N	% AREA	GROOVE #3 1-1.9 LACQUER AREA PERCENT
4320	4	1K1N	G3L2D	7	2	N	DEMERITS	GROOVE #3 1-1.9 LACQUER DEMERITS
4330	4	1K1N	L1L2A	4	0	N	% AREA	LAND #1 1-1.9 LACQUER AREA PERCENT
4340	4	1K1N	L1L2D	7	2	N	DEMERITS	LAND #1 1-1.9 LACQUER DEMERITS
4350	4	1K1N	L2L2A	4	0	N	% AREA	LAND #2 1-1.9 LACQUER AREA PERCENT
4360	4	1K1N	L2L2D	7	2	N	DEMERITS	LAND #2 1-1.9 LACQUER DEMERITS
4370	4	1K1N	L3L2A	4	0	N	% AREA	LAND #3 1-1.9 LACQUER AREA PERCENT
4380	4	1K1N	L3L2D	7	2	N	DEMERITS	LAND #3 1-1.9 LACQUER DEMERITS
4390	4	1K1N	USV2A	4	0	N	% AREA	UPPER SKIRT 1-1.9 LACQUER AREA PERCENT
4400	4	1K1N	USV2D	7	2	N	DEMERITS	UPPER SKIRT 1-1.9 LACQUER DEMERITS
4410	4	1K1N	UCV2A	4	0	N	% AREA	UNDER CROWN 1-1.9 LACQUER AREA PERCENT
4420	4	1K1N	UCV2D	7	2	N	DEMERITS	UNDER CROWN 1-1.9 LACQUER DEMERITS
4430	4	1K1N	PFV2A	4	0	N	% AREA	PIN BORE FRONT 1-1.9 LACQUER AREA PERCENT
4440	4	1K1N	PFV2D	7	2	N	DEMERITS	PIN BORE FRONT 1-1.9 LACQUER DEMERITS
4450	4	1K1N	PRV2A	4	0	N	% AREA	PIN BORE REAR 1-1.9 LACQUER AREA PERCENT
4460	4	1K1N	PRV2D	7	2	N	DEMERITS	PIN BORE REAR 1-1.9 LACQUER DEMERITS
4470	4	1K1N	G1L1A	4	0	N	% AREA	GROOVE #1 0-0.9 LACQUER AREA PERCENT
4480	4	1K1N	G1L1D	7	2	N	DEMERITS	GROOVE #1 0-0.9 LACQUER DEMERITS
4490	4	1K1N	G2L1A	4	0	N	% AREA	GROOVE #2 0-0.9 LACQUER AREA PERCENT
4500	4	1K1N	G2L1D	7	2	N	DEMERITS	GROOVE #2 0-0.9 LACQUER DEMERITS
4510	4	1K1N	G3L1A	4	0	N	% AREA	GROOVE #3 0-0.9 LACQUER AREA PERCENT
4520	4	1K1N	G3L1D	7	2	N	DEMERITS	GROOVE #3 0-0.9 LACQUER DEMERITS
4530	4	1K1N	L1L1A	4	0	N	% AREA	LAND #1 0-0.9 LACQUER AREA PERCENT
4540	4	1K1N	L1L1D	7	2	N	DEMERITS	LAND #1 0-0.9 LACQUER DEMERITS
4550	4	1K1N	L2L1A	4	0	N	% AREA	LAND #2 0-0.9 LACQUER AREA PERCENT
4560	4	1K1N	L2L1D	7	2	N	DEMERITS	LAND #2 0-0.9 LACQUER DEMERITS
4570	4	1K1N	L3L1A	4	0	N	% AREA	LAND #3 0-0.9 LACQUER AREA PERCENT
4580	4	1K1N	L3L1D	7	2	N	DEMERITS	LAND #3 0-0.9 LACQUER DEMERITS
4590	4	1K1N	USV1A	4	0	N	% AREA	UPPER SKIRT 0-0.9 LACQUER AREA PERCENT
4600	4	1K1N	USV1D	7	2	N	DEMERITS	UPPER SKIRT 0-0.9 LACQUER DEMERITS
4610	4	1K1N	UCV1A	4	0	N	% AREA	UNDER CROWN 0-0.9 LACQUER AREA PERCENT
4620	4	1K1N	UCV1D	7	2	N	DEMERITS	UNDER CROWN 0-0.9 LACQUER DEMERITS
4630	4	1K1N	PFV1A	4	0	N	% AREA	PIN BORE FRONT 0-0.9 LACQUER AREA PERCENT
4640	4	1K1N	PFV1D	7	2	N	DEMERITS	PIN BORE FRONT 0-0.9 LACQUER DEMERITS
4650	4	1K1N	PRV1A	4	0	N	% AREA	PIN BORE REAR 0-0.9 LACQUER AREA PERCENT
4660	4	1K1N	PRV1D	7	2	N	DEMERITS	PIN BORE REAR 0-0.9 LACQUER DEMERITS
4670	4	1K1N	G1LCLNA	4	0	N	% AREA	GROOVE #1 CLEAN LACQUER AREA PERCENT
4680	4	1K1N	G2LCLNA	4	0	N	% AREA	GROOVE #2 CLEAN LACQUER AREA PERCENT
4690	4	1K1N	G3LCLNA	4	0	N	% AREA	GROOVE #3 CLEAN LACQUER AREA PERCENT
4700	4	1K1N	L1LCLNA	4	0	N	% AREA	LAND #1 CLEAN LACQUER AREA PERCENT
4710	4	1K1N	L2LCLNA	4	0	N	% AREA	LAND #2 CLEAN LACQUER AREA PERCENT
4720	4	1K1N	L3LCLNA	4	0	N	% AREA	LAND #3 CLEAN LACQUER AREA PERCENT
4730	4	1K1N	USVCLNA	4	0	N	% AREA	UPPER SKIRT CLEAN LACQUER AREA PERCENT
4740	4	1K1N	UCVCLNA	4	0	N	% AREA	UNDER CROWN CLEAN LACQUER AREA PERCENT
4750	4	1K1N	PFVCLNA	4	0	N	% AREA	PIN BORE FRONT CLEAN LACQUER AREA PERCENT
4760	4	1K1N	PRVCLNA	4	0	N	% AREA	PIN BORE REAR CLEAN LACQUER AREA PERCENT
4770	4	1K1N	G1ALTOT	4	0	N	% AREA	TOTAL GROOVE #1 LACQUER AREA PERCENT
4780	4	1K1N	G1DLTOT	7	2	N	DEMERITS	TOTAL GROOVE #1 LACQUER DEMERITS
4790	4	1K1N	G2ALTOT	4	0	N	% AREA	TOTAL GROOVE #2 LACQUER AREA PERCENT
4800	4	1K1N	G2DLTOT	7	2	N	DEMERITS	TOTAL GROOVE #2 LACQUER DEMERITS
4810	4	1K1N	G3ALTOT	4	0	N	% AREA	TOTAL GROOVE #3 LACQUER AREA PERCENT
4820	4	1K1N	G3DLTOT	7	2	N	DEMERITS	TOTAL GROOVE #3 LACQUER DEMERITS
4830	4	1K1N	L1ALTOT	4	0	N	% AREA	TOTAL LAND #1 LACQUER AREA PERCENT
4840	4	1K1N	L1DLTOT	7	2	N	DEMERITS	TOTAL LAND #1 LACQUER DEMERITS

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
4850	4	1K1N	L2ALTOT	4	0	N	% AREA	TOTAL LAND #2 LACQUER AREA PERCENT
4860	4	1K1N	L2DLTOT	7	2	N	DEMERITS	TOTAL LAND #2 LACQUER DEMERITS
4870	4	1K1N	L3ALTOT	4	0	N	% AREA	TOTAL LAND #3 LACQUER AREA PERCENT
4880	4	1K1N	L3DLTOT	7	2	N	DEMERITS	TOTAL LAND #3 LACQUER DEMERITS
4890	4	1K1N	USALTOT	4	0	N	% AREA	TOTAL UPPER SKIRT LACQUER AREA PERCENT
4900	4	1K1N	USDLTOT	7	2	N	DEMERITS	TOTAL UPPER SKIRT LACQUER DEMERITS
4910	4	1K1N	UCALTOT	4	0	N	% AREA	TOTAL UNDER CROWN LACQUER AREA PERCENT
4920	4	1K1N	UCDLTOT	7	2	N	DEMERITS	TOTAL UNDER CROWN LACQUER DEMERITS
4930	4	1K1N	PFALTOT	4	0	N	% AREA	TOTAL PIN BORE FRONT LACQUER AREA PERCENT
4940	4	1K1N	PFDLTOT	7	2	N	DEMERITS	TOTAL PIN BORE FRONT LACQUER DEMERITS
4950	4	1K1N	PRALTOT	4	0	N	% AREA	TOTAL PIN BORE REAR LACQUER AREA PERCENT
4960	4	1K1N	PRDLTOT	7	2	N	DEMERITS	TOTAL PIN BORE REAR LACQUER DEMERITS
4970	4	1K1N	G1UWD	7	2	N	DEMERITS	GROOVE 1 UNWEIGHTED DEMERITS
4980	4	1K1N	G2UWD	7	2	N	DEMERITS	GROOVE 2 UNWEIGHTED DEMERITS
4990	4	1K1N	G3UWD	7	2	N	DEMERITS	GROOVE 3 UNWEIGHTED DEMERITS
5000	4	1K1N	L1UWD	7	2	N	DEMERITS	LAND 1 UNWEIGHTED DEMERITS
5010	4	1K1N	L2UWD	7	2	N	DEMERITS	LAND 2 UNWEIGHTED DEMERITS
5020	4	1K1N	L3UWD	7	2	N	DEMERITS	LAND 3 UNWEIGHTED DEMERITS
5030	4	1K1N	USUWD	7	2	N	DEMERITS	UPPER SKIRT UNWEIGHTED DEMERITS
5040	4	1K1N	UCUWD	7	2	N	DEMERITS	UNDER CROWN UNWEIGHTED DEMERITS
5050	4	1K1N	PFUWD	7	2	N	DEMERITS	PIN BORE FRONT UNWEIGHTED DEMERITS
5060	4	1K1N	PRUWD	7	2	N	DEMERITS	PIN BORE REAR UNWEIGHTED DEMERITS
5070	4	1K1N	G1WD	7	2	N	DEMERITS	GROOVE 1 WEIGHTED DEMERITS
5080	4	1K1N	G2WD	7	2	N	DEMERITS	GROOVE 2 WEIGHTED DEMERITS
5090	4	1K1N	G3WD	7	2	N	DEMERITS	GROOVE 3 WEIGHTED DEMERITS
5100	4	1K1N	L1WD	7	2	N	DEMERITS	LAND 1 WEIGHTED DEMERITS
5110	4	1K1N	L2WD	7	2	N	DEMERITS	LAND 2 WEIGHTED DEMERITS
5120	4	1K1N	L3WD	7	2	N	DEMERITS	LAND 3 WEIGHTED DEMERITS
5130	4	1K1N	USWD	7	2	N	DEMERITS	UPPER SKIRT WEIGHTED DEMERITS
5140	4	1K1N	UCWD	7	2	N	DEMERITS	UNDER CROWN WEIGHTED DEMERITS
5150	4	1K1N	PFWD	7	2	N	DEMERITS	PIN BORE FRONT WEIGHTED DEMERITS
5160	4	1K1N	PRWD	7	2	N	DEMERITS	PIN BORE REAR WEIGHTED DEMERITS
5170	4	1K1N	IGF	4	0	N	%	INT. GROOVE FILL
5180	4	1K1N	UWD	7	1	N	DEMERITS	UNWEIGHTED TOTAL DEMERITS
5190	4	1K1N	TLFC	4	0	N	%	T.L. FLAKED CARBON
5200	4a	1K1N	RATEWSIM	70	0	C		PISTON RATING WORKSHEET PLOT IMAGE
5210	5	1K1N	G1THCA	4	0	N	% AREA	TOP GROOVE 1 HEAVY CARBON
5220	5	1K1N	G1TMCA	4	0	N	% AREA	TOP GROOVE 1 MEDIUM CARBON
5230	5	1K1N	G1TLCA	4	0	N	% AREA	TOP GROOVE 1 LIGHT CARBON
5240	5	1K1N	G1T9A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 9 - 8
5250	5	1K1N	G1T8A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 7.9 - 7
5260	5	1K1N	G1T7A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 6.9 - 6
5270	5	1K1N	G1T6A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 5.9 - 5
5280	5	1K1N	G1T5A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 4.9 - 4
5290	5	1K1N	G1T4A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 3.9 - 3
5300	5	1K1N	G1T3A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 2.9 - 2
5310	5	1K1N	G1T2A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 1.9 - 1
5320	5	1K1N	G1T1A	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT 0.9 - 0
5330	5	1K1N	G1TCLNA	4	0	N	% AREA	TOP GROOVE 1 DEPOSIT CLEAN
5340	5	1K1N	G1BHCA	4	0	N	% AREA	BOTTOM GROOVE 1 HEAVY CARBON
5350	5	1K1N	G1BMCA	4	0	N	% AREA	BOTTOM GROOVE 1 MEDIUM CARBON
5360	5	1K1N	G1BLCA	4	0	N	% AREA	BOTTOM GROOVE 1 LIGHT CARBON
5370	5	1K1N	G1B9A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 9 - 8
5380	5	1K1N	G1B8A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 7.9 - 7

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
5390	5	1K1N	G1B7A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 6.9 - 6
5400	5	1K1N	G1B6A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 5.9 - 5
5410	5	1K1N	G1B5A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 4.9 - 4
5420	5	1K1N	G1B4A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 3.9 - 3
5430	5	1K1N	G1B3A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 2.9 - 2
5440	5	1K1N	G1B2A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 1.9 - 1
5450	5	1K1N	G1B1A	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT 0.9 - 0
5460	5	1K1N	G1BCLNA	4	0	N	% AREA	BOTTOM GROOVE 1 DEPOSIT CLEAN
5470	5	1K1N	G2THCA	4	0	N	% AREA	TOP GROOVE 2 HEAVY CARBON
5480	5	1K1N	G2TMCA	4	0	N	% AREA	TOP GROOVE 2 MEDIUM CARBON
5490	5	1K1N	G2TLCA	4	0	N	% AREA	TOP GROOVE 2 LIGHT CARBON
5500	5	1K1N	G2T9A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 9 - 8
5510	5	1K1N	G2T8A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 7.9 - 7
5520	5	1K1N	G2T7A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 6.9 - 6
5530	5	1K1N	G2T6A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 5.9 - 5
5540	5	1K1N	G2T5A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 4.9 - 4
5550	5	1K1N	G2T4A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 3.9 - 3
5560	5	1K1N	G2T3A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 2.9 - 2
5570	5	1K1N	G2T2A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 1.9 - 1
5580	5	1K1N	G2T1A	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT 0.9 - 0
5590	5	1K1N	G2TCLNA	4	0	N	% AREA	TOP GROOVE 2 DEPOSIT CLEAN
5600	5	1K1N	G2BHCA	4	0	N	% AREA	BOTTOM GROOVE 2 HEAVY CARBON
5610	5	1K1N	G2BMCA	4	0	N	% AREA	BOTTOM GROOVE 2 MEDIUM CARBON
5620	5	1K1N	G2BLCA	4	0	N	% AREA	BOTTOM GROOVE 2 LIGHT CARBON
5630	5	1K1N	G2B9A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 9 - 8
5640	5	1K1N	G2B8A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 7.9 - 7
5650	5	1K1N	G2B7A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 6.9 - 6
5660	5	1K1N	G2B6A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 5.9 - 5
5670	5	1K1N	G2B5A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 4.9 - 4
5680	5	1K1N	G2B4A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 3.9 - 3
5690	5	1K1N	G2B3A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 2.9 - 2
5700	5	1K1N	G2B2A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 1.9 - 1
5710	5	1K1N	G2B1A	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT 0.9 - 0
5720	5	1K1N	G2BCLNA	4	0	N	% AREA	BOTTOM GROOVE 2 DEPOSIT CLEAN
5730	5	1K1N	G3THCA	4	0	N	% AREA	TOP GROOVE 3 HEAVY CARBON
5740	5	1K1N	G3TMCA	4	0	N	% AREA	TOP GROOVE 3 MEDIUM CARBON
5750	5	1K1N	G3TLCA	4	0	N	% AREA	TOP GROOVE 3 LIGHT CARBON
5760	5	1K1N	G3T9A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 9 - 8
5770	5	1K1N	G3T8A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 7.9 - 7
5780	5	1K1N	G3T7A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 6.9 - 6
5790	5	1K1N	G3T6A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 5.9 - 5
5800	5	1K1N	G3T5A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 4.9 - 4
5810	5	1K1N	G3T4A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 3.9 - 3
5820	5	1K1N	G3T3A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 2.9 - 2
5830	5	1K1N	G3T2A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 1.9 - 1
5840	5	1K1N	G3T1A	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT 0.9 - 0
5850	5	1K1N	G3TCLNA	4	0	N	% AREA	TOP GROOVE 3 DEPOSIT CLEAN
5860	5	1K1N	G3BHCA	4	0	N	% AREA	BOTTOM GROOVE 3 HEAVY CARBON
5870	5	1K1N	G3BMCA	4	0	N	% AREA	BOTTOM GROOVE 3 MEDIUM CARBON
5880	5	1K1N	G3BLCA	4	0	N	% AREA	BOTTOM GROOVE 3 LIGHT CARBON
5890	5	1K1N	G3B9A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 9 - 8
5900	5	1K1N	G3B8A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 7.9 - 7
5910	5	1K1N	G3B7A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 6.9 - 6
5920	5	1K1N	G3B6A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 5.9 - 5

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
5930	5	1K1N	G3B5A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 4.9 - 4
5940	5	1K1N	G3B4A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 3.9 - 3
5950	5	1K1N	G3B3A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 2.9 - 2
5960	5	1K1N	G3B2A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 1.9 - 1
5970	5	1K1N	G3B1A	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT 0.9 - 0
5980	5	1K1N	G3BCLNA	4	0	N	% AREA	BOTTOM GROOVE 3 DEPOSIT CLEAN
5990	5	1K1N	R1THCA	4	0	N	% AREA	TOP RING 1 HEAVY CARBON
6000	5	1K1N	R1TMCA	4	0	N	% AREA	TOP RING 1 MEDIUM CARBON
6010	5	1K1N	R1TLCA	4	0	N	% AREA	TOP RING 1 LITE CARBON
6020	5	1K1N	R1T9A	4	0	N	% AREA	TOP RING 1 DEPOSIT 9 - 8
6030	5	1K1N	R1T8A	4	0	N	% AREA	TOP RING 1 DEPOSIT 7.9 - 7
6040	5	1K1N	R1T7A	4	0	N	% AREA	TOP RING 1 DEPOSIT 6.9 - 6
6050	5	1K1N	R1T6A	4	0	N	% AREA	TOP RING 1 DEPOSIT 5.9 - 5
6060	5	1K1N	R1T5A	4	0	N	% AREA	TOP RING 1 DEPOSIT 4.9 - 4
6070	5	1K1N	R1T4A	4	0	N	% AREA	TOP RING 1 DEPOSIT 3.9 - 3
6080	5	1K1N	R1T3A	4	0	N	% AREA	TOP RING 1 DEPOSIT 2.9 - 2
6090	5	1K1N	R1T2A	4	0	N	% AREA	TOP RING 1 DEPOSIT 1.9 - 1
6100	5	1K1N	R1T1A	4	0	N	% AREA	TOP RING 1 DEPOSIT 0.9 -0
6110	5	1K1N	R1TCLNA	4	0	N	% AREA	TOP RING 1 DEPOSIT CLEAN
6120	5	1K1N	R1BHCA	4	0	N	% AREA	BOTTOM RING 1 HEAVY CARBON
6130	5	1K1N	R1BMCA	4	0	N	% AREA	BOTTOM RING 1 MEDIUM CARBON
6140	5	1K1N	R1BLCA	4	0	N	% AREA	BOTTOM RING 1 LITE CARBON
6150	5	1K1N	R1B9A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 9 - 8
6160	5	1K1N	R1B8A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 7.9 - 7
6170	5	1K1N	R1B7A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 6.9 - 6
6180	5	1K1N	R1B6A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 5.9 - 5
6190	5	1K1N	R1B5A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 4.9 - 4
6200	5	1K1N	R1B4A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 3.9 - 3
6210	5	1K1N	R1B3A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 2.9 - 2
6220	5	1K1N	R1B2A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 1.9 - 1
6230	5	1K1N	R1B1A	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT 0.9 - 0
6240	5	1K1N	R1BCLNA	4	0	N	% AREA	BOTTOM RING 1 DEPOSIT CLEAN
6250	5	1K1N	R1BKHCA	4	0	N	% AREA	BACK RING 1 HEAVY CARBON
6260	5	1K1N	R1BKMCA	4	0	N	% AREA	BACK RING 1 MEDIUM CARBON
6270	5	1K1N	R1BKLCA	4	0	N	% AREA	BACK RING 1 LITE CARBON
6280	5	1K1N	R1BK9A	4	0	N	% AREA	BACK RING 1 DEPOSIT 9 - 8
6290	5	1K1N	R1BK8A	4	0	N	% AREA	BACK RING 1 DEPOSIT 7.9 - 7
6300	5	1K1N	R1BK7A	4	0	N	% AREA	BACK RING 1 DEPOSIT 6.9 - 6
6310	5	1K1N	R1BK6A	4	0	N	% AREA	BACK RING 1 DEPOSIT 5.9 - 5
6320	5	1K1N	R1BK5A	4	0	N	% AREA	BACK RING 1 DEPOSIT 4.9 - 4
6330	5	1K1N	R1BK4A	4	0	N	% AREA	BACK RING 1 DEPOSIT 3.9 - 3
6340	5	1K1N	R1BK3A	4	0	N	% AREA	BACK RING 1 DEPOSIT 2.9 - 2
6350	5	1K1N	R1BK2A	4	0	N	% AREA	BACK RING 1 DEPOSIT 1.9 - 1
6360	5	1K1N	R1BK1A	4	0	N	% AREA	BACK RING 1 DEPOSIT 0.9 - 0
6370	5	1K1N	R1BKCLNA	4	0	N	% AREA	BACK RING 1 DEPOSIT CLEAN
6380	5	1K1N	R2THCA	4	0	N	% AREA	TOP RING 2 HEAVY CARBON
6390	5	1K1N	R2TMCA	4	0	N	% AREA	TOP RING 2 MEDIUM CARBON
6400	5	1K1N	R2TLCA	4	0	N	% AREA	TOP RING 2 LITE CARBON
6410	5	1K1N	R2T9A	4	0	N	% AREA	TOP RING 2 DEPOSIT 9 - 8
6420	5	1K1N	R2T8A	4	0	N	% AREA	TOP RING 2 DEPOSIT 7.9 - 7
6430	5	1K1N	R2T7A	4	0	N	% AREA	TOP RING 2 DEPOSIT 6.9 - 6
6440	5	1K1N	R2T6A	4	0	N	% AREA	TOP RING 2 DEPOSIT 5.9 - 5
6450	5	1K1N	R2T5A	4	0	N	% AREA	TOP RING 2 DEPOSIT 4.9 - 4
6460	5	1K1N	R2T4A	4	0	N	% AREA	TOP RING 2 DEPOSIT 3.9 - 3

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
6470	5	1K1N	R2T3A	4	0	N	% AREA	TOP RING 2 DEPOSIT 2.9 - 2
6480	5	1K1N	R2T2A	4	0	N	% AREA	TOP RING 2 DEPOSIT 1.9 - 1
6490	5	1K1N	R2T1A	4	0	N	% AREA	TOP RING 2 DEPOSIT 0.9 - 0
6500	5	1K1N	R2TCLNA	4	0	N	% AREA	TOP RING 2 DEPOSIT CLEAN
6510	5	1K1N	R2BHCA	4	0	N	% AREA	BOTTOM RING 2 HEAVY CARBON
6520	5	1K1N	R2BMCA	4	0	N	% AREA	BOTTOM RING 2 MEDIUM CARBON
6530	5	1K1N	R2BLCA	4	0	N	% AREA	BOTTOM RING 2 LITE CARBON
6540	5	1K1N	R2B9A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 9 - 8
6550	5	1K1N	R2B8A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 7.9 - 7
6560	5	1K1N	R2B7A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 6.9 - 6
6570	5	1K1N	R2B6A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 5.9 - 5
6580	5	1K1N	R2B5A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 4.9 - 4
6590	5	1K1N	R2B4A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 3.9 - 3
6600	5	1K1N	R2B3A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 2.9 - 2
6610	5	1K1N	R2B2A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 1.9 - 1
6620	5	1K1N	R2B1A	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT 0.9 - 0
6630	5	1K1N	R2BCLNA	4	0	N	% AREA	BOTTOM RING 2 DEPOSIT CLEAN
6640	5	1K1N	R2BKHCA	4	0	N	% AREA	BACK RING 2 HEAVY CARBON
6650	5	1K1N	R2BKMCA	4	0	N	% AREA	BACK RING 2 MEDIUM CARBON
6660	5	1K1N	R2BKLCA	4	0	N	% AREA	BACK RING 2 LITE CARBON
6670	5	1K1N	R2BK9A	4	0	N	% AREA	BACK RING 2 DEPOSIT 9 - 8
6680	5	1K1N	R2BK8A	4	0	N	% AREA	BACK RING 2 DEPOSIT 7.9 - 7
6690	5	1K1N	R2BK7A	4	0	N	% AREA	BACK RING 2 DEPOSIT 6.9 - 6
6700	5	1K1N	R2BK6A	4	0	N	% AREA	BACK RING 2 DEPOSIT 5.9 - 5
6710	5	1K1N	R2BK5A	4	0	N	% AREA	BACK RING 2 DEPOSIT 4.9 - 4
6720	5	1K1N	R2BK4A	4	0	N	% AREA	BACK RING 2 DEPOSIT 3.9 - 3
6730	5	1K1N	R2BK3A	4	0	N	% AREA	BACK RING 2 DEPOSIT 2.9 - 2
6740	5	1K1N	R2BK2A	4	0	N	% AREA	BACK RING 2 DEPOSIT 1.9 - 1
6750	5	1K1N	R2BK1A	4	0	N	% AREA	BACK RING 2 DEPOSIT 0.9 - 0
6760	5	1K1N	R2BKCLNA	4	0	N	% AREA	BACK RING 2 DEPOSIT CLEAN
6770	5	1K1N	R3THCA	4	0	N	% AREA	TOP RING 3 HEAVY CARBON
6780	5	1K1N	R3TMCA	4	0	N	% AREA	TOP RING 3 MEDIUM CARBON
6790	5	1K1N	R3TLCA	4	0	N	% AREA	TOP RING 3 LITE CARBON
6800	5	1K1N	R3T9A	4	0	N	% AREA	TOP RING 3 DEPOSIT 9 - 8
6810	5	1K1N	R3T8A	4	0	N	% AREA	TOP RING 3 DEPOSIT 7.9 - 7
6820	5	1K1N	R3T7A	4	0	N	% AREA	TOP RING 3 DEPOSIT 6.9 - 6
6830	5	1K1N	R3T6A	4	0	N	% AREA	TOP RING 3 DEPOSIT 5.9 - 5
6840	5	1K1N	R3T5A	4	0	N	% AREA	TOP RING 3 DEPOSIT 4.9 - 4
6850	5	1K1N	R3T4A	4	0	N	% AREA	TOP RING 3 DEPOSIT 3.9 - 3
6860	5	1K1N	R3T3A	4	0	N	% AREA	TOP RING 3 DEPOSIT 2.9 - 2
6870	5	1K1N	R3T2A	4	0	N	% AREA	TOP RING 3 DEPOSIT 1.9 - 1
6880	5	1K1N	R3T1A	4	0	N	% AREA	TOP RING 3 DEPOSIT 0.9 - 0
6890	5	1K1N	R3TCLNA	4	0	N	% AREA	TOP RING 3 DEPOSIT CLEAN
6900	5	1K1N	R3BHCA	4	0	N	% AREA	BOTTOM RING 3 HEAVY CARBON
6910	5	1K1N	R3BMCA	4	0	N	% AREA	BOTTOM RING 3 MEDIUM CARBON
6920	5	1K1N	R3BLCA	4	0	N	% AREA	BOTTOM RING 3 LITE CARBON
6930	5	1K1N	R3B9A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 9 - 8
6940	5	1K1N	R3B8A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 7.9 - 7
6950	5	1K1N	R3B7A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 6.9 - 6
6960	5	1K1N	R3B6A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 5.9 - 5
6970	5	1K1N	R3B5A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 4.9 - 4
6980	5	1K1N	R3B4A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 3.9 - 3
6990	5	1K1N	R3B3A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 2.9 - 2
7000	5	1K1N	R3B2A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 1.9 - 1

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
7010	5	1K1N	R3B1A	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT 0.9 - 0
7020	5	1K1N	R3BCLNA	4	0	N	% AREA	BOTTOM RING 3 DEPOSIT CLEAN
7030	5	1K1N	R3BKHCA	4	0	N	% AREA	BACK RING 3 HEAVYCARBON
7040	5	1K1N	R3BKMCA	4	0	N	% AREA	BACK RING 3 MEDIUM CARBON
7050	5	1K1N	R3BKLCA	4	0	N	% AREA	BACK RING 3 LITE CARBON
7060	5	1K1N	R3BK9A	4	0	N	% AREA	BACK RING 3 DEPOSIT 9 - 8
7070	5	1K1N	R3BK8A	4	0	N	% AREA	BACK RING 3 DEPOSIT 7.9 - 7
7080	5	1K1N	R3BK7A	4	0	N	% AREA	BACK RING 3 DEPOSIT 6.9 - 6
7090	5	1K1N	R3BK6A	4	0	N	% AREA	BACK RING 3 DEPOSIT 5.9 - 5
7100	5	1K1N	R3BK5A	4	0	N	% AREA	BACK RING 3 DEPOSIT 4.9 - 4
7110	5	1K1N	R3BK4A	4	0	N	% AREA	BACK RING 3 DEPOSIT 3.9 - 3
7120	5	1K1N	R3BK3A	4	0	N	% AREA	BACK RING 3 DEPOSIT 2.9 - 2
7130	5	1K1N	R3BK2A	4	0	N	% AREA	BACK RING 3 DEPOSIT 1.9 - 1
7140	5	1K1N	R3BK1A	4	0	N	% AREA	BACK RING 3 DEPOSIT 0.9 - 0
7150	5	1K1N	R3BKCLNA	4	0	N	% AREA	BACK RING 3 DEPOSIT CLEAN
7160	5	1K1N	CROWNAD	70	0	C		ADDITIONAL DEPOSIT & CONDITION RATINGS PISTON CROWN
7170	5	1K1N	LINERAD	70	0	C		ADDITIONAL DEPOSIT & CONDITION RATINGS LINER
7180	5	1K1N	RINGSAD	70	0	C		ADDITIONAL DEPOSIT & CONDITION RATINGS RINGS
7190	5a	1K1N	RRNO	10	0	C		REFEREE RATING NUMBER
7200	5a	1K1N	RRDATE	8	0	C	YYYYMMDD	REFEREE RATING DATE
7210	5a	1K1N	RRINIT	3	0	C		REFEREE RATING INITIALS
7220	5a	1K1N	RRG1HCA	4	0	N	% AREA	REFEREE GROOVE #1 HC-1.0 CARBON AREA PERCENT
7230	5a	1K1N	RRG1HCD	7	2	N	DEMERITS	REFEREE GROOVE #1 HC-1.0 CARBON DEMERITS
7240	5a	1K1N	RRG2HCA	4	0	N	% AREA	REFEREE GROOVE #2 HC-1.0 CARBON AREA PERCENT
7250	5a	1K1N	RRG2HCD	7	2	N	DEMERITS	REFEREE GROOVE #2 HC-1.0 CARBON DEMERITS
7260	5a	1K1N	RRG3HCA	4	0	N	% AREA	REFEREE GROOVE #3 HC-1.0 CARBON AREA PERCENT
7270	5a	1K1N	RRG3HCD	7	2	N	DEMERITS	REFEREE GROOVE #3 HC-1.0 CARBON DEMERITS
7280	5a	1K1N	RRL1HCA	4	0	N	% AREA	REFEREE LAND #1 HC-1.0 CARBON AREA PERCENT
7290	5a	1K1N	RRL1HCD	7	2	N	DEMERITS	REFEREE LAND #1 HC-1.0 CARBON DEMERITS
7300	5a	1K1N	RRL2HCA	4	0	N	% AREA	REFEREE LAND #2 HC-1.0 CARBON AREA PERCENT
7310	5a	1K1N	RRL2HCD	7	2	N	DEMERITS	REFEREE LAND #2 HC-1.0 CARBON DEMERITS
7320	5a	1K1N	RRL3HCA	4	0	N	% AREA	REFEREE LAND #3 HC-1.0 CARBON AREA PERCENT
7330	5a	1K1N	RRL3HCD	7	2	N	DEMERITS	REFEREE LAND #3 HC-1.0 CARBON DEMERITS
7340	5a	1K1N	RRUSHCA	4	0	N	% AREA	REFEREE RATING UPPER SKIRT HC-1.0 CARBON AREA %
7350	5a	1K1N	RRUSHCD	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT HC-1.0 CARBON DEMERITS
7360	5a	1K1N	RRUCHCA	4	0	N	% AREA	REFEREE RATING UNDER CROWN HC-1.0 CARBON AREA %
7370	5a	1K1N	RRUCHCD	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN HC-1.0 CARBON DEMERITS
7380	5a	1K1N	RRPFHCA	4	0	N	% AREA	REFEREE RATING PIN BORE FRONT HC-1.0 CARBON AREA %
7390	5a	1K1N	RRPFHCD	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT HC-1.0 CARBON DEMERITS
7400	5a	1K1N	RRPRHCA	4	0	N	% AREA	REFEREE RATING PIN BORE REAR HC-1.0 CARBON AREA %
7410	5a	1K1N	RRPRHCD	7	2	N	DEMERITS	REF. RATING PIN BORE REAR HC-1.0 CARBON DEMERITS
7420	5a	1K1N	RRG1MCA	4	0	N	% AREA	REFEREE GROOVE #1 MC-1.0 CARBON AREA PERCENT
7430	5a	1K1N	RRG1MCD	7	2	N	DEMERITS	REFEREE GROOVE #1 MC-1.0 CARBON DEMERITS
7440	5a	1K1N	RRG3MCA	4	0	N	% AREA	REFEREE GROOVE #3 MC-1.0 CARBON AREA PERCENT
7450	5a	1K1N	RRG3MCD	7	2	N	DEMERITS	REFEREE GROOVE #3 MC-1.0 CARBON DEMERITS
7460	5a	1K1N	RRG1LCA	4	0	N	% AREA	REFEREE GROOVE #1 LC-1.0 CARBON AREA PERCENT
7470	5a	1K1N	RRG1LCD	7	2	N	DEMERITS	REFEREE GROOVE #1 LC-1.0 CARBON DEMERITS
7480	5a	1K1N	RRG2LCA	4	0	N	% AREA	REFEREE GROOVE #2 LC-1.0 CARBON AREA PERCENT
7490	5a	1K1N	RRG2LCD	7	2	N	DEMERITS	REFEREE GROOVE #2 LC-1.0 CARBON DEMERITS
7500	5a	1K1N	RRG3LCA	4	0	N	% AREA	REFEREE GROOVE #3 LC-1.0 CARBON AREA PERCENT
7510	5a	1K1N	RRG3LCD	7	2	N	DEMERITS	REFEREE GROOVE #3 LC-1.0 CARBON DEMERITS
7520	5a	1K1N	RRL1LCA	4	0	N	% AREA	REFEREE LAND #1 LC-1.0 CARBON AREA PERCENT
7530	5a	1K1N	RRL1LCD	7	2	N	DEMERITS	REFEREE LAND #1 LC-1.0 CARBON DEMERITS
7540	5a	1K1N	RRL2LCA	4	0	N	% AREA	REFEREE LAND #2 LC-1.0 CARBON AREA PERCENT

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
7550	5a	1K1N	RRL2LCD	7	2	N	DEMERITS	REFEREE LAND #2 LC-1.0 CARBON DEMERITS
7560	5a	1K1N	RRL3LCA	4	0	N	% AREA	REFEREE LAND #3 LC-1.0 CARBON AREA PERCENT
7570	5a	1K1N	RRL3LCD	7	2	N	DEMERITS	REFEREE LAND #3 LC-1.0 CARBON DEMERITS
7580	5a	1K1N	RRUSLCA	4	0	N	% AREA	REFEREE RATING UPPER SKIRT LC-1.0 CARBON AREA %
7590	5a	1K1N	RRUSLCD	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT LC-1.0 CARBON DEMERITS
7600	5a	1K1N	RRUCLCA	4	0	N	% AREA	REFEREE RATING UNDER CROWN LC-1.0 CARBON AREA %
7610	5a	1K1N	RRUCLCD	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN LC-1.0 CARBON DEMERITS
7620	5a	1K1N	RRPFLCA	4	0	N	% AREA	REF. RATING PISTON BORE FRONT LC-1.0 CARBON AREA %
7630	5a	1K1N	RRPFLCD	7	2	N	DEMERITS	REF. RATING PISTON BORE FRONTLC-1.0 CARBON DEMERIT
7640	5a	1K1N	RRPRLCA	4	0	N	% AREA	REF. RATING PISTON BORE REAR LC-1.0 CARBON AREA %
7650	5a	1K1N	RRPRLCD	7	2	N	DEMERITS	REF. RATING PISTON BORE REAR LC-1.0 CARBON DEMERIT
7660	5a	1K1N	RG1ACTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #1 CARBON AREA PERCENT
7670	5a	1K1N	RG1DCTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #1 CARBON DEMERITS
7680	5a	1K1N	RG2ACTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #2 CARBON AREA PERCENT
7690	5a	1K1N	RG2DCTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #2 CARBON DEMERITS
7700	5a	1K1N	RG3ACTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #3 CARBON AREA PERCENT
7710	5a	1K1N	RG3DCTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #3 CARBON DEMERITS
7720	5a	1K1N	RL1ACTOT	4	0	N	% AREA	REFEREE TOTAL LAND #1 CARBON AREA PERCENT
7730	5a	1K1N	RL1DCTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #1 CARBON DEMERITS
7740	5a	1K1N	RL2ACTOT	4	0	N	% AREA	REFEREE TOTAL LAND #2 CARBON AREA PERCENT
7750	5a	1K1N	RL2DCTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #2 CARBON DEMERITS
7760	5a	1K1N	RL3ACTOT	4	0	N	% AREA	REFEREE TOTAL LAND #3 CARBON AREA PERCENT
7770	5a	1K1N	RL3DCTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #3 CARBON DEMERITS
7780	5a	1K1N	RUSACTOT	4	0	N	% AREA	REFEREE RATING TOTAL UPPER SKIRT CARBON AREA PERCENT
7790	5a	1K1N	RUSDCTOT	7	2	N	DEMERITS	REFEREE RATING TOTAL UPPER SKIRT CARBON DEMERITS
7800	5a	1K1N	RUCACTOT	4	0	N	% AREA	REFEREE RATING TOTAL UNDER CROWN CARBON AREA PERCENT
7810	5a	1K1N	RUCDCTOT	7	2	N	DEMERITS	REFEREE RATING TOTAL UNDER CROWN CARBON DEMERITS
7820	5a	1K1N	RPFACTOT	4	0	N	% AREA	REFEREE RATING TOTAL PIN BORE FRONT CARBON AREA %
7830	5a	1K1N	RPFDCTOT	7	2	N	DEMERITS	REF. RATING TOTAL PIN BORE FRONT CARBON DEMERITS
7840	5a	1K1N	RPRACTOT	4	0	N	% AREA	REF. RATING TOTAL PIN BORE REAR CARBON AREA PERCENT
7850	5a	1K1N	RPRDCTOT	7	2	N	DEMERITS	REF. RATING TOTAL PIN BORE REAR CARBON DEMERITS
7860	5a	1K1N	RRG1L9A	4	0	N	% AREA	REFEREE GROOVE #1 8-9 LACQUER AREA PERCENT
7870	5a	1K1N	RRG1L9D	7	2	N	DEMERITS	REFEREE GROOVE #1 8-9 LACQUER DEMERITS
7880	5a	1K1N	RRG2L9A	4	0	N	% AREA	REFEREE GROOVE #2 8-9 LACQUER AREA PERCENT
7890	5a	1K1N	RRG2L9D	7	2	N	DEMERITS	REFEREE GROOVE #2 8-9 LACQUER DEMERITS
7900	5a	1K1N	RRG3L9A	4	0	N	% AREA	REFEREE GROOVE #3 8-9 LACQUER AREA PERCENT
7910	5a	1K1N	RRG3L9D	7	2	N	DEMERITS	REFEREE GROOVE #3 8-9 LACQUER DEMERITS
7920	5a	1K1N	RRL1L9A	4	0	N	% AREA	REFEREE LAND #1 8-9 LACQUER AREA PERCENT
7930	5a	1K1N	RRL1L9D	7	2	N	DEMERITS	REFEREE LAND #1 8-9 LACQUER DEMERITS
7940	5a	1K1N	RRL2L9A	4	0	N	% AREA	REFEREE LAND #2 8-9 LACQUER AREA PERCENT
7950	5a	1K1N	RRL2L9D	7	2	N	DEMERITS	REFEREE LAND #2 8-9 LACQUER DEMERITS
7960	5a	1K1N	RRL3L9A	4	0	N	% AREA	REFEREE LAND #3 8-9 LACQUER AREA PERCENT
7970	5a	1K1N	RRL3L9D	7	2	N	DEMERITS	REFEREE LAND #3 8-9 LACQUER DEMERITS
7980	5a	1K1N	RRUSV9A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 8-9 LACQUER AREA PERCENT
7990	5a	1K1N	RRUSV9D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 8-9 LACQUER DEMERITS
8000	5a	1K1N	RRUCV9A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 8-9 LACQUER AREA PERCENT
8010	5a	1K1N	RRUCV9D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 8-9 LACQUER DEMERITS
8020	5a	1K1N	RRPFV9A	4	0	N	% AREA	REFEREE RATING PIN BORE FRONT 8-9 LACQUER AREA %
8030	5a	1K1N	RRPFV9D	7	2	N	DEMERITS	REFEREE RATING PIN BORE FRONT 8-9 LACQUER DEMERITS
8040	5a	1K1N	RRPRV9A	4	0	N	% AREA	REFEREE RATING PIN BORE REAR 8-9 LACQUER AREA %
8050	5a	1K1N	RRPRV9D	7	2	N	DEMERITS	REFEREE RATING PIN BORE REAR 8-9 LACQUER DEMERITS
8060	5a	1K1N	RRG1L8A	4	0	N	% AREA	REFEREE GROOVE #1 7-7.9 LACQUER AREA PERCENT
8070	5a	1K1N	RRG1L8D	7	2	N	DEMERITS	REFEREE GROOVE #1 7-7.9 LACQUER DEMERITS
8080	5a	1K1N	RRG2L8A	4	0	N	% AREA	REFEREE GROOVE #2 7-7.9 LACQUER AREA PERCENT

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
8090	5a	1K1N	RRG2L8D	7	2	N	DEMERITS	REFEREE GROOVE #2 7-7.9 LACQUER DEMERITS
8100	5a	1K1N	RRG3L8A	4	0	N	% AREA	REFEREE GROOVE #3 7-7.9 LACQUER AREA PERCENT
8110	5a	1K1N	RRG3L8D	7	2	N	DEMERITS	REFEREE GROOVE #3 7-7.9 LACQUER DEMERITS
8120	5a	1K1N	RRL1L8A	4	0	N	% AREA	REFEREE LAND #1 7-7.9 LACQUER AREA PERCENT
8130	5a	1K1N	RRL1L8D	7	2	N	DEMERITS	REFEREE LAND #1 7-7.9 LACQUER DEMERITS
8140	5a	1K1N	RRL2L8A	4	0	N	% AREA	REFEREE LAND #2 7-7.9 LACQUER AREA PERCENT
8150	5a	1K1N	RRL2L8D	7	2	N	DEMERITS	REFEREE LAND #2 7-7.9 LACQUER DEMERITS
8160	5a	1K1N	RRL3L8A	4	0	N	% AREA	REFEREE LAND #3 7-7.9 LACQUER AREA PERCENT
8170	5a	1K1N	RRL3L8D	7	2	N	DEMERITS	REFEREE LAND #3 7-7.9 LACQUER DEMERITS
8180	5a	1K1N	RRUSV8A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 7-7.9 LACQUER AREA %
8190	5a	1K1N	RRUSV8D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 7-7.9 LACQUER DEMERITS
8200	5a	1K1N	RRUCV8A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 7-7.9 LACQUER AREA %
8210	5a	1K1N	RRUCV8D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 7-7.9 LACQUER DEMERITS
8220	5a	1K1N	RRPFV8A	4	0	N	% AREA	REF. RATING PIN BORE FRONT 7-7.9 LACQUER AREA %
8230	5a	1K1N	RRPFV8D	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT 7-7.9 LACQUER DEMERITS
8240	5a	1K1N	RRPRV8A	4	0	N	% AREA	REF. RATING PIN BORE REAR 7-7.9 LACQUER AREA PERCENT
8250	5a	1K1N	RRPRV8D	7	2	N	DEMERITS	REF. RATING PIN BORE REAR 7-7.9 LACQUER DEMERITS
8260	5a	1K1N	RRG1L7A	4	0	N	% AREA	REFEREE GROOVE #1 6-6.9 LACQUER AREA PERCENT
8270	5a	1K1N	RRG1L7D	7	2	N	DEMERITS	REFEREE GROOVE #1 6-6.9 LACQUER DEMERITS
8280	5a	1K1N	RRG2L7A	4	0	N	% AREA	REFEREE GROOVE #2 6-6.9 LACQUER AREA PERCENT
8290	5a	1K1N	RRG2L7D	7	2	N	DEMERITS	REFEREE GROOVE #2 6-6.9 LACQUER DEMERITS
8300	5a	1K1N	RRG3L7A	4	0	N	% AREA	REFEREE GROOVE #3 6-6.9 LACQUER AREA PERCENT
8310	5a	1K1N	RRG3L7D	7	2	N	DEMERITS	REFEREE GROOVE #3 6-6.9 LACQUER DEMERITS
8320	5a	1K1N	RRL1L7A	4	0	N	% AREA	REFEREE LAND #1 6-6.9 LACQUER AREA PERCENT
8330	5a	1K1N	RRL1L7D	7	2	N	DEMERITS	REFEREE LAND #1 6-6.9 LACQUER DEMERITS
8340	5a	1K1N	RRL2L7A	4	0	N	% AREA	REFEREE LAND #2 6-6.9 LACQUER AREA PERCENT
8350	5a	1K1N	RRL2L7D	7	2	N	DEMERITS	REFEREE LAND #2 6-6.9 LACQUER DEMERITS
8360	5a	1K1N	RRL3L7A	4	0	N	% AREA	REFEREE LAND #3 6-6.9 LACQUER AREA PERCENT
8370	5a	1K1N	RRL3L7D	7	2	N	DEMERITS	REFEREE LAND #3 6-6.9 LACQUER DEMERITS
8380	5a	1K1N	RRUSV7A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 6-6.9 LACQUER AREA %
8390	5a	1K1N	RRUSV7D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 6-6.9 LACQUER DEMERITS
8400	5a	1K1N	RRUCV7A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 6-6.9 LACQUER AREA %
8410	5a	1K1N	RRUCV7D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 6-6.9 LACQUER DEMERITS
8420	5a	1K1N	RRPFV7A	4	0	N	% AREA	REFEREE RATING PIN BORE FRONT 6-6.9 LACQUER AREA %
8430	5a	1K1N	RRPFV7D	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT 6-6.9 LACQUER DEMERITS
8440	5a	1K1N	RRPRV7A	4	0	N	% AREA	REF. RATING PIN BORE REAR 6-6.9 LACQUER AREA PERCENT
8450	5a	1K1N	RRPRV7D	7	2	N	DEMERITS	REF. RATING PIN BORE REAR 6-6.9 LACQUER DEMERITS
8460	5a	1K1N	RRG1L6A	4	0	N	% AREA	REFEREE GROOVE #1 5-5.9 LACQUER AREA PERCENT
8470	5a	1K1N	RRG1L6D	7	2	N	DEMERITS	REFEREE GROOVE #1 5-5.9 LACQUER DEMERITS
8480	5a	1K1N	RRG2L6A	4	0	N	% AREA	REFEREE GROOVE #2 5-5.9 LACQUER AREA PERCENT
8490	5a	1K1N	RRG2L6D	7	2	N	DEMERITS	REFEREE GROOVE #2 5-5.9 LACQUER DEMERITS
8500	5a	1K1N	RRG3L6A	4	0	N	% AREA	REFEREE GROOVE #3 5-5.9 LACQUER AREA PERCENT
8510	5a	1K1N	RRG3L6D	7	2	N	DEMERITS	REFEREE GROOVE #3 5-5.9 LACQUER DEMERITS
8520	5a	1K1N	RRL1L6A	4	0	N	% AREA	REFEREE LAND #1 5-5.9 LACQUER AREA PERCENT
8530	5a	1K1N	RRL1L6D	7	2	N	DEMERITS	REFEREE LAND #1 5-5.9 LACQUER DEMERITS
8540	5a	1K1N	RRL2L6A	4	0	N	% AREA	REFEREE LAND #2 5-5.9 LACQUER AREA PERCENT
8550	5a	1K1N	RRL2L6D	7	2	N	DEMERITS	REFEREE LAND #2 5-5.9 LACQUER DEMERITS
8560	5a	1K1N	RRL3L6A	4	0	N	% AREA	REFEREE LAND #3 5-5.9 LACQUER AREA PERCENT
8570	5a	1K1N	RRL3L6D	7	2	N	DEMERITS	REFEREE LAND #3 5-5.9 LACQUER DEMERITS
8580	5a	1K1N	RRUSV6A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 5-5.9 LACQUER AREA %
8590	5a	1K1N	RRUSV6D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 5-5.9 LACQUER DEMERITS
8600	5a	1K1N	RRUCV6A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 5-5.9 LACQUER AREA %
8610	5a	1K1N	RRUCV6D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 5-5.9 LACQUER DEMERITS
8620	5a	1K1N	RRPFV6A	4	0	N	% AREA	REF RATING PISTON BORE FRONT 5-5.9 LACQUER AREA %

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
8630	5a	1K1N	RRPFV6D	7	2	N	DEMERITS	REF RATING PIN BORE FRONT 5-5.9 LACQUER DEMERITS
8640	5a	1K1N	RRPRV6A	4	0	N	% AREA	REF RATING PIN BORE REAR 5-5.9 LACQUER AREA PERCENT
8650	5a	1K1N	RRPRV6D	7	2	N	DEMERITS	REF RATING PIN BORE REAR 5-5.9 LACQUER DEMERITS
8660	5a	1K1N	RRG1L5A	4	0	N	% AREA	REFEREE GROOVE #1 4-4.9 LACQUER AREA PERCENT
8670	5a	1K1N	RRG1L5D	7	2	N	DEMERITS	REFEREE GROOVE #1 4-4.9 LACQUER DEMERITS
8680	5a	1K1N	RRG2L5A	4	0	N	% AREA	REFEREE GROOVE #2 4-4.9 LACQUER AREA PERCENT
8690	5a	1K1N	RRG2L5D	7	2	N	DEMERITS	REFEREE GROOVE #2 4-4.9 LACQUER DEMERITS
8700	5a	1K1N	RRG3L5A	4	0	N	% AREA	REFEREE GROOVE #3 4-4.9 LACQUER AREA PERCENT
8710	5a	1K1N	RRG3L5D	7	2	N	DEMERITS	REFEREE GROOVE #3 4-4.9 LACQUER DEMERITS
8720	5a	1K1N	RRL1L5A	4	0	N	% AREA	REFEREE LAND #1 4-4.9 LACQUER AREA PERCENT
8730	5a	1K1N	RRL1L5D	7	2	N	DEMERITS	REFEREE LAND #1 4-4.9 LACQUER DEMERITS
8740	5a	1K1N	RRL2L5A	4	0	N	% AREA	REFEREE LAND #2 4-4.9 LACQUER AREA PERCENT
8750	5a	1K1N	RRL2L5D	7	2	N	DEMERITS	REFEREE LAND #2 4-4.9 LACQUER DEMERITS
8760	5a	1K1N	RRL3L5A	4	0	N	% AREA	REFEREE LAND #3 4-4.9 LACQUER AREA PERCENT
8770	5a	1K1N	RRL3L5D	7	2	N	DEMERITS	REFEREE LAND #3 4-4.9 LACQUER DEMERITS
8780	5a	1K1N	RRUSV5A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 4-4.9 LACQUER AREA %
8790	5a	1K1N	RRUSV5D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 4-4.9 LACQUER DEMERITS
8800	5a	1K1N	RRUCV5A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 4-4.9 LACQUER AREA %
8810	5a	1K1N	RRUCV5D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 4-4.9 LACQUER DEMERITS
8820	5a	1K1N	RRPFV5A	4	0	N	% AREA	REF. RATING PIN BORE FRONT 4-4.9 LACQUER AREA %
8830	5a	1K1N	RRPFV5D	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT 4-4.9 LACQUER DEMERITS
8840	5a	1K1N	RRPRV5A	4	0	N	% AREA	REF. RATING PIN BORE REAR 4-4.9 LACQUER AREA PERCENT
8850	5a	1K1N	RRPRV5D	7	2	N	DEMERITS	REF. RATING PIN BORE REAR 4-4.9 LACQUER DEMERITS
8860	5a	1K1N	RRG1L4A	4	0	N	% AREA	REFEREE GROOVE #1 3-3.9 LACQUER AREA PERCENT
8870	5a	1K1N	RRG1L4D	7	2	N	DEMERITS	REFEREE GROOVE #1 3-3.9 LACQUER DEMERITS
8880	5a	1K1N	RRG2L4A	4	0	N	% AREA	REFEREE GROOVE #2 3-3.9 LACQUER AREA PERCENT
8890	5a	1K1N	RRG2L4D	7	2	N	DEMERITS	REFEREE GROOVE #2 3-3.9 LACQUER DEMERITS
8900	5a	1K1N	RRG3L4A	4	0	N	% AREA	REFEREE GROOVE #3 3-3.9 LACQUER AREA PERCENT
8910	5a	1K1N	RRG3L4D	7	2	N	DEMERITS	REFEREE GROOVE #3 3-3.9 LACQUER DEMERITS
8920	5a	1K1N	RRL1L4A	4	0	N	% AREA	REFEREE LAND #1 3-3.9 LACQUER AREA PERCENT
8930	5a	1K1N	RRL1L4D	7	2	N	DEMERITS	REFEREE LAND #1 3-3.9 LACQUER DEMERITS
8940	5a	1K1N	RRL2L4A	4	0	N	% AREA	REFEREE LAND #2 3-3.9 LACQUER AREA PERCENT
8950	5a	1K1N	RRL2L4D	7	2	N	DEMERITS	REFEREE LAND #2 3-3.9 LACQUER DEMERITS
8960	5a	1K1N	RRL3L4A	4	0	N	% AREA	REFEREE LAND #3 3-3.9 LACQUER AREA PERCENT
8970	5a	1K1N	RRL3L4D	7	2	N	DEMERITS	REFEREE LAND #3 3-3.9 LACQUER DEMERITS
8980	5a	1K1N	RRUSV4A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 3-3.9 LACQUER AREA %
8990	5a	1K1N	RRUSV4D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 3-3.9 LACQUER DEMERITS
9000	5a	1K1N	RRUCV4A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 3-3.9 LACQUER AREA %
9010	5a	1K1N	RRUCV4D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 3-3.9 LACQUER DEMERITS
9020	5a	1K1N	RRPFV4A	4	0	N	% AREA	REF. RATING PIN BORE FRONT 3-3.9 LACQUER AREA %
9030	5a	1K1N	RRPFV4D	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT 3-3.9 LACQUER DEMERITS
9040	5a	1K1N	RRPRV4A	4	0	N	% AREA	REF. RATING PIN BORE REAR 3-3.9 LACQUER AREA PERCENT
9050	5a	1K1N	RRPRV4D	7	2	N	DEMERITS	REF. RATING PIN BORE REAR 3-3.9 LACQUER DEMERITS
9060	5a	1K1N	RRG1L3A	4	0	N	% AREA	REFEREE GROOVE #1 2-2.9 LACQUER AREA PERCENT
9070	5a	1K1N	RRG1L3D	7	2	N	DEMERITS	REFEREE GROOVE #1 2-2.9 LACQUER DEMERITS
9080	5a	1K1N	RRG2L3A	4	0	N	% AREA	REFEREE GROOVE #2 2-2.9 LACQUER AREA PERCENT
9090	5a	1K1N	RRG2L3D	7	2	N	DEMERITS	REFEREE GROOVE #2 2-2.9 LACQUER DEMERITS
9100	5a	1K1N	RRG3L3A	4	0	N	% AREA	REFEREE GROOVE #3 2-2.9 LACQUER AREA PERCENT
9110	5a	1K1N	RRG3L3D	7	2	N	DEMERITS	REFEREE GROOVE #3 2-2.9 LACQUER DEMERITS
9120	5a	1K1N	RRL1L3A	4	0	N	% AREA	REFEREE LAND #1 2-2.9 LACQUER AREA PERCENT
9130	5a	1K1N	RRL1L3D	7	2	N	DEMERITS	REFEREE LAND #1 2-2.9 LACQUER DEMERITS
9140	5a	1K1N	RRL2L3A	4	0	N	% AREA	REFEREE LAND #2 2-2.9 LACQUER AREA PERCENT
9150	5a	1K1N	RRL2L3D	7	2	N	DEMERITS	REFEREE LAND #2 2-2.9 LACQUER DEMERITS
9160	5a	1K1N	RRL3L3A	4	0	N	% AREA	REFEREE LAND #3 2-2.9 LACQUER AREA PERCENT

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
9170	5a	1K1N	RRL3L3D	7	2	N	DEMERITS	REFEREE LAND #3 2-2.9 LACQUER DEMERITS
9180	5a	1K1N	RRUSV3A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 2-2.9 LACQUER AREA %
9190	5a	1K1N	RRUSV3D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 2-2.9 LACQUER DEMERITS
9200	5a	1K1N	RRUCV3A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 2-2.9 LACQUER AREA PERCENT
9210	5a	1K1N	RRUCV3D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 2-2.9 LACQUER DEMERITS
9220	5a	1K1N	RRPFV3A	4	0	N	% AREA	REF. RATING PIN BORE FRONT 2-2.9 LACQUER AREA %
9230	5a	1K1N	RRPFV3D	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT 2-2.9 LACQUER DEMERITS
9240	5a	1K1N	RRPRV3A	4	0	N	% AREA	REF. RATING PIN BORE REAR 2-2.9 LACQUER AREA PERCENT
9250	5a	1K1N	RRPRV3D	7	2	N	DEMERITS	REF. RATING PIN BORE REAR 2-2.9 LACQUER DEMERITS
9260	5a	1K1N	RRG1L2A	4	0	N	% AREA	REFEREE GROOVE #1 1-1.9 LACQUER AREA PERCENT
9270	5a	1K1N	RRG1L2D	7	2	N	DEMERITS	REFEREE GROOVE #1 1-1.9 LACQUER DEMERITS
9280	5a	1K1N	RRG2L2A	4	0	N	% AREA	REFEREE GROOVE #2 1-1.9 LACQUER AREA PERCENT
9290	5a	1K1N	RRG2L2D	7	2	N	DEMERITS	REFEREE GROOVE #2 1-1.9 LACQUER DEMERITS
9300	5a	1K1N	RRG3L2A	4	0	N	% AREA	REFEREE GROOVE #3 1-1.9 LACQUER AREA PERCENT
9310	5a	1K1N	RRG3L2D	7	2	N	DEMERITS	REFEREE GROOVE #3 1-1.9 LACQUER DEMERITS
9320	5a	1K1N	RRL1L2A	4	0	N	% AREA	REFEREE LAND #1 1-1.9 LACQUER AREA PERCENT
9330	5a	1K1N	RRL1L2D	7	2	N	DEMERITS	REFEREE LAND #1 1-1.9 LACQUER DEMERITS
9340	5a	1K1N	RRL2L2A	4	0	N	% AREA	REFEREE LAND #2 1-1.9 LACQUER AREA PERCENT
9350	5a	1K1N	RRL2L2D	7	2	N	DEMERITS	REFEREE LAND #2 1-1.9 LACQUER DEMERITS
9360	5a	1K1N	RRL3L2A	4	0	N	% AREA	REFEREE LAND #3 1-1.9 LACQUER AREA PERCENT
9370	5a	1K1N	RRL3L2D	7	2	N	DEMERITS	REFEREELAND #3 1-1.9 LACQUER DEMERITS
9380	5a	1K1N	RRUSV2A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 1-1.9 LACQUER AREA %
9390	5a	1K1N	RRUSV2D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 1-1.9 LACQUER DEMERITS
9400	5a	1K1N	RRUCV2A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 1-1.9 LACQUER AREA %
9410	5a	1K1N	RRUCV2D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 1-1.9 LACQUER DEMERITS
9420	5a	1K1N	RRPFV2A	4	0	N	% AREA	REF. RATING PIN BORE FRONT 1-1.9 LACQUER AREA %
9430	5a	1K1N	RRPFV2D	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT 1-1.9 LACQUER DEMERITS
9440	5a	1K1N	RRPRV2A	4	0	N	% AREA	REF. RATING PIN BORE REAR 1-1.9 LACQUER AREA PERCENT
9450	5a	1K1N	RRPRV2D	7	2	N	DEMERITS	REF. RATING PIN BORE REAR 1-1.9 LACQUER DEMERITS
9460	5a	1K1N	RRG1L1A	4	0	N	% AREA	REFEREE GROOVE #1 0-0.9 LACQUER AREA PERCENT
9470	5a	1K1N	RRG1L1D	7	2	N	DEMERITS	REFEREE GROOVE #1 0-0.9 LACQUER DEMERITS
9480	5a	1K1N	RRG2L1A	4	0	N	% AREA	REFEREE GROOVE #2 0-0.9 LACQUER AREA PERCENT
9490	5a	1K1N	RRG2L1D	7	2	N	DEMERITS	REFEREE GROOVE #2 0-0.9 LACQUER DEMERITS
9500	5a	1K1N	RRG3L1A	4	0	N	% AREA	REFEREE GROOVE #3 0-0.9 LACQUER AREA PERCENT
9510	5a	1K1N	RRG3L1D	7	2	N	DEMERITS	REFEREE GROOVE #3 0-0.9 LACQUER DEMERITS
9520	5a	1K1N	RRL1L1A	4	0	N	% AREA	REFEREE LAND #1 0-0.9 LACQUER AREA PERCENT
9530	5a	1K1N	RRL1L1D	7	2	N	DEMERITS	REFEREE LAND #1 0-0.9 LACQUER DEMERITS
9540	5a	1K1N	RRL2L1A	4	0	N	% AREA	REFEREE LAND #2 0-0.9 LACQUER AREA PERCENT
9550	5a	1K1N	RRL2L1D	7	2	N	DEMERITS	REFEREE LAND #2 0-0.9 LACQUER DEMERITS
9560	5a	1K1N	RRL3L1A	4	0	N	% AREA	REFEREE LAND #3 0-0.9 LACQUER AREA PERCENT
9570	5a	1K1N	RRL3L1D	7	2	N	DEMERITS	REFEREE LAND #3 0-0.9 LACQUER DEMERITS
9580	5a	1K1N	RRUSV1A	4	0	N	% AREA	REFEREE RATING UPPER SKIRT 0-0.9 LACQUER AREA %
9590	5a	1K1N	RRUSV1D	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT 0-0.9 LACQUER DEMERITS
9600	5a	1K1N	RRUCV1A	4	0	N	% AREA	REFEREE RATING UNDER CROWN 0-0.9 LACQUER AREA %
9610	5a	1K1N	RRUCV1D	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN 0-0.9 LACQUER DEMERITS
9620	5a	1K1N	RRPFV1A	4	0	N	% AREA	REF. RATING PIN BORE FRONT 0-0.9 LACQUER AREA %
9630	5a	1K1N	RRPFV1D	7	2	N	DEMERITS	REF. RATING PIN BORE FRONT 0-0.9 LACQUER DEMERITS
9640	5a	1K1N	RRPRV1A	4	0	N	% AREA	REF. RATING PIN BORE REAR 0-0.9 LACQUER AREA PERCENT
9650	5a	1K1N	RRPRV1D	7	2	N	DEMERITS	REF. RATING PIN BORE REAR 0-0.9 LACQUER DEMERITS
9660	5a	1K1N	RRG1LCLA	4	0	N	% AREA	REFEREE GROOVE #1 CLEAN LACQUER AREA PERCENT
9670	5a	1K1N	RRG2LCLA	4	0	N	% AREA	REFEREE GROOVE #2 CLEAN LACQUER AREA PERCENT
9680	5a	1K1N	RRG3LCLA	4	0	N	% AREA	REFEREE GROOVE #3 CLEAN LACQUER AREA PERCENT
9690	5a	1K1N	RRL1LCLA	4	0	N	% AREA	REFEREE LAND #1 CLEAN LACQUER AREA PERCENT
9700	5a	1K1N	RRL2LCLA	4	0	N	% AREA	REFEREE LAND #2 CLEAN LACQUER AREA PERCENT

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
9710	5a	1K1N	RRL3LCLA	4	0	N	% AREA	REFEREE LAND #3 CLEAN LACQUER AREA PERCENT
9720	5a	1K1N	RRUSVCLA	4	0	N	% AREA	REFEREE RATING UPPER SKIRT CLEAN LACQUER AREA %
9730	5a	1K1N	RRUCVCLA	4	0	N	% AREA	REFEREE RATING UNDER CROWN CLEAN LACQUER AREA %
9740	5a	1K1N	RRPFVCLA	4	0	N	% AREA	REF. RATING PIN BORE FRONT CLEAN LACQUER AREA %
9750	5a	1K1N	RRPRVCLA	4	0	N	% AREA	REF. RATING PIN BORE REAR CLEAN LACQUER AREA PERCENT
9760	5a	1K1N	RG1ALTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #1 LACQUER AREA PERCENT
9770	5a	1K1N	RG1DLTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #1 LACQUER DEMERITS
9780	5a	1K1N	RG2ALTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #2 LACQUER AREA PERCENT
9790	5a	1K1N	RG2DLTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #2 LACQUER DEMERITS
9800	5a	1K1N	RG3ALTOT	4	0	N	% AREA	REFEREE TOTAL GROOVE #3 LACQUER AREA PERCENT
9810	5a	1K1N	RG3DLTOT	7	2	N	DEMERITS	REFEREE TOTAL GROOVE #3 LACQUER DEMERITS
9820	5a	1K1N	RL1ALTOT	4	0	N	% AREA	REFEREE TOTAL LAND #1 LACQUER AREA PERCENT
9830	5a	1K1N	RL1DLTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #1 LACQUER DEMERITS
9840	5a	1K1N	RL2ALTOT	4	0	N	% AREA	REFEREE TOTAL LAND #2 LACQUER AREA PERCENT
9850	5a	1K1N	RL2DLTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #2 LACQUER DEMERITS
9860	5a	1K1N	RL3ALTOT	4	0	N	% AREA	REFEREE TOTAL LAND #3 LACQUER AREA PERCENT
9870	5a	1K1N	RL3DLTOT	7	2	N	DEMERITS	REFEREE TOTAL LAND #3 LACQUER DEMERITS
9880	5a	1K1N	RUSALTOT	4	0	N	% AREA	REFEREE RATING TOTAL UPPER SKIRT LACQUER AREA %
9890	5a	1K1N	RUSDLTOT	7	2	N	DEMERITS	REFEREE RATING TOTAL UPPER SKIRT LACQUER DEMERITS
9900	5a	1K1N	RUCALTOT	4	0	N	% AREA	REFEREE RATING TOTAL UNDER CROWN LACQUER AREA %
9910	5a	1K1N	RUCDLTOT	7	2	N	DEMERITS	REFEREE RATING TOTAL UNDER CROWN LACQUER DEMERITS
9920	5a	1K1N	RPFALTOT	4	0	N	% AREA	REF. RATING TOTAL PIN BORE FRONT LACQUER AREA %
9930	5a	1K1N	RPFDLTOT	7	2	N	DEMERITS	REF. RATING TOTAL PIN BORE FRONT LACQUER DEMERITS
9940	5a	1K1N	RPRALTOT	4	0	N	% AREA	REF. RATING TOTAL PIN BORE REAR LACQUER AREA PERCENT
9950	5a	1K1N	RPRDLTOT	7	2	N	DEMERITS	REF. RATING TOTAL PIN BORE REAR LACQUER DEMERITS
9960	5a	1K1N	RRG1UWD	7	2	N	DEMERITS	REFEREEE GROOVE 1 UNWEIGHTED DEMERITS
9970	5a	1K1N	RRG2UWD	7	2	N	DEMERITS	REFEREE GROOVE 2 UNWEIGHTED DEMERITS
9980	5a	1K1N	RRG3UWD	7	2	N	DEMERITS	REFEREE GROOVE 3 UNWEIGHTED DEMERITS
9990	5a	1K1N	RRL1UWD	7	2	N	DEMERITS	REFEREE LAND 1 UNWEIGHTED DEMERITS
10000	5a	1K1N	RRL2UWD	7	2	N	DEMERITS	REFEREE LAND 2 UNWEIGHTED DEMERITS
10010	5a	1K1N	RRL3UWD	7	2	N	DEMERITS	REFEREE LAND 3 UNWEIGHTED DEMERITS
10020	5a	1K1N	RRUSUWD	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT UNWEIGHTED DEMERITS
10030	5a	1K1N	RRUCUWD	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN UNWEIGHTED DEMERITS
10040	5a	1K1N	RRPFUWD	7	2	N	DEMERITS	REFEREE RATING PIN BORE FRONT UNWEIGHTED DEMERITS
10050	5a	1K1N	RRPRUWD	7	2	N	DEMERITS	REFEREE RATING PIN BORE REAR UNWEIGHTED DEMERITS
10060	5a	1K1N	RRG1WD	7	2	N	DEMERITS	REFEREE GROOVE 1 WEIGHTED DEMERITS
10070	5a	1K1N	RRG2WD	7	2	N	DEMERITS	REFEREE GROOVE 2 WEIGHTED DEMERITS
10080	5a	1K1N	RRG3WD	7	2	N	DEMERITS	REFEREE GROOVE 3 WEIGHTED DEMERITS
10090	5a	1K1N	RRL1WD	7	2	N	DEMERITS	REFEREE LAND 1 WEIGHTED DEMERITS
10100	5a	1K1N	RRL2WD	7	2	N	DEMERITS	REFEREE LAND 2 WEIGHTED DEMERITS
10110	5a	1K1N	RRL3WD	7	2	N	DEMERITS	REFEREE LAND 3 WEIGHTED DEMERITS
10120	5a	1K1N	RRUSWD	7	2	N	DEMERITS	REFEREE RATING UPPER SKIRT WEIGHTED DEMERITS
10130	5a	1K1N	RRUCWD	7	2	N	DEMERITS	REFEREE RATING UNDER CROWN WEIGHTED DEMERITS
10140	5a	1K1N	RRPFWD	7	2	N	DEMERITS	REFEREE RATING PIN BORE FRONT WEIGHTED DEMERITS
10150	5a	1K1N	RRPRWD	7	2	N	DEMERITS	REFEREE RATING PIN BORE REAR WEIGHTED DEMERITS
10160	5a	1K1N	RRIGF	4	0	N	%	REFEREE RATING IGF
10170	5a	1K1N	RRUWD	7	1	N	DEMERITS	REFEREE RATING UWDK
10180	6	1K1N	V100Hxxx	7	2	N	cSt	VISC @ 100 °C AT XXX HOURS
10190	6	1K1N	TBN_Hxxx	7	2	N		TBN D4739 AT XXX HOURS
10200	6	1K1N	FEWMHxxx	4	0	A	ppm	FE - WEAR METALS AT XXX HOURS [<]
10210	6	1K1N	ALWMHxxx	4	0	A	ppm	AL - WEAR METALS AT XXX HOURS [<]
10220	6	1K1N	SIWMHxxx	4	0	A	ppm	SI - WEAR METALS AT XXX HOURS [<]
10230	6	1K1N	CUWMHxxx	4	0	A	ppm	CU - WEAR METALS AT XXX HOURS [<]
10240	6	1K1N	CRWMHxxx	4	0	A	ppm	CR - WEAR METALS AT XXX HOURS [<]

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FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
10250	6	1K1N	PBWMHxxx	4	0	A	ppm	PB - WEAR METALS AT XXX HOURS [<]
10260	6	1K1N	FDILHxxx	5	1	N	%	FUEL DILUTION ENGINE HOURS AT XXX HOURS
10270	6	1K1N	BLBYHxxx	6	1	N	L/min	BLOWBY ENGINE HOURS AT XXX HOURS
10280	6	1K1N	BSOCHxxx	5	2	N	g/kW-h	BSOC ENGINE HOURS AT XXX HOURS
10290	7	1K1N	DWNOCR	3	0	Z		NUMBER OF DOWNTIME OCCURENCES
10300	7	1K1N	DOWNRxxx	6	0	C	HHH:MM	DOWNTIME TEST HOURS
10310	7	1K1N	DDATRxxx	8	0	C	YYYYMMDD	DOWNTIME DATE
10320	7	1K1N	DTIMRxxx	6	0	C	HHH:MM	DOWNTIME TIME
10330	7	1K1N	DREARxxx	60	0	C		DOWNTIME REASON
10340	7	1K1N	TOTLDOWN	6	0	C	HHH:MM	DOWNTIME TIME TOTAL
10350	7	1K1N	TOTCOM	3	0	Z		TOTAL LINES OF COMMENTS & OUTLIERS
10360	7	1K1N	OCOMRxxx	70	0	C		OTHER DOWNTIME COMMENTS XXX
10370	8	1K1N	RINGGTE	6	3	N	mm	TOP RING GAP PRE-TEST
10380	8	1K1N	RINGGI1E	6	3	N	mm	INTERMEDIATE 1 RING GAP PRE-TEST
10390	8	1K1N	RINGGOE	6	3	N	mm	OIL RING GAP PRE-TEST
10400	8	1K1N	RINGGTO	6	3	N	mm	TOP RING GAP POST-TEST
10410	8	1K1N	RINGGI1O	6	3	N	mm	INTERMEDIATE 1 RING GAP POST-TEST
10420	8	1K1N	RINGGOO	6	3	N	mm	OIL RING GAP POST-TEST
10430	8	1K1N	SIDETPE1	7	3	A	mm	TOP PRETEST RING SIDE CLEARANCE A [STUCK, <, >]
10440	8	1K1N	SIDETPE2	7	3	A	mm	TOP POSTTEST RING SIDE CLEARANCE A [STUCK, <, >]
10450	8	1K1N	SIDETPE3	7	3	A	mm	TOP POSTTEST RING SIDE CLEARANCE C [STUCK, <, >]
10460	8	1K1N	SIDETPE4	7	3	A	mm	TOP POSTTEST RING SIDE CLEARANCE D [STUCK, <, >]
10470	8	1K1N	ASIDETPE	7	3	A	mm	TOP POSTTEST RING SIDE CLEARANCE AVG [STUCK, <, >]
10480	8	1K1N	ISIDETPE	6	3	A	mm	MINIMUM RING SIDE CLEARANCE -TOP- PRETEST [STUCK, <, >]
10490	8	1K1N	SIDETPO1	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST A [STUCK, <, >]
10500	8	1K1N	SIDETPO2	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST B [STUCK, <, >]
10510	8	1K1N	SIDETPO3	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST C [STUCK, <, >]
10520	8	1K1N	SIDETPO4	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST D [STUCK, <, >]
10530	8	1K1N	ASIDETPO	7	3	A	mm	RING SIDE CLEARANCE TOP POST-TEST AVERAGE [STUCK, <, >]
10540	8	1K1N	ISIDETPO	6	3	A	mm	MIN. RING SIDE CLEARANCE POSTTEST-0.114-0.185[STUCK,<,>]
10550	8	1K1N	LSCT1	7	3	A	mm	RING SIDE CLEARANCE TOP LSC A [STUCK, <, >]
10560	8	1K1N	LSCT2	7	3	A	mm	RING SIDE CLEARANCE TOP LSC B [STUCK, <, >]
10570	8	1K1N	LSCT3	7	3	A	mm	RING SIDE CLEARANCE TOP LSC C [STUCK, <, >]
10580	8	1K1N	LSCT4	7	3	A	mm	RING SIDE CLEARANCE TOP LSC D [STUCK, <, >]
10590	8	1K1N	ILSCT	7	3	A	mm	RING SIDE CLEARANCE TOP LSC MINIMUM [STUCK, <, >]
10600	8	1K1N	ISIDE1PE	6	3	A	mm	MINIMUM RING SIDE CLEARANCE - INT1 PRETEST [STUCK, <, >]
10610	8	1K1N	SIDE1PE1	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST A [STUCK, <, >]
10620	8	1K1N	SIDE1PE2	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST B [STUCK, <, >]
10630	8	1K1N	SIDE1PE3	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST C [STUCK, <, >]
10640	8	1K1N	SIDE1PE4	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST D [STUCK, <, >]
10650	8	1K1N	ASIDE1PE	7	3	A	mm	RING SIDE CLEARANCE INT. PRETEST D [STUCK, <, >]
10660	8	1K1N	ISIDE1PO	6	3	A	mm	MINIMUM RING SIDE CLEARANCE-INT1-POSTTEST [STUCK, <, >]
10670	8	1K1N	SIDE1PO1	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST A [STUCK, <, >]
10680	8	1K1N	SIDE1PO2	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST B [STUCK, <, >]
10690	8	1K1N	SIDE1PO3	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST C [STUCK, <, >]
10700	8	1K1N	SIDE1PO4	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST D [STUCK, <, >]
10710	8	1K1N	ASIDE1PO	7	3	A	mm	RING SIDE CLEARANCE INT. POST-TEST AVG [STUCK, <, >]
10720	8	1K1N	LSCI1	7	3	A	mm	RING SIDE CLEARANCE INT. LSC A [STUCK, <, >]
10730	8	1K1N	LSCI2	7	3	A	mm	RING SIDE CLEARANCE INT. LSC B [STUCK, <, >]
10740	8	1K1N	LSCI3	7	3	A	mm	RING SIDE CLEARANCE INT. LSC C [STUCK, <, >]
10750	8	1K1N	LSCI4	7	3	A	mm	RING SIDE CLEARANCE INT. LSC D [STUCK, <, >]
10760	8	1K1N	ILSCINT	7	3	A	mm	RING SIDE CLEARANCE INT. LSC MINIMUM [STUCK, <, >]
10770	8	1K1N	SIDEOPE1	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST A [STUCK, <, >]
10780	8	1K1N	SIDEOPE2	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST B [STUCK, <, >]

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
10790	8	1K1N	SIDEOPE3	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST C [STUCK, <, >]
10800	8	1K1N	SIDEOPE4	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST D [STUCK, <, >]
10810	8	1K1N	ASIDEOPE	7	3	A	mm	RING SIDE CLEARANCE OIL PRE-TEST AVG [STUCK, <, >]
10820	8	1K1N	ISIDEOPE	6	3	A	mm	MINIMUM RING SIDE CLEARANCE-OIL-PRETEST [STUCK, <, >]
10830	8	1K1N	SIDEOPO1	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST A [STUCK, <, >]
10840	8	1K1N	SIDEOPO2	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST B [STUCK, <, >]
10850	8	1K1N	SIDEOPO3	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST C [STUCK, <, >]
10860	8	1K1N	SIDEOPO4	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST D [STUCK, <, >]
10870	8	1K1N	ASIDEOPO	7	3	A	mm	RING SIDE CLEARANCE OIL POST-TEST AVG [STUCK, <, >]
10880	8	1K1N	ISIDEOPO	6	3	A	mm	MINIMUM RING SIDE CLEARANCE-OIL-POSTTEST [STUCK, <, >]
10890	8	1K1N	LSCO1	7	3	A	mm	RING SIDE CLEARANCE OIL LSC A [STUCK, <, >]
10900	8	1K1N	LSCO2	7	3	A	mm	RING SIDE CLEARANCE OIL LSC B [STUCK, <, >]
10910	8	1K1N	LSCO3	7	3	A	mm	RING SIDE CLEARANCE OIL LSC C [STUCK, <, >]
10920	8	1K1N	LSCO4	7	3	A	mm	RING SIDE CLEARANCE OIL LSC D [STUCK, <, >]
10930	8	1K1N	ILSCO	7	3	A	mm	RING SIDE CLEARANCE OIL LSC MINIMUM [STUCK, <, >]
10940	9	1K1N	BBLFINT1	5	2	N	micrometre	LINER BORE SURFACE FINISH - TRANSVERSE - 130 MM
10950	9	1K1N	BBLFINL1	5	2	N	micrometre	LINER BORE SURFACE FINISH -LONGITUDINAL- 130 MM
10960	9	1K1N	BBLFINA1	5	2	N	micrometre	LINER BORE SURFACE FINISH - AVERAGE - 130 MM
10970	9	1K1N	BBLFINT2	5	2	N	micrometre	LINER BORE SURFACE FINISH - TRANSVERSE - 50 MM
10980	9	1K1N	BBLFINL2	5	2	N	micrometre	LINER BORE SURFACE FINISH -LONGITUDINAL- 50 MM
10990	9	1K1N	BBLFINA2	5	2	N	micrometre	LINER BORE SURFACE FINISH - AVERAGE - 50 MM
11000	9	1K1N	BBLFINT3	5	2	N	micrometre	LINER BORE SURFACE FINISH - TRANSVERSE - 25 MM
11010	9	1K1N	BBLFINL3	5	2	N	micrometre	LINER BORE SURFACE FINISH -LONGITUDINAL- 25 MM
11020	9	1K1N	BBLFINA3	5	2	N	micrometre	LINER BORE SURFACE FINISH - AVERAGE - 25 MM
11030	9	1K1N	BBLFIN	5	2	N	micrometre	BEFORE TEST LINER BORE SURFACE FINISH TOTAL AVG
11040	9	1K1N	BOREPT	6	1	N	%	LINER BORE POLISH - GRID - THRUST
11050	9	1K1N	BOREPAT	6	1	N	%	LINER BORE POLISH - GRID - ANTI-THRUST
11060	9	1K1N	BBLONG1	8	3	N	mm	BEFORE TEST LINER BORE MEA.--230 MM HT-LONGITUDINAL
11070	9	1K1N	BBTRAN1	8	3	N	mm	BEFORE TEST LINER BORE MEA.--230 MM HT-TRANSVERSE
11080	9	1K1N	BBLONG2	8	3	N	mm	BEFORE TEST LINER BORE MEA.--130 MM HT-LONGITUDINAL
11090	9	1K1N	BBTRAN2	8	3	N	mm	BEFORE TEST LINER BORE MEA.--130 MM HT-TRANSVERSE
11100	9	1K1N	BBLONG3	8	3	N	mm	BEFORE TEST LINER BORE MEA.--50 MM HT-LONGITUDINAL
11110	9	1K1N	BBTRAN3	8	3	N	mm	BEFORE TEST LINER BORE MEA.--50 MM HT-TRANSVERSE
11120	9	1K1N	BBLONG4	8	3	N	mm	BEFORE TEST LINER BORE MEA.--25 MM HT-LONGITUDINAL
11130	9	1K1N	BBTRAN4	8	3	N	mm	BEFORE TEST LINER BORE MEA.--25 MM HT-TRANSVERSE
11140	9	1K1N	BBLONG5	8	3	N	mm	BEFORE TEST LINER BORE MEA.--15 MM HT-LONGITUDINAL
11150	9	1K1N	BBTRAN5	8	3	N	mm	BEFORE TEST LINER BORE MEA.--15 MM HT-TRANSVERSE
11160	9	1K1N	AWEARLF	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--LONGITUDINAL FRONT
11170	9	1K1N	AWEARLR	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--LONGITUDINAL REAR
11180	9	1K1N	AWEARTT	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--TRANSVERSE T
11190	9	1K1N	AWEARTAT	6	3	N	mm	AFTER TEST LINER BORE WEAR STEP--TRANSVERSE AT
11200	10	1K1N	RPMSENS	17	0	C		ENGINE SPEED SENSING DEVICE
11210	10	1K1N	RPMCALF	13	0	C		ENGINE SPEED CALIBRATION FREQUENCY
11220	10	1K1N	RPMRECD	16	0	C		ENGINE SPEED RECORD DEVICE
11230	10	1K1N	RPMOBSF	12	0	C		ENGINE SPEED OBSERVATION FREQUENCY
11240	10	1K1N	RPMRECF	12	0	C		ENGINE SPEED RECORD FREQUENCY
11250	10	1K1N	RPMLOGF	12	0	C		ENGINE SPEED LOG FREQUENCY
11260	10	1K1N	RPMSYSR	8	0	C		ENGINE SPEED SYSTEM RESPONSE
11270	10	1K1N	PWRSENS	17	0	C		ENGINE POWER SENSING DEVICE
11280	10	1K1N	PWRCALF	13	0	C		ENGINE POWER CALIBRATION FREQUENCY
11290	10	1K1N	PWRRECD	16	0	C		ENGINE POWER RECORD DEVICE
11300	10	1K1N	PWROBSF	12	0	C		ENGINE POWER OBSERVATION FREQUENCY
11310	10	1K1N	PWRRECF	12	0	C		ENGINE POWER RECORD FREQUENCY
11320	10	1K1N	PWRLOGF	12	0	C		ENGINE POWER LOG FREQUENCY

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
11330	10	1K1N	PWRSYSR	8	0	C		ENGINE POWER SYSTEM RESPONSE
11340	10	1K1N	FFLOSENS	17	0	C		FUEL RATE SENSING DEVICE
11350	10	1K1N	FFLOCALF	13	0	C		FUEL RATE CALIBRATION FREQUENCY
11360	10	1K1N	FFLORECD	16	0	C		FUEL RATE RECORD DEVICE
11370	10	1K1N	FFLOOBSF	12	0	C		FUEL RATE OBSERVATION FREQUENCY
11380	10	1K1N	FFLORECF	12	0	C		FUEL RATE RECORD FREQUENCY
11390	10	1K1N	FFLOLOGF	12	0	C		FUEL RATE ENGINE SPEED LOG FREQUENCY
11400	10	1K1N	FFLOSYSR	8	0	C		FUEL RATE SYSTEM RESPONSE
11410	10	1K1N	HUMSENS	17	0	C		HUMIDITY SENSING DEVICE
11420	10	1K1N	HUMCALF	13	0	C		HUMIDITY CALIBRATION FREQUENCY
11430	10	1K1N	HUMRECD	16	0	C		HUMIDITY RECORD DEVICE
11440	10	1K1N	HUMOBSF	12	0	C		HUMIDITY OBSERVATION FREQUENCY
11450	10	1K1N	HUMRECF	12	0	C		HUMIDITY RECORD FREQUENCY
11460	10	1K1N	HUMLOGF	12	0	C		HUMIDITY LOG FREQUENCY
11470	10	1K1N	HUMSYSR	8	0	C		HUMIDITY SYSTEM RESPONSE
11480	10	1K1N	COTSENS	17	0	C		COOLANT OUT TEMPERATURE SENSING DEVICE
11490	10	1K1N	COTCALF	13	0	C		COOLANT OUT TEMPERATURE CALIBRATION FREQUENCY
11500	10	1K1N	COTRECD	16	0	C		COOLANT OUT TEMPERATURE ENGINE SPEED RECORD DEVICE
11510	10	1K1N	COTOBSF	12	0	C		COOLANT OUT TEMPERATURE OBSERVATION FREQUENCY
11520	10	1K1N	COTRECF	12	0	C		COOLANT OUT TEMPERATURE RECORD FREQUENCY
11530	10	1K1N	COTLOGF	12	0	C		COOLANT OUT TEMPERATURE LOG FREQUENCY
11540	10	1K1N	COTSYSR	8	0	C		COOLANT OUT TEMPERATURE SYSTEM RESPONSE
11550	10	1K1N	CONSENS	17	0	C		COOLANT IN TEMPERATURE SENSING DEVICE
11560	10	1K1N	CONCALF	13	0	C		COOLANT IN TEMPERATURE CALIBRATION FREQUENCY
11570	10	1K1N	CONRECD	16	0	C		COOLANT IN TEMPERATURE RECORD DEVICE
11580	10	1K1N	CONOBSF	12	0	C		COOLANT IN TEMPERATURE OBSERVATION FREQUENCY
11590	10	1K1N	CONRECF	12	0	C		COOLANT IN TEMPERATURE RECORD FREQUENCY
11600	10	1K1N	CONLOGF	12	0	C		COOLANT IN TEMPERATURE LOG FREQUENCY
11610	10	1K1N	CONSYSR	8	0	C		COOLANT IN TEMPERATURE SYSTEM RESPONSE
11620	10	1K1N	OBRGSENS	17	0	C		OIL TO BEARING TEMPERATURE SENSING DEVICE
11630	10	1K1N	OBRGCALF	13	0	C		OIL TO BEARING TEMPERATURE CALIBRATION FREQUENCY
11640	10	1K1N	OBRGRECD	16	0	C		OIL TO BEARING TEMPERATURE RECORD DEVICE
11650	10	1K1N	OBRGOBSF	12	0	C		OIL TO BEARING TEMPERATUREOBSERVATION FREQUENCY
11660	10	1K1N	OBRGRECF	12	0	C		OIL TO BEARING TEMPERATURE RECORD FREQUENCY
11670	10	1K1N	OBRGLOGF	12	0	C		OIL TO BEARING TEMPERATURE LOG FREQUENCY
11680	10	1K1N	OBRGSYSR	8	0	C		OIL TO BEARING TEMPERATURE SYSTEM RESPONSE
11690	10	1K1N	OCOLSENS	17	0	C		OIL COOLER IN TEMPERATURE SENSING DEVICE
11700	10	1K1N	OCOLCALF	13	0	C		OIL COOLER IN TEMPERATURE CALIBRATION FREQUENCY
11710	10	1K1N	OCOLRECD	16	0	C		OIL COOLER IN TEMPERATURE RECORD DEVICE
11720	10	1K1N	OCOLOBSF	12	0	C		OIL COOLER IN TEMPERATURE OBSERVATION FREQUENCY
11730	10	1K1N	OCOLRECF	12	0	C		OIL COOLER IN TEMPERATURE RECORD FREQUENCY
11740	10	1K1N	OCOLLOGF	12	0	C		OIL COOLER IN TEMPERTURE LOG FREQUENCY
11750	10	1K1N	OCOLSYSR	8	0	C		OIL COOLER IN TEMPERATURE SYSTEM RESPONSE
11760	10	1K1N	AIRTSENS	17	0	C		INLET AIR TEMPERATURE SENSING DEVICE
11770	10	1K1N	AIRTCALF	13	0	C		INLET AIR TEMPERATURE CALIBRATION FREQUENCY
11780	10	1K1N	AIRTRECD	16	0	C		INLET AIR TEMPERATURE RECORD DEVICE
11790	10	1K1N	AIRTOBSF	12	0	C		INLET AIR TEMPERATURE OBSERVATION FREQUENCY
11800	10	1K1N	AIRTRECF	12	0	C		INLET AIR TEMPERATURE ENGINE SPEED RECORD FREQUENCY
11810	10	1K1N	AIRTLOGF	12	0	C		INLET AIR TEMPERATURE LOG FREQUENCY
11820	10	1K1N	AIRTSYSR	8	0	C		INLET AIR TEMPERATURE SYSTEM RESPONSE
11830	10	1K1N	EXTSENS	17	0	C		EXHAUST TEMPERATURE SENSING DEVICE
11840	10	1K1N	EXTCALF	13	0	C		EXHAUST TEMPERATURE CALIBRATION FREQUENCY
11850	10	1K1N	EXTRECD	16	0	C		EXHAUST TEMPERATURE RECORD DEVICE
11860	10	1K1N	EXTOBSF	12	0	C		EXHAUST TEMPERATURE OBSERVATION FREQUENCY

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
11870	10	1K1N	EXTRECF	12	0	C		EXHAUST TEMPERATURE RECORD FREQUENCY
11880	10	1K1N	EXTLOGF	12	0	C		EXHAUST TEMPERATURE LOG FREQUENCY
11890	10	1K1N	EXTSYSR	8	0	C		EXHAUST TEMPERATURE SYSTEM RESPONSE
11900	10	1K1N	FUELSENS	17	0	C		FUEL TEMPERATURE SENSING DEVICE
11910	10	1K1N	FUELCALF	13	0	C		FUEL TEMPERATURE CALIBRATION FREQUENCY
11920	10	1K1N	FUELRECD	16	0	C		FUEL TEMPERATURE RECORD DEVICE
11930	10	1K1N	FUELOBSF	12	0	C		FUEL TEMPERATURE OBSERVATION FREQUENCY
11940	10	1K1N	FUELRECF	12	0	C		FUEL TEMPERATURE RECORD FREQUENCY
11950	10	1K1N	FUELLOGF	12	0	C		FUEL TEMPERATURE LOG FREQUENCY
11960	10	1K1N	FUELSYSR	8	0	C		FUEL TEMPERATURE SYSTEM RESPONSE
11970	10	1K1N	OBRPSENS	17	0	C		OIL TO BEARING PRESSURE SENSING DEVICE
11980	10	1K1N	OBRPCALF	13	0	C		OIL TO BEARING PRESSURE CALIBRATION FREQUENCY
11990	10	1K1N	OBRPRECD	16	0	C		OIL TO BEARING PRESSURE RECORD DEVICE
12000	10	1K1N	OBRPOBSF	12	0	C		OIL TO BEARING PRESSURE OBSERVATION FREQUENCY
12010	10	1K1N	OBRPRECF	12	0	C		OIL TO BEARING PRESSURE RECORD FREQUENCY
12020	10	1K1N	OBRPLOGF	12	0	C		OIL TO BEARING PRESSURE LOG FREQUENCY
12030	10	1K1N	OBRPSYSR	8	0	C		OIL TO BEARING PRESSURE SYSTEM RESPONSE
12040	10	1K1N	OJETSENS	17	0	C		OIL TO JET PRESSURE SENSING DEVICE
12050	10	1K1N	OJETCALF	13	0	C		OIL TO JET PRESSURE CALIBRATION FREQUENCY
12060	10	1K1N	OJETRECD	16	0	C		OIL TO JET PRESSURE RECORD DEVICE
12070	10	1K1N	OJETOBSF	12	0	C		OIL TO JET PRESSURE OBSERVATION FREQUENCY
12080	10	1K1N	OJETRECF	12	0	C		OIL TO JET PRESSURE RECORD FREQUENCY
12090	10	1K1N	OJETLOGF	12	0	C		OIL TO JET PRESSURE ENGINE SPEED LOG FREQUENCY
12100	10	1K1N	OJETSYSR	8	0	C		OIL TO JET PRESSURE SYSTEM RESPONSE
12110	10	1K1N	AIRPSENS	17	0	C		INLET AIR PRESSURE SENSING DEVICE
12120	10	1K1N	AIRPCALF	13	0	C		INLET AIR PRESSURE CALIBRATION FREQUENCY
12130	10	1K1N	AIRPRECD	16	0	C		INLET AIR PRESSURE RECORD DEVICE
12140	10	1K1N	AIRPOBSF	12	0	C		INLET AIR PRESSURE OBSERVATION FREQUENCY
12150	10	1K1N	AIRPRECF	12	0	C		INLET AIR PRESSURE RECORD FREQUENCY
12160	10	1K1N	AIRPLOGF	12	0	C		INLET AIR PRESSURE LOG FREQUENCY
12170	10	1K1N	AIRPSYSR	8	0	C		INLET AIR PRESSURE SYSTEM RESPONSE
12180	10	1K1N	EXPSENS	17	0	C		EXHAUST PRESSURE SENSING DEVICE
12190	10	1K1N	EXPCALF	13	0	C		EXHAUST PRESSURE CALIBRATION FREQUENCY
12200	10	1K1N	EXPRECD	16	0	C		EXHAUST PRESSURE RECORD DEVICE
12210	10	1K1N	EXPOBSF	12	0	C		EXHAUST PRESSURE OBSERVATION FREQUENCY
12220	10	1K1N	EXPRECF	12	0	C		EXHAUST PRESSURE RECORD FREQUENCY
12230	10	1K1N	EXPLOGF	12	0	C		EXHAUST PRESSURE LOG FREQUENCY
12240	10	1K1N	EXPSYSR	8	0	C		EXHAUST PRESSURE SYSTEM RESPONSE
12250	10	1K1N	FFILSENS	17	0	C		FUEL FILTER HOUSING PRESSURE SENSING DEVICE
12260	10	1K1N	FFILCALF	13	0	C		FUEL FILTER HOUSING PRESSURE CALIBRATION FREQUENCY
12270	10	1K1N	FFILRECD	16	0	C		FUEL FILTER HOUSING PRESSURE RECORD DEVICE
12280	10	1K1N	FFILOBSF	12	0	C		FUEL FILTER HOUSING PRESSURE OBSERVATION FREQUENCY
12290	10	1K1N	FFILRECF	12	0	C		FUEL FILTER HOUSING PRESSURE RECORD FREQUENCY
12300	10	1K1N	FFILLOGF	12	0	C		FUEL FILTER HOUSING PRESSURE LOG FREQUENCY
12310	10	1K1N	FFILSYSR	8	0	C		FUEL FILTER HOUSING PRESSURE SYSTEM RESPONSE
12320	10	1K1N	CCVSENS	17	0	C		CRANKCASE VACUUM SENSING DEVICE
12330	10	1K1N	CCVCALF	13	0	C		CRANKCASE VACUUM ENGINE SPEED CALIBRATION FREQUENCY
12340	10	1K1N	CCVRECD	16	0	C		CRANKCASE VACUUM RECORD DEVICE
12350	10	1K1N	CCVOBSF	12	0	C		CRANKCASE VACUUM OBSERVATION FREQUENCY
12360	10	1K1N	CCVRECF	12	0	C		CRANKCASE VACUUM RECORD FREQUENCY
12370	10	1K1N	CCVLOGF	12	0	C		CRANKCASE VACUUM LOG FREQUENCY
12380	10	1K1N	CCVSYSR	8	0	C		CRANKCASE VACUUM SYSTEM RESPONSE
12390	10	1K1N	BLBYSENS	17	0	C		BLOWBY SENSING DEVICE
12400	10	1K1N	BLBYCALF	13	0	C		BLOWBY ENGINE SPEED CALIBRATION FREQUENCY

FIG. A14.1 Data Dictionary *(continued)*

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Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
12410	10	1K1N	BLBYRECD	16	0	C		BLOWBY RECORD DEVICE
12420	10	1K1N	BLBYOBSF	12	0	C		BLOWBY OBSERVATION FREQUENCY
12430	10	1K1N	BLBYRECF	12	0	C		BLOWBY RECORD FREQUENCY
12440	10	1K1N	BLBYLOGF	12	0	C		BLOWBY LOG FREQUENCY
12450	10	1K1N	BLBYSYSR	8	0	C		BLOWBY SYSTEM RESPONSE
12460	10	1K1N	CFLWSENS	17	0	C		COOLANT FLOW SENSING DEVICE
12470	10	1K1N	CFLWCALF	13	0	C		COOLANT FLOW CALIBRATION FREQUENCY
12480	10	1K1N	CFLWRECD	16	0	C		COOLANT FLOW RECORD DEVICE
12490	10	1K1N	CFLWOBSF	12	0	C		COOLANT FLOW OBSERVATION FREQUENCY
12500	10	1K1N	CFLWRECF	12	0	C		COOLANT FLOW ENGINE SPEED RECORD FREQUENCY
12510	10	1K1N	CFLWLOGF	12	0	C		COOLANT FLOW LOG FREQUENCY
12520	10	1K1N	CFLWSYSR	8	0	C		COOLANT FLOW SYSTEM RESPONSE
12530	11	1K1N	INAIRIM	70	0	C		INLET AIR TEMPERATURE PLOT IMAGE
12540	11	1K1N	OBEARIM	70	0	C		OIL TO BEARING TEMPERATURE PLOT IMAGE
12550	11	1K1N	COLINIM	70	0	C		COOLANT IN TEMPERATURE PLOT IMAGE
12560	11	1K1N	COLOUTIM	70	0	C		COOLANT OUT TEMPERATURE PLOT IMAGE
12570	11	1K1N	EXHTMPIM	70	0	C		EXHAUST TEMPERATURE PLOT IMAGE
12580	11	1K1N	FRATEIM	70	0	C		FUEL RATE PLOT IMAGE
12590	11	1K1N	RPMIM	70	0	C		ENGINE SPEED PLOT IMAGE
12600	11	1K1N	POWERIM	70	0	C		POWER PLOT IMAGE
12610	12	1K1N	OBEARPIM	70	0	C		OIL TO BEARING PRESSURE PLOT IMAGE
12620	12	1K1N	OJETPIM	70	0	C		OIL TO JET PRESSURE PLOT IMAGE
12630	12	1K1N	INAIRPIM	70	0	C		INLET AIR PRESSURE PLOT IMAGE
12640	12	1K1N	EXHPIM	70	0	C		EXHAUST PRESSURE PLOT IMAGE
12650	12	1K1N	HUMIDIM	70	0	C		HUMIDITY PLOT IMAGE
12660	12	1K1N	COLFLOIM	70	0	C		COOLANT FLOW PLOT IMAGE
12670	12	1K1N	CCVACIM	70	0	C		CRANKCASE VACUUM PLOT IMAGE
12680	12	1K1N	BLOBYIM	70	0	C		BLOWBY PLOT IMAGE
12690	13	1K1N	OCPIM	70	0	C		OIL CONSUMPTION PLOT IMAGE
12700	14	1K1N	PRLIM	70	0	C		PISTON RING AND LINER PHOTOGRAPHS PLOT IMAGE
12710	15	1K1N	DTSTRxxx	8	0	C	YYYYMMDD	USAGE START DATES
12720	15	1K1N	DTTMRxxx	6	0	C	HHH:MM	USAGE DATES TIME
12730	15	1K1N	WDZIRxxx	7	3	N		WEIGHTED TOTAL DEMERITS ZI
12740	15	1K1N	WDSARxxx	6	1	N		WEIGHTED TOTAL DEMERITS SEVERITY ADJUSTMENT
12750	15	1K1N	TGZIRxxx	7	3	N		TGF % ZI
12760	15	1K1N	TGSARxxx	4	0	N		TGF % S.A.
12770	15	1K1N	TLZIRxxx	7	3	N		TRANSFORMED TLHC % ZI
12780	15	1K1N	TLSARxxx	6	3	N		TRANSFORMED TLHC % S.A.
12790	16	1K1N	CCHIM	70	0	C		TMC CONTROL CHART ANALYSIS PLOT IMAGE
12800	17	1K1N	FUELIM	70	0	C		FUEL BATCH ANALYSIS PLOT IMAGE

FIG. A14.1 Data Dictionary *(continued)*

```
##########################################################################
#                                                                        #
#            D a t a  D i c t i o n a r y  R e p e a t i n g              #
#               F i e l d  S p e c i f i c a t i o n s                    #
#                                                                        #
##########################################################################
# The following contains specifications and field groupings for fields in the
# Data Dictionary that are REPEATING Fields.  These fields can be identified
# in the Data Dictionary by the Hxxx or Rxxx in the last four positions of the
# field name.
#
# Repeating fields are used to specify repeating measurements.
#
# The format for a repeating field name is 4 descriptive characters followed
# by the letter H or R followed by 3 characters for the actual interval
# the measurement was taken. The field will always be a total of 8 characters.
#
# Example ABCDHxxx.
#
# The following is the format of this specification:
#
# Column 1 - 8:   Repeating Field Name
# Column 10 - 17: The Parent Field Name of the Group
# Column 19 - 80: Comments about the Repeating Field Group.
#
# The lines following the Repeating Field Name Record will contain the required
# measurements for the particular field.  Multiple 80 characters lines
# can be specified.  A blank line marks the end of each specification.
#
# The Field Name in Column 10-17 designates the the Group in which the field
# belongs.  The First field name in a group is the Parent of the grouping
# and can be used to determine how fields should be grouped.
# The changing of the Parent Field marks the end of a repeating group
# specification.
#
# Example:
#
# VIS_Hxxx, DVISHxxx and PVISHxxx expanded for transmission (8 and 16 hours):
#
#           VIS_H008
#           DVISH008
#           PVISH008
#           VIS_H016
#           DVISH016
#           PVISH016
#
# Note:  During electronic transmission, repeating field groups must be kept
#        together with in the specified group but the order with in the group
#        does not have to be maintained.
#
##########################################################################
#                 Start of Field Grouping Specifications                 #
##########################################################################
#
1K1N VERSION 19980923
V100Hxxx V100Hxxx   VISC @ 100 DEG C AT XXX HOURS (cSt)
NEW 024 204 252

TBN_Hxxx V100Hxxx   TBN D4739 AT XXX HOURS
NEW 024 204 252
```

FIG. A14.2 Repeating Field Specifications

```
FEWMHxxx V100Hxxx   FE - WEAR METALS AT XXX HOURS [<] (ppm)
NEW 024 204 252

ALWMHxxx V100Hxxx   AL - WEAR METALS AT XXX HOURS [<] (ppm)
NEW 024 204 252

SIWMHxxx V100Hxxx   SI - WEAR METALS AT XXX HOURS [<] (ppm)
NEW 024 204 252

CUWMHxxx V100Hxxx   CU - WEAR METALS AT XXX HOURS [<] (ppm)
NEW 024 204 252

CRWMHxxx V100Hxxx   CR - WEAR METALS AT XXX HOURS [<] (ppm)
NEW 024 204 252

PBWMHxxx V100Hxxx   PB - WEAR METALS AT XXX HOURS [<] (ppm)
NEW 024 204 252

FDILHxxx V100Hxxx   FUEL DILUTION ENGINE HOURS AT XXX HOURS (%)
024 204 252

BLBYHxxx V100Hxxx   BLOWBY ENGINE HOURS AT XXX HOURS (L/min)
024 204 252

BSOCHxxx V100Hxxx   BSOC ENGINE HOURS AT XXX HOURS (g/kW-h)
024 048 072 108 132 156 180 204 228 252

DOWNHxxx DOWNHxxx   DOWNTIME TEST HOURS (HH:MM)

DDATHxxx DOWNHxxx   DOWNTIME DATE (YYYYMMDD)

DTIMHxxx DOWNHxxx   DOWNTIME TIME (HH:MM)

DREAHxxx DOWNHxxx   DOWNTIME REASON

OCOMHxxx OCOMHxxx   OTHER DOWNTIME COMMENTS XXX

DTSTRxxx DTSTRxxx   USAGE START DATES (YYYYMMDD)

DTTMRxxx DTSTRxxx   USAGE DATES TIME (HHH:MM)

WDZIRxxx DTSTRxxx   WEIGHTED TOTAL DEMERITS ZI

WDSARxxx DTSTRxxx   WEIGHTED TOTAL DEMERITS SEVERITY ADJUSTMENT

TGZIRxxx DTSTRxxx   TGF % ZI

TGSARxxx DTSTRxxx   TGF % S.A.
```

FIG. A14.2 Repeating Field Specifications *(continued)*

```
TLZIRxxx DTSTRxxx   TRANSFORMED TLHC % ZI

TLSARxxx DTSTRxxx   TRANSFORMED TLHC % S.A.
```

FIG. A14.2 Repeating Field Specifications *(continued)*

A15. TEST ENGINE/PARTS/ACCESSORIES

A15.1 Table A15.1 provides the test engine, parts, and accessories list.

A15.2 *Engine Parts Warranty*:

A15.2.1 All parts of the 1Y540 engine and the 1Y540 conversion kit that are nonconforming due to faulty manufacture shall be noted by the laboratory and brought to the attention of Engine System Technology Department (ESTD).

A15.2.2 ESTD shall determine whether the part is to be returned or warranty is to be provided without viewing the part.

A15.2.3 If ESTD determines that the part is nonconforming without viewing the part, the test laboratory shall be asked by ESTD to return the part to its Caterpillar dealer. ESTD shall contact the dealer and inform the dealer that the part is coming and to provide warranty for it.

A15.2.4 If ESTD wants to view the part, then ESTD shall issue a return goods authorization number (RGA) to the test laboratory. The laboratory shall fill out the return goods authorization claim form (RGA) (see Fig. A15.1) and shall send the completed claim form in a package with the part and separately by FAX as follows:

A15.2.4.1 Send claim form in a package with the part to Caterpillar, Inc., Tech Center TC-L, Wing 4-Rm 406, 14009 Old Galena Rd., Mossville, IL 61552.

A15.2.4.2 FAX a separate copy of the claim form to Caterpillar, Inc., Tech Services Div., Tech Center Bldg. L.

TABLE A15.1 Test Engine/Parts/Accessories List

Part Number (P/N)	Engine/Part/Accessory Name
307946	elbow
BR 12705-16-31	Barco flowmeter
8C3684	coolant in 1-gal container
8C3686	Coolant in 55-Gal drum
9L8791	solenoid
9L9098	seal
8N9586	engine oil filter
5P0957	commercial tester
5P3514	commercial tester
5P4150	nozzle tester
6V7020	service kit
2W1230	screw
2W6163	fibre washer
7W8629	line assembly
1Y27	piston
1Y73	Cat diesel engine and service manual
1Y466	thermocouple (fluids)
1Y467	thermocouple (engine exhaust)
1Y468	thermocouple (air to engine)
1Y479	valve (to crankcase breather)
1Y496	orifice
1Y506	piston ring
1Y507	piston ring
1Y508	piston ring
1Y540	Cat diesel engine and service manual
1Y541	conversion arrangement for 1Y73
1Y544	cylinder block
1Y631-2	elbow
1Y632	adapter
1Y636	oil/filter group (factory)
1Y648	line assembly
1Y653	rocker shaft oil line
1Y702	cylinder liner
1Y0699	oil/filter group (new-replacement)
1Y1990	governor housing cover
1Y2592	crankcase breather assembly
1Y3549	screen (last chance)
1Y3698	multiple block gaskets
1Y5700	filter element
1Y7277	bracket

CATERPILLAR SCOTE 1K/1N TEST 4:3
2/98

RETURN GOODS AUTHORIZATION FORM

RETURN GOODS AUTHORIZATION NUMBER _____

CLAIM DATE _____

CONTACT: CATERPILLAR, INC.
ENGINE SYS TECH DEV
P.O. BOX 610
MOSSVILLE, IL 61552
PHONE: 309-578-2131
FAX: 309-578-6457
ATTN: R.A. RIVIERE

PART NUMBER/QUANTITY _____

PART NAME/HOURS ON PART _____

DATE PART PURCHASED _____

PURCHASE ORDER NUMBER _____

TEST LAB

NAME _____

ADDRESS _____

CONTACT PERSON'S NAME _____

PHONE NUMBER _____

FAX NUMBER _____

NAME OF CAT DEALER/MORTON PARTS THAT SOLD PART _____

INCLUDE DOCUMENTATION AND PHOTOS OF NON-CONFORMING PART

FIG. A15.1 Example of Return Goods Claim Form

A15.2.5 If ESTD determines that the part is nonconforming, ESTD shall contact the dealer on behalf of the test laboratory and have the dealer provide warranty.

A15.2.6 The return goods authorization (RGA) claim form shall include a return goods authorization number; part name; hours on the part; part number; quantity; purchase order number; date purchased; test laboratory that purchase; the part and contact person's name, telephone number, FAX number and address; dealer's name that sold the part; measurements or photos, or both, to document the noncomformance.

A15.2.6.1 Fig. A15.1 is a sample of a blank RGA claim form.

A16. THE ROLE OF THE ASTM TEST MONITORING CENTER AND THE CALIBRATION PROGRAM

A16.1 *Nature and Functions of the ASTM Test Monitoring Center (TMC)*—The ASTM TMC is a non-profit organization located in Pittsburgh, PA and is staffed to administer engineering studies; conduct oil laboratory visits; perform statistical analyses of reference oil test data; blend, store and ship reference oils; and provide the associated administrative functions to maintain the referencing calibration program for various lubricant tests as directed by the Subcommittee D02.B and the Test Monitoring Board. The TMC coordinates its activities with the test sponsors, the test developers, the surveillance panels and the testing laboratories.

A16.2 *Rules of Operation of the ASTM TMC*—The TMC operates in accordance with the ASTM charter, the ASTM by-laws, the Regulations Governing ASTM Technical Committees, the by-laws governing ASTM Committee D02 and the rules and regulations governing the test monitoring system.

A16.3 *Management of the ASTM TMC*—The management of the ASTM Test Monitoring System is vested in the Test Monitoring Board (TMB) elected by Subcommittee D02.B. The TBM selects the TMC administrator who is responsible for directing the activities of the TMC staff.

A16.4 *Operating Income of the ASTM TMC*—The TMC operating income is obtained from the fees levied on the reference oils supplied and on the calibration tests conducted. Fee schedules are established and reviewed by Subcommittee D02.B.

A16.5 *Conducting a Reference Oil Test*:

A16.5.1 For those laboratories that choose to utilize the services of the ASTM TMC in maintaining calibration of test stands, full-scale calibration testing shall be conducted at regular intervals. These full-scale tests are conducted using coded reference oils supplied by the ASTM TMC. It is a laboratory's responsibility to maintain the calibration in accordance with the test procedure. It is also a laboratory's responsibility to keep the on-site reference of inventory at or above the minimum level specified by the TMC test engineers.

A16.5.2 When laboratory personnel decide to run a reference calibration test, they shall request an oil code from the cognizant TMC engineer. Upon completion of the reference oil test, the data shall be sent in summary form (use TMC-acceptable forms) to the TMC by telephone facsimile transmission, or by some other method acceptable to the TMC. The TMC will review the data and contact the laboratory engineer to report the laboratory's calibration status. All reference oil tests, whether aborted, invalidated, or successfully completed, shall be reported to the TMC. Subsequent to sending the data in summary form to the TMC, the laboratory is required to submit to the TMC the written test report specified in the test procedure.

A16.6 *New Laboratories*—Laboratories wishing to become a part of the ASTM Test Monitoring System will be requested to conduct reference oil tests to ensure that the laboratory is using the proper testing techniques. Information concerning fees, laboratory inspection, reagents, testing practices, appropriate committee membership, and rater training can be obtained by contacting the TMC Administrator at the ASTM Test Monitoring Center.

A16.7 *Introducing New 1K/1N Test Procedures Reference Oils*—The calibrating reference oils produce wear, piston and ring groove deposit forming tendency, and oil consumption characteristics. When new reference oils are selected, member laboratories will be requested to conduct their share of tests to enable the TMC to establish the proper industry average and test acceptance limits. The ASTM D02.B0.02 1K/1N Test Procedures Surveillance Panel determines the number of tests to be conducted prior to establishing the industry average and test acceptance targets for new reference oils.

A16.8 *TMC Information Letters*:

A16.8.1 Occasionally, it becomes necessary to change the procedure and notify the test laboratories of the change prior to consideration of the change by either ASTM Subcommittee D02.B on Automotive Lubricants or ASTM Committee D02 on Petroleum Products and Lubricants. When this occurs, the TMC will issue an Information Letter. Subsequently, prior to each semi-annual Committee D02 meeting, the accumulated Information Letters are balloted by ASTM Subcommittee D02.B. The ballot is reviewed at the ASTM Subcommittee D02.B meeting and the actions taken are considered at a meeting of ASTM Committee D02. By this means, the Society due process procedures are applied to these Information Letters.

A16.8.2 The review of an Information Letter prior to its original issue will differ according to its nature. TMC is authorized to issue an Information Letter concerning a part number change that does not affect test results. Long-term studies by the 1K/1N Test Procedures Surveillance Panel to improve the test procedures through improved operation and hardware control may result in a recommendation to issue an Information Letter. If obvious procedural items affecting test results need immediate attention, the test sponsor and the TMC will issue an Information Letter and present the background data to the 1K/1N surveillance panel for approval prior to the semi-annual ASTM Subcommittee D02.B meeting.

A16.8.3 Authority for issuance of Information Letters was given by the ASTM Committee on Technical Committee Operations (COTCO) in 1984 as follows:
"COTCO recognizes that D02 has a unique and complex situation. The use of Information Letters is approved provided each letter contains a disclaimer to the effect that such has not obtained ASTM consensus. These Information Letters should be moved to such consensus as rapidly as possible."

A16.8.4 Information Letters pertaining to this procedure issued prior to March 21, 2002 are incorporated in this test method. A listing of such Information Letters and copies of the letters may be obtained from TMC. Information Letters issued subsequent to this date may also be obtained from the TMC.

A16.9 *TMC Memoranda*—Memoranda, supplementary to Information Letters, are also issued. These are developed by the TMC and distributed to the 1K/1N Test Procedures Surveillance Panel as well as to participating laboratories. They convey such information as batch approvals for test parts or materials, clarification of the test procedures, notes and suggestions for the collection and analysis of special data that the TMC may request, or for any other pertinent matters having no direct effect on the test performance, results, or, precision and bias.

A16.10 *Precision Data*—The TMC determines the current 1K/1N test procedures precision by analyzing results of calibration tests conducted on reference oils. Current precision data can be obtained from the TMC.

A17. SAFETY

A17.1 *General Considerations*:

A17.1.1 Performing engine tests on engine oils exposes personnel and facilities to many hazards. This includes all aspects associated with the test itself, preparations for the test, conclusion of the test, housekeeping, and, indeed, anything and everything else that could come to mind as possible hazards.

A17.1.2 Only personnel who are thoroughly trained and experienced in engine testing shall undertake the design, installation, and operation of engine test stands.

A17.1.3 The engine test installation shall be inspected and approved by a competent authority external to the laboratory, such as, a safety department or safety officer.

A17.2 *Personnel in the Work Area*:

A17.2.1 Personnel working on the engines shall be provided with the proper tools, be alert to common safety practices, and avoid contact with hot surfaces and external moving parts.

A17.2.2 When working on the engines, personnel shall wear safety masks or safety glasses.

A17.2.3 In the vicinity of running engines, personnel shall not wear loose or flowing clothing (notably ties), nor transport bulky material that could topple on the running engines.

A17.2.4 Preferably personnel working on engines should not have long hair or long beards. If these hairy appendages are permitted, then they shall be firmly secured to the person possessing them so that they will not get caught in moving parts.

A17.3 *Guards and Barriers*:

A17.3.1 Barriers shall be provided appropriately around the engine to protect personnel. In addition, heavy duty guards shall be placed alongside the engine and coupling shaft.

A17.4 *Fuel and Oil Lines, and Electrical Wiring*:

A17.4.1 All fuel and oil lines, and electrical wiring shall be properly routed, guarded, kept clean and dry and, generally, in good order.

A17.5 *Housekeeping*:

A17.5.1 The external parts of the engines and the floor area around the engines shall be kept clean and free from spills of fuel, oil, coolant and so forth.

A17.5.2 The working area shall be free from obstacles that could cause injury or falls.

A17.5.3 The testing area shall not be used for storage. Containers of fuel, oil, coolant, and so forth, shall not be allowed to accumulate there.

A17.6 *Toxic Fume and Fire Hazards*—Exhaust gases shall be vented by way of appropriate leakfree ductwork. Fuel containers shall not be left open. Fuel leaks shall be corrected, and fuel and oil spills shall be immediately treated with absorbent and removed.

A17.7 *First Aid*—Good safety measures avoid both major injuries and minor ones such as scraped knuckles and minor burns. All injuries require first aid treatment and subsequent recording and reporting of the incident.

A17.8 *Automatic Shutdown, Remote Cut-off and Interlocks*:

A17.8.1 The test installation shall be equipped with a fuel shut-off valve which shall automatically cut off the fuel supply when the engine is not running.

A17.8.2 There shall be a remote station for cutting off fuel from the test stand.

A17.8.3 There shall be an excessive vibration pickup interlock if the engine runs unattended.

A17.8.4 Provide suitable interlocks that shut down the engine automatically when any of the following occurs:

A17.8.4.1 The engine dynamometer loses field current,

A17.8.4.2 The engine overspeeds,

A17.8.4.3 Low oil pressure develops,

A17.8.4.4 High water temperature develops,

A17.8.4.5 The exhaust system fails,

A17.8.4.6 The room ventilation system fails, or

A17.8.4.7 The fire protection system is activated.

A17.9 *Fire Protection Equipment*:

A17.9.1 Provide fixed fire protection equipment.

A17.9.2 Place dry chemical fire extinguishers at a number of locations at the test stands.

APPENDIXES

(Nonmandatory Information)

X1. HUMIDITY DATA

X1.1 *Humidify Correction Factors for Non-Standard Barometric Conditions*—See Tables X1.1-X1.8.

X1.2 *Correcting Humidity by Applying the Perfect Gas Law Equation–With Examples*:

$$\text{corrected humidity} = 7000\left(\frac{M_v}{M_a}\right) P_v\,(P_B - P_v) \qquad \text{(X1.1)}$$

where:

7000 = number of grains/lb.
M_v = molecular weight of water vapor,
M_a = molecular weight of dry air,
P_v = partial pressure of water vapor at dew point, and
P_B = barometric pressure.

$$\text{or humidity} = 7000\left(\frac{18.0152}{28.96247}\right)\frac{P_v}{(P_B - P_v)} \qquad \text{(X1.2)}$$

$$\text{or humidity} = 4354.13\,\frac{P_v}{(P_B - P_v)} \qquad \text{(X1.3)}$$

X1.3 *Saturation Vapor Pressure Over Water*—See Table X1.9.

TABLE X1.1 Grains/lb; Range: 30.0 to 30.9 in. Hg

		30.9	30.8	30.7	30.6	30.5	30.4	30.3	30.2	30.1	30.0
	65	–3.1	–2.8	–2.5	–2.2	–1.9	–1.6	–1.2	–0.9	–0.6	–0.3
D	66	–3.2	–2.9	–2.6	–2.2	–1.9	–1.6	–1.3	–1.0	–0.6	–0.3
E	67	–3.3	–3.0	–2.6	–2.3	–2.0	–1.7	–1.3	–1.0	–0.7	–0.3
W	68	–3.4	–3.1	–2.7	–2.4	–2.0	–1.7	–1.4	–1.0	–0.7	–0.3
	69	–3.5	–3.2	–2.8	–2.5	–2.1	–1.8	–1.4	–1.1	–0.7	–0.4
P	70	–3.7	–3.3	–3.0	–2.6	–2.2	–1.9	–1.5	–1.1	–0.7	–0.4
O	71	–3.8	–3.4	–3.0	–2.7	–2.3	–1.9	–1.5	–1.1	–0.8	–0.4
I	72	–3.9	–3.5	–3.1	–2.7	–2.3	–2.0	–1.6	–1.2	–0.8	–0.4
N	73	–4.1	–3.7	–3.3	–2.9	–2.5	–2.1	–1.6	–1.2	–0.8	–0.4
T	74	–4.2	–3.8	–3.4	–2.9	–2.5	–2.1	–1.7	–1.3	–0.8	–0.4
	75	–4.4	–4.0	–3.5	–3.1	–2.6	–2.2	–1.8	–1.3	–0.9	–0.4
T	76	–4.5	–4.1	–3.6	–3.2	–2.7	–2.3	–1.8	–1.4	–0.9	–0.5
E	77	–4.7	–4.2	–3.8	–3.3	–2.8	–2.4	–1.9	–1.4	–0.9	–0.5
M	78	–4.9	–4.4	–3.9	–3.4	–2.9	–2.5	–2.0	–1.5	–1.0	–0.5
P	79	–5.0	–4.5	–4.0	–3.5	–3.0	–2.5	–2.0	–1.5	–1.0	–0.5
°F	80	–5.2	–4.7	–4.2	–3.6	–3.1	–2.6	–2.1	–1.6	–1.0	–0.5

TABLE X1.2 Grains/lb; Range: 29.0 to 29.9 in. Hg

		29.9	29.8	29.7	29.6	29.5	29.4	29.3	29.2	29.1	29.0
	65	0.0	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.6	3.0
D	66	0.0	0.3	0.7	1.0	1.4	1.7	2.0	2.4	2.7	3.1
E	67	0.0	0.4	0.7	1.1	1.4	1.8	2.1	2.5	2.8	3.2
W	68	0.0	0.4	0.7	1.1	1.5	1.9	2.2	2.6	3.0	3.3
	69	0.0	0.4	0.8	1.1	1.5	1.9	2.3	2.7	3.0	3.4
P	70	0.0	0.4	0.8	1.2	1.6	2.0	2.3	2.7	3.1	3.5
O	71	0.0	0.4	0.8	1.2	1.6	2.1	2.5	2.9	3.3	3.7
I	72	0.0	0.4	0.8	1.3	1.7	2.1	2.5	2.9	3.4	3.8
N	73	0.0	0.4	0.9	1.3	1.8	2.2	2.6	3.1	3.5	4.0
T	74	0.0	0.5	0.9	1.4	1.8	2.3	2.8	3.2	3.7	4.1
	75	0.0	0.5	0.9	1.4	1.9	2.4	2.8	3.3	3.8	4.2
T	76	0.0	0.5	1.0	1.5	2.0	2.5	2.9	3.4	3.9	4.4
E	77	0.0	0.5	1.0	1.5	2.0	2.6	3.1	3.6	4.1	4.6
M	78	0.0	0.5	1.0	1.6	2.1	2.6	3.1	3.6	4.2	4.7
P	79	0.0	0.5	1.1	1.6	2.2	2.7	3.2	3.8	4.3	4.9
°F	80	0.0	0.6	1.1	1.7	2.2	2.8	3.4	3.9	4.5	5.0

TABLE X1.3 Grains/lb; Range: 28.0 to 28.9 in. Hg

		28.9	28.8	28.7	28.6	28.5	28.4	28.3	28.2	28.1	28.0
	65	3.3	3.7	4.0	4.4	4.7	5.1	5.4	5.8	6.1	6.5
D	66	3.4	3.8	4.1	4.5	4.9	5.3	5.6	6.0	6.4	6.7
E	67	3.5	3.9	4.3	4.6	5.0	5.4	5.8	6.2	6.5	6.9
W	68	3.7	4.1	4.5	4.9	5.3	5.7	6.0	6.4	6.8	7.2
	69	3.8	4.2	4.6	5.0	5.4	5.9	6.3	6.7	7.1	7.5
P	70	3.9	4.3	4.7	5.2	5.6	6.0	6.4	6.8	7.3	7.7
O	71	4.1	4.5	5.0	5.4	5.8	6.3	6.7	7.1	7.5	8.0
I	72	4.2	4.7	5.1	5.6	6.0	6.5	6.9	7.4	7.8	8.3
N	73	4.4	4.9	5.3	5.8	6.2	6.7	7.2	7.6	8.1	8.5
T	74	4.6	5.1	5.6	6.0	6.5	7.0	7.5	8.0	8.4	8.9
	75	4.7	5.2	5.7	6.2	6.7	7.2	7.7	8.2	8.7	9.2
T	76	4.9	5.4	5.9	6.4	6.9	7.5	8.0	8.5	9.0	9.5
E	77	5.1	5.6	6.2	6.7	7.2	7.8	8.3	8.8	9.3	9.9
M	78	5.2	5.8	6.3	6.9	7.4	8.0	8.6	9.1	9.7	10.2
P	79	5.4	6.0	6.6	7.1	7.7	8.3	8.9	9.5	10.0	10.6
°F	80	5.6	6.2	6.8	7.4	8.0	8.6	9.2	9.8	10.4	11.0

TABLE X1.4 Grains/lb; Range: 27.0 to 27.9 in. Hg

		27.9	27.8	27.7	27.6	27.5	27.4	27.3	27.2	27.1	27.0
	65	6.8	7.2	7.5	7.9	8.2	8.6	8.9	9.3	9.6	10.0
D	66	7.1	7.5	7.9	8.3	8.7	9.1	9.4	9.8	10.2	10.6
E	67	7.3	7.7	8.1	8.5	8.9	9.4	9.8	10.2	10.6	11.0
W	68	7.6	8.0	8.4	8.9	9.3	9.7	10.1	10.5	11.0	11.4
	69	7.9	8.3	8.8	9.2	9.6	10.1	10.5	10.9	11.3	11.8
P	70	8.1	8.6	9.0	9.5	9.9	10.4	10.9	11.3	11.8	12.2
O	71	8.1	8.9	9.3	9.8	10.3	10.8	11.2	11.7	12.2	12.6
I	72	8.7	9.2	9.7	10.2	10.7	11.2	11.6	12.1	12.6	13.1
N	73	9.0	9.5	10.0	10.5	11.0	11.6	12.1	12.6	13.1	13.6
T	74	9.4	9.9	10.4	11.0	11.5	12.0	12.5	13.0	13.6	14.1
	75	9.7	10.2	10.8	11.3	11.9	12.4	12.9	13.5	14.0	14.6
T	76	10.0	10.6	11.1	11.7	12.3	12.9	13.4	14.0	14.6	15.1
E	77	10.4	11.0	11.6	12.2	12.8	13.4	13.9	14.5	15.1	15.7
M	78	10.8	11.4	12.0	12.6	13.2	13.9	14.5	15.1	15.7	16.3
P	79	11.2	11.8	12.5	13.1	13.7	14.4	15.0	15.6	16.2	16.9
°F	80	11.6	12.3	12.9	13.6	14.2	14.9	15.5	16.2	16.8	17.5

TABLE X1.5 Grams/kg; Range: 101.6 to 104.6 kPa

		104.6	104.3	104.0	103.6	103.3	102.9	102.6	102.1	101.9	101.6
	18.3	–0.44	–0.40	–0.36	–0.32	–0.27	–0.23	–0.17	–0.13	–0.09	–0.04
D	18.9	–0.46	–0.41	–0.37	–0.32	–0.27	–0.23	–0.19	–0.14	–0.09	–0.04
E	19.4	–0.47	–0.43	–0.37	–0.33	–0.29	–0.24	–0.19	–0.14	–0.10	–0.04
W	20.0	–0.49	–0.44	–0.39	–0.34	–0.29	–0.24	–0.20	–0.14	–0.10	–0.04
	20.6	–0.50	–0.46	–0.40	–0.36	–0.30	–0.26	–0.20	–0.16	–0.10	–0.06
P	21.1	–0.53	–0.47	–0.43	–0.37	–0.32	–0.27	–0.21	–0.16	–0.10	–0.06
O	21.7	–0.54	–0.49	–0.43	–0.39	–0.33	–0.27	–0.21	–0.16	–0.11	–0.06
I	22.2	–0.56	–0.50	–0.44	–0.39	–0.33	–0.29	–0.23	–0.17	–0.11	–0.06
N	22.8	–0.59	–0.53	–0.47	–0.41	–0.36	–0.30	–0.23	–0.17	–0.11	–0.06
T	23.3	–0.60	–0.54	–0.49	–0.41	–0.36	–0.30	–0.24	–0.19	–0.11	–0.06
	23.9	–0.63	–0.57	–0.50	–0.44	–0.37	–0.31	–0.26	–0.19	–0.13	–0.06
T	24.4	–0.64	–0.59	–0.51	–0.46	–0.39	–0.33	–0.26	–0.20	–0.13	–0.07
E	25.0	–0.67	–0.60	–0.54	–0.47	–0.40	–0.34	–0.27	–0.20	–0.13	–0.07
M	25.6	–0.70	–0.63	–0.56	–0.49	–0.41	–0.36	–0.29	–0.21	–0.14	–0.07
P	26.1	–0.72	–0.64	–0.57	–0.50	–0.43	–0.36	–0.29	–0.21	–0.14	–0.07
°C	26.7	–0.74	–0.67	–0.60	–0.51	–0.44	–0.37	–0.30	–0.23	–0.14	–0.07

TABLE X1.6 Grams/kg; Range: 98.2 to 101.2 kPa

		101.2	100.9	100.6	100.2	99.9	99.5	99.2	98.9	98.5	98.2
	18.3	0	0.04	0.10	0.14	0.19	0.24	0.29	0.33	0.37	0.43
D	18.9	0	0.04	0.10	0.14	0.20	0.24	0.29	0.34	0.39	0.44
E	19.4	0	0.06	0.10	0.16	0.20	0.26	0.30	0.36	0.40	0.46
W	20.0	0	0.06	0.10	0.16	0.21	0.27	0.32	0.37	0.43	0.47
	20.6	0	0.06	0.11	0.16	0.21	0.27	0.33	0.39	0.43	0.49
P	21.1	0	0.06	0.11	0.17	0.23	0.29	0.33	0.39	0.44	0.50
O	21.7	0	0.06	0.11	0.17	0.23	0.30	0.36	0.41	0.47	0.53
I	22.2	0	0.06	0.11	0.19	0.24	0.30	0.36	0.41	0.49	0.54
N	22.8	0	0.06	0.13	0.19	0.26	0.32	0.37	0.44	0.50	0.57
T	23.3	0	0.07	0.13	0.20	0.26	0.33	0.40	0.46	0.53	0.59
	23.9	0	0.07	0.13	0.20	0.27	0.34	0.40	0.47	0.54	0.60
T	24.4	0	0.07	0.14	0.21	0.29	0.36	0.41	0.49	0.56	0.63
E	25.0	0	0.07	0.14	0.21	0.29	0.37	0.44	0.51	0.59	0.66
M	25.6	0	0.07	0.14	0.23	0.30	0.37	0.44	0.51	0.60	0.67
P	26.1	0	0.07	0.16	0.23	0.32	0.39	0.46	0.54	0.61	0.70
°C	26.7	0	0.09	0.16	0.24	0.32	0.40	0.49	0.56	0.64	0.72

TABLE X1.7 Grams/kg; Range: 94.8 to 97.9 kPa

		97.9	97.5	97.2	96.8	96.5	96.2	95.8	95.5	95.2	94.8
	18.3	0.47	0.53	0.57	0.63	0.67	0.73	0.77	0.83	0.87	0.93
D	18.9	0.49	0.54	0.59	0.65	0.70	0.76	0.80	0.86	0.92	0.96
E	19.4	0.50	0.56	0.61	0.66	0.72	0.77	0.83	0.89	0.93	0.99
W	20.0	0.53	0.59	0.64	0.70	0.76	0.82	0.86	0.92	0.97	1.03
	20.6	0.54	0.60	0.66	0.72	0.77	0.84	0.90	0.96	1.02	1.07
P	21.1	0.56	0.61	0.67	0.74	0.80	0.86	0.92	0.97	1.04	1.10
O	21.7	0.59	0.64	0.72	0.77	0.83	0.90	0.96	1.02	1.07	1.14
I	22.2	0.60	0.67	0.73	0.80	0.86	0.93	0.99	1.06	1.12	1.19
N	22.8	0.63	0.70	0.76	0.83	0.89	0.96	1.03	1.09	1.16	1.22
T	23.3	0.66	0.73	0.80	0.86	0.93	1.00	1.07	1.14	1.20	1.27
	23.9	0.67	0.74	0.82	0.89	0.96	1.03	1.10	1.17	1.24	1.32
T	24.4	0.70	0.77	0.84	0.92	0.99	1.07	1.14	1.22	1.29	1.36
E	25.0	0.73	0.80	0.89	0.96	1.03	1.12	1.19	1.26	1.33	1.42
M	25.6	0.74	0.83	0.90	0.99	1.06	1.14	1.23	1.30	1.39	1.46
P	26.1	0.77	0.86	0.94	1.02	1.10	1.19	1.27	1.36	1.43	1.52
°C	26.7	0.80	0.89	0.97	1.06	1.14	1.23	1.32	1.40	1.49	1.57

TABLE X1.8 Grams/kg; Range: 91.4 to 94.5 kPa

		94.5	94.1	93.8	93.5	93.1	92.8	92.4	92.1	91.7	91.4
	18.3	0.97	1.03	1.07	1.13	1.17	1.23	1.27	1.33	1.37	1.43
D	18.9	1.02	1.07	1.13	1.19	1.24	1.30	1.34	1.40	1.46	1.52
E	19.4	1.04	1.10	1.16	1.22	1.27	1.34	1.40	1.46	1.52	1.57
W	20.0	1.09	1.14	1.20	1.27	1.33	1.39	1.44	1.50	1.57	1.63
	20.6	1.13	1.19	1.26	1.32	1.37	1.44	1.50	1.56	1.62	1.69
P	21.1	1.14	1.23	1.29	1.36	1.42	1.49	1.56	1.62	1.69	1.74
O	21.7	1.16	1.27	1.33	1.40	1.47	1.54	1.60	1.67	1.74	1.80
I	22.2	1.24	1.32	1.39	1.46	1.53	1.60	1.66	1.73	1.80	1.87
N	22.8	1.29	1.36	1.43	1.50	1.57	1.66	1.73	1.80	1.87	1.94
T	23.3	1.34	1.42	1.49	1.57	1.64	1.72	1.79	1.86	1.94	2.02
	23.9	1.39	1.46	1.54	1.62	1.70	1.77	1.84	1.93	2.00	2.09
T	24.4	1.43	1.52	1.59	1.67	1.76	1.84	1.92	2.00	2.09	2.16
E	25.0	1.49	1.57	1.66	1.74	1.83	1.92	1.99	2.07	2.16	2.25
M	25.6	1.54	1.63	1.72	1.80	1.89	1.99	2.07	2.16	2.25	2.33
P	26.1	1.60	1.69	1.79	1.87	1.96	2.06	2.15	2.23	2.32	2.42
°C	26.7	1.66	1.76	1.84	1.94	2.03	2.13	2.22	2.32	2.40	2.50

TABLE X1.9 Saturation Vapor Pressure Over Water (Smithsonian Tables)[A]

Dew Point Temperature,° F	Vapor Pressure, in. Hg	Dew Point Temperature, °F	Vapor Pressure, in. Hg
60	0.52160	75	0.87506
61	0.54047	76	0.90472
62	0.55994	77	0.93524
63	0.58002	78	0.96666
64	0.60073	79	0.99900
65	0.62209	80	1.03230
66	0.64411	81	1.06650
67	0.66681	82	1.10170
68	0.69021	83	1.13800
69	0.71432	84	1.17520
70	0.73916	85	1.21360
71	0.76467	86	1.25300
72	0.79113	87	1.29350
73	0.81829	88	1.33510
74	0.84626	89	1.37790

[A] Reprinted from "Selecting Humidity Sensors for Industrial Processes Handbook", General Eastern Instrument Corp., March 1982.

X2. STATISTICAL EQUATIONS FOR MEAN AND STANDARD DEVIATION

X2.1 See Eq X2.1 and X2.2 where:

$$\bar{x} = \text{mean} = \frac{1}{n}\sum_{i=1}^{n}[Y_i\ (\text{standard}) - Z_i\ (\text{reading})], \qquad \text{(X2.1)}$$

$$s = \text{standard deviation} = \sqrt{\frac{\sum_{i=1}^{n}[(Y_i - Z_i) - \bar{x}]^2}{df}} \qquad \text{(X2.2)}$$

n = total number of data pairs (Y_i, Z_i), and
df = degrees of freedom = n – 1.

X3. EXAMPLES OF FORMS FOR REPORTING

X3.1 *Examples of Reporting Test Results*—See Figs. X3.1-X3.4.

X3.2 When testing candidate oil against the limits of Specification D 4485, report the results of multiple tests on the form shown as Fig. X3.5.

CATERPILLAR 1K/1N TEST REPORT

Form 4A (Example)

Rating Worksheet

METHOD: 1K

TEST NO: 72-112 OIL CODE: CMIR 19869 SR-0177 RATER : GC EOT DATE: 19971130

Grooves															
C	NO. 1			NO. 2			NO. 3			UNDERCROWN			UPPERSKIRT		
a	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM
r	19	1.0	10.00	57	1.0	57.00		1.0			1.0			1.0	
b	40	.50	20.00					.50							
o	41	.25	10.25	42	.25			.25			.25			.25	
n	100	Sub T	49.25	99	Sub T	67.50		Sub T			Sub T			Sub T	
V		1040.0		1	10-1.0	0.090	10	10-9.6	0.040	20	10-8.5	0.300	15	10-9.0	0.15
a		1040.0			10-10.0		20	10-9.9	0.020	15	10-9.0	0.150	45	10.9.5	0.225
r		1040.0			10-10.0		70	1040.0		65	1040.0		40	1040.0	
n		1040.0			10-10.0			1040.0			1040.0			1040.0	
i		1040.0			10-10.0			1040.0			1040.0			1040.0	
s		1040.0			10-10.0			1040.0			1040.0			1040.0	
h		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		Sub T	0.00	1	Sub T	0.090		Sub T	0.060	100	Sub T	0.45	100	Sub T	0.38
		TOTAL	49.25		TOTAL	67.59		TOTAL	0.060		TOTAL	0.45		TOTAL	0.38

LANDS										PINS					
C	NO. 1			NO. 2			NO. 3			FRONT			REAR		
a	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM	A%	FCT	DEM
r	18	1.0	18.00	8	1.0	8.00		1.0			1.0			1.0	
b															
o	65	.25	16.25	87	.25	21.75		.25			.25			.25	
n	83	Sub T	34.25	95	Sub T	29.75		Sub T			Sub T			Sub T	
V	17	10-9.5	0.086	3	10-7.0	0.090	5	10-8.5	0.075	10	10-8.0	0.200	5	10-7.0	0.150
a		1040.0		2	10-5.5	0.090	15	10-9.0	0.150	90	1040.0		5	10.8.0	0.100
r		1040.0			10-10.0		20	10-9.5	0.100		1040.0		90	1040.0	
n		1040.0			10-10.0		25	10-9.9	0.025		1040.0			1040.0	
i		1040.0			10-10.0		35	1040.0			1040.0			1040.0	
s		1040.0			10-10.0			1040.0			1040.0			1040.0	
h		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
		1040.0			10-10.0			1040.0			1040.0			1040.0	
	17	Sub T	0.09	5	Sub T	0.180	100	Sub T	0.350	100	Sub T	0.20	100	Sub T	0.25
		TOTAL	34.34		TOTAL	29.93		TOTAL	0.350		TOTAL	0.20		TOTAL	0.25

	GROOVES			LANDS			UPPER SKIRT	UNDER CROWN	PIN BORE	
	1	2	3	1	2	3			FRONT	REAR
RATING	49.25	67.59	0.06	34.34	29.93	0.35	0.38	0.45	0.20	0.25
WDK LOC FCT	1.5	1.5	25	1	1	25	50	20	0	0
WT RATING	73.88	101.39	1.5	34.34	29.93	8.75	19.00	9.00	0.0	0
TGF 41	INT. GROOVE FILL		62	WDK/WDN		277.8	TOP LAND HVY CARBON			18

FIG. X3.1 Example of Piston Rating Worksheet (Form 4A)

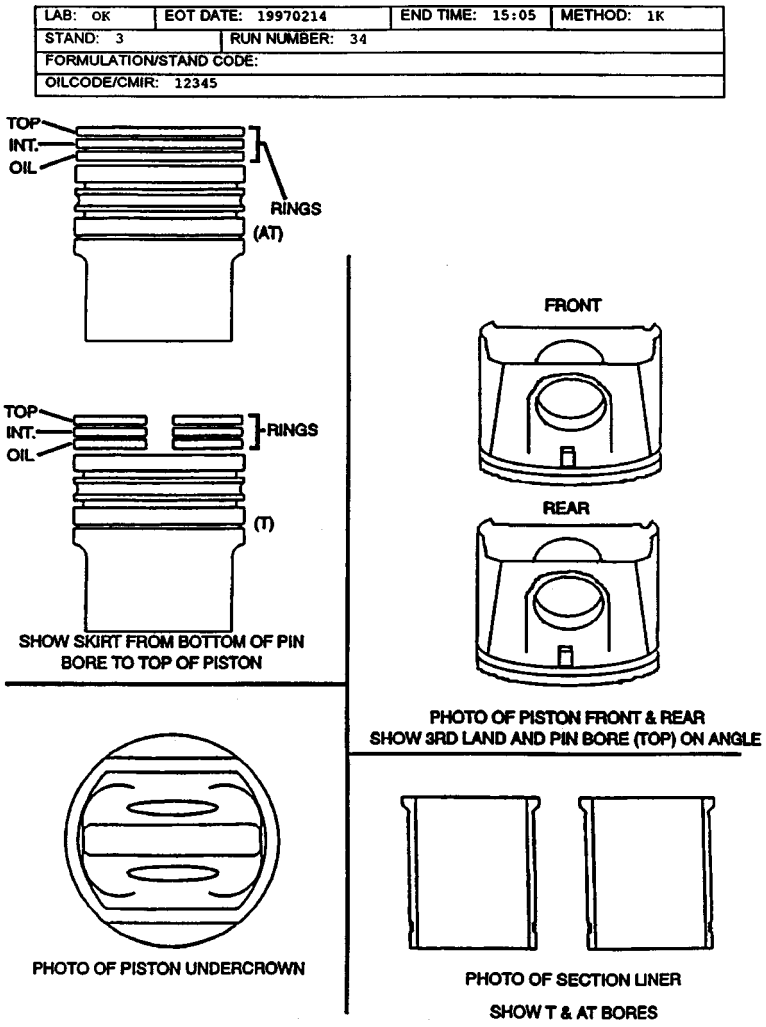

FIG. X3.2 Piston, Ring and Liner Photographs (Example of Form 14)

1K/1N
Form 16 (Example)
TMC CONTROL CHART ANALYSIS

LAB: OK	EOT DATE: 19970214	END TIME: 15:05	METHOD: 1K
STAND: 3	RUN NUMBER: 34		
FORMULATION/STAND CODE:			
OILCODE/CMIR: 12345			

Fax To: JOE ENGINEER
Company: OK OIL TEST LAB
Fax Number: 800-555-1212

*** ASTM TMC ***
*** CATERPILLAR 1K ***
** Control Chart Analysis **

Start = 19970202
EOT date = 19970214
EOT time = 15:05
LTMS date = 19970214
LTMS time = 15:05

Lab = OK
Stand = 3
Run = 34
Reported = 19970218

CMIR = 12345
Oil = 809-1

Analysis compiled: 30FEB97 13:37:09

Parameter	Measured Units	Transformed Units	Targets Mean	Targets s
WDK	175.6		216.4000	35.6000
TGF	19		17.5000	15.7000
TLHC	0	0.0000	0.6050	1.1000
BSOC	0.180		0.2680	0.1450
EOTOC	0.170		0.2750	

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

Key: A - Action alarm
W - Warning alarm

Stand Analysis

	N	EWMA Z(I)	EWMA Severity Limit	EWMA Severity Alarm	EWMA Q(I)	EWMA Precision Limit	EWMA Precision Alarm	SHEWHART Y(I)	SHEWHART Severity Limit	SHEWHART Severity Alarm	SHEWHART R(I)	SHEWHART Precision Limit	SHEWHART Precision Alarm
WDK	9	-0.444	±0.882		-0.611	+0.756		-1.146	±1.750		-0.940	+1.800	
TGF	9	-0.125	±0.882		-0.107	+0.756		0.096	±1.750		-0.228	+1.800	
TLHC	9	-0.348	±0.882		-1.015	+0.756		-0.550	±1.750		-2.329	+1.800	
BSOC	9	-0.632	±0.882		-0.981	+0.756		-0.607	±1.750		-1.437	+1.800	
EOTOC	9	-0.307	±0.882		-1.134	+0.756		-0.344	±1.750		-1.796	+1.800	

Laboratory Analysis

	N	EWMA Z(I)	EWMA Severity Limit	EWMA Severity Alarm	EWMA Q(I)	EWMA Precision Limit	EWMA Precision Alarm	SHEWHART Y(I)	SHEWHART Severity Limit	SHEWHART Severity Alarm	SHEWHART R(I)	SHEWHART Precision Limit	SHEWHART Precision Alarm
WDK	124	-1.007	±0.653	SA	-0.673	+0.600 +0.860		-1.146	±1.750		-1.489	+1.800	
TGF	124	-0.320	±0.653		-0.331	+0.600 +0.860		0.096	±1.750		0.302	+1.800	
TLHC	124	-0.503	±0.653		-1.043	+0.600 +0.860		-0.550	±1.750		-0.974	+1.800	
BSOC	124	-0.708	±0.653	SA	-0.990	+0.600 +0.860		-0.607	±1.750		-1.488	+1.800	
EOTOC	124	-0.380	±0.653		-1.331	+0.600 +0.860		-0.344	±1.750		-1.635	+1.800	

** SEVERITY ADJUSTMENTS **
WDN SA = 35.8 TGF SA = TLHC SA =

* TMC Validity Code:____

AC = Acceptable Calibration.
OC = Oper. Valid, Failed Acceptance Criteria.

Calibration Expires: _____
__ Stand Pulled From LTMS
* Based on review of call-in report of operational data and control chart analysis shown above.

		EWMA				SHEWHART	
		Lambda		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Action	0.3	0.3	1.8	2.1	1.8	1.75
Lab	Warning	0.2		1.8			
	Action	0.2	0.2	2.58	1.96	1.8	1.75
Industry	Warning	0.15	0.15	1.74	2.05		
	Action	0.15	0.15	2.58	2.81		

FIG. X3.3 TMC Control Chart Analysis (Example of Form 16)

1K/1N
Form 17 (Example)
FUEL BATCH ANALYSIS

LAB: OK	EOT DATE: 19970301	END TIME: 17:15	METHOD: 1K
STAND: 3	RUN NUMBER: 35		
FORMULATION/STAND CODE:			
OILCODE/CMIR: 12346			

Product: LSRD-4 Batch: 9701234
Date: 19970121 Tank: 84

SPECIFICATIONS

TEST	METHOD		MIN	MAX	RESULT
Distillation, °F (°C)	D-86	IBP	350 (177)	390 (199)	196
		5%			214
		10%	410 (210)	450 (232)	219
		30%			239
		50%	480 (249)	530 (277)	262
		70%			287
		90%	570 (299)	620 (327)	316
		95%			327
		EP	620(327)	680 (360)	339
		Recovery, vol %	Report		98.4
		Residue, vol %	Report		1.6
		Loss, vol %	Report		0.0
Gravity, °API[A]	D-287		32.0	36.0	34.5
Cetane Number[B]	D-613		42.0	48.0	46.8
Cetane Index	D-976		Report		45.3
Cetane Index	D-4737		42.0	48.0	45.3
Flash Point, °F (°C)	D-93		130 (54)		81
Cloud Point, °F (°C)	D-2500			10 (-12)	17
Pour Point, °F (°C)	D-97			0 (-18)	-21
Sulfur, wt. %	D-2622		0.030	0.050	0.041
Acid Number, mg KOH/g	D-664		Report		<0.05
Viscosity, cSt @ 40°C	D-445		2	3.2	2.7
Hydrocarbon Composition, vol %					
Aromatics	D-5186		28.0	35.0	29.6
Olefins	D-1319		Report		1.4
Saturates	D-1319		Report		69
Copper Corrosion, 3h @ 212°F	D-130			3	1A
Ash, wt. %	D-482			0.01	.002
Ramsbottom Carbon, 10% residuum	D-524			0.35	0.08
Basic Sediment & Water, vol %	D-2709			0.05	<0.01
Aliphatic paraffins	D-2425		Report		46.78
Monocycloparaffins			Report		10.55
Dicycloparaffins			Report		8.08
Tricycloparaffins			Report		5.37
Alkylbenzenes			Report		9.16
Indanes/Tetralins			Report		5.32
Indenes			Report		4.12
Naphthalene			Report		0.77
Naphthalenes			Report		6.56
Acenaphthenes			Report		1.49
Acenaphthylenes			Report		1.13
Tricyclic aromatices			Report		0.67

[A]Alarm Spec 34.0 - 36.0 [B]Alarm Spec 45.0 - 48.0

Approved by: _____ _____
HHC Laboratory Analyst

FIG. X3.4 Fuel Batch Analysis (Example of Form 17)

OIL CODE NO. _____

CHECK ONE	
1K	1N

TEST NO.	DATE TEST COMP.	OIL CODE NO.	TEST LAB.	ENGINE NUMBER			FINAL LAB RATING			BSOC, g/kW-h	
				SERIAL	STAND	RUN	WDK	TGF	TLHC	0-252	0-24
1ST											
2											
3											
4											
TEST AVERAGE											
1ST											
2											
3											
4											
		2 TEST AVERAGE WITH OUTLIER REMOVED									
		3 TEST AVERAGE WITH OUTLIER REMOVED									

FIG. X3.5 1K/1N Multiple Test Data Summary Sheet

X4. OPTIONAL RECORDING OF RELEVANT CANDIDATE OIL PASS LIMIT INFORMATION

X4.1 If the non-reference oil test result is to be offered as a candidate oil test result against an engine oil specification, such as Specification D 4485, then the relevant candidate oil pass limit information may be recorded on Fig. A13.2 using the mnemonics LDESC, DTCEFF, WPDL, TGFPL, TLHCPL, BSCOPL, and EPTOCPL.