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1K/1N Information Letter No. 04-1
Sequence No. 23
February 23, 2004

ASTM consensus has not yet been obtained on this information letter. An appropriate ASTM ballot will be issued in order to achieve such consensus.

TO: Single Cylinder Diesel Mailing List

SUBJECT: Report Package Revision and Removal of Report Package from Test Method Editorial Changes

The Single Cylinder Surveillance Panel has approved several changes to Test Method D 6750 (1K/1N). The changes below are effective immediately.

The report forms and data dictionary (Annexes A13 and A14) are being removed from the test method. Instead, the test method will refer the reader to the TMC website for the most recent report package.

Several editorial changes are also being made. The updated sections of the test method are attached.

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Attachment

c: ftp://ftp.astmtmc.cmu.edu/docs/diesel/scote/procedure_and_ils/1k-1n/il04-01.pdf

Distribution: Email

(Revises Test Method D 6750-02)

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 (TMC)[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 uses 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.

Section 3.2.1 — *heavy land carbon*, *n*—see CRC Manual 20.[14]

Section 3.2.3 — *liner bore polishing*, *n*—see CRC Manual 20.

Section 3.2.6 — *scratching*, *n*—see CRC Manual 20.

Section 3.2.7 — *scuffing*, *n—in lubrication*, see CRC Manual 20.

Section 3.2.9 — *varnish*, *n—in internal combustion engines*, see CRC Manual 20.

Section 5 — Replace the entirety of Section 5 with the following:

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.

5.2 The 1K test was correlated with vehicles equipped with certain multi-cylinder direct injection engines used in heavy duty and high speed service prior to 1989, particularly with respect to aluminum piston deposits, and oil consumption, when fuel sulfur was nominally 0.4% by mass. These data are given in research report RR:D02-1273 (footnote 11).

5.3 The 1N test has been used to predict piston deposit formation in four-stroke cycle, direct injection, diesel engines that have been calibrated to meet 1994 U.S. federal exhaust emission requirements

for heavy-duty engines operated on fuel containing less than 0.05% mass sulfur. See research report RR:D02-1321 (footnote 11).

5.4 These test methods are used in the establishment of diesel engine oil specification requirements as cited in Specification D 4485 for appropriate API Performance Category oils (API 1509).

5.5 These test methods are also used in diesel engine oil development.

Section 6.1.3 *Parts Rating Area*—Maintain as specified in CRC Manual No. 20.

Section 6.3.7.4 *Fuels*—The required 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.

(1) Use the high heating value to calculate the fuel rate as specified in Annex A10 and Table A12.2.
(2) A fuel analysis form is provided for each batch of fuel by Haltermann Products. Include this analysis as the Fuel Batch Analysis form of the test report.
(3) If more than one batch is used, note that on the Unscheduled Downtime & Maintenance Summary form of the test report. List appropriate percentage of run time for each batch.
(4) For stands calibrated for both 1K and 1N tests simultaneously, take a sample of the fuel at the stand prior to each test and have it analyzed for sulfur. Report the results of this analysis in the Unscheduled Downtime & Maintenance Summary form of the test report.

Section 7.3 *Solvent*—Use only mineral spirits meeting the requirements of Specification D 235, Type II, Class C. (Warning – Combustible. Health hazard.)

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

Section 9.2.2.1 Flush with mineral spirits.

Section 9.2.2.2 Flush with a mixture of mineral spirits and a dispersant engine cleaner.

Section 9.2.2.3 Flush with additional repeated flushes with mineral spirits until the solvent remains clean.

Section 9.2.2.4 Flush 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).

Section 9.2.2.5 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.

Section 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 mineral spirits. Allow to air dry.

Section 9.2.7.7 Place the flushing pump inlet in a clean supply tank containing 7.6 L (2 gal) of mineral spirits. 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.

Section 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 mineral spirits.

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

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

Section 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 mineral spirits left in the system out through the crankcase drain. After the mineral spirits 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).

Section 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.

Section 9.3.3.1 Before the test clean all three rings using pentane and a lint-free cotton cloth.

Section 9.3.3.2 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, confine the ring 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.

Section 9.3.3.3 Measure minimum side clearance in accordance with directions in CRC Manual 20. Measurement may also be made using taper gages.

Section 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 mineral spirits, then clean the liner bore with a hot water/detergent solution (see 7.5) and rinse with hot water.

Section 9.3.4.1 Measure the surface finish and record the results on the Liner Measurements form of the test report. Oil the liner bore with Exxon-Mobil EF-411 oil.

Section 9.3.4.2 Assemble the cylinder liner, block and head, torquing the stud nuts as shown in Fig. A1.5.

Section 9.3.4.3 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.

Section 9.3.4.4 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.

Section 10.1.3 Begin all non-reference oil tests at least 252 h before the expiration of the current calibration.

Section 10.3.1 Top groove fill (TGF), percent volume (critical parameter).

Section 10.3.2 Weighted total deposits (WD), demerits (critical parameter).

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

Section 10.8.3 Control Chart Techniques for Severity Adjustment *(SA)*— Include all operationally valid calibration test results on a laboratory control chart. Record the test results on the chart in order of completion. Record EOT date and time for all tests. Report all time as hour and minutes according to the 24 h clock (1 a.m. = 1:00, 1 p.m. = 13:00). Reporting completion time allows proper ordering of tests completing on the same day. 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. Compute the exponentially weighted moving average (EWMA) for all standardized calibration oil test results. To calculate EWMA, standardize the test results using the following ratio: Delta/SD ((result — target)/standard deviation). The target and standard deviation values are available from the TMC. Calculate EWMA values using the following equation:

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

where:
$Z_0 = 0$
Y_i = standardized test result

Z_i = EWMA of the standardized test result at test order *i*
Lambda = the appropriate lambda from the LTMS document

Section 10.8.4.2 Since | 0.896 | > 0.653, apply an SA as follows: SA = –1 × EWMA × SD (in the example, SA = –14). For TGF, round the SA to a whole percent; for WD, round to one decimal place; and for TTLHC, round to three decimal places. Do not adjust BSOC and EOTOC for severity. Enter these SA numbers on the Test Report Summary of the test report and add them to the test results. Recalculate all SA's at the completion of every calibration test.

Section 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 these values on the Operational Summary - Offset And Deviation form of the test report.

Section 11.5.3 Derive 12-h oil consumption data points.

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

Section 11.5.4 Derive average values of oil consumption for recording on the Oil Analysis And Results Summary form of the test report. Also derive and record average oil consumptions between 0 to 24 h and 0 to 252 h.

Section 11.7 *Shutdowns, Lost Time, and Off Tolerance Conditions*— Report the test hours, date, and length of off-test conditions for all occurrences on the Unscheduled Downtime & Maintenance Summary of the test report. Record the occurrence of off-test conditions, early engine 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.

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

Section 11.7.2 In the event of an emergency shutdown, allow the engine to cool for 2-h before restarting.

Section 11.10 *Recording of Engine Conditions*—Note the engine conditions listed in Table A10.1 at least once per hour. Record data before adjustments are made. These data show the actual engine conditions at each hour of the test; do not average data logged during the course of the test hour.

Section 12.1 Refer to the appropriate report forms before doing the inspections and recording the data. Standard report forms are available from the TMC website (http://www.astmtmc.cmu.edu).

Section 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 and rings and section the cylinder liner (see Fig. X3.2).

Section 12.3.1 *Deposit Ratings, Photographs, Measurements*— Remove the piston and ring assembly from the engine. Examine the assembly and rate the components in accordance with the CRC Diesel Piston Rating System Manual No. 20 that uses the varnish scale (see A11.1). Photograph the pistons and rings, and perform deposit ratings as follows:

Section 12.3.1.2 When rating second groove and land deposits, categorize all deposits as either heavy or light. For this test method, any deposits not meeting the definition of heavy are categorized as light.

Section 12.3.1.4 Use a piston deposit demerit rating as specified in CRC Manual 20.[14]

Section 12.3.1.8 *Referee Ratings*—To detect quickly and correct any shifts in rater severity, obtain referee ratings for all operationally valid calibration tests. Referee ratings are also required for tests reviewed by the test developer. Provide the rating breakdown for land 1 to the referee laboratory so that the referee rater can use those figures in computing weighted piston deposits (WD). Do not provide any other rating information to the referee laboratory. For shipping to the referee laboratory, wrap pistons in paper and seal them in a plastic bag along with the CRC-approved desiccant chips. Report referee results to the TMC within ten working days of test completion.

Section 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. 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 on the Test Report Summary and Ring Measurements forms of the test report.

Section 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 implement made from a soft material such as wood. Measure and record the end gap in accordance with 9.3.3 and record on the Ring Measurements form of the test report.

Section 12.3.4.3 Record the measurements as liner wear on the Liner Measurements form of the test report.

Section 12.3.4.4 Section the cylinder liner for measurement of the amount of bore polishing and for photographing. Photograph the sectioned liner so as to show the thrust and anti-thrust sides (see Annex A11 and Fig. X3.2). Use the proposed CRC Diesel Liner Rating Method (May 1985) (see A11.3).

Section 12.4.1 *New Oil Inspections*—Perform the following tests on the new oil (see the Oil Analysis And Results Summary for of the test report):

Section 12.5 *Oil Consumption*— Delete the entirety of this section. It is a repeat of Section 11.5.

Section 12.6 *Unscheduled Shutdowns and Off-Limit Operation*— Delete the entirety of this section. The material is covered in Section 11.7 and Section 13.

Section 13 Replace the entirety of Section 13 with the following:

13. Report

13.1 Report Forms — For reference oil tests, the standardized report forms and data dictionary for reporting test results and for summarizing the operational data are required. All report forms making up the 1M-PC final report are available at the TMC website (http://www.astmtmc.cmu.edu).

13.1.1 Report all deposits, wear and engine operational data as required by the report forms.

13.1.2 Report a summary of the overall test results on the Test Report Summary form of the test report.

13.1.3 Show the engine operating conditions on the Operational Summary form and Engine Operational Data Plots forms of the test report. Plot each hourly data point.

13.1.3.1 The graphs may be formatted as one per page or any combination that the laboratory desires so long as the parameters are presented in the same order as shown and with adequate resolution.

13.1.4 Oil Consumption:

13.1.4.1 Calculate average oil consumption for each 12-h period and record on the Oil Consumption Plot.

13.1.4.2 For end-of-test oil consumption (EOTOC), report 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.

13.1.5 Ring and Liner Wear Measurements:

13.1.5.1 Report ring and liner measurements on the Ring Measurements and Liner Measurements forms respectively.

13.1.6 Reporting of Unusual Conditions – Report any unusual conditions on the Unscheduled Downtime & Maintenance Summary form of the test report.

13.1.6.1 Record instances of missing or mis-recorded test data.

13.1.6.2 If a test has more than four hours without data acquisition on any controlled parameter, report it as operationally invalid.

13.1.6.3 Note in the Comments section of the Unscheduled Downtime & Maintenance Summary form if any alternative, backup data acquisition method is used to record data.

13.1.6.4 Record the test hours and time and date of all occasions where the engine is shut down or operated out of test limits on the Unscheduled Downtime & Maintenance Summary form of the test report.

13.1.6.5 Report all prior reference test events that were deemed operationally and statistically invalid or aborted. Account for all runs during the calibration sequence.

13.1.7 Include in the report photographs of the pistons, rings and sectioned liner showing the thrust and anti-thrust sides (see Fig. X3.2 for an example).

13.2 Electronic Transmission of Test Results (Optional):

13.2.1 Transmit test results electronically using the ASTM Data Communications Committee Electronic Test Report Transmission Model (see Section 2 – Flat File Transmission Format) available from TMC.

13.3 Reporting Calibration Test Results

13.3.1 Transmit calibration test results to TMC immediately after completion of the test. For the test to be considered valid, the laboratories shall transmit data to TMC within seven days of end of test (EOT).

13.3.2 Only laboratories approved by TMC for doing so may transmit test results electronically (see 13.2).

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

13.3.3.1 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.

13.3.3.2 If the calibration test results are judged not acceptable, make every effort to determine the cause of the anomalous result. If an explanation is not readily available, check all test related equipment. If a fault is still not identifed, consider the problem to be laboratory-

related and contact the TMC to schedule another reference oil assignment.

13.3.4 Send one copy of the standard final test report for reference oil tests to both of the following:

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

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

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

Section 14.1.2 *Intermediate Precision Conditions*—Conditions where test results are obtained with the same test method using the same test oil, with changing conditions such as operators, measuring equipment, test stands, test engines, and time.

Note 1: Intermediate precision is the appropriate term for this test method rather than repeatability which defines more rigorous within-laboratory conditions.

Section 14.1.2.1 *Intermediate Precision Limit (i.p.)*—The difference between two results obtained under intermediate precision conditions that would in the long run, in the normal and correct conduct of the test method, exceed the values shown in Tables 2 and 3 in only one case in twenty.

Section 14.1.3 *Reproducibility Conditions*—Conditions where test results are obtained with the same test method using the same test oil in different laboratories with different operators using different equipment.

Section 14.1.3.1 *Reproducibility Limit (R)*—The difference between two results obtained under reproducibility conditions that would, in the long run, in the normal and correct conduct of the test method, exceed the values in Tables 2 and 3 in only one case in twenty.

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) [1]	0.918	2.570	0.932	2.610
Average oil consumption, g/Kw-h	0.086	0.241	0.089	0.249

[1] This parameter is transformed using ln(TLHC + 1). When comparing two test results on this parameter, first apply this transformation to each test result. Compare the absolute difference between the transformed results with the appropriate (repeatability, intermediate precision, or reproducibility) precision limit.

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) [1]	0.838	2.346	0.846	2.369
Average oil consumption, g/Kw-h	0.084	0.235	0.085	0.238

[1] This parameter is transformed using ln(TLHC + 1). When comparing two test results on this parameter, first apply this transformation to each test result. Compare the absolute difference between the transformed results with the appropriate (repeatability, intermediate precision, or reproducibility) precision limit.

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

Annex A1.2.2 Clean valves with a clean cloth and mineral spirits.

Annex A1.2.9 Clean the head and guides with mineral spirits and blow dry.

Annex A1.2.10 Lubricate the valves and guides with engine oil (Mobil EF-411) and assemble into the head.

Annex A11.1 *Manual for Rating Piston and Liner*—Rate piston and liner in accordance with CRC Manual No. 20. This includes rating the varnish deposit and using 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 as described in CRC Manual No. 20.

Annex 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 mineral spirits and then with a soft, clean, dry cloth.

Annex A12.2.6 Record these percent calculations on the Operational Summary - Offset And Deviation form of the test report.

Annex A13 Download report forms and data dictionary from the ASTM Test Monitoring Center (TMC) Web Page at: http://www.astmtmc.cmu.edu/. TMC can also provide hardcopies on request.

Report Form Table of Contents

1. Final Report Cover Sheet — Cover
2. Test Report Summary — Form 1
3. Operational Summary — Form 2
4. Operational Summary – Offset and Deviation — Form 3
5. Piston Rating Summary — Form 4

6.	Piston Rating Worksheet	Form 4a
7.	Supplemental Piston Deposits(Groove Sides And Rings)	Form 5
8.	Referee Rating	Form 5a
9.	Oil Analysis And Results Summary	Form 6
10.	Unscheduled Downtime & Maintenance Summary	Form 7
11.	Ring Measurements	Form 8
12.	Liner Measurements	Form 9
13.	Characteristics of the Data Acquisition System	Form 10
14.	Engine Operational Data Plots	Form 11
15.	Engine Operational Data Plots (2)	Form 12
16.	Oil Consumption Plot	Form 13
17.	Piston, Ring, and Liner Photographs	Form 14
18.	Severity Adjustment History	Form 15
19.	TMC Control Chart Analysis	Form 16
20.	Fuel Batch Analysis	Form 17

Note 1 – If the test will be submitted to the registration organization as a candidate oil, then use the same forms used for reporting reference test results and add the ACC Conformance Statement, Form 18.

Annex A14 Delete entirety of this section.

Section 1.5 (Table of Contents) and Annexes: Renumber as necessary.