Designation: DXXXX

IIIH *DRAFT* Procedure

Standard Test Method for

Evaluation of Automotive Engine Oils in the Sequence IIIH, Spark-Ignition Engine[1]

This standard is issued under the fixed designation DXXXX; 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

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)[2] services (see Annex A1). Laboratories that choose not to use the TMC services may simply disregard these portions.[3]

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. Organizations such as the American Chemistry Council require that a laboratory utilize the TMC services as part of their test registration process. In addition, the American Petroleum Institute and the Gear Lubricant Review Committee of the Lubricant Review Institute (SAE International) require that a laboratory utilize the TMC services in seeking qualification of oils against their specifications.

1. Scope

2. Referenced Documents

3. Terminology

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.B0.02 on Heavy-Duty Engine Oils.
Current edition approved XXXX. Published YYYY.

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

[3] The advantage of utilizing 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.

4. Summary of Test Method

4.1 A Chrysler Pentastar V-6 test engine with a displacement of 3.6 L is disassembled, solvent-cleaned, measured, and rebuilt, using new parts installed as specified in this test method.

4.2 The engine is installed on a test stand equipped with an appropriate data acquisition system, the required fluids process control system, and all necessary accessories for controlling speed, torque, and various other operating parameters.

4.3 The engine is charged with the test oil.

4.4 The engine is operated for an initial run-in period of 8 min to check all test stand operating systems and to establish a zero-hour, oil-level reading. An oil sample is also taken to allow the measurement of the initial oil viscosity.

4.5 The initial oil level in the oil pan is determined after the 8 min initial run-in, and subsequent oil-level calculations are determined during the oil-leveling period at the end of each 20 h segment.

4.6 Following the run-in and oil-leveling period of 8 min, the engine is ramped up to test conditions over a 5 min period then operated under non-cyclic, moderately-high-speed, torque, and specified temperature conditions for 90 h, in four 20 h segments and one 10 hour segment.

4.7 Used-oil samples are taken after the 8 min initial run-in and after each 20 h test segment; kinematic viscosity at 40 °C is determined for each of the six samples; the percentage change in viscosity of the five latter samples is determined relative to the viscosity of the first used-oil sample (8 min initial run-in).

4.8 At the conclusion of the test, the engine is disassembled and the parts are visually rated to determine the extent of deposits formed.

5. Significance and Use

6. Apparatus

6.1 Laboratory:

6.1.1 Observe the following laboratory conditions to ensure good control of test operations and good repeatability:

6.1.2 Maintain the ambient laboratory atmosphere relatively free of dirt, dust and other contaminants.

6.1.3 Control the temperature of the room in which parts measurements are made so that the temperature for after-test measurements is within a range of ± 3 °C relative to the temperature for the before-test measurements.

6.1.4 Filter the air in the engine build-up area, and control its temperature and humidity to prevent accumulation of dirt or rust on engine parts.

6.1.5 If an engine is assembled in an area of controlled environment and moved to a non-controlled area, provide suitable protection of the engine so that moist air cannot enter the engine and promote rusting before the test.

6.1.6 Do not permit air from fans or ventilation systems to blow directly onto an engine mounted on a test stand during test operation

6.2 Drawings—Obtain the equipment drawings referenced in Table 2 from the TMC[2]. Because the drawings may not be to scale or may not contain dimensions, when using them to fabricate special parts, do not use a dimensionless drawing as a pattern. Drawings supplied with dimensions are considered to be correct when the temperature of the equipment is 22 °C ± 3 °C, unless otherwise specified.

6.3 Specified Equipment:

6.3.1 Use the equipment specified in the procedure whenever possible. Substitution of equivalent equipment is allowed, but only after equivalency has been proven to the satisfaction of the TMC, the Test Procedure Developer and the ASTM Sequence IIIH Surveillance Panel.

6.3.2 Do not use heat lamps or fans directed at the engine and do not use insulation on the engine for oil or coolant temperature control.

6.3.2.1 Discussion—For operator safety and the protection of test components, the use of shielding and insulation on the exhaust system may be incorporated downstream of the oxygen sensor elbow.

6.3.2.2 Small fans with less than 140 L/s may be placed at the front of the engine with the air flow directed toward the exhaust pipes, parallel to the driveshaft. Fans must be placed a minimum of 35 cm from the centerline of the harmonic balancer.

6.4 Test Engine:

6.4.1 The test engine is based on a 2014 Pentastar V-6 engine with a displacement of 3.6 L, a compression ratio of 10.2:1, equipped with a production fuel-injection system and a special Powertrain Control Module (PCM) for test specific dynamometer operation. The Variable Valve Timing is disabled by the use of fixed phasers in place of the production cam phasers. Complete test engines are available for purchase from Chrysler P/N 05184464AH[4,5]. Each test will consist of a single, new complete test engine that will be assembled according to the Sequence IIIH Engine Assembly Manual[6].

6.4.2 *Engine Parts*—Use the engine parts specified in the Sequence IIIH Engine Assembly Manual[6].

---

[4] The sole source of supply of the apparatus known to the committee at this time is ???.

[5] If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee[1] which you may attend.

[6] The Sequence IIIH Engine Assembly Manual is available at ftp://ftp.astmtmc.cmu.edu/docs/gas/sequenceiii/procedure_and_ils/IIIG.

6.4.3 Refer to Table 1 for a complete list of parts required to assemble the test engine.

6.4.4 Use all engine parts as received from the supplier, Central Parts Distributor, Special Parts Supplier or original equipment manufacturer unless modifications are specified in this test method or the Sequence IIIH Engine Assembly Manual.

6.4.5 Before disposing of any Sequence IIIH engine parts, destroy or otherwise render them useless for automotive engine applications.

6.5 Engine Speed and Torque Control—Use dynamometer speed and torque control systems that are capable of controlling the speed and torque requirements described in 10.4.

6.6 Fluid Conditioning Module:

6.6.1 The components for this module are given in Table 3. The module controls the following parameters: engine coolant, coolant through the engine oil cooler, and the test fuel supply.

6.6.2 *Engine Cooling System*—The Fluid Conditioning Module supplies coolant pressurized to 200 kPa, at a flow rate of 170 L/min and controls the coolant temperature at 115 °C at the engine coolant outlet. The system incorporates the following features: pump, coriolis-type flow meter, flow-control and three-way control valves, external cooling system, and low-point drains.

6.6.2.1 The system integrates with the test stand data acquisition and control computer for process control and maintains the specified engine coolant temperature and flow.

6.6.2.2 Refer to Fig. 1 for the required engine coolant flow schematic.

6.6.3 Refer to Table 2 for a complete list of acceptable control system/engine interface components.

6.6.3.1 Refer to Table 3 for a list of suitable coolant flow system control equipment.

6.6.3.2 Flush the test stand coolant system with clean water at least once each reference period.

6.6.4 *Coolant Mixing Tank*—Use a mixing tank large enough to premix the entire batch of coolant and de-ionized water. Alternatively, a premix solution may be used (refer to section 7.2).

6.6.5 *Engine Oil Cooling System* – The Fluid Conditioning Module controls engine oil temperature at 150 °C by controlling the flow of engine coolant through the production oil cooler with the use of a 2-way, flow-control valve.

6.6.5.1 Do not use cuprous lines or fittings in the oil cooling system.

6.6.5.2 Do not use magnetic plugs in the oil system.

6.6.6 *Fuel System*—The Fluid Conditioning Module contains a pressurized, recirculation fuel system that includes a pressure regulator to provide 420 kPa ± 20 kPa. Switch the system off so no fuel pressure is present at the injector rail during engine shutdowns.

6.6.7 *Induction Air System*—Maintain the throttle body intake air at a moisture content of 11.4 g/kg ± 0.7 g/kg of dry air, a dry bulb temperature of 35 °C ± 2 °C, dew point of

16.1 °C and a static pressure of 0.050 kPa. Measure air intake temperature and pressure at Air Resonator (Chrysler P/N 04861731AB) in the center of flow 7 mm from the opening as shown in Fig. A2.1.

6.6.8 Pressure Transducer Locations:

6.6.8.1 Coolant Pressure—Connect the transducer to the modified Coolant Crossover Adapter P/N OHT3H-303-1. Transducers with a range of 0 to 700 kPa have been found to be suitable.

6.6.8.2 Intake Air Pressure—Connect the transducer to the location shown in Fig. A2.1. Transducers with a range of -125 to +125 Pa have been found to be suitable.

6.6.8.3 Right and Left Exhaust Backpressure—Insert probe into the Exhaust Turndown Pipes (TMC print IIIH-ETP40-B position 4). Transducers with a range of 0 to 100 kPa have been found to be suitable.

6.6.8.4 Oil Pump Pressure—Connect the transducer to the location shown in Fig A2.2. Transducers with a range of 0 to 700 kPa have been found to be suitable.

6.6.8.5 Oil Gallery Pressure—Connect the transducer to the location shown in Fig. A2.3. Transducers with a range of 0 to 700 kPa have been found to be suitable.

6.6.8.6 Manifold Absolute Pressure—Connect the transducer to the vacuum port on top of the throttle body and behind the throttle plate. Transducers with a range of 0 to 100 kPa have been found to be suitable.

6.6.8.7 Fuel Pressure—Connect the transducer within 30 cm of the fuel rail inlet. Transducers with a range of 0 to 700 kPa have been found to be suitable.

6.6.8.8 Crankcase Pressure—Use a transducer having a range of -125 Pa to +125 Pa. Connect the transducer port tapped in the upper portion of the Oil Pan P/N OHT3H-304-2. Transducers with a range of -125 to +125 Pa have been found to be suitable.

6.6.9 Thermocouple Locations—Locate the sensing tip of all thermocouples in the center of the stream of the medium being measured unless otherwise specified.

6.6.9.1 Oil Gallery Temperature—Install the thermocouple in the rear of the oil cooler as shown in Fig. A2.3. Ensure the sensing tip is in the middle of the flow by fully inserting the sensing tip and reversing it out by 8 mm.

6.6.9.2 Coolant Out of the Engine Temperature—Install the thermocouple in the Coolant Crossover P/N OHT3H-302-1 with the sensing tip centered in the coolant flow.

6.6.9.3 Intake Air Temperature—Install the thermocouple through top of Air Resonator 7 mm from the edge where it joins the throttle body (see Fig. A2.1). Center the sensing tip in the center of the air flow.

6.6.9.4 Fuel Temperature—Install the thermocouple in the fuel line within 30 cm of the fuel rail inlet. **Warning**—Safety Hazard—Exercise care to reduce overhung masses at fuel-rail connections.

6.6.9.5 Oil Pump Temperature—Install the thermocouple in the oil pump pressure/temperature assembly as shown in Fig A2.2.

6.6.9.6 Oil Sump Temperature—Install the thermocouple in the oil sump drain plug located on the underside of the oil pan P/N OHT3H-304-2 with the sensing tip extending 6 mm beyond the end of the sump drain plug.

6.6.9.7 Coolant Into the Engine Temperature—Install the thermocouple in the modified water pump P/N OHT3H-300-1 with the sensing tip centered in the coolant flow.

6.6.9.8 Right Exhaust Temperature—Install thermocouple in the exhaust turndown pipe (drawing IIIH-ETP30-B) with the sensing tip centered in the exhaust flow.

6.6.9.9 Left Exhaust Temperature—Install thermocouple in the exhaust turndown pipe (drawing IIIH-ETP30-B) with the sensing tip centered in the exhaust flow.

6. Reagents and Materials

6.8 Test Fuel—Use only Sequence III HF-003 EEE unleaded fuel[7,5]. (**Warning** Flammable. Health hazard.) The required fuel properties and tolerances are shown in Table A3.1.

6.8.1 Make certain that all tanks used for transportation and storage are clean before filling with test fuel.

6.8.2 Ensure that at least 3450 L of test fuel is available.

6.9 Engine Coolant—Use a mixture of ShellZone[8] Dex-Cool[9] antifreeze/coolant[10] and deionized water with a volume fraction of water of 50 %. (**Warning**—Health hazard—see appropriate MSDS).

6.9.1 Use new coolant for every test.

6.9.2 *Coolant Preparation*—Use a container of a size adequate to hold the entire coolant blend required for the system.

6.9.3 *Measure equal parts of coolant and deionized water.* Verify with a refractometer that the mixture is between 48 and 52% coolant prior to each use.

6.9.4 *Alternatively a 50/50 premix may be purchased for use if desired.*

6.10 *Degreasing Solvent*—Use only mineral spirits meeting the specifications for volume fraction of aromatics 0 % to 2 %, flash point 61 °C minimum, and color not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale from Specification D235 for the Type II, Class C mineral spirits. (**Warning** – Combustible. Health hazard.)

[7] The sole source of supply of this fuel known to the committee at this time is Haltermann Products, 1201 Sheldon Road, P.O. Box 429, Channelview, TX 77530-0429.
[8] ShellZone is a registered trademark of Shell Trademark Management BV.
[9] Dex-Cool is a registered trademark of General Motors Corporation.
[10] Available from Halvoline retailers, auto parts stores or Chrysler/Dodge dealerships.

6.11 Sealing and Anti-Seize Compounds—Mopar[11] ThreeBond Engine RTV[12] P/N 68082860AA RTV silicone[13,5].

6.12 Use Ultrasonic-7[14] soap and Ultrasonic-B[14] in ultrasonic parts washers to clean engine block, cylinder heads and fixed phasers. Cleaning solution shall be at a temperature of 150 °C ± 5°.

6.13 Engine build up oil, EF-411[15,5].

7. Test Oil Sample Requirements

7.8 Selection—The supplier of the test oil sample shall determine that the test oil sample is representative of the lubricant formulation to be evaluated and that it is not contaminated.

7.9 Quantity—The supplier shall provide the test oil sample of 7.5 L.

7.10 Storage Prior to Test—The test laboratory shall store the test oil sample in a covered building to prevent contamination by rainwater. Ambient temperature of storage area shall be between -10°C and +50°C.

8. Preparation of Apparatus

9.1 Pre-Test Engine Tear Down and Cleaning:

9.1.1 Disassemble the engine according to the section on Pre-Test Engine Disassembly and Test Preparation of the Sequence IIIH Engine Assembly Manual[6].

9.2 Cylinder head disassembly—Disassemble cylinder heads according to the Sequence IIIH Engine Assembly Manual.

9.2.1 Set aside new cylinder heads to be sent to the central parts supplier for replacement of intake valve-seats.

9.2.2 Wash test cylinder heads in ultrasonic washer for 10 min prior to assembly. Immediately after removing heads from the ultrasonic washer, spray down with warm water, and spray with a mix of solvent and EF-411 engine build up oil containing 50 % volume fraction of solvent.

9.2.3 Assemble modified cylinder heads P/N RH451AO-MS and LH516AO-MSD with valves, springs, keepers, retainers, and shims removed from new engine cylinder heads.

9.2.4 Use new valve-stem seals for each test.

9.3 Block Preparation—

9.3.1 Refer to Sequence IIIH Engine Assembly Manual for Oil Gallery Thermocouple

[11] Mopar is a registered trademark of Chrysler Group LLC.
[12] ThreeBond is a registered trademark of ThreeBond International, Inc.
[13] Available from Chrysler/Dodge dealerships.
[14] Available from Purvis Industries, 10500 North Stemmons Freeway, Dallas, TX 75200.
[15] The sole source of supply of this product known to the committee at this time is Exxon-Mobil Oil Corp., P.O. Box 66940, AMF O'Hare, IL 60666, Attention Illinois Order Board.

drilling procedure.

9.3.2 Refer to the Sequence IIIH Engine Assembly Manual for honing procedure.

9.3.3 After honing wash the block in the ultrasonic washer for 20 minutes, immediately spray down with warm water followed by spraying with the solvent/EF-411oil mix described in 9.2.2.2. Ensure all oil and coolant passages in the block are sprayed through.

9.3.4 Using a soft cloth, wipe the cylinder bores with the solvent/EF-411 oil mix described in 9.2.2.2.

9.4 Oil Pump Cleaning—Remove factory engine oil from the oil pump as follows:

9.4.1 Submerge engine oil pump in degreasing solvent and turn the pump gear by pulling the chain back and forth from either side to agitate solvent inside the pump.

9.4.2 Spray compressed air into the pump while pulling the chain back and forth from either side to dry the inside of the pump.

9.5 Oil Cooler Cleaning—Remove factory engine oil from the oil cooler as follows:

9.5.1 Spray degreasing solvent into the production oil cooler to remove any traces of factory oil.

9.5.2 Rotate the oil cooler back and forth to fully distribute degreasing solvent inside the cooler.

9.5.3 Drain solvent from cooler by rotating the oil cooler until empty.

9.5.4 Spray compressed air inside oil cooler for a minimum of 20 min to evaporate the degreasing solvent.

9.6 Clean all remaining engine parts with degreasing solvent to remove all traces of factory engine oil.

9.7 Test Engine Build-Up: Refer to the Sequence IIIH Engine Assembly Manual for engine build instructions. Table 1 contains a list of all parts required for the test engine build.

9.7.1 Refer to the engine build data sheet in A.8 for required measurements obtained during the engine build up.

9.8 Test Stand Preparation:

9.8.1 For every test, replace the tubing (for example, Tygon[16] or equivalent) that vents the crankcase gasses from the rocker cover (see Figure A2.4).

9.8.2 Flush all oil pressure lines with solvent and dry with shop air prior to the start of each test.

9.8.3 Charge the coolant system with the coolant/water mixture, cycle the coolant flow pump on and off in five min intervals while cycling all two-way and three-way control valves to eliminate any trapped air from the system for a minimum of 20 min prior to starting any Sequence IIIH Test.

10. Calibration

[16] Tygon is a registered trademark of Saint-Gobain Corporation.

10.3 Calibration Procedures - See Annex A4.

10.4 Maintenance Activities – see Annex A5.

10.5 Related Information – see Annex A6.

10.6 Data Acquisition System: The Sequence IIIH test requires the use of computerized data acquisition and control for all measured and controlled parameters outlined in this procedure. The system chosen by individual testing laboratories shall be capable of integrating with the Sequence IIIH Process Controller for many of these operations. The system shall also be capable of meeting or exceeding certain test specific performance requirements for maximum allowable response times and minimum allowable sample rates. In addition to the aforementioned requirements, the system shall also be capable of data logging to test specific archival files for each test parameter at minimum allowable record intervals, that is, no greater than 2 min intervals between successive logs for each parameter. See the Data Acquisition and Control Automation II Task Force Report (DACA II)[17] and additional requirements as outlined in this procedure.

10.6.1 *Sample Rate*—The preferred sample rate is 100 Hz with the minimum allowable sample rate for the Sequence IIIH data acquisition and control system set at 1 Hz.

10.6.2 *Measurement Accuracy*—All measurement devices used for sensing speed, force, flow, pressure, and temperature shall meet the minimum requirements as outlined in the DACA II report[17] and also conforms to total system response requirements as outlined by the TMC (see 10.6.10).

10.6.2.1 *Pressure Measurements*—For pressures > 6.9 kPa, use only measuring devices with a full-scale accuracy of ± 0.2 % for capacitive systems and ± 0.25 % for strain-type systems. For pressures < 6.9 kPa, use only devices with an accuracy of ± 15 Pa for capacitive systems and ± 14 Pa for strain-type systems. Refer to Table 4 for a list of controlled and uncontrolled pressures.

10.6.2.2 *Temperature Measurements*—Use only Type E Chromel-Constantan or Type J iron-constantan thermocouples with an accuracy of ± 0.5 °C over a range of 0 °C to 200 °C. Refer to Table 4 for a list of controlled and uncontrolled temperatures.

10.6.2.3 *Flow* – For Coriolis flow meter measurements use a mass flow accuracy of ±0.50%, and mass flow repeatability of ±0.05%.

10.6.2.4 *Speed*—For speeds measured by frequency, use ± 1 r/min.

10.6.2.5 *Force*—For forces measured by strain gage, use ± 0.25 % of full scale.

10.6.3 *Measurement Resolution*—The minimum resolution for all parameters shall be at least $^{1}/_{4}$ the required system accuracy for that parameter, that is, if a test procedure requires an accuracy of 1.0 units, then the minimum resolution for that parameter = 0.25 unit.

---

[17] Available at ftp://ftp.astmtmc.cmu.edu/docs/Misc/QualityIndex/minutes/daca_II_report_and_system_time_response.pdf.

10.6.4 *System Time Response*—Total system time response is the time required for the complete data acquisition system including all filtering, transducer lines, and surge tanks to measure a step change input for a given parameter. Determine system response times by measuring the time required to reach a certain percentage of an imposed step change. For first order systems, use the time to 63.2 % of the imposed step change; for moving average systems use the time to 45.4 % of the imposed step change.

10.6.4.1 See the TMC System Time Response Measurement Guidelines for methods of imposing step changes for calibration of Sequence IIIH test stands.

10.6.4.2 Maximum allowable system time responses for the data acquisition system are listed in Table 5.

10.6.5 *Quality Index*—Use of the quality index method of measuring the control capability of the test stand is required for certain parameters. Use the following formula with a minimum of 2400 data points for the final, end-of-test values:

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

where:

QI = quality index,

X_i = recorded test-measurement parameter,

U = upper-specification limit for that parameter,

L = Lower-specification limit for that parameter, and

n = total number of data points taken as determined from test length and procedural specified sampling rate.

10.6.6 The upper and lower values used for QI calculations for the required parameters are listed in Table 4.

10.6.7 Calibrate the stand instrumentation used for data acquisition and control on all controlled and non-controlled parameters (see Table 4) every six months.

10.6.8 As a minimum, calibrate the following parameters prior to every reference test sequence, unless the required six–month calibration was completed within 60 days prior to reference test start: engine speed, dynamometer torque, engine coolant flow, engine coolant out thermocouple, main oil gallery thermocouple.

10.6.9 Calibrate the intake air-humidity system every six months, at a minimum.

11. **Engine Operating Procedure**

11.1 Engine Start-up procedure:

11.1.1 Charge the engine with 5.92 L of test oil using a calibrated beaker.

11.1.2 Prior to starting the engine, prime the oil pump by turning the starter for 20 s with the ignition off.

11.1.3 Additional, optional priming may be done by drawing oil into the pump by means of applying low pressure to the oil sample valve, provided that test oil is not removed from the engine in the process.

11.1.4 Supply dc power of 13 V to 15 V to the Power Control Module and fuel pump. Start the coolant pump and allow coolant flow to reach 170 L/min.

11.1.5 Start the engine and set the speed to 1000 r/min and a load of 25 N•m.

11.2 Initial run-in:

11.2.1 Ramp the engine speed and load linearly to 1500 r/min and 100 N•m over 45 s maintaining this speed and load for 8 min. See Table 6 for the control states for each ramp and step.

11.2.2 Check all stand operating conditions.

11.2.3 After the 8 min initial run ramp the engine down to 1500 r/min and 100 N•m in 45 s, and take the initial oil sample of 236 mL (see 11.3 for oil sampling procedure).

11.3 *Oil Sampling:*

11.3.1 Ramp speed and load linearly to 1000 r/min and 25 N•m (see Table 6 for ramp times) and hold for 2 min to allow operator to obtain the initial oil sample.

11.3.2 Before taking the samples in each of the following steps, first remove a purge sample of 472 mL; then remove the oil sample of the specified volume.

11.3.3 Add the 472 mL purge sample back to the engine.

11.4 Oil Leveling:

11.4.1 Determine the oil level in the crankcase as follows:

11.4.2 Stop the engine after the 2 minute oil sample step, and allow the oil to drain to the oil pan for 20 minutes. Maintain an engine oil coolant flow rate of 170 L/min during the drain down period.

11.4.3 Determine the oil level using the calibrated dipstick.

11.5 Engine Oil Quality test: After the initial run in is complete, and the initial oil level is determined, and the engine will be ramped up to 3900 rev/min and 250 N•m for four 20 h segments followed by a shorter 10 h segment.

11.5.1 Start the engine as in 11.1.5 and verify there are no oil or coolant leaks and the engine is running properly.

11.5.2 Ramp the engine to 3900 rev/min and 250 N•m linearly in 5 min (see Table 6 for the required control states).

11.5.3 Maintain a stabilization period of a minimum of 5 additional minutes. The ramp and stabilization time together will be a minimum of 10 min.

11.5.4 Start accumulating test time at the end of the 10 minute stabilization or when the oil gallery temperature reaches 150° C, whichever is later.

11.5.5 Run the engine at the test condition for 20 hours, follow the oil sample procedure in 11.3 to obtain a 59 mL sample immediately followed by the oil leveling procedure in 11.4.

11.5.6 Repeat steps 11.5.1 – 11.5.5 for three additional 20 hour segments followed by one 10 hour segment.

11.6 *Air-to-Fuel Ratio and NOx verification*:

11.6.1 Air-to-fuel ratio is controlled by the PCM and should be maintained at stoichiometric conditions. This can be verified by one of the following methods:

11.6.2 Real time exhaust analysis can be obtained with an ECM AFR/NOx 5210, or

11.6.3 Exhaust samples can be taken at test hours 1, 9 and every 10 hours thereafter until the end of test for exhaust analysis.

11.7*Blowby Flow Rate Measurement:*

11.7.1 Using a sharp edge orifice meter, measure the engine blowby flow rate according to the following instructions:

11.7.2 Blowby readings should be take every 5 test hours starting at test hour 1 with an additional reading within 15 minutes of the end of test.

11.7.3 Measure the blowby flow rate between the crankcase ventilation and the suitable vent hood used during the test.

11.7.4 Portable cart applications need to be positioned near the testing area for a sufficient time to ensure temperature stabilization of the system components prior to taking any blowby measurements.

11.7.5 Select an orifice size such that the observed blowby flow, ΔP, lies in the midrange of the calibration curve, and record the orifice size used.

11.7.6 Maintain blowby gas flow through the orifice meter for 2 min or more to ensure flow stability, prior to taking the actual readings. Due to the relatively low flow rates, allow time for the engine blowby gas to fill the system and further enhance temperature stabilization.

12 Determination of Results

12.1 This section describes techniques used to evaluate oil performance with respect to oxidation (as measured by viscosity increase), piston deposits, ring sticking, and oil consumption.

12.2 *Engine Disassembly*—In preparation for inspection and rating, disassemble the engine as follows:

12.2.1 Plan the disassembly so that the parts to be rated for ring sticking, ring plugging and piston deposits are removed from the engine within 24 h of taking the end of test (EOT) oil sample.

12.2.2 Remove the components from the top of the engine in order to gain access to the cylinder bores.

12.2.3 Remove the carbon deposits from the top portion of the cylinder walls, above the top compression ring travel, before removing the pistons from the engine.

12.2.3.1 If the piston deposits cannot be rated immediately after the pistons are removed from the engine, store the pistons in a desiccator for no longer than 72 h from end of test before rating. Do not wipe the pistons before storing them.

12.2.4 Disassemble the remainder of the engine.

12.3 *Ring Sticking:*

12.3.1 Check all piston rings for freedom of movement in the grooves when removing the pistons from the engine.

12.3.2 Determine which rings are hot-stuck or cold-stuck and record the piston number and ring identification (for example, piston No. 3, top ring) for such rings on Form 8[18] (Summary of Ring Sticking). Record the total number of cold-stuck and hot-stuck rings on Form 4[18] (Test Result Summary).

12.3.3 At the time of disassembly, remove all piston rings that are free. Leave any stuck rings in place. Apply a rating of 100 % heavy carbon for any piston groove that cannot be rated due to the presence of a stuck ring – see 12.4.5.4.

12.3.4 *Oil Ring Plugging*—Measure the percent oil ring plugging for each piston, record the results on Form 8[18] (Summary of Ring Sticking), calculate the average per piston and record on Form 4[18] (Test Result Summary).

12.4 *Process for Rating Piston Parts for Deposits:*

12.4.1 Gently wipe off excess oil from the piston skirts with a soft cloth.

12.4.2 Rate each piston pin boss for varnish and each piston top groove, second groove, oil ring groove, second land, and undercrown area for carbon deposits using

[18] This form is part of the standardized report form set and data dictionary available from the TMC at ftp://ftp.astmtmc.cmu.edu/datadict/IIIH/current/dictionary/. See also Annex A8 and 13.1.

ASTM Deposit Rating Manual No. 20 rating techniques and breakdown methods. Carbon deposit ratings consist of only two levels: heavy (0.00 merit value) or light (0.75 merit value).

12.4.2.1 Report the ratings in decimal form.

12.4.2.2 Perform these ratings in a rating booth, using a 20-segment piston-rating cap, a piston-rating stand, and a 22 W circular rating lamp.

12.4.2.3 Report any unusual deposits observed in the comments Section of Form 9[18] (Summary of Piston Deposits).

12.4.3 If multiple ratings are deemed necessary of a given part or parts, consensus rating may be used according to the following:

12.4.3.1 The raters shall be from the laboratory in question. Outside raters shall not be used unless requested and directed through the Sequence IIIH Surveillance Panel.

12.4.3.2 No averaging of ratings is permitted.

12.4.3.3 Report only one rating value, which is agreed to by the raters.

12.4.4 All raters of Sequence IIIH engine pistons shall attend an ASTM Light Duty Deposit Rating Workshop[19] every 12 months ± 30 days and produce data that meet the TMC definitions of Blue, Red, or White for piston deposits. If a rater is unable to meet this requirement, the rater can continue to rate Sequence IIIH pistons after the completion of the workshop for a grace period of 45 days and can follow the procedure described in 12.4.4.1 to generate data that meet the TMC definitions of Blue, Red, or White.

12.4.4.1 A rater who is unable to meet the requirement in 12.4.4 can schedule a visit to the TMC to generate data on ASTM Light Duty Deposit Rating Workshop pistons and receive an assessment of rating performance compared to data collected at recent workshops. Visits to the TMC will be scheduled based on availability of parts.

12.4.4.2 The TMC selects a minimum of six pistons from a collection of workshop parts for the rater to rate piston deposits. The TMC provides rating booths and lights, but the rater is responsible for providing any necessary rating aids. The TMC analyzes the data and determines if the requirement in 12.4.4 has been met. If the requirement in 12.4.4 has not been met, any time remaining in the 45 day grace period is forfeited.

12.4.5 *Weighted Piston Deposit (WPD) Rating:*

12.4.5.1 The WPD rating comprises ratings for deposits for piston undercrown, 2nd land, oil ring land (3rd land), top groove, 2nd groove, oil-ring groove, and pin boss varnish. Record results on Form 9 (Summary of Piston Deposits) and Form 4 (Test Results Summary).

[19] ftp://ftp.astmtmc.cmu.edu/docs/rater_calibration/RatingWorkshopOverview.pdf

12.4.5.2 The undercrown area to be rated is where the horizontal and vertical planes meet and is defined as the flat area on the undercrown of the piston between the pin bosses and piston skirts. Do not rate any parts on the inside surface of the piston skirts as part of the undercrown rating.

12.4.5.3 For each groove and ring land multiply each rating value by the percentage of surface area covered by that rating. The sum of these values will constitute the unweighted merit rating for each part.

12.4.5.4 Rate the piston varnish on the pin boss area of each piston. Use an average of the front and back of each piston as the unwighted rating for varnish.

12.4.5.5 Use the unweighted ratings to calculate the weighted rating for each piston part by multiplying the average result for that part by the following weighting factors:

piston undercrown	10 %
2nd land	15 %
3rd land (ORLD)	30 %
pin boss varnish	10 %
top groove	5 %
2nd groove	10 %
oil ring groove	20 %

12.4.5.6 See 12.3.3 for how to rate groves with stuck rings.

12.4.5.7 Calculate the weighted rating for each piston as the sum of the weighted ratings of the individual piston parts.

12.4.5.8 Calculate the WPD result for the test as the average of the weighted ratings for the six pistons and record on Forms 9 and 4[18].

12.4.6 *Oil Ring Land Deposit*—Record on Form 4 the average oil ring land (land 3) deposit (as calculated in Form 9) for the 6 pistons.

12.4.7 *Piston Skirt Varnish (PSV)*—For each piston, average the piston skirt varnish for the front and rear side, record the results on Form 9[18] (Summary of Piston Deposits), calculate the average for the 6 pistons and record the result on Form 4[18].

12.5 *Kinematic Viscosity Measurements*—Using Test method D445, determine the kinematic viscosity at 40 °C of the fresh (ie, new) test oil, the initial oil sample, each of the 20 h analysis samples and the EOT sample.

12.5.1 Do not filter the samples.

12.5.2 Use either the Cannon-Fenske Routine Viscometer of the Ostwald Type for Transparent Liquids or the Cannon-Fenske Opaque Viscometer of the Reverse-Flow Type for Transparent and Opaque Liquids.

12.5.3 The viscosity of the initial sample can be as much as 10 mm^2/s less than that of the new oil due permanent shearing effects. If the difference is greater than 10 mm^2/s, explore possible causes such as failure to take the 472 mL purge sample prior to withdrawing the 236 mL analysis sample, or an excessive amount of build-up oil in the system.

12.5.4 Calculate the change in viscosity relative to that of the initial sample, for the 20 h, 40 h, 60 h, 80 h and EOT samples. Record the changes on Form 7[18] (Used Oil Analysis Results) and the EOT (final) percent viscosity increase on Form 4[18] (Test Result Summary).

12.5.5 The Special Case of the Viscosity Increase Being Zero or Negative—In this case, record 0.1 % as the percent change on Form 7 and for the EOT result on Form 4.

Note 1—The minimum viscosity increase that will be considered for this method is 0.1 % so this value replaces any value that is ≤ 0 %.

12.5.5.1 Comment on Form 14[18] (Test Comments) that the original Units result has been replaced by 0.1 % because the viscosity change was zero or negative.

12.5.6 The Special Case of the Viscosity being Too Viscous to Measure (TVTM)—If the viscosity is > 8000 mm^2/s, record 8000 mm^2/s on Form 7 and use this value to calculate the change in viscosity.

NOTE 2—The maximum viscosity that will be considered by this method is 8000 mm^2/s so this value replaces any value > 8000 mm^2/s.

12.5.6.1 Complete the calculations on Form 4 for percent viscosity increase using the percent value for the final drain from Form 7 and using a severity adjustment (SA) of zero.

12.5.6.2 Comment on Form 14 (Test Comments) that a severity adjustment of zero was used for the viscosity increase because the measured viscosity was > 8000 mm^2/s.

12.5.7 Kinematic Viscosity Increase Plot—Plot the percent viscosity increase for the initial, each of the 20-h samples and EOT sample and report the results on Form 11.

12.6MRV and CCS—Perform MRV (Test Method D4684) and Cold Crank Simulator (CCS) measurements (Test Method D5293) on the fresh oil and on the EOT sample. Report the results on Form 4a.

12.7Testing Oil Samples for Element Concentration—Use Inductively Coupled Plasma Optical Emission Spectrometry (ICP) Analysis (Test Method D5185) to determine the concentration of the 15 elements shown in Form 7a for the initial oil sample, each of the 20 h analysis samples and the EOT sample. Report the results in mg/kg on Form7a.

12.8Blowby Flow Rate Measurements—Measure the blowby flow rate in L/min, as described in 11.6, for the initial oil sample, each of the 20 h analysis samples and the EOT sample. Plot the results on Form 10[18] (Blowby Values and Plot).

12.9Oil Consumption Computation—Compute the oil consumption for the test as follows:

12.9.1 Oil Level - Determine oil level, in mL, at 20 h, 40 h, 60 h, 80 h and EOT using Table A7.1 Determination of Volume of Engine Oil in Pan. Each mm on the dipstick corresponds to an oil volume in mL. Record the value in the Oil Level (mL) line of the oil level worksheet (see Table A7.2)

12.9.2 *Oil Consumption at 20 h Intervals*—Calculate the oil consumption at each 20 h interval by adding 118 mL to the difference between the current oil level and the previous oil level. EOT oil consumption is calculated by adding 236 mL to the difference between the 80h oil level and the EOT oil level.

12.9.3 Determine the total oil consumed for the test as the sum of the oil consumption for each 20 h segment and the final 10 h segment. Enter the total in the EOT column of Table A7.1. Report the oil consumption results on Form 4.

12.9.4 *Oil Consumption Plot*—Plot the cumulative oil consumption results on Form 6.

12.10 *DIR Oxidation & Nitration*—Carry out quantitative infrared analysis on each of the 20 h analysis samples and the EOT sample using Standard practice E168. Report the results on Form 7a.

12.11 *Total Acid Number (TAN) and Total Base Number (TBN)—Determine TAN (Test Method D664) and TBN (Test Method D4739) for each of the 20 h samples and the EOT sample and report the results on Form 7a.*

12.12 *Phosphorus retention:*

12.12.2 Using the element concentrations reported on Form 7a, ascertain which is the highest concentration detergent metal (M) in the fresh oil.

12.12.3 Determine the phosphorus retention value using the following equation:

$$\text{Phosphorus Retention} = 100(M_I/M_{EOT}) \times (P_{EOT}/P_I), \% \qquad (2)$$

where:
M_I = concentration of detergent metal in the initial oil sample, mg/kg;
P_I = concentration of phosphorus in the initial oil sample, mg/kg;
M_{EOT} = concentration of detergent metal in the EOT sample, mg/kg;

P_{EOT} = concentration of phosphorus in the EOT sample, mg/kg.

12.12.4 Using the ICP Test method D5185, determine the metal and phosphorus concentrations sequentially, in duplicate, using the same calibration (that is, as close in time as practical). Background correction, internal standard, and peristaltic pump are required. Use sample dilutions of at least 1:20. Once a dilution is established, use it for all samples from a test. Report the average of the two determinations as the final result. If the duplicate determinations are outside the repeatability calculations shown in Table 2 of Test Method D5185, follow the procedure shown in 6.2 of Test Method D3244.

12.12.4 Report the phosphorus retention results on Forms 4a and 7.

12.13 *Photographs of Test Parts*—Take color photographs of the test parts for inclusion in the test report as follows:

12.13.1 Photograph pistons after completing all ratings.

12.13.2 Do not coat the pistons with build-up oil (for preservation) before the photographs are taken. Do not reinstall piston rings.

12.13.3 Photograph all six piston front sides in one shot. Piston labels are not required (see 12.13.7).

12.13.4 Photograph all six piston rear sides in one shot. Piston labels are not required (see 12.13.7).

12.13.5 Size the final piston photographs for inclusion in the test report so that the overall piston height is not less than 5 cm, but small enough that three photographs can be mounted in a column on the 28 cm dimension of a 22 cm by 28 cm sheet of paper.

12.13.6 Assemble the photographs on two pages, with the front side photographs on one page, and the rear photographs on the other page.

12.13.7 Mount the photographs on each of the two pages with the reciprocating axes of the pistons parallel to the 28 cm dimension of the page. Arrange the photographs in two vertical columns of three each, with the No. 1 piston in the upper left corner of the page, No. 2 piston in the upper right corner, No. 3 piston in the center of the left column, etc.

12.14 *Determination of Operational Validity*—Determine and document the operational validity of every Sequence IIIH test conducted, as follows:

12.14.1 Complete the report forms to substantiate that the test stand, engine build-up, installation of the engine on the test stand, and the test operation conformed to the procedures specified in this test method.

12.14.2 Inspect the test records for instances of downtime (excluding the initial oil level run of the test), and record any such instances on Form 13[18], 'Downtime and Outlier Report Form', in standardized report form set. When performing the oil level adjustment at each 20 h interval, identify as downtime any time in excess of 60 min from the time when the engine ramps down until the test is back on test operating conditions. Enter the total downtime on Form 13, 'Downtime and Outlier Report Form', in standardized report form set. If the downtime exceeds either a total of 36 h, or exceeds 24 h in the last 45 h of the test time note on Form 1[18] that the test is invalid.

12.14.3 If the end of test quality-index value is below 0.000, the test laboratory shall conduct an engineering review of the test operations and document the results. Report any findings of such an engineering review of reference oil tests to the TMC. If needed, additional industry experts may be consulted.

13. Report

13.1 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.

NOTE ?—Report the non-reference oil test results on these same forms if the results are intended to be submitted as candidate oil results against a specification.

13.1.1 Fill out the report forms according to the formats shown in the data dictionary.
13.1.2 Transmit results to the TMC within 5 working days of test completion.
13.1.3 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.
13.2 Report all reference oil test results, whether aborted, invalidated, or successfully completed, to the TMC.
13.3 *Deviations from Test Operational Limits*—Report all deviations from specified test operational limits.
13.4 *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.
13.5 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.
13.6 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.

Table 1 Engine Build Part List

Part Name	Quantity per Test	Part Number	Required Supplier
Test Engine, 2014 3.6L Pentastar RT	1	05184464AG	Mopar
Cylinder Head – Left[A]	1	LH516AO-MSD	IMTS
Cylinder Head – Right[A]	1	RH451AO-MS	IMTS
Piston, Special Test	6	OHT3H-070-1	OH Technologies
Head Gasket, Right	1		Chrysler Dealer
Head Gasket, Left	1		Chrysler Dealer
Head Bolts	8		Chrysler Dealer
Rod Bolts	12		Chrysler Dealer
Piston Ring Pack:	1		OH Technologies
Ring, Special Test, UCR (0.025 mm gap, 96.040 mm bore)		3H96040-TOP	OH Technologies
Ring, Special Test, LCR (0.035 mm. gap, 96.040 mm bore)		3H96040-SECOND	
Expander, Seq. IIIH		3H96040-EXP	
Rail, Seq. IIIH		3H96040-RAIL	
Pin, Wrist, Piston	6	OHT3H-071-1	OH Technologies
Clip, Piston, Wrist Pin	6	OHT3H-072-1	OH Technologies
Phaser, Intake (Fixed at 110°, Less Rotor Holes)	2	OHT3H-001-1	OH Technologies
Phaser, Exhaust (Fixed at 112°, Less Rotor Holes)	2	OHT3H-002-1	OH Technologies
Oil Pan[B]	1	OHT3H-304-2	OH Technologies
Gasket, Oil Pan	1	TBD	OH Technologies
Oil Pan Plug[C]	1	E9DZ-6730-B	Ford
Seal, Valve Guide	24	5184168AB	Chrysler Dealer

[A] All cylinder head purchases require a core exchange from each test engine.

[B] Oil pan and plug may be used for multiple tests, and shall be replaced at the discretion of the laboratory upon failure of pressure check or visual inspection.

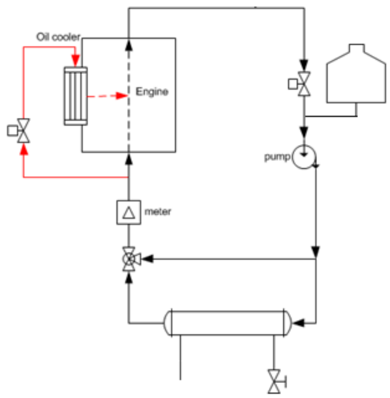


FIG. 1 Engine Coolant Flow Schematic

Table 2 Control System/Engine Interface Components

Component Description	Part Number	Supplier
Pump, Water, Modified, Seq. IIIH Chrysler	OHT3H-300-1	OH Technologies
Coolant Crossover, Seq. IIIH Chrysler	OHT3H-302-1	OH Technologies
Adapter, Coolant Crossover, Seq. IIIH Chrysler	OHT3H-303-1	OH Technologies
Jumper, Harness Segment, Throttle Control, Seq. IIIH Chrysler	OHT3H-004-1	OH Technologies
Harness, Dyno, Seq. IIIH Chrysler	OHT3H-005-1	OH Technologies
Exhaust Turndown Pipe Prints	IIIH-ETB30-B	TMC
	IIIH-ETB31-B	
	IIIH-ETB32-B	
	IIIH-ETB40-B	
	IIIH-ETP42-B	
Air Cleaner (optional)	04861729AB	Chrysler Dealer
Air Resonator	04861731AB	Chrysler Dealer
Air Hose (optional)	04861732AB	Chrysler Dealer
Throttle Pedal (optional)	68043161AB	Chrysler Dealer
Starter	56029852AA	Chrysler Dealer
O_2 Sensor	56029050AA	Chrysler Dealer
PCM[A]	RL150588AC	Chrysler Dealer
Manual Flywheel (2013 JK)	05184438AB	Chrysler Dealer

[A] Purchase PCM from local dealer and send to the test sponsor for installation of proper test calibration files.

Table 3 Engine Coolant Flow Module Control Parts

Control Parts	Supplier	Part Number	Description
2-way Coolant Flow Control Valve	Badger Meter Inc.	9003GCW36SV3A29L36	2" 2-way Air to close
Heat Exchanger	Kinetic Engineering Corp		Elanco M-71-FL Heat Exchanger*
Coolant Micromotion Coriolis Flow Meter	Micro Motion, Inc	R200S418NCAMEZZZZ** 1700I13ABMEZZZ	Flow meter Transmitter
Fuel Temp Heat Exchanger		laboratory determined	
3-way Coolant Temp Control Valve	Badger Meter Inc.	9003TCW36SV3AXXL36	2"GLOBE CAST 3_WAY WAFER-NPT316/316L STAINLESS, SIZE 35 ACTUATOR AIR TO CLOSE 3-15 PSI 3 SPRINGS
Oil Temp Control Valve	Badger Meter Inc.	1002GCN36SVCSALN36	1/2" 2-way Research valve, A-trim
Drive Shaft			Driveshaft w/1410 U-Joints

*Tube and shell heat exchanger is an acceptable alternative.

**Recommended model. Model used must meet or exceed a mass flow accuracy of ±0.50%, and mass flow repeatability of ±0.05%.

Table 4 Test Parameters

CONTROLLED PARAMETERS			
Parameter	Units	Target	QI values
Speed	r/min	3900	± 5
Load	N·m	250	± 0.98
Oil Gallery Temp	° C	150	± 0.42
Coolant Out Temp	° C	115	± 0.46
Intake Air Temp	° C	35	TBD
Fuel Temp	° C	30	TBD
Dew Point	° C	16.1	± 5
Coolant Pressure	kPa	200	TBD
Intake Air Pressure	kPaG	0.05	± 0.009
Right Exhaust Pressure	kPaG	3	± 0.08
Left Exhaust Pressure	kPaG	3	± 0.08
Coolant Flow	L/min	170	± 1.43

UNCONTROLLED PARAMETERS		
Parameter	Units	Average
Oil Pump Temp	° C	R
Oil Sump Temp	° C	R
Coolant In Temp	° C	R
Left Exhaust Temp	° C	R
Right Exhaust Temp	° C	R
Oil Pump Pressure	kPaG	R
Oil Gallery Pressure	kPaG	R
Manifold Vacuum	kPaV	R
Fuel Pressure	kPaG	R
Crankcase Pressure	kPaG	R
Ignition Voltage	V	R
Right AFR		R
Left AFR		R
Right NO_x	ppm[A]	R
Left NO_x	ppm[A]	R
Fuel flow	kg/hr	R

[A]*Mass fraction*

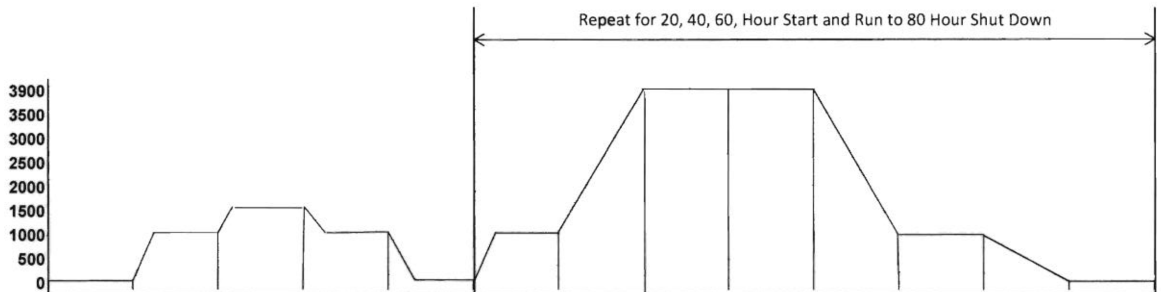
Table 5 Maximum System Time Response

For controlled (QI) parameters only

Parameter	**Time (s)**
Speed	0.10
Torque	0.60
Coolant Flow	8.0
Intake Air Pressure	0.75
Exhaust Backpressure	1.20
Temperatures	2.40

Table 6 Control States

Chrysler IIIH Control States



Ramp Time (seconds)	0		45*	15			300	**		45			
Dyno Speed Setpoint	0	1000	1500	1000	0	1000	3900	3900	3900	1000	1000	0	0
Dyno Load Setpoint	0	25	100	25	0	25	250	250	250	25	25	0	0
Step Time (seconds)		90	480	120	1200	90	300	600	72000	45	120		1200
State Name	Hold	Engine Start Systems Check	Initial Run-in Includes 45 sec Ramp	Ramp Down Oil Sample	Oil Level Return Sample Purge	Engine Start Systems Check	Linear Speed Load Ramp-up	Warm-Up to Test Condition	On-Test Condition	Ramp Down	Oil Sample	Shut Down	Oil Level Return Sample Purge
Temperature °C													
Oil Temp Setpoint	150	150	65	65	65	150	150	150	150	65	65	65	65
Engine Coolant Out	115	115	60	60	60	115	115	115	115	60	60	60	60
Pressure kPa													
Exh. Back Right/Left	Open	Open	Open	Open	Open	Open	4.5	4.5	4.5	Open	Open	Open	Open
Inlet Air	Off	0.05	0.05	0.05	Off	0.05	0.05	0.05	0.05	0.05	0.05	0.05	Off
Fuel	Off	400	400	400	Off	400	400	400	400	400	400	400	Off
Flow L/m													
Engine Coolant	170	170	170	170	170	170	170	170	170	170	170	170	170

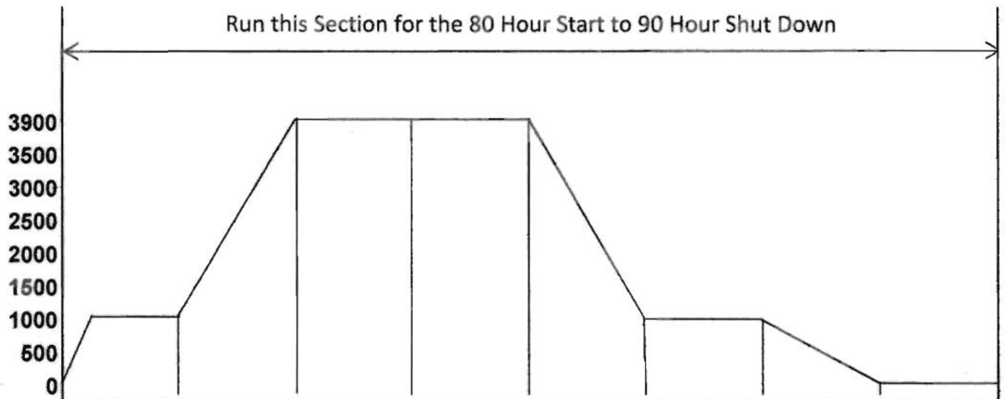
* 45 second ramp included in step time 480 seconds for initial run-in.

** 600 second minimum and greater than 149°C oil temperature criterion to advance to on-test condition.

All ramp times are linear with respect to dyno speed and load settings.

All temp., press., and flow settings are setpoint changes between states. Control systems should allow for overshoot and stabilization.

Chrysler IIIH Control States



Ramp Time (seconds)		300	**		45			
Dyno Speed Setpoint	1000	3900	3900	3900	1000	1000	0	0
Dyno Load Setpoint	25	250	250	250	25	25	0	0
Step Time (seconds)	90	300	600	36000	45	120		1200
State Name	Engine Start Systems Check	Linear Speed Load Ramp-up	Warm-Up to Test Condition	On-Test Condition	Ramp Down	Oil Sample	Shut Down	Oil Level Return Sample Purge
Temperature °C								
Oil Temp Setpoint	150	150	150	150	65	65	65	65
Engine Coolant Out	115	115	115	115	60	60	60	60
Pressure kPa								
Exh. Back Right/Left	Open	4.5	4.5	4.5	Open	Open	Open	Open
Inlet Air	0.05	0.05	0.05	0.05	0.05	0.05	0.05	Off
Fuel	400	400	400	400	400	400	400	Off
Flow L/m								
Engine Coolant	170	170	170	170	170	170	170	170

ANNEXES

(Mandatory Information)

A1. ASTM TEST MONITORING CENTER ORGANIZATION

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. PRESSURE AND TEMPERATURE MEASUREMENT LOCATIONS

A2.1 Figs A2.1 to A2.3 show the location of the pressure and temperature transducers.

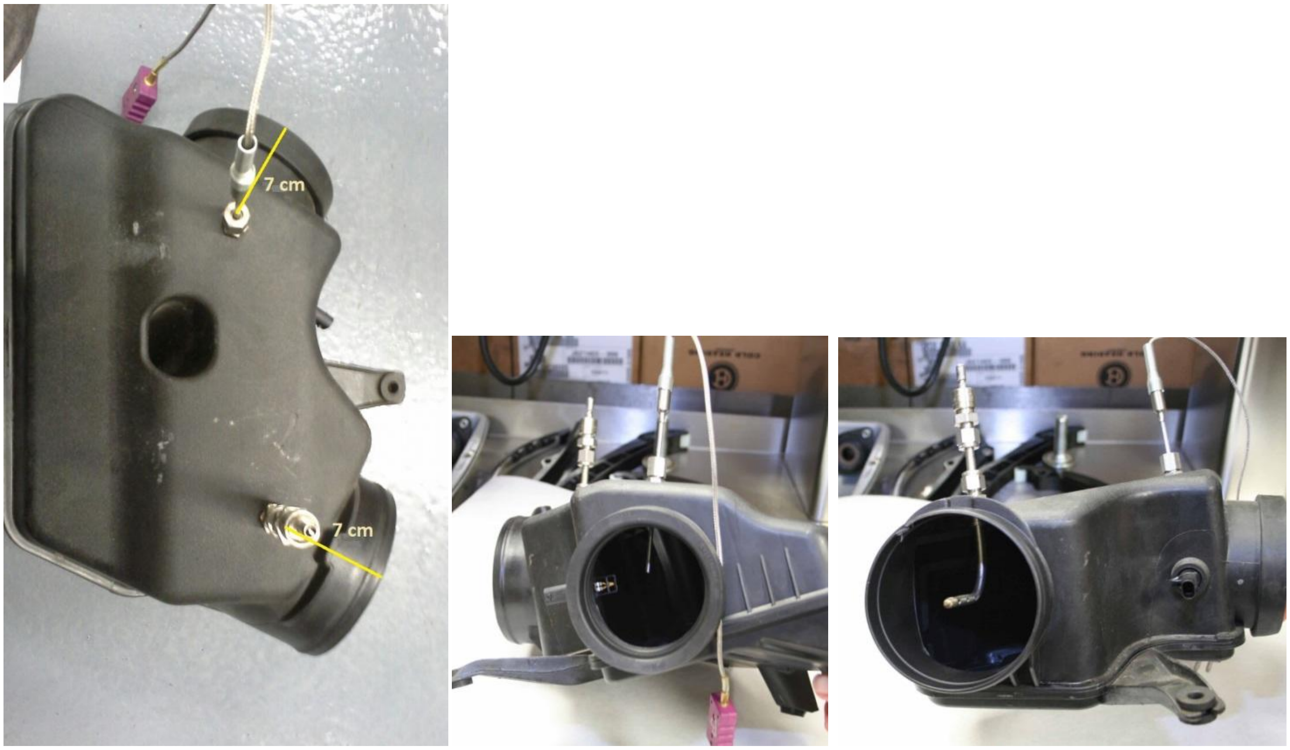


FIG. A2.1 Intake Air Temperature and Pressure – Air Resonator

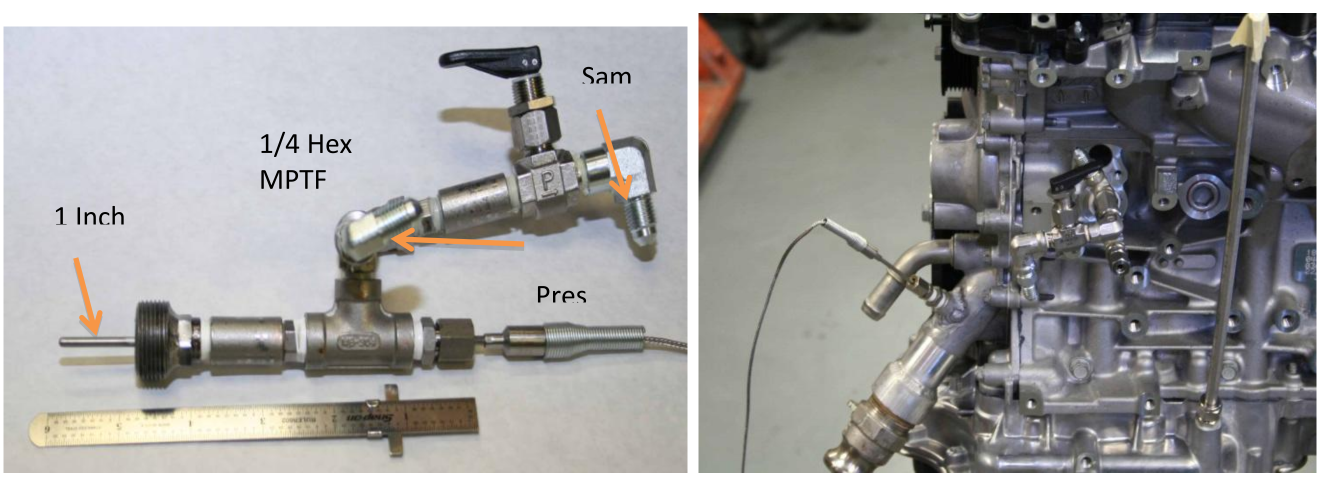


FIG. A2.2 Oil Pump Temperature and Pressure

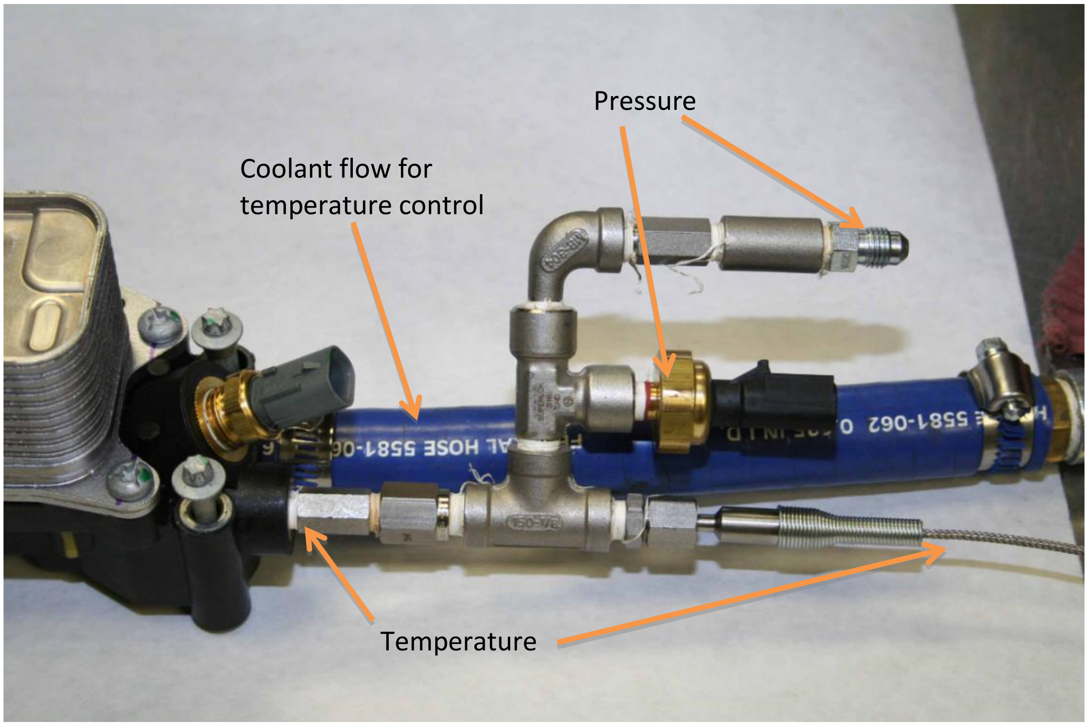
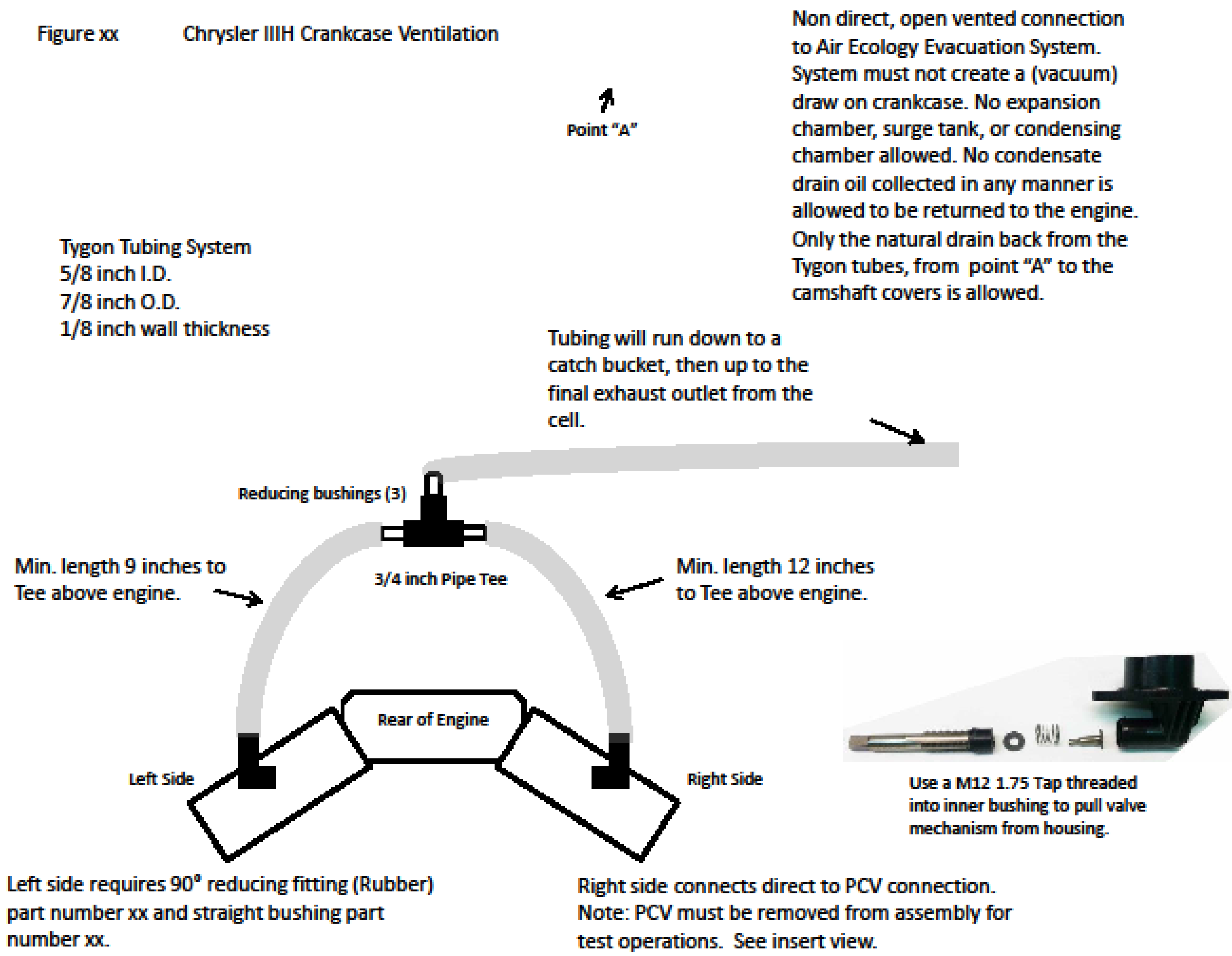


FIG. A2.3 Oil Gallery Temperature and Pressure

Figure A2.4 Blowby Ventilation Setup



A3. SEQUENCE IIIH TEST FUEL ANALYSIS

A3.1 See Table A4.1.

TABLE A3.1 Sequence III Test Fuel Analysis (Haltermann HF003 Test Fuel)

TEST	METHOD	UNITS	HALTERMANN HF003 Specs MIN	TARGET	MAX
Distillation - IBP	ASTM D86	°C	23.9		35
5%		°C			
10%		°C	48.9		57.2
20%		°C			
30%		°C			
40%		°C			
50%		°C	93.3		110.0
60%		°C			
70%		°C			
80%		°C			
90%		°C	151.7		162.8
95%		°C			
Distillation - EP		°C			212.8
Recovery		vol %		Report	
Residue		vol %		Report	
Loss		vol %		Report	
API Gravity (@60°F/60°F)	ASTM D4052	°API	58.7		61.2
Density (@15°C)	ASTM D4052	kg/L	0.734		0.744
Reid Vapor Pressure	ASTM D5191	kPa	60.8		63.4
Reid Vapor Pressure	ASTM D323	kPa		Report	
Carbon	ASTM D3343	wt fraction		Report	
Carbon	ASTM E191	wt fraction		Report	
Hydrogen	ASTM E191	wt fraction		Report	
Hydrogen/Carbon ratio	ASTM E191	mole/mole		Report	
Oxygen	ASTM D4815	wt %			0.05
Sulfur ppm	ASTM D5453	mg/kg	3		15
Lead	ASTM D3237	mg/L			2.6
Phosphorus	ASTM D3231	mg/L			1.3
Composition, aromatics	ASTM D1319	vol %	26.0		32.5
Composition, olefins	ASTM D1319	vol %			10.0
Composition, saturates	ASTM D1319	vol %		Report	
Particulate matter	ASTM D5452	mg/L			1
Oxidation Stability	ASTM D525	minutes	240		
Copper Corrosion	ASTM D130				1
Gum content, washed	ASTM D381	mg/100mL			5
Fuel Economy Numerator/C Density	ASTM E191		2401		2441
C Factor	ASTM E191			Report	
Research Octane Number	ASTM D2699		96.0		
Motor Octane Number	ASTM D2700			Report	
Sensitivity			7.5		
Net Heating Value	ASTM D3338	J/kg		Report	
Net Heating Value	ASTM D240	J/kg		Report	
Color	VISUAL	1.75 ptb		Red	

A4. ASTM TEST MONITORING CENTER: CALIBRATION PROCEDURES

A4.1 *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.

A4.1.1 *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.

A4.2 *Calibration Testing:*

A4.2.1 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.

A4.2.2 *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.

A4.3 *Reference Oil Storage*—Store reference oils under cover in locations where the ambient temperature is between -10 °C and +50 °C.

A4.4 *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.

A4.5 *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.

A4.6 *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 13 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.

A4.6.1 All deviations from the specified test method shall be reported.

A5 ASTM TEST MONITORING CENTER: MAINTENANCE ACTIVITIES

A5.1 *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.

A5.2 *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.

A5.3 *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.

A5.4 *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.

A5.5 *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.

A5.6 *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.

A5.6.1 *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.

A5.7 *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.

A6. ASTM TEST MONITORING CENTER: RELATED INFORMATION

A6.1 *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.

A6.2 *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."

A6.3 *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.

A7. SEQUENCE IIIH OIL LEVEL AND CONSUMPTION WORKSHEET

A7.1 Use this Table to record oil levels

Oil Level at end of initial run:____________

Initial Fill = 5.92 L = 5915 mL	Initial Run	At 20 h	At 40 h	At 60 h	At 80 h	EOT	EOT Total
Add 177 mL of New Oil to Purge Container							
Remove 472 mL Purge							
Remove 236 mL Analysis Sample							
Remove 59 mL Analysis Sample							
Replace 472 mL Purge and New Oil mix	*					*	
Dipstick Mark After Drain down (mm)							
Oil Level (mL)							
New Oil Added – Analysis Sample		118	118	118	118	236	
20-h Oil Consumption (mL)							
Performed by:							

*Purge only with no new oil at initial and EOT

Table A7.2 Determination of Volume of Engine Oil in Pan

mm	mL in pan	mm	mL in pan	mm	mL in pan
3	500	48	2300	77	4100
5	600	50	2400	78	4200
7	700	52	2500	79	4300
10	800	51	2600	80	4400
12	900	57	2700	81	4500
15	1000	60	2800	82	4600
18	1100	62	2900	83	4700
20	1200	63	3000	84	4800
22	1300	65	3100	85	4900
25	1400	67	3200	86	5000
28	1500	68	3300	87	5100
30	1600	69	3400	88	5200
32	1700	70	3500	89	5300
35	1800	72	3600	90	5400
38	1900	73	3700	92	5500
40	2000	74	3800	93	5600
43	2100	75	3900	94	5700
45	2200	76	4000	95	5800

A.8 Chrysler Pentastar Build Data Worksheet

Test #:______________________________

Block Assembled by:___________________

Lab Engine #:_________________________

Right Head Number #:__________________

Left Head Number #:___________________

Date:_________________________________

Build Completed Date:__________________

Crankshaft serial #:_____________________

Chrysler Block

Code:____________________

ANs

Micrometer: __________________________

Bore Gage: ___________________________

Torque Wrench 3/8”: __________________

Taper Gage: _________________________

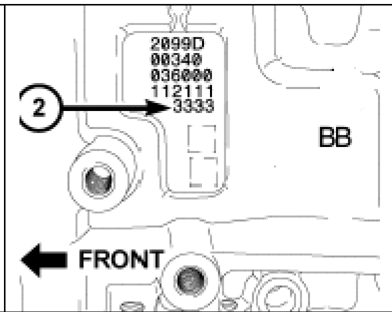
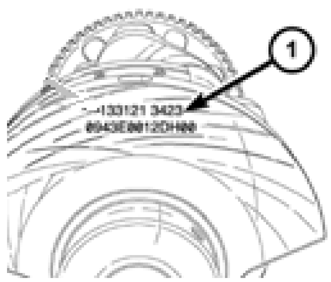
Dial Indicator: ________________________

Torque Wrench 1/2”: __________________

Chrysler Pentastar Build Data Worksheet

<u>Main Bearing Size Selection</u>

Engine #:______________________________ Buildup Mechanic:____________________
Run #:________________________________ Date:_________________________________

Bore #			Upper/Lower Main bearing selection from Table A*
	Engine Block Marking	Crankshaft Marking	Bearing
1			/
2			/
3			/
4			/

*Upper bearing grade will always be equal to or lesser than the lower bearing grade.

Table A: Main bearing selection table.

Engine Block Marking	**Crankshaft Marking**				
	1	**2**	**3**	**4**	**5**
1	1/1	1/2	2/2	2/3	3/3
2	1/2	2/2	2/3	3/3	3/4
3	2/2	2/3	3/3	3/4	4/4
4	2/3	3/3	3/4	4/4	4/5
5	3/3	3/4	4/4	4/5	5/5
	UPPER/LOWER Main Bearings to Achieve 0.024 - 0.050 mm Oil Clearance				

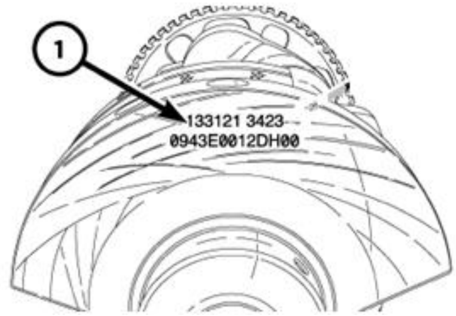
Connecting Rod Bore Measurements

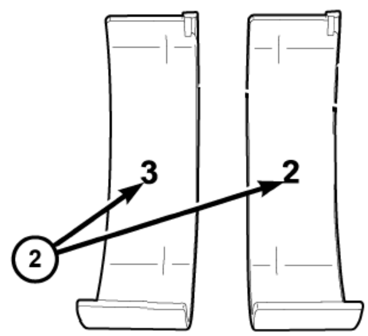
Engine #:______________________________ Buildup Mechanic:____________________

Run #:________________________________ Date:_______________________

Rod Bearing Size

Rod #	Marking on Crank (1)	Marking on Bearing (2)
1		
2		
3		
4		
5		
6		





Crankshaft End Play: _________________ mm

Factory Specification: 0.050 – 0.290 mm

Chrysler Pentastar Build Data Worksheet

Camshaft Bore Clearance

Engine #:______________________________ Buildup Mechanic:_____________________
Run #:________________________________ Date:________________________

Cam Journal OD

Bore Gauge Set: 31.________ mm and 24.____________

	Bank 1		Bank 2		Factory Specification
Journal #	R Intake	R Exhaust	L Intake	L Exhaust	
1	31.9	31.9	31.9	31.9	31.976 -31.995 mm
2	23.9	23.9	23.9	23.9	23.977 – 23.996 mm
3	23.9	23.9	23.9	23.9	
4	23.9	23.9	23.9	23.9	

Cam Bore ID

Journal #	Bank 1		Bank 2		Factory Specification
	R Intake	R Exhaust	L Intake	L Exhaust	
1	32.0	32.0	32.0	32.0	32.020 – 32.041 mm
2	24.0	24.0	24.0	24.0	24.020 – 24.041 mm
3	24.0	24.0	24.0	24.0	
4	24.0	24.0	24.0	24.0	

Camshaft End Play

	Bank 1		Bank 2		Factory Specification
	R Intake	R Exhaust	L Intake	L Exhaust	
SOT	0.	0.	0.	0.	0.075 – 0.251 mm
EOT	0.	0.	0.	0.	

Chrysler Pentastar Build Data Worksheet

Cylinder Bore Measurements

Engine No.:_______________ Date Honed : _______________
Bore Gage Set At: 95.________ Honed By : ____________________

Cylinder Bore Measurement

Transverse Diameter

	Top:	Middle:	Bottom:	Taper:
1	0.0	0.0	0.0	
2	0.0	0.0	0.0	
3	0.0	0.0	0.0	
4	0.0	0.0	0.0	
5	0.0	0.0	0.0	
6	0.0	0.0	0.0	

Longitudinal Diameter

	Top:	Middle:	Bottom:	Taper:
1	0.0	0.0	0.0	
2	0.0	0.0	0.0	
3	0.0	0.0	0.0	
4	0.0	0.0	0.0	
5	0.0	0.0	0.0	
6	0.0	0.0	0.0	

***Record taper as the difference between top and bottom positions.**

Microfinish:

	Rk	**Rpk**	**Rvk**	**Rz**	**Mr2**
1					
2					
3					
4					
5					
6					

Chrysler Pentastar Build Data Worksheet

Ring End Gap

Engine #:_____________________________ Buildup Mechanic:_____________________
Run #:_______________________________ Date:________________________

Ring End Gap In Honed Block (in)

Cylinder	Top Compression	2nd Compression	Test Specification
1	0.0	0.0	Top 0.024 – 0.026 in
2	0.0	0.0	
3	0.0	0.0	
4	0.0	0.0	2nd 0.034 – 0.036 in
5	0.0	0.0	
6	0.0	0.0	