A Program of ASTM International

Test Monitoring Center

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Sequence VG Information Letter 14-5
Sequence No. 42
November 10, 2014

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

TO: Sequence VG Mailing List

SUBJECT: 1. Additional AFR Monitoring Device
2. Modification to Figure 7
3. Standardized wording describing the role of the TMC

1. During the October 22, 2014 Sequence VG Surveillance Panel meeting, the panel agreed to allow the use of an additional Horiba AFR measurement device. Section X1.22. has been revised to include the Horiba devices. This change is effective October 22, 2014.
2. During the October 22, 2014 Sequence VG Surveillance Panel meeting, the panel agreed to allow the use of a pressure sensor for blowby gas measurement. Figure 7 has been revised to show a manometer or pressure sensor under (6) in the legend. This change is effective October 22, 2014.
3. At a June 23, 2014 meeting, ASTM Section D02.B0.10 on Standards Acceleration approved standardized wording describing the role of the Test Monitoring Center. Subcommittee B has requested that the TMC incorporate this wording into all test methods through the information letter system. These changes are effective with the issuance of this letter.

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Attachment

c: ftp://ftp.astmtmc.cmu.edu/docs/gas/sequencev/procedure_and_ils/vgil14-5-42.pdf

Distribution: Email

(Revises Test Method D6593-14, as amended by information letters 14-1, 14-2, 14-3 and 14-4)

The following Table summarizes the renumbering of Annexes.

Current Annex Description	Current Annex Number	New Annex Number
Safety Hazards	Annex A1	Annex A5
Control and Data Acquisition Requirements	Annex A2	Annex A6
Detailed Specifications and Photographs of Apparatus	Annex A3	Annex A7
Special Service Tools for the Test Engine	Annex A4	Annex A8
Test Engine Part Number Listing	Annex A5	Annex A9
External Oil Heat Exchanger Cleaning Technique	Annex A6	Annex A10
Sequence VG Report Forms and Data Dictionary	Annex A7	Annex A11
Dipstick Calibration	Annex A8	Annex A12
Critical Part Supplier List	Annex A9	Annex A13
Operational Data Log-Engine Oil	Annex A10	Annex A14
Rating Worksheets	Annex A11	Annex A15
Fuel Injector Flow Measurements	Annex A12	Annex A16

Revised introduction section to address additional TMC description items

INTRODUCTION

This test method is written for use by laboratories that utilize the portions of the test method that refer to ASTM Test Monitoring Center (TMC) services (see Annex A1). Laboratories that choose not to use the TMC services may simply disregard these portions.

The TMC provides reference oils, and engineering and statistical services to laboratories that desire to produce test results that are statistically similar to those produced by laboratories previously calibrated by the TMC.

In general, the Test Purchaser decides if a calibrated test stand is to be used. An organization such as the American Chemistry Council requires that a laboratory use the TMC services as part of their test registration process. In addition, the American Petroleum Institute requires that a laboratory utilize the TMC services in seeking of qualification of oils against its specifications.
Added new note one

Note 1--The advantage of using the TMC services to calibrate test stands is that the test laboratory (and hence the Test Purchaser) has an assurance that the test stand was operating at the proper level of test severity. It should also be borne in mind that results obtained in a non calibrated test stand may not be the same as those obtained in a test stand participating in the ASTM TMC services process.

The following Sections have been revised to update references to Annexes, NOTEs or Figures in Annexes whose designation has changed.

6.5 The control and data acquisition system shall meet the requirements listed in Annex A6.

7.1 *Sequence VG Test Engine*—The test engine kit is available from the Ford Motor Co. (A13.1). Parts from the engine may be used for as many as four tests. A detailed listing of all parts included in the kit is

given in Annex A9.

7.2 *Required New Engine Parts*—Use the parts listed in the engine kit (see A9.1). Use a new gasket kit for each test. Do not modify or alter test parts without the approval of Sequence V Surveillance Panel.

7.3 *Reusable Engine Parts*—The parts listed in the test stand set up kit, supplemental stand set up kit, engine dress kit, and engine finish and fastener kit can be reused (all of these can be used in numerous engine assemblies as long as they remain serviceable). See Annex A9. Crankshaft, connecting rods, timing chain covers and cylinder heads may be used for multiple engine assemblies as long as they remain serviceable. Camshafts can be used for as many as four tests as long as they remain serviceable. As the block can be used for as many as four tests, damaged threads in the block can be corrected with commercially available thread inserts.

7.4.1 *Intake Air System* (see Fig. 2 and Figs. A7.1 and A7.2)—Intake air system shall use the stock Crown Victoria configuration with the air horn removed from the air cleaner.

7.4.2 *Camshaft Baffles* (see Fig. A7.3)—These are fabricated for attachment to the under side of the rocker cover. The clearance between the edges of the baffle and the (rocker arm cover) RAC permits a limited splash flow of oil to the top of the baffle and the RAC. Therefore, the dimensional accuracy of the baffle is important to minimize the influence on test severity. The camshaft baffle is available from the supplier listed in A13.2.

7.4.3 *Crankcase Oil Fill Port*—The crankcase oil fill port is located towards the rear of the left rocker cover. See item 8 and 9 on Fig. A7.4.

7.4.4 *Dipstick and Dipstick Tube* (see Fig. A7.6)—The dipstick has been modified for accurate oil level measurements. The dipstick and dipstick tube are calibrated as a pair. If either part is replaced, recalibrate the pair. Use the dipstick and dipstick tube available from the supplier listed in A13.2.

7.4.5 *Oil Pan*—Use a modified oil pan with removable baffles as shown in Fig. A7.7 from the supplier listed in A13.2.

7.4.6 *Exhaust Manifold*—The required exhaust manifolds (see A13.4), transition plates (see A13.3) and exhaust system are shown in Figs. A7.15 and A7.16. A heated exhaust gas oxygen (HEGO) sensor is installed in the exhaust system after each exhaust manifold.

7.4.7 *Flywheel*—Use the flywheel listed in Annex A9.

7.4.8 *Rocker Arm Cover (RAC)*—The RAC is fabricated from stainless steel and incorporates a water jacket and bolt bosses for the camshaft baffle (see Figs. A7.3-A7.5). The RAC, bolts, and washers supplier is listed in A13.2. As the RAC is used for multiple tests, leaks to the external cooling jacket may be repaired by welding or other suitable means. Do not modify the rated surfaces of the RAC.

7.4.9 *Oil Filter*—Use a 60 µm screen type oil filter with a bypass (see Fig. A7.8) available from the supplier listed in X2.1.20.

7.4.10 *Oil Pan Insulation*—The oil pan is covered with a fiberglass insulation to reduce the effects of ambient temperature variations. The insulation supplier is listed in A13.2.

7.5 *Special Engine Measurement and Assembly Equipment*—Items routinely used in laboratory and workshop are not included. Use any special tools or equipment shown in the 1994 and 2000 Crown Victoria Service Manual[19] for assembly. A list of these tools is shown in Annex A8. Complete any assembly instructions not detailed in Section 7 according to the instructions in the 1994 and 2000 Crown Victoria Service Manual.

7.5.1 *Piston Ring Positioner*—Use the piston ring positioner to locate the piston rings from the cylinder block deck surface by 28.5 mm. This allows the compression rings to be positioned in a consistent location in the cylinder bore before measurement. Fabricate the positioner according to the details shown in Fig. A7.9.

7.5.2 *Piston Ring Grinder*—A ring grinder is required for adjusting ring gaps. A suitable ring grinder is noted in 7.8.5.1.

7.5.3 *PCV Valve Flow Rate Device:*

7.5.3.1 Use this device to verify the flow rate of the PCV valve before the test and measure the degree of clogging after the test. Fabricate the device according to the details shown in Fig. A7.10. The device shall have a full scale accuracy of 5 % and a resolution of 0.05 L/s (see 7.6.7).

7.5.4 *Engine Service Tools*—A complete list of special tools for the test engine is shown in Annex A8.

The tools are available from a Ford dealership. These are designed to aid in performing several service items, in addition to the following specific service items that require special tools to perform the functions indicated (if not self-explanatory).

7.5.6 *Oil Screen Blowdown Device*—Use the device available from the supplier listed in A13.3 to blow a controlled amount of compressed air across the oil screen to remove any oil that is retained on the oil screen after allowing it to drain.

7.6.2.1 The required intake manifold modifications entail blocking off the EGR port (block off plate shown in Fig. A7.11) and the coolant bypass port. Block coolant bypass port in intake manifold by tapping the hole and installing a $^{1}/_{2}$ in. NPT pipe plug. Replace the idle air bypass motor with the idle load control system. A schematic of the system and the idle air block off plate are shown in Fig. A7.12 and Fig. A7.13, respectively.

7.6.7 *PCV Valve*—Measure and record the flow rates of the PCV valve with the calibrated flow device described in 7.5.3 and Fig. A7.10. Measure the flow rate at (25 and 60) kPa vacuum. Because of the hysteresis in the PCV valve spring, make the vacuum adjustments in one direction only. Measure the flow rate twice and average the readings. Reject any PCV valve that does not exhibit an average flow rate of (90 to 140) L/min at 25 kPa and (30 to 50) L/min at 60 kPa.

7.6.8 *Water Pump Drive System*—Use only the pulleys provided in the Sequence VG test stand set-up kit (see Annex A9), crankshaft, water pump, grooved idler and tensioner, and a five or six groove belt, 956 mm in length to ensure that the water pump rotates at the proper speed and direction.

7.6.9 *Engine Coolant Temperature Sensor*—Modify engine coolant temperature sensor by attaching a relay and a resistor of 13 kΩ between the ECT sensor and the EEC as shown in Fig. A7.14.

7.7 *Solvents and Cleaners Required*—No substitutions for 7.7.1 – 7.7.5 are allowed. (**Warning—**Use adequate safety provisions with all solvents and cleaners. See Annex A5.)

7.8.4.1 *Honing:*

(1) Install the block in the honing machine. Use a Sunnen CV-616 honing machine to hone the block. Install the block with the right cylinder bank on the outside and the front of the block to the right. Verify the honing oil has been changed within the past 15 h, and change if necessary.

(2) Set the honing machine to flow Sunnen LP8X fluid at a nominal rate of 7 L/min. Set the feed rate to 4 with 57 strokes per minute and spindle speed of 170 r/min. Set the stroke for 133.35 mm and lower the block for 10 mm overstroke.

(3) Install EHU512 stones. Typical pressures of 25 to 40 units have found to be acceptable. Hone the right bank in the following order, cylinder 1, 3, 4 and 2. Hone the left bank in the following order, Cylinder 7, 5, 8 and 6. Following this order will minimize the possibility of overheating one area of the block. The block may be rotated in the honing machine and does not have to be removed to hone the other bank.

(4) Install JHU725 stones and hone for approximately five strokes at 20 to 25 units of pressure in the order described in 7.8.4.1*(3)*.

(5) Install a plateau hone brush and hone at 25 to 30 units of pressure to obtain a surface finish of (8 to 13) µm. Typically 45 strokes have provided acceptable results.

(6) Measure the cylinder bore using a bore ladder shown in Fig. A7.28. Measure bore both longitudinally and transversely. Determine the bore diameter for piston clearance purposes by adding the middle and bottom transverse bore measurements and dividing by two. Measure the piston skirt 42 mm from the top of the piston. Subtract this value from the bore measurement and verify that the piston-to-bore clearance is within (0.020 to 0.046) mm. Re-hone the block or choose a different diameter piston to obtain this clearance.

7.8.2.1 Use silicon-based sealer sparingly since it can elevate the indicated silicon content of the used oil.

NOTE 2—Non-silicon liquid or tape thread sealers can be used on bolts and plugs.

7.9.4 *Cylinder Head Installation*—Cylinder heads are obtained from the supplier in A13.3. Heads may be used for multiple tests, as long as they remain serviceable.

7.9.4.1 Heads may also be procured from the source listed in A13.5. Modify heads from this source to accept cam bearings, and have new valve guides installed, by the source listed in A13.6.

7.9.5.4 Repeat the procedure in 7.9.5.3 for the right hand timing chain. After installation, the timing chain shall hang between the chain guide and the tensioner dowel.

NOTE 3—There should be a minimum of chain slack on the tension side between the two sprockets.

7.9.6 *Rocker Arm Cover and Baffle*—Fasten the camshaft baffle to the rocker cover. Cut off the tabs from the rocker cover gasket and install it in the gasket groove on cover rail. Install rocker arm cover on the cylinder head and confirm that the baffle does not contact any valve train components. Using new rubber washers on the bolts, torque the bolts to (8 to 12) N·m (the rubber washers are not reusable). The two rocker covers are different, ensure that the correct cover is installed on the correct head (Figs. A7.4 and A7.5).

7.9.7 *Oil Pan, Baffles, and Insulation*—Install front and rear oil pan baffles to the oil pan as shown in Fig. A7.7. Install front baffle first. Install the oil pan according to the procedure in the service manual. Install the oil pan insulation over the oil pan.

7.10.2.1 The required exhaust manifold, a typical exhaust system, and fittings for exhaust gas sampling are illustrated in Figs. A7.15 and A7.16. Exhaust components should be constructed of either solid or bellows pipe/tubing. Other type flexible pipe is not acceptable.

7.10.3 *Oil Dipstick and Tube*—Install modified oil dipstick and dipstick tube, described in 7.4.4, in the engine block at the production location and attachment points.

NOTE 4—The intake manifold, the rocker arm covers, and the exhaust manifolds can be installed after the engine is installed on the test stand.

7.10.4.1 *Fuel Rail Injectors:*

(*1*) The fuel injectors can be used for multiple tests providing they meet the requirements delineated in Annex A16. Fuel injectors that have caused misfires in previous tests should be cleaned before reuse. Commercial injector cleaning fluids and flow benches are available from various manufacturers. *Do not use injector cleaning fluids while operating the engine*

7.10.4.2 *Electronic Engine Control (EEC) System*—The fuel injector operation, cylinder firing, pulse width, ignition timing, and so forth, are controlled by the specified EEC. The EEC module is available from the supplier listed in A13.2.

7.10.5 *Spark Plugs*—Install new Motorcraft AWSF-32PP spark plugs that have been gapped to 1.37 mm. Torque the spark plugs to (9 to 12) N·m. Install the spark plug wiring harness. Do not use anti-seize compounds on spark plug threads.

NOTE 5—The components used in the ignition system do not require modification.

7.10.6 *Crankcase Ventilation System*—The crankcase ventilation system is a closed system allowing blowby to be vented from the crankcase and drawn into the intake manifold. A description of the system operation is shown in Fig. 4. Install PCV system components and hoses as shown in Fig. A7.17.

7.10.6.1 *Oil Separator and PCV Valve*—Use two clean oil separators and a new PCV valve listed in the parts list Annex A9. Oil separators can be reused as long as they remain serviceable.

7.10.6.2 *Three-Way Valve*—Install a clean three-way valve and attach the PCV valve hose. Install the remaining PCV valve hose between the three-way valve and the intake manifold (see Fig. A7.17). Do not allow the hose to flatten at the bend after installation.

7.10.7 *Intake Air Components*—Install the throttle body, air cleaner assembly, and new air cleaner. Modify the air cleaner assembly to accept fittings for inlet air temperature thermocouple, pressure tap and fresh air, as shown in Fig. A7.1.

7.10.9 *Wiring Harness*—There are two wiring harnesses used on the test stand, a dynamometer harness and an engine harness. Obtain the dynamometer wiring harness from the supplier listed in A13.2. The engine harness is listed in Annex A9.

8.3.2.1 Configure the oil system as shown in Fig. A7.8 to minimize stand-to-stand variations that could influence test severity. Measure engine oil pressure at the points shown in Fig. 5. The oil flow rate and external pressure drop are controlled by specifying the volume, plumbing configuration, and orientation of the heat exchanger. The oil flow out of the vertically mounted heat exchanger shall be level with the oil-in thermocouple. The lengths of the lines are not specified although the line diameters are indicated in

Fig. A7.8. The line length and diameter have a large influence on the volume of the external system. The internal volume of the entire external system shall be (540 ± 30) mL.

8.3.4.1 Clean the external oil cooling system thoroughly before each test. An acceptable technique for cleaning the oil heat exchanger is detailed in Annex A10. Flush and rinse the external lines before each test. The specific technique used (removed from or flushed on the stand, and so forth) is left to the discretion of the laboratory.

8.4.3.1 Configure the engine cooling system according to the schematic diagram shown in Fig. A7.18. The engine coolant system volume shall be (24 ± 2) L. This volume includes all equipment, plumbing, and the engine excluding the coolant reservoir and plumbing connecting the coolant reservoir with the main system (see Fig. A 7.18) The coolant reservoir volume shall be (9.0 ± 2) L. The thermostat housing is modified to accept the coolant outlet temperature thermocouple (9.1.3). *Do not install the thermostat.* Block coolant bypass port in intake manifold (7.6.2.1). Inspect the water pump drive belt for defects before installation.

8.4.3.2 A radiator cap is used to limit system pressure to 105 kPa. Pressurize the coolant system to (70 ± 10) kPa at the top of the coolant reservoir (Fig. A7.18).

8.6.1 Modify the mass airflow sensor to engine control module wiring in accordance with Fig. A7.14 to supply a simulated mass air flow sensor signal to provide closed loop AFR control during Stage III.

9.1.2 *Engine Coolant Inlet*—Install the sensor in the outlet perpendicular to the run of the tee fitting upstream from the water pump inlet (300 to 400) mm. Install sensor with the tip in the center of the stream of flow, directly opposite of the perpendicular outlet. (See Fig. A7.18).

9.1.4 *Engine Oil Inlet*—Install the tip of the sensor at the center of the flow stream through the external oil filter adapter (see Fig. A7.8). Tip of sensor shall be even with the machined surface of the oil filter adapter.

9.1.5 *Engine Oil Outlet*—Install the tip of the sensor at the center of the cross fitting attached to the bottom of the heat exchanger (see Fig. A7.8). Locate the sensor along the same axis, but opposite, the outlet port connected to the heat exchanger. The tip shall be within 2 mm of the center distance between the external most surfaces of the outlets along the axes.

9.1.6 *Intake Air*—Install the tip of the thermocouple midstream in the air cleaner (see Fig. A7.1). Insertion depth shall be (55 ± 2) mm.

9.2.1 *Equipment*—Pressure measurement for each of the eight required parameters is detailed in the following sections. This allows reasonable opportunity for adaptation of existing test stand instrumentation. However, the accuracy and resolution of the pressure measurement sensors and the complete pressure measurement system shall follow the guidelines detailed in ASTM Research Report RR:D02-1218.[222] Replace pressure sensors that are part of the EEC system with only Ford specified equipment.

NOTE 6—Tubing between the pressure tap locations and the final pressure sensors should incorporate condensate traps, as indicated by good engineering practice. This is particularly important in applications where low air pressures are transmitted by means of lines which pass through low-lying trenches between the test stand and the instrument console.

9.2.2 *Intake Manifold Absolute*—Measure the manifold absolute pressure at the port on the top side of the throttle body spacer (see Figs. A7.2 and A7.27).

9.2.3 *Engine Oil*—Measure oil pump pressure at the bottom port of the oil filter adapter housing on the engine block (see Fig. 5 and Figs. A7.24 and A7.25). Take cylinder head oil pressure measurements on the sides of the cylinder heads on the rear of the left cylinder head and front of the right cylinder head (see Fig. 5 and Figs. A7.23 and A7.26). Use individually dedicated pressure sensors.

9.2.4 *Engine Coolant Pressure*—Measure engine coolant pressure at the top of the coolant reservoir as shown in Fig. A7.18.

9.2.7 *Intake Air*—Measure the intake-air pressure in the air cleaner housing in the location shown in Fig. A7.1. Insertion depth of the probe shall be (50 ± 2) mm. If a manometer is used, install a liquid trap to prevent manometer fluid from entering the intake-air cleaner.

9.2.9 *Exhaust Back Pressure*—Measure the exhaust back pressure with the exhaust gas sampling probe

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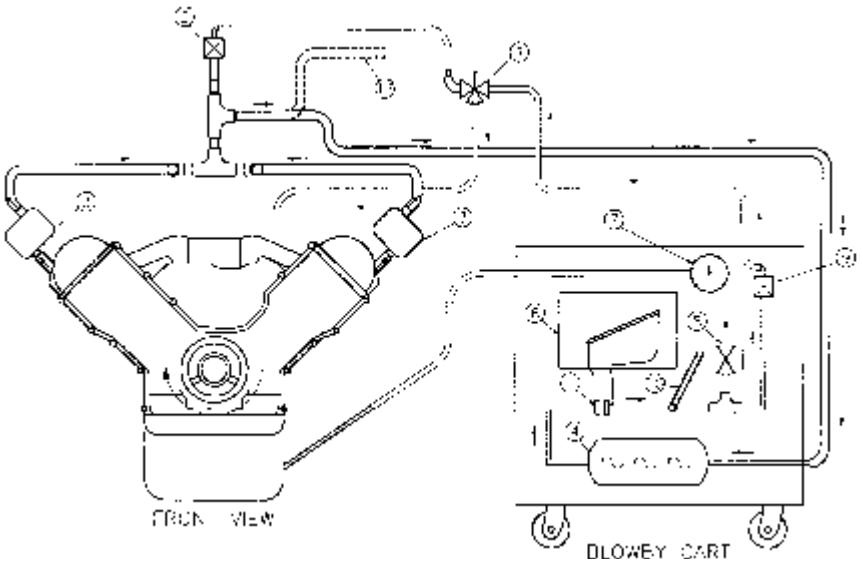
[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1218.

located downstream in the *Y* (see Fig. A7.16). A sensor capable of absolute or gage measurement corrected with barometric pressure reading is recommended. Install a condensate trap between the probe and sensor to accumulate water present in the exhaust gas.

9.3.2 *Engine Coolant*—Determine the engine coolant flow rate by measuring the differential pressure drop across the specified venturi flowmeter (see Fig. A7.18) Flowmeter is available from the supplier in X2.1.6. Take precautions to prevent air pockets from forming in the lines to the pressure sensor. Transparent lines or bleed lines, or both, are beneficial in this application. Ensure that the manufacturer's required straight sections of pipe are installed immediately up and down stream of the flowmeter.

The following pertains to item 2 on the information letter cover page.



Legend	
(1)	12.7 mm full flow stainless steel ball valve
(2)	PCV valve
(3)	Oil separator part no. F1ZE-6A785-AA (2)
(4)	Surge chamber
(5)	Orifice meter
(6)	Manometer or pressure sensor
(7)	Crankcase pressure gage
(8)	Bleed valve
(9)	Dummy PCV valve
(10)	Thermometer or temperature sensor
(11)	Excess blowby vent pipe. (during normal operation)

FIG. 7 Blowby Measurement Apparatus

Revisions pertaining to test stand calibration as a result of including D0.02.B0.10 recommended wording

11. Test Stand Calibration

11.1 *Verification:*

11.1.1 Verify the calibration of test stands with reference oils supplied by the TMC. See Annex A2

prior to attempting calibration of a new stand. Stand calibration tests are normally conducted upon expiration of either the 180-day calibration time period or after completing 15 non-reference oil tests. However, calibration time periods may be adjusted by the TMC. Additionally, any test terminated with 50 test hours or less will not be counted towards the 15 allowed runs. Any non-reference oil test started within 180 days of the previous calibration test is considered within the calibration period, provided the 15 allowed non-reference oil tests that have been completed since the previous calibration test in the stand are not exceeded.

11.1.2 A reference oil sample of 22.4 L is provided by the TMC for each stand calibration test.

11.2 *Unacceptable Calibration Results:*

11.2.1 It is recognized that a certain percentage of calibration tests fall outside the acceptance limits because of the application of statistics in the development of the acceptance limits. Failure of a reference oil test to meet Shewhart or EWMA precision control chart limits can be indicative of a false alarm or a stand, laboratory, or industry problem. When this occurs, the laboratory, in conjunction with the TMC shall attempt to determine the problem source. The TMC may solicit input from industry expertise (other testing laboratories, the test sponsor, ASTM Technical Guidance Committee, Sequence VG Surveillance Panel, Sequence VG Operation and Hardware Subpanel, and so on) to help determine the cause and extent of a problem. The Sequence VG Surveillance Panel adjudicates industry problems.

11.2.2 If the TMC determines the problem is a false alarm and is stand-related, there is no impact on other non-reference tests running in other stands within the laboratory. If the TMC determines the problem is laboratory-related, non-reference tests run during the problem period shall be considered invalid, unless there is specific evidence to the contrary for each individual test.

11.2.3 The TMC reschedules a calibration test once it is satisfied that no particular problem exists or the problem has been resolved. The laboratory shall provide adequate documentation to support conclusions reached during this process. Attach this documentation to the acceptable calibration test report. It shall provide sufficient information to show how the problem related to other tests operated during the same period.

11.3 *Test Stand Modifications*—A nonstandard test includes any test completed under a modified procedure requiring hardware or controller modifications to the test stand. The TMC determines whether another calibration test is necessary after the modifications have been completed.

11.4 *Reference Oil Accountability: Deleted replaced with wording in new Annex A2. Section 11.5 renumbered as 11.4*

11.4 *Test Numbering System:*

11.4.1 *Acceptable Tests*—The test number shall follow the format *AAA-BB-CCC. AAA* represents the test stand number. *BB* represents the number of tests since last reference. *CCC* represents the total number of tests on the stand. As an example, 6-10-175 represents the 175 test on Stand 6 and the tenth test since the last reference. Consecutively number all tests on a given stand.

11.4.2 *Unacceptable or Aborted Tests*—If a calibration test is aborted or the results are outside the acceptance limits, the *CCC* portion of the test number for subsequent calibration test(s) shall include a letter suffix. Begin the suffix with the letter *A* and continue alphabetically until a calibration test is completed within the acceptance limits. For example, if three consecutive unacceptable calibration test are completed on the same test stand, and the test stand number of the first test is 6-0-175, the next two test numbers would be 6-0-175A and 6-0-175B. If the results of the next calibration test are acceptable, the test number 6-0-175C would permanently identify the test and appear on future correspondence. The completion of any amount of operational time on tests other than calibration tests will cause the test number to increase by one. Add no letter suffix to the test number of tests other than calibration tests.

The following Sections have been revised to update references to Annexes or Figures in Annexes whose designation has changed and or have renumbered NOTEs.

12.1.1.1 Charge the engine with 3000 g of test oil before the break-in run. Run the engine at (1500 ± 25) r/min and 37.6 kPa MAP until the oil temperature reaches (80 ± 2) °C or for at least 2 min. Record the dipstick level (20 ± 2) min after shutdown. This shall be the Test Full mark for this test. Use the table in Annex A12 to determine the oil level.

12.1.1.7 Record all normal parameters in Steps 2 and 3 after operation at each step for 35 min. (**Warning—**Prolonged operation at a rich air-fuel ratio can cause excessive fuel dilution and alter test severity.)

NOTE 7—The engine normally requires approximately 20 min to reach steady-state conditions after a step change.

12.2.2.2 *Unscheduled Engine Shutdown*—Follow the procedure detailed as follows, each time an unscheduled engine shutdown is performed:

(*1*) Stop test timer when ramp down starts.

(*2*) *Ramp to Stage 3:*

From Stage 1—15 s speed and load setpoint ramp; 6 min setpoint ramp of other controlled parameters.

From Stage 2—Perform Stage 2 to 3 ramp (Table 4).

NOTE 8—Total cooldown time is 6 min after the initiation of the ramp to Stage 3 conditions.

12.2.2.3 *Start-Up After Unscheduled Shutdown*—Follow the procedure detailed as follows, each time an engine start-up is performed after an unscheduled shutdown.

(*1*) *Start*—5 min in Stage 3, then to:

Return to Stage 1—Stage 3 to 1 ramp (Table 4).

Return to Stage 2—60 s speed and load setpoint ramp; 10 min setpoint ramp of other controlled parameters.

NOTE 9—Test time resumes after all controlled parameters are within specification

12.3.4.1 *Oil Leveling and Sampling Procedure*—Make-up oil additions for leveling and oil sampling occur at intervals of 24 h. Annex A14 shows the cycle when this is to occur. Used oil additions are permitted only during engine reassembly for maintenance (see 12.4.2.2). Add new oil to the engine only when the level is below the original test full level by more than 400 g. Add only enough new oil to reach the low mark of 400 g. No other new oil additions are permitted during the test, except after piston ring gap adjustment (see 12.1.1.8). In the event that the oil level is above the test full mark, do not remove oil until the level is above the test full mark by more than 200 g. Drain off a sufficient amount of oil so that the level is at the 200 g above test full mark. Record the amount drained on the oil leveling sheet. The procedure is shown on the *Oil Sampling, Addition and Leveling Worksheet* in Annex A14. This form serves as the oil sampling and oil addition data sheet.

(*1*) Remove a 150 mL purge sample within first 10 min of Stage III.

(*2*) Remove a 60 mL analysis sample within first 10 min of Stage III.

(*3*) Return the purge sample to the engine.

(*4*) Shut-down the engine 10 min after the start of Stage III. Do not shut off the RAC coolant pump.

(*5*) Record the dipstick level in millimetres (20 ± 2) min after the engine is shutdown.

(*6*) Compute the oil level in grams. The difference between the oil level and the Test Full mark is oil consumed or gained. Use the chart in Annex A12 to determine the level. Do not add oil at 216 h. This allows the final drain to be used as a backup to the sample taken at 216 h.

(*7*) If the level is more than 400 g below the Test Full mark, record the amount of new oil added to bring the level to the mark, –400 g. However, never add more than 400 g during an oil addition.

(*8*) If the level is more than 200 g above the Test Full mark, record the amount of oil drained to bring the level to the mark, +200 g.

(*9*) Restart the engine (30 ± 1) min after shutdown (Step *4*). Allow the engine to run at Stage III conditions for (5 ± 1) min, then resume normal operation.

13.2.1 Rate the following parts for sludge deposits: RAC (2), valve deck (2), camshaft baffle (2), timing chain cover, oil pan, and oil pan baffle. Use the rating locations identified on the rating worksheets (see Annex A15). Determine the ratings using the techniques detailed in ASTM Deposit Rating Manual 20. Perform the sludge ratings before performing any other required ratings or measurements.

13.3.1 *Preparation of Parts*—Rate the following parts for varnish deposits–piston skirts (8, thrust side

only) and left and right camshaft baffles. Perform the varnish ratings after the sludge ratings are completed. The rating locations and dimensions shall conform with the locations and dimensions detailed on the rating worksheets (see Annex A15). Avoid disturbing adjacent sludge deposits when the parts are being prepared for varnish ratings. Heavy sludge can be removed from a varnish rating area prior to wiping with a 25 mm rubber spatula. Wipe all parts firmly with wiping materials specified in CRC Manual No. 20. Firmly rub all wiping areas in the same direction until the surface is dry and free of sludge (until no more deposit is present on the wiping material after wiping).

14.8 *Quality Index*—Requirements for quality index are listed in Annex A6. If the end of test quality index value is below 0.000 for reference oil tests, review the test operations with the TMC. The TMC issues a letter to the laboratory and the test purchaser on its opinion. The laboratory documents its comments regarding end of test quality index values less than 0.000 for non-reference oil tests. The laboratory or test purchaser might request TMC review of test operations for non-reference oil tests. The TMC issues a letter to document its opinion. If a test has greater than 2 h without recorded operational data on any controlled parameter, the test is operationally invalid.

New section 15 added to conform with D0.02.B0.10 Guidelines

15.1 For reference oil results, use the standardized report form set available from the ASTM TMC and data dictionary for reporting test results and for summarizing operational data.

15.1.1 Fill out the report forms according to the formats shown in the data dictionary.

15.1.2 Transmit results to the TMC within 5 working days of test completion.

15.1.3 Transmit the results electronically as described in the ASTM Data Communications Committee Test Report Transmission Model (Section 2 — Flat File Transmission Format) available from the ASTM TMC. Upload files via the TMC's website.

15.2 Report all reference oil test results, whether aborted, invalidated, or successfully completed, to the TMC.

15.3 *Deviations from Test Operational Limits*—Report all deviations from specified test operational limits.

15.4 *Precision of Reported Units*—Use the Practice E29 rounding-off method for critical pass/fail test result data. Report the data to the same precision as indicated in data dictionary.

15.5 In the space provided, note the time, date, test hour, and duration of any shutdown or off-test condition. Document the outcome of all prior reference oil tests from the current calibration sequence that were operationally or statistically invalid.

15.6 If a calibration period is extended beyond the normal calibration period length, make a note in the comment section and attach a written confirmation of the granted extension from the TMC to the test report. List the outcomes of previous runs that may need to be considered as part of the extension in the comment section.

16.1.1 *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 10—"Intermediate precision" is the appropriate term for this test method rather than "repeatability," which defines more rigorous within-laboratory conditions.

ANNEXES
(Mandatory Information)

A1.1 *Nature and Functions of the ASTM Test Monitoring Center (TMC)*—The TMC is a non-profit organization located in Pittsburgh, Pennsylvania and is staffed to: administer engineering studies; conduct laboratory inspections; 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 ASTM Subcommittee D02.B0 and the ASTM Executive

Committee. The TMC coordinates its activities with the test sponsors, the test developers, the surveillance panels, and the testing laboratories. Contact TMC through the TMC Director at:

ASTM Test Monitoring Center
6555 Penn Avenue
Pittsburgh, PA 15206-4489
www.astmtmc.cmu.edu

A1.2 *Rules of Operation of the ASTM TMC*—The TMC operates in accordance with the ASTM Charter, the ASTM Bylaws, the Regulations Governing ASTM Technical Committees, the Bylaws Governing ASTM Committee D02, and the Rules and Regulations Governing the ASTM Test Monitoring System.

A1.3 *Management of the ASTM TMC*—The management of the Test Monitoring System is vested in the Executive Committee elected by Subcommittee D02.B0. The Executive Committee selects the TMC Director who is responsible for directing the activities of the TMC.

A1.4 *Operating Income of the ASTM TMC*—The TMC operating income is obtained from fees levied on the reference oils supplied and on the calibration tests conducted. Fee schedules are established by the Executive Committee and reviewed by Subcommittee D02.B0.

A2. ASTM TEST MONITORING CENTER: CALIBRATION PROCEDURES

A2.1 *Reference Oils*—These oils are formulated or selected to represent specific chemical, or performance levels, or both. They are usually supplied directly to a testing laboratory under code numbers to ensure that the laboratory is not influenced by prior knowledge of acceptable results in assessing test results. The TMC determines the specific reference oil the laboratory shall test.

A2.1.1 *Reference Oil Data Reporting* – Test laboratories that receive reference oils for stand calibration shall submit data to the TMC on every sample of reference oil they receive. If a shipment contains any missing or damaged samples, the laboratory shall notify the TMC immediately.

A2.2 *Calibration Testing:*

A2.2.1 Full-scale calibration testing shall be conducted at regular intervals. These full-scale tests are conducted using coded reference oils supplied by the TMC. It is a laboratory's responsibility to keep the on-site reference oil inventory at or above the minimum level specified by the TMC test engineers.

A2.2.2 *Test Stands Used for Non-Standard Tests*—If a non-standard test is conducted on a previously calibrated test stand, the laboratory shall conduct a reference oil test on that stand to demonstrate that it continues to be calibrated, prior to running standard tests.

A2.3 *Reference Oil Storage*—Store reference oils under cover in locations where the ambient temperature is between -10 °C and +50 °C.

A2.4 *Analysis of Reference Oil*—Unless specifically authorized by the TMC, do not analyze TMC reference oils, either physically or chemically. Do not resell ASTM reference oils or supply them to other laboratories without the approval of the TMC. The reference oils are supplied only for the intended purpose of obtaining calibration under the ASTM Test Monitoring System. Any unauthorized use is strictly forbidden. The testing laboratory tacitly agrees to use the TMC reference oils exclusively in accordance with the TMC's published Policies for Use and Analysis of ASTM Reference Oils, and to run and report the reference oil test results according to TMC guidelines. Additional policies for the use and analysis of ASTM Reference Oils are available from the TMC.

A2.5 *Conducting a Reference Oil Test*—When laboratory personnel are ready to run a reference calibration test, they shall request an oil code via the TMC website.

A2.6 *Reporting Reference Oil Test Results*—Upon completion of the reference oil test, the test laboratory transmits the data electronically to the TMC, as described in Section 15. The TMC reviews the data and contacts the laboratory engineer to report the laboratory's calibration status. All reference oil test results, whether aborted, invalidated, or successfully completed, shall be reported to the TMC.

A2.6.1 All deviations from the specified test method shall be reported.

A3. ASTM TEST MONITORING CENTER: MAINTENANCE ACTIVITIES

A3.1 *Special Reference Oil Tests*—To ensure continuous severity and precision monitoring, calibration tests are conducted periodically throughout the year. Occasionally, the majority or even all of the industry's test stands will conduct calibration tests at roughly the same time. This could result in an unacceptably large time frame when very few calibration tests are conducted. The TMC can shorten or extend calibration periods as needed to provide a consistent flow of reference oil test data. Adjustments to calibration periods are made such that laboratories incur no net loss or gain in calibration status.

A3.2 *Special Use of the Reference Oil Calibration System*—The surveillance panel has the option to use the reference oil system to evaluate changes that have potential impact on test severity and precision. This option is only taken when a program of donated tests is not feasible. The surveillance panel and the TMC shall develop a detailed plan for the test program. This plan requires all reference oil tests in the program to be completed as close to the same time as possible, so that no laboratory/stand calibration status is left pending for an excessive length of time. In order to maintain the integrity of the reference oil monitoring system, each reference oil test is conducted so as to be interpretable for stand calibration. To facilitate the required test scheduling, the surveillance panel may direct the TMC to lengthen and shorten reference oil calibration periods within laboratories such that the laboratories incur no net loss or gain in calibration status. To ensure accurate stand, or laboratory, or both severity assessments, conduct non-reference oil tests the same as reference oil tests.

A3.3 *Donated Reference Oil Test Programs*—The surveillance panel is charged with maintaining effective reference oil test severity and precision monitoring. During times of new parts introductions, new or re-blended reference oil additions, and procedural revisions, it may be necessary to evaluate the possible effects on severity and precision levels. The surveillance panel may choose to conduct a program of donated reference oil tests in those laboratories participating in the monitoring system, in order to quantify the effect of a particular change on severity and precision. Typically, the surveillance panel requests its panel members to volunteer enough reference oil test results to create a robust data set. Broad laboratory participation is needed to provide a representative sampling of the industry. To ensure the quality of the data obtained, donated tests are conducted on calibrated test stands. The surveillance panel shall arrange an appropriate number of donated tests and ensure completion of the test program in a timely manner.

A3.4 *Intervals Between Reference Oil Tests*—Under special circumstances, such as extended downtime caused by industry-wide parts or fuel shortages, the TMC may extend the intervals between reference oil tests.

A3.5 *Introducing New Reference Oils*—Reference oils produce various results. When new reference oils are selected, participating laboratories will be requested to conduct their share of tests to enable the TMC to recommend industry test targets. ASTM surveillance panels require a minimum number of tests to establish the industry test targets for new reference oils.

A3.6 *TMC Information Letters*—Occasionally it is necessary to revise the test method, and notify the test laboratories of the change, prior to consideration of the revision by Subcommittee D02.B0. In such a case, the TMC issues an Information Letter. Information Letters are balloted semi-annually by Subcommittee D02.B0, and subsequently by D02. By this means, the Society due process procedures are applied to these Information Letters.

A3.6.1 *Issuing Authority*—The authority to issue an Information Letter differs according to its nature. In the case of an Information Letter concerning a part number change which does not affect test results, the TMC is authorized to issue such a letter. Long-term studies by the surveillance panel to improve the test procedure through improved operation and hardware control may result in the issuance of an Information Letter. If obvious procedural items affecting test results need immediate attention, the test sponsor and the TMC issue an Information Letter and present the background and data supporting that action to the surveillance panel for approval prior to the semiannual Subcommittee D02.B0 meeting.

A3.7 *TMC Memoranda*—In addition to the Information Letters, supplementary memoranda are issued. These are developed by the TMC and distributed to the appropriate surveillance panel and participating laboratories. They convey such information as batch approvals for test parts or materials, clarification of

the test procedure, notes and suggestions of 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.

A4. ASTM TEST MONITORING CENTER: RELATED INFORMATION

A4.1 *New Laboratories*—Laboratories wishing to become 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 Director.

A4.2 *Information Letters: COTCO Approval*—Authority for the issuance of Information Letters was given by the committee on Technical Committee Operations in 1984, as follows: "COTCO recognizes that D02 has a unique and complex situation. The use of Information Letters is approved providing each letter contains a disclaimer to the affect that such has not obtained ASTM consensus. These Information Letters should be moved to such consensus as rapidly as possible."

A4.3 *Precision Data*—The TMC determines the precision of test methods by analyzing results of calibration tests conducted on reference oils. Precision data are updated regularly. Current precision data can be obtained from the TMC

CURRENT ANNEXES A1 THROUGH A12 HAVE BEEN RENUMBERED A5 THROUGH A16. REVISE NUMBERING ACCORDINGLY.

The following change pertains to item 1 of the information letter cover page.

X2.1.22 *Lambda Measurement Devices*—Recommended devices for measuring exhaust gas Lambda are available from the following suppliers:

Innovative LM-1
Innovative Technology, Inc.
5 Jenner, Suite 100
Irvine, CA 92618

AFM1000 single channel AFR module
Engine Control and Engineering
Sunnyvale, CA 94089
http://www.ecm-co.com

Horiba MEXA 700 or 110
Horiba Instruments, Inc.
17671 Armstrong
Irvine Industrial Complex
Irvine, CA 92623
Telephone: (714) 250-4811