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Designation: DXXXX

IIH DRAFT Procedure

Standard Test Method for Evaluation of Automotive Engine Oils in the Sequence IIH, Spark-Ignition Engine¹

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

Portions of this test method are written for use by laboratories that make use of ASTM Test Monitoring Center (TMC)² services (see Annex A1).

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 use the TMC services in seeking qualification of oils against their specifications.

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.

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.

Laboratories that choose not to use the TMC services may simply disregard these portions.

1. Scope

1.1 This test method covers an engine test procedure for evaluating automotive engine oils for certain high-temperature performance characteristics, including oil thickening (as measured by viscosity increase), piston deposits, ring sticking, oil consumption and phosphorus retention. Such oils include both single viscosity grade and multiviscosity grade oils that are used in both spark-ignition, gasoline-fueled engines, as well as in diesel engines.

NOTE 1—Companion test methods used to evaluate engine oil performance for specification requirements are discussed in SAE J304.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.2.1 *Exception*—Where there is no direct SI equivalent such as screw threads, national pipe threads/diameters, tubing sizes, and valve sizes and springs.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Specific warning statements are provided in 6.11.5, 7.1, 7.2.1, and 7.3.*

2. Referenced Documents

2.1 ASTM Standards:³

D235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D644 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D3244 Practice for Utilization of Test Data to Determine Conformance with Specifications

D4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants

D4485 Specification for Performance of Active API Service Category Engine Oils

D4684 Test Method for Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature

D4739 Test Method for Base Number Determination by Potentiometric Hydrochloric Acid Titration

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D5185 Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

D5293 Test Method for Apparent Viscosity of Engine Oils and Base Stocks Between –5 and –35°C Using Cold-Cranking Simulator

D6750 Test Methods for Evaluation of Engine Oils in a High-Speed, Single-Cylinder Diesel Engine—1K Procedure (0.4 % Fuel Sulfur) and 1N Procedure (0.04 % Fuel Sulfur)

D7320 Test Method Evaluation of Automotive Engine Oils in the Sequence IIIG, Spark-Ignition Engine

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *Military Specification:*⁴

MIL-PRF-2104, Lubricating Oil, Internal Combustion Engine, Tactical Service

2.3 *SAE Standards:*⁵

J183, Engine Oil Performance and Engine Service Classification (Other Than “Energy-Conserving”)

J300, Engine Oil Viscosity Classification

*HS-23/00 J304, Engine Oil Tests

2.4 *Other ASTM Documents:*

Guidelines for Calibration⁶

The Lubricant Test Monitoring System, Sequence IIH Test Control Chart Technique for Developing and Applying Severity Adjustments (SA)⁷

ASTM Deposit Rating Manual No. 20 (Formerly CRC Manual 20)⁸

3. Terminology

3.1 *Definitions:*

3.1.1 *air-fuel ratio, n*—in internal combustion engines, the mass ratio of air-to-fuel in the mixture being induced into the combustion chambers. **D4175**

3.1.2 *automotive, adj*—descriptive of equipment associated with self-propelled machinery, usually vehicles driven by internal combustion engines. **D4175**

⁴ Hardcopy available from Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. Also, can be downloaded from <http://assist2.daps.dla.mil/quicksearch/>

⁵ Available from Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096-0001. These standards are not available separately. Order either *SAE Handbook*, Vol. 3, or *SAE Fuels and Lubricants Standards Manual*, HS-23.

⁶ Guidelines for Calibration can be found in the Lubricant Test Monitoring System, available from the Test Monitoring Center, <http://www.astmtmc.cmu.edu/>

⁷ Available at: <ftp://ftp.astmtmc.cmu.edu>.

⁸ Available as stock # TCMNL20 at www.astm.org, or contact ASTM Customer Service at service@astm.org.

3.1.3 *blowby, n*—in internal combustion engines, that portion of the combustion products and unburned air/fuel mixture that leaks past piston rings into the engine crankcase during operation. **D7320**

3.1.4 *build-up oil, n*—EF-411, non-compounded, ISO VG 32 (SAE 10) oil used in lubricating some of the Sequence IIH parts during engine assembly. **D7320**

3.1.5 *calibrate, v*—to determine the indication or output of a device (e.g., thermometer, manometer, engine) with respect to that of a standard. **D4175**

3.1.6 *corrosion, n*—the chemical or electrochemical reaction between a material, usually a metal surface, and its environment that can produce a deterioration of the material and its properties. **D4175**

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

3.1.6.1 *Discussion*—It may contain additives to enhance certain properties. Inhibition of engine rusting, deposit formation, valve train wear, oil oxidation, and foaming are examples. **D6750**

3.1.8 *lubricant, n*—any material interposed between two surfaces that reduces the friction or wear, or both, between them. **D4175**

3.1.9 *Material Safety Data Sheet (MSDS), n*—a fact sheet summarizing information about material identification; hazardous ingredients; health, physical, and fire hazards; first aid; chemical reactivities and incompatibilities; spill, leak, and disposal procedures; and protective measures required for safe handling and storage.

<http://www.msdssearch.com>

3.1.10 *non-reference oil, n*—any oil, other than a reference oil; such as a research formulation, commercial oil, or candidate oil. **D4175**

3.1.11 *oxidation, n*—of engine oil, the reaction of the oil with an electron acceptor, generally oxygen, that can produce deleterious acidic or resinous materials often manifested as sludge formation, varnish formation, viscosity increase, or corrosion, or a combination thereof. **D4175**

3.1.12 *quality index (QI), n*—a mathematical formula that uses data from controlled parameters to calculate a value indicative of control performance.

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

3.1.12.1 *Discussion*—Reference oils are used to calibrate testing facilities, to compare the performance of other oils, or to evaluate other materials (such as seals) that interact with oils. **D4175**

3.1.13 *test oil, n*—any oil subjected to evaluation in an established procedure.

3.1.14.1 *Discussion*—It can be any oil selected by the laboratory conducting the test. It could be an experimental product or a commercially available oil. Often, it is an oil that is a candidate for approval against engine oil specifications (such as manufacturers' or military specifications, etc.). **D4175**

3.1.14 *test procedure, n*—one where test parameters, apparatus, apparatus preparation, and measurements are principal items specified. **D4175**

3.1.15 *used oil, n*—any oil that has been in a piece of equipment (for example, an engine, gearbox, transformer, or turbine), whether operated or not. **D4175**

3.1.16 *varnish, n*—in internal combustion engines, a hard, dry, generally lustrous, deposit that can be removed by solvents but not by wiping with a cloth. **D4175**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *calibrated test stand, n*—a test stand on which Sequence IIH engine oil tests are conducted as administered by the TMC. (See Introduction and A5.3.)

3.2.2 *central parts distributor (CPD), n*—the manufacturer and supplier of many of the parts and fixtures used in this test method.

3.2.2.1 *Discussion*—Because of the need for rigorous inspection and control of many of the parts used in this test method, and because of the need for careful manufacture of special parts and fixtures used, companies having the capabilities to provide the needed services have been selected as the official suppliers for the Sequence IIH test method. These companies work closely with the original parts suppliers, with the Test Procedure Developer, and with the ASTM groups associated with the test method to help ensure that the equipment and materials used in the method function satisfactorily. **D7320**

3.2.3 *cold-stuck piston ring, n—in internal combustion engines*, a piston ring that is stuck when the piston and ring are at room temperature, but inspection shows that it was free during engine operation.

3.2.3.1 *Discussion*—A cold-stuck piston ring cannot be moved with moderate finger pressure. It is characterized by a polished face over its entire circumference, indicating essentially no blowby passed over the outside of the ring during operation. **D4175**

3.2.4 *hot-stuck piston ring, n—in internal combustion engines*, a piston ring that is stuck when the piston and ring are at room temperature, and inspection shows that it was stuck during engine operation.

3.2.4.1 *Discussion*—The portion of the ring that is stuck cannot be moved with moderate finger pressure. A hot-stuck ring is characterized by varnish or carbon across a portion of its face, indicating that portion of the ring was not contacting the cylinder wall during engine operation. **D4175**

3.2.5 *mass fraction, n—of a component A in a solution*, mass of component A

divided by the total mass of all the constituents of the solution.

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

3.2.6.1 *Discussion*—Reference oils are used to calibrate testing facilities, to compare the performance of other oils, or to evaluate other materials (such as seals) that interact with oils. **D4175**

3.2.7 *reference oil test, n*—a standard Sequence IIH engine oil test of a reference oil designated by the TMC.

3.2.8 *special parts supplier (SPS), n*—the manufacturer and supplier of many of the parts and fixtures used in this test method. **D7320**

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

3.2.9.1 *Discussion*—The specified operating conditions in some test methods include requirements for determining a test's operational validity. These requirements are applied after a test is completed and can include (1) mid-limit ranges for the *average values* of primary and secondary parameters that are narrower than the specified control ranges for the *individual values*, (2) allowable *deviations* for *individual* primary and secondary parameters for the specified control ranges, (3) downtime limitations, and (4) *special* parameter limitations. **D4175**

3.2.10 *test procedure developer, n*—the group or agency which developed the Sequence IIH test procedure before its standardization by ASTM, and which continues to be involved with the test in respect to modifications in the test method, development of Information Letters, supply of test parts, and so forth.

3.2.10.1 *Discussion*—In the case of the Sequence IIH test, the Test Procedure Developer is the Chrysler Technology Center.

3.2.10 *test stand, n*—a suitable foundation (such as a bedplate) to which is mounted a dynamometer, and which is equipped with a suitable data acquisition system, fluids process control system, supplies of electricity, compressed air, and so forth, to provide a means for mounting and operating an engine in order to conduct a Sequence IIH engine oil test. **D7320**

3.2.11 *test start, n*—introduction of test oil into the engine after the final assembly and mounting in the test stand. **D7320**

3.2.12 *volume fraction, n*—of a component B in a solution, volume of component B divided by the total volume of the all the constituents of the solution prior to mixing.

3.2.13 *Varnish, n*—in internal combustion engines, a hard, dry, generally lustrous deposit that can be removed by solvents but not by wiping with a cloth. **D4175**

3.3. *Acronyms and Abbreviations:*

AFR—air fuel ratio

APP—accelerator pedal position

AWG—American Wire Gauge

CCS—cold cranking simulator

CPD—central parts distributor

DC—direct current

FCM—fluid conditioning module

ECU—electronic control unit

EOT—end of test

ICP-AES—Inductively Coupled Plasma Atomic Emission Spectrometry

I.D.—Inside Diameter

MRV—mini rotary viscometer

MSDS—Material Safety Data Sheet

O.D.—Outside Diameter

OE—original equipment

PCM—powertrain control module

P/N—part number

PTFE—polytetrafluoroethylene

QI—quality index

SA—severity adjustment

SOT—start of test

SPS—special parts supplier

TMC—Test Monitoring Center

TAN—Total Acid Number

TBN—Total Base Number

TVTM—Too Viscous to Measure

4 Summary of Test Method

4.1 A Chrysler Pentastar V-6 test engine with a displacement of 3.6 L is disassembled, honed, 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 h segment.

4.7 Used-oil samples are taken after the 8 min initial run-in, after each 20 h test segment and at the end of test (EOT); 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

5.1 This test method was developed to evaluate automotive engine oils for protection against oil thickening and piston deposits during moderately high-speed, high-temperature service.

5.1.1 The increase in oil viscosity obtained in this test indicates the tendency of an oil to thicken because of oxidation. In automotive service, such thickening can cause oil pump starvation and resultant catastrophic engine failures.

5.1.2 The deposit ratings for an oil indicate the tendency for the formation of deposits throughout the engine, including those that can cause sticking of the piston rings in their grooves. This can be involved in the loss of compression pressures in the engine.

5.2 The test method was developed to correlate with oils of known good and poor protection against oil thickening and piston deposits. Specially formulated oils that produce less than desirable results with unleaded fuels were also used during the development of this test.

5.3 The Sequence IIH engine oil test has replaced the Sequence IIG test and can be used in specifications and classifications of engine lubricating oils, such as the following:

5.3.1 Specification **D4485**,

5.3.2 Military Specification MIL-PRF-2104

5.3.3 SAE Classification J183.

6 Apparatus

6.1 *Laboratory:*

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

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

6.1.1.2 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.

6.1.1.3 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.

6.1.1.4 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.

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

6.1 *Drawings*—Obtain the equipment drawings referenced in Table 2 from the TMC². 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.

6.2 *Specified Equipment:*

6.2.1 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 IIH Surveillance Panel.

6.2.2 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.

6.2.2.1 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.

6.2.2.2 Small fans with an output 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. Place fans at a minimum of 35 cm from the centerline of the harmonic balancer.

6.3 *Test Engine:*

6.3.2 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 Part Number (P/N) 05184464AH^{9,10}. Each test will consist of a single, new complete test engine that will be assembled according to the Sequence IIIH Engine Assembly Manual¹¹.

6.3.3 *Engine Parts*—Use the engine parts specified in the Sequence IIIH Engine Assembly Manual¹¹.

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

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

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

6.4 *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**.

6.5 *Fluid Conditioning Module (FCM):*

6.5.2 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.

6.5.3 *Engine Cooling System*—The FCM 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.

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

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

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

⁹ The sole source of supply of this equipment known to the committee at this time is **?????** Any Mopar dealer

¹⁰ 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 committee¹ which you may attend.

¹¹ The Sequence IIIH Engine Assembly Manual is available at ftp://ftp.astmtmc.cmu.edu/docs/gas/sequenceiii/procedure_and_ils/IIIH.

6.6.2.4 Refer to [Table 3](#) for a list of suitable coolant flow system control equipment.

6.6.1.5 Install a 3 k Ω resistor across the engine coolant temperature sensor to allow the PCM to receive an appropriate signal voltage to run the engine without the need for the sensor wire on the wiring harness to be plugged in.

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

6.7 Engine Oil Cooling System—The FCM 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.

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

6.7.2 Do not use magnetic plugs in the oil system.

6.8 Fuel System—The FCM includes a pressure regulator to provide fuel at 420 kPa \pm 20 kPa. Maintain fuel temperature at 30 °C throughout the test. Switch the system off so that no fuel pressure is present at the injector rail during engine shutdowns.

6.9 Induction Air System—Maintain the throttle body intake air at a moisture content of 11.4 g/kg \pm 0.7 g/kg of dry air, a dry bulb temperature of 35 °C \pm 2 °C, dew point of 16.1 °C and a static pressure of 0.050 kPa. Measure air intake temperature and pressure at the Air Resonator (Chrysler P/N 04861731AB)^{9,9} in the center of flow 7 mm from the opening as shown in [Fig. A2.1](#).

6.10 *Pressure Transducer Locations:*

6.10.1 Coolant Pressure—Connect the transducer to the modified Coolant Crossover Adapter P/N OHT3H-303-1^{12,10}. Transducers with a gage pressure range of 0 kPa to 300 kPa have been found to be suitable.

6.10.1 *Intake Air Pressure*—Install the transducer to the location shown in [Fig. A2.1 and A2.2](#). Transducers with a gage pressure range of -125 Pa to +125 Pa have been found to be suitable.

6.10.2 *Right and Left Exhaust Backpressure*—Insert probe into the Exhaust Turndown Pipes (TMC print IIH-ETP40-B position 4). Transducers with a gage pressure range of 0 kPa to 70 kPa have been found to be suitable.

6.10.3 *Oil Pump Pressure*—Connect the transducer to the location shown in [Fig. A2.8](#). Transducers with a gage pressure range of 0 kPa to 700 kPa have been found to be suitable.

6.10.4 *Oil Gallery Pressure*—Connect the transducer to the location shown in [Fig. A2.6](#). Transducers with a gage pressure range of 0 kPa to 700 kPa have been found to be suitable.

¹² The sole source of supply of the apparatus known to the committee at this time is OH Technologies Inc. PO Box 5039, Mentor. OH 44061-5039.

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

6.10.6 *Fuel Pressure*—Mount a fuel distribution block to the front of the engine within 30 cm of the fuel rail inlet as shown in Fig. A2.4. Russell Performance P/N RUS-650370^{13,10} (shown in Fig. A2.5) has been found to be suitable for fuel pressure and temperature measurements. Transducers with a gage pressure range of 0 kPa to 700 kPa have been found to be suitable.

6.10.7 *Crankcase Pressure*—Connect the transducer port tapped in the upper portion of the Oil Pan P/N OHT3H-304-2¹², **Error! Bookmark not defined.** Transducers with a gage pressure range of -13 kPa to +13 kPa have been found to be suitable.

6.10.8 *Blowby Pressure* -- Install a transducer in the blowby ventilation system at the exit of the blowby canister. Maintain a minimum of 20 straight pipe diameters between the thermocouple and the J-TEC meter (see A10.1). Transducers with a gage pressure range of -13 kPa to +13 kPa have been found to be suitable.

6.11 *Thermocouple Locations:*

6.11.1 Locate the sensing tip of all thermocouples in the center of the stream of the medium being measured unless otherwise specified.

6.11.2 *Oil Cooler Temperature*—*This thermocouple is optional.* Install the thermocouple in the rear of the oil cooler as shown in Fig. A2.6 and A2.7. Ensure the sensing tip is in the middle of the flow by fully inserting the sensing tip and reversing it out by 8 mm.

6.11.3 *Coolant Out of the Engine Temperature*—Install the thermocouple in the Coolant Crossover P/N OHT3H-302-1¹², **Error! Bookmark not defined.** with the sensing tip centered in the coolant flow.

6.11.4 *Intake Air Temperature*—Install the thermocouple through top of Air Resonator 7 cm from the edge where it joins the throttle body (see Fig. A2.3). Center the sensing tip in the center of the air flow.

6.11.5 *Fuel Temperature*—Install the thermocouple in a fuel distribution block within 30 cm of the fuel rail inlet (see 6.10.7). **Warning**—Safety Hazard—Exercise care to reduce overhung masses at fuel-rail connections.

6.11.6 *Oil Pump Temperature*—Install the thermocouple in the oil pump pressure/temperature assembly as shown in Fig A2.8. Use a straight-thread plug and washer with a through hole no larger than 6 mm. A screw plug M24 x 1.5 (P/N HAR111.301.127.E) with an aluminum washer (P/N HAR 22 x 7 x 1.5 Al) has been found to be suitable¹⁴.

¹³ Available from Summit Racing Equipment, PO Box 909, Akron OH 44309-0909, tel 1-800-230-3039; www.summitracing.com.

¹⁴ Patrick Motor Sports, 4025 E Madison Street, Phoenix, AZ. tel: 602-244-0911; www.patrickmotorsports.com.

6.11.7 *Oil Sump Temperature*—Install the thermocouple in the oil-sump drain plug located on the underside of the oil pan P/N OHT3H-304-2¹²**Error! Bookmark not defined.**, the sensing tip extending 10 mm beyond the end of the sump drain plug as shown in **Fig A2.9**.

6.11.8 *Engine Block Oil Temperature*—Refer to Section 4, Sheets 1 to 4, of the IIH Engine Assembly Manual for the modification of the block required to accommodate the engine-block, oil-temperature thermocouple. To ensure the thermocouple is inserted to the correct depth, use the IMTS Thermocouple Setting Fixture P/N 151132-F002^{15,10}.

6.11.9 *Coolant Into the Engine Temperature*—Install the thermocouple in the modified water pump P/N OHT3H-300-1¹²**Error! Bookmark not defined.** with the sensing tip centered in the coolant flow.

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

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

6.11.12 *Blowby Gas Temperature* – Install thermocouple in the blowby ventilation system at the exit of the blowby canister. Maintain a minimum of 20 straight pipe diameters between the thermocouple and the J-TEC meter (see A10.1).

6.12 *Crankcase Ventilation:*

6.12.1 Ventilate blowby gasses ventilated from the test cell through a scavenger fan. Do not allow the fan to create a vacuum on the crankcase. An Air Ecology Evacuation System¹⁶**Error! Bookmark not defined.** has been found to be suitable. The crankcase ventilation configuration is shown in **Annex A3**.

7 Reagents and Materials

7.1 *Test Fuel*—Use only Sequence III HF-003 EEE unleaded fuel^{17,10}. (**Warning** Flammable. Health hazard.)

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

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

7.2 *Engine coolant:*

¹⁵ The sole source of supply known to the committee at this time is International Machine Tool & Service (IMTS) Co., 8460 Ronda Dr., Canton, MI 48187. Tel: 810-588-9591. <http://www.imtsind.com>.

¹⁶ Purchase from AER Control Systems, 90 River St., New Haven, CT 06513. Tel: 1-866-265-2372, www.aercontrolsystems.com.

¹⁷ 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.

7.2.1—Use a mixture of ShellZone DEX-COOL antifreeze/coolant^{18,19} and de-ionized water with a volume fraction of water of 50 %. (**Warning**—Health hazard—see appropriate MSDS).

7.2.1.1 Use new coolant for every test.

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

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

7.2.2 Alternatively a 50/50 premix¹⁹ may be purchased for use if desired.

7.3 *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.)

7.4 *Sealing and Anti-Seize Compounds*—

7.4.1 Mopar²⁰ ThreeBond Engine RTV²¹ P/N 68082860AA²²; RTV silicone^{22,10}.

7.4.2 Loctite²³ 545 Thread Sealant, Anaerobic^{24,10}.

7.4.3 Loctite 567 Thread Sealant, Low strength, Anaerobic^{24,10}.

7.4.4 Loctite 648 Retaining Compound, Anaerobic^{24,10}.

7.4.5 Loctite Gasket Sealant 2 (Permatex #2)^{24,10} Badger Meter Inc.^{25,10}.

7.4.6 polytetrafluoroethylene (PTFE) Tape

7.5 Use Ultrasonic-7²⁶ soap and Ultrasonic-B degreaser²⁶ in ultrasonic parts washers to clean engine block, cylinder heads and fixed phasers. Cleaning solution shall be at a temperature of 150 °C ± 5°.

7.6 Engine build up oil, EF-411^{27,10}.

¹⁸ ShellZone is a registered trademark of Shell Trademark Management BV.

¹⁹ Available from retailers, autoparts stores or Chrysler/Dodge dealerships.

²⁰ Mopar is the registered trade mark of Chrysler Group Customer Care, PO Box 21-8004, Auburn Hills, MI 48321-8004. www.mopar.com.

²¹ ThreeBond is a registered trademark of ThreeBond International, Inc.

²² Available from Chrysler/Dodge dealerships.

²³ Loctite is a registered trademark of Henkel Corporation.

²⁴ The sole source of supply of this product known to the committee at this time is Henkel. Corporation, One Henkel Way, Rocky Hill, CT 06067, USA. Tel. 860-571-5100. www.henkelna.com.

²⁵ The sole source of supply of the apparatus known to the committee at this time is Badger Meter Inc. Tel: 1-800-616-3837. www.badgermeter.com.

²⁶ Available from Purvis Industries, 10500 North Stemmons Freeway, Dallas, TX 75200. 800-580-5588. www.purvisindustries.com.

²⁷ The sole source of supply of this product known to the committee at this time is Exxon-Mobil Oil Corp.,

8 Test Oil Sample Requirements

8.1 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.

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

8.3 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.

9 Preparation of Apparatus

9.1 Pre-Test Engine Tear Down and Cleaning:

9.1.1 Disassemble the new engine according to the guidelines in section 3 of the New Engine Disassembly of the Sequence IIH Engine Assembly Manual¹¹.

9.2 Cylinder head disassembly:

9.2.1 Disassemble the production cylinder heads according to information supplied in sections 2 and 3 of the Sequence IIH Engine Assembly Manual.

9.2.2 Send the disassembled, production cylinder heads (Cylinder Head Cores) to the SPS for replacement of intake valve-seats^{15,10}. See section 2 sheet 2 of the Sequence IIH Engine Assembly Manual for details.

9.2.3 Clean the test cylinder heads as outlined in sections 5 and 6 of the Sequence IIH Engine Assembly Manual.

9.2.4 Assemble the modified cylinder heads P/N LH451AO-MS and RH516AO-MSD^{15,10} with valves, springs, keepers, retainers, and shims removed from new engine cylinder heads. See section 6 of the Sequence IIH Engine Assembly Manual.

9.2.5 Use new valve-stem seals for each test.

9.3 Block Preparation:

9.3.1 Refer to sections 4 and 7 of the Sequence IIH Engine Assembly Manual for Oil Gallery modifications and thermocouple drilling procedures.

9.3.2 Refer to section 4 of the Sequence IIH Engine Assembly Manual for honing procedure.

9.4 Oil Pump Cleaning:

9.4.1 Refer to section 5 of the Sequence IIH Engine Assembly Manual for special cleaning information of the factory engine oil pump.

9.5 Oil Cooler Cleaning:

9.5.1 Refer to section 5 of the Sequence IIH Engine Assembly Manual for special cleaning information of the factory engine oil filter/oil cooler assembly.

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

9.7 Test Engine Build-Up:

9.7.1 Refer to the Sequence IIH Engine Assembly Manual for engine build instructions. **Table 1** contains a list of all parts required for the test engine build.

9.7.2 Laboratories shall maintain engine-build data sheets as shown in Annex A7. This data shall be available to the TMC and the Test Procedure Developer for investigative studies as deemed necessary for hardware investigations during times of industry severity shifts or other problems

9.7 Test Stand Preparation:

9.8.1 For every test, replace the tubing (for example, Tygon²⁸ 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 5 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 IIH Test.

10 Calibration

10.1 *Calibration Procedures*—Annex **A4** describes calibration procedures using the TMC reference oils, including their storage and conditions of use, the conducting of tests, and the reporting of results.

10.2 *Maintenance Activities*—Annex **A5** describes maintenance activities involving TMC reference oils, including special reference oil tests, special use of the reference oil calibration system, donated reference oil test programs, introducing new reference oils, and TMC information letters and memoranda.

10.3 *Related Information*—Annex **A6** provides information regarding new laboratories, the role of the TMC regarding precision data, and the calibration of test stands used for non-standard tests.

10.4 Data Acquisition System:

10.4.1 The Sequence IIH test requires the use of computerized data acquisition and control for all measured and controlled parameters outlined in this procedure. The

²⁸ Tygon is a registered trademark of Saint-Gobain Corporation.

system chosen by individual testing laboratories shall be capable of integrating with the Sequence IIH 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)²⁹ and additional requirements as outlined in this procedure.

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

10.4.3 *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 report²⁹ and also conform to total system response requirements as outlined by the TMC (see 10.4.5).

10.4.3.1 *Pressure Measurements*—For pressures > 6.9 kPa, use only measuring devices with a full-scale accuracy of $\pm 0.2\%$ for capacitive systems and $\pm 0.25\%$ 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.

10.4.3.2 *Temperature Measurements*—Use only Type E Chromel-Constantan or Type J iron-constantan thermocouples with an accuracy of $\pm 0.5\text{ }^{\circ}\text{C}$ over a range of 0 $^{\circ}\text{C}$ to 200 $^{\circ}\text{C}$. Refer to [Table 4](#) for a list of controlled and uncontrolled temperatures.

10.4.3.3 *Flow*—For Coriolis flow meter measurements use a mass-flow accuracy of $\pm 0.50\%$, and mass-flow repeatability of $\pm 0.05\%$.

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

10.4.3.5 *Force*—For forces measured by strain gage, use $\pm 0.25\%$ of full scale.

10.4.4 *Measurement Resolution*—The minimum resolution for all parameters shall be at least 25 % of the required system accuracy for that parameter. For example, if a test procedure requires an accuracy of 1.0 unit, then the minimum resolution for that parameter is 0.25 unit.

10.4.5 *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

²⁹

http://ftp.astmtmc.cmu.edu/docs/TechnicalGuidanceCommittee/minutes/BestPractices/DACA_II_Data%20Acquisition%20and%20Control%20Automation.pdf.

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.

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

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

10.4.6 *Quality Index (QI)*—Use of the QI method of measuring the control capability of the test stand is required for certain parameters. Use the following formula with a minimum of 2700 data points for the final, end-of-test values:

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

where:

QI is the quality index,

X_i is the recorded test-measurement parameter,

U is the upper-specification limit for that parameter,

L is the lower-specification limit for that parameter, and

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

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

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

10.4.9 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.

10.4.10 Calibrate the intake air-humidity system at least every six months.

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 P/N OHT3H-075-1¹². **Error! Bookmark not defined..**

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-in ramp the engine down to 1000 r/min and 25 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 the operator to obtain the initial oil sample.

11.3.2 Before taking the sample, first remove a purge sample of 472 mL.

11.3.3 Remove the oil sample of the specified volume.

11.3.4 Add the 472 mL purge sample back to the engine. Also add 177 mL new oil at 20 h, 40 h, 60 h and 80 h. Note that no new oil is added when the initial or EOT oil samples are taken.

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 min oil sample step and allow the oil to drain to the oil pan for 20 min. 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 provided with the oil pan (see [12.9.1](#)).

11.5 Record dipstick level on the *Sequence IIH Oil Level and Consumption Worksheet* (see Annex [A.9](#)).

11.6 Engine Oil Quality Test:

11.6.1 After the initial run-in is complete and the initial oil level is determined, 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.

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

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

11.6.1.3 Maintain a stabilization period for a minimum of an additional 5 min. The ramp and stabilization time together shall be a minimum of 10 min.

11.6.1.4 Start accumulating test time at the end of the 10 min stabilization or when the oil gallery temperature reaches 151 °C, whichever is later.

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

11.6.1.6 Repeat steps 11.6.1.1 to 11.6.1.5 for three additional 20 h segments followed by one 10 h segment.

11.7 *Air Fuel Ratio (AFR) and NO_x Verification:*

11.7.1 AFR is controlled by the PCM; maintained at stoichiometric conditions. Obtain real time AFR readings using either an ECM AFM1000/AFM1500 or an ECM NO_x 5210 Single/Dual NO_x Analyzer^{30,10}.

11.7.2 Obtain real-time NO_x analysis with an ECM NO_x 5210 Single/Dual NO_x Analyzer^{30,10}.

11.7.3 Alternatively, take exhaust samples for subsequent NO_x analysis at test hours 1, 9, and every 10 h thereafter until the EOT.

11.8 *Blowby Flow-Rate Measurement:*

11.8.1.1 Take blowby readings every 5 test hours starting at test hour 1 with an additional reading within 15 min of the EOT.

11.8.2 Determine the blowby flow rate using a J-TEC Model VF563AA Blowby Flow Meter^{31,10}. Refer to Annex A10 for setup and maintenance instructions.

11.8.3 Using the temperature and pressure taken from the exit of the blowby canister apply the following correction factor:

11.8.3.1 Record the uncorrected blowby flow rate in liters per minute and correct it for an atmospheric pressure of 100 kPa and a temperature of 37.8 °C.

Use the following equation to correct the blowby flow rate:

³⁰ The sole source of supply known to the committee at this time is ECM (Engine Control and Monitoring), 586 E Weddell Dr # 2, Sunnyvale, CA 94089, United States. Tel: 408-734-3433. www.ecm-co.com.

³¹ The sole source of supply of this pump known to the committee at this time is J-Tec Associates, Inc., 5005 Blairs Forest Lane NE, Suite L, Cedar Rapids, IA 52402. Tel: 319-393-5200. www.j-teccassociates.com.

$$CF=(3.1002*P/(273.15+T))^{0.5}$$

where:

CF = corrected blowby flow rate, L/min,

P = blowby pressure, kPa, absolute

T = temperature, °C

11.8.4 Report each corrected blowby measurement on form 10.

11.8.5 Bypass blowby gas around the J-TEC meter when blowby flowrate is not being measured.

11 12Determination 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 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 EOT before rating. Do not wipe the pistons before storing them.

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 9**³² (Summary of Ring Sticking). Record the total number of cold-stuck and hot-stuck rings on **Form 4**³² (Test Result Summary).

Note 1: All subsequent references to Forms and Form numbers refer to footnote **32 and Annex A8**.

³² This form is part of the standardized report form set and data dictionary available from the TMC at <ftp://ftp.astmtmc.cmu.edu/datadict/IIH/current/dictionary/>. A summary of the forms is given in Annex A8.

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.

12.3.4 *Oil Ring Plugging*—Measure the percent oil ring plugging for each piston, record the results on **Form 9** (Summary of Ring Sticking), calculate the average per piston and record on **Form 4** (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, lint free 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 ASTM Deposit Rating Manual No. 20⁸ 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 10** (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 IIH 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 IIH engine pistons shall attend an ASTM TMC Light Duty Deposit Rating Workshop² every 12 months \pm 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 IIH 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 10](#) (Summary of Piston Deposits) and [Form 4](#) (Test Results Summary).

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 boss varnish on the pin boss area of each piston. Use an average of the front and rear of each piston as the unweighted rating for piston boss 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 grooves 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](#).

12.5 *Kinematic Viscosity Measurements*—Using Test Method D445, determine the kinematic viscosity at 40 °C of the fresh (i.e., new) test oil, the initial oil sample (i.e., the initial oil sample taken), 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 mm²/s less than that of the new oil due permanent shearing effects. If the difference is greater than 10 mm²/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** (Used Oil Analysis Results) and the EOT (final) percent viscosity increase on **Form 4** (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 2—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 15** (Test Comments) that the original 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 mm²/s, record 8000 mm²/s on **Form 7** and use this value to calculate the change in viscosity.*

NOTE 3—The maximum viscosity that will be considered by this method is 8000 mm²/s so this value replaces any value > 8000 mm²/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 15** (Test Comments) that a severity adjustment of zero was used for the viscosity increase because the measured viscosity was > 8000 mm²/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 12**.

12.6 *MRV and CCS*—Perform mini rotary viscometer (MRV), Test Method D4684, and Cold Crank Simulator (CCS), Test Method D5293, measurements on the EOT sample. Report the results on **Form 4**.

12.7 *Testing Oil Samples for Element Concentration*—Use Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) Analysis, Test Method D5185, to determine the mass fraction of the 15 elements shown in **Form 7a** for the fresh oil, the initial oil sample, each of the 20 h analysis samples and the EOT sample. Report the results in

mg/kg on **Form 7a**.

12.8 Blowby Flow-Rate Measurements—Measure the blowby flow rate in L/min, as described in **11.8**, for the initial oil sample, each of the 20 h analysis samples and the EOT sample. Plot the results on **Form 11** (Blowby Values and Plot).

12.9 Oil 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 A9.1** 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 A9.2**)

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 subtracting 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 A9.1**. 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:

12.12.1 Using the element concentrations reported on **Form 7a**, ascertain and report on **Form 7** which of the detergent metals Ba, Ca or Mg has the highest concentration in the fresh oil.

12.12.2 Determine the phosphorus retention, P_{ret} , using the following equation:

$$P_{ret} = [w(M_i)/w(M_{EOT})] \times [w(P_i)/w(P_{EOT})] \times 100, \% \quad (2)$$

where:

M denotes the detergent metal with the highest concentration in the fresh oil;

$w(M_i)$ is the mass fraction of M in the initial oil sample, mg/kg;

$w(M_{EOT})$ is the mass fraction of M at EOT, mg/kg;

$w(P_i)$ is the mass fraction of phosphorus in the initial oil sample, mg/kg

$w(P_{EOT})$ is the mass fraction of phosphorus in the EOT sample, mg/kg.

12.12.3 Using the ICP-AES 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 mass/mass (that is, 1 part solute by mass mixed with 20 parts solvent by mass). 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 values shown in the repeatability table of Test Method D5185, follow the procedure shown in the section “Significance of repeatability (r)” in Test Method D3244.

12.12.4 Report the phosphorus retention results on [Form 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 IIH 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 14](#), ‘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 14**, '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**³² that the test is invalid.

12.14.3 If the EOT QI 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 dictionary³² for reporting test results and for summarizing operational data. A list of the forms is given in **Annex A8**

NOTE 4—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.

14. Precision and Bias

Table 1 Engine Build Part List

| Part Name | Quantity per Test | Part Number | Required Supplier |
|---|-------------------|----------------|----------------------------------|
| Test Engine, 2014 3.6L Pentastar RT | 1 | 05184464AH | Mopar ^{9,20,10} |
| Cylinder Head – Left ^A (MS Seed/MC Core) | 1 | LH451AO-MSD | IMTS ^{15,10} |
| Cylinder Head – Right ^A (MS Seed/MC Core) | 1 | RH516AO-MS | IMTS ^{15,10} |
| Piston, Special Test | 6 | OHT3H-070-1 | OH Technologies ^{12,10} |
| Head Gasket, Right | 1 | 05184456AH | Chrysler Dealer |
| Head Gasket, Left | 1 | 05184455AI | Chrysler Dealer |
| Head Bolts | 8 | 06509564AA | Chrysler Dealer |
| Rod Bolts | 12 | 06509128AA | Chrysler Dealer |
| Exhaust Flange Gasket (cylinder head to exhaust) | 2 | 68093232AA | Chrysler Dealer |
| Piston Ring Pack: | 1 | | OH Technologies ^{12,10} |
| Ring, Special Test, UCR (0.025 mm gap, 96.040 mm bore) | | 3H96040-TOP | OH Technologies ^{12,10} |
| 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 ^{12,10} |
| Clip, Piston, Wrist Pin | 12 | OHT3H-072-1 | OH Technologies ^{12,10} |
| Phaser, Intake (Fixed at 100°, Less Rotor Holes) | 2 | OHT3H-001-1 | OH Technologies ^{12,10} |
| Phaser, Exhaust (Fixed at 112°, Less Rotor Holes) | 2 | OHT3H-002-1 | OH Technologies ^{12,10} |
| Oil Pan ^B | 1 | OHT3H-304-2 | OH Technologies ^{12,10} |
| Gasket, Oil Pan | 1 | OHT3H304-18 | OH Technologies ^{12,10} |
| 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.

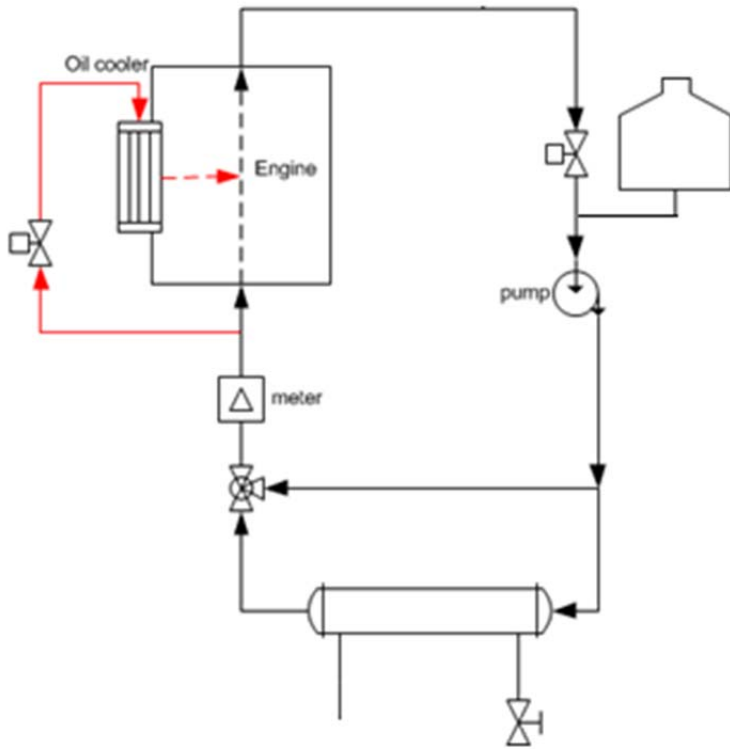


FIG. 1 Engine Coolant Flow Schematic

Table 2 Control System/Engine Interface Components

| Component Description | Part Number | Supplier |
|--|--------------|----------------------------------|
| Pump, Water, Modified, Seq. IIIH Chrysler ⁹ | OHT3H-300-1 | OH Technologies ^{12,10} |
| Coolant Crossover, Seq. IIIH Chrysler | OHT3H-302-1 | OH Technologies ^{12,10} |
| Adapter, Coolant Crossover, Seq. IIIH Chrysler | OHT3H-303-1 | OH Technologies ^{12,10} |
| Jumper, Harness Segment, Throttle Control, Seq. IIIH Chrysler ^A | OHT3H-004-1 | OH Technologies ^{12,10} |
| Harness, Dyno, Seq. IIIH Chrysler | OHT3H-005-1 | OH Technologies ^{12,10} |
| Exhaust Turndown Pipe Prints | IIIH-ETB30-B | TMC ² |
| | 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 ^B | RL150588AC | Chrysler Dealer |
| Manual Flywheel (2013 JK) | 05184438AB | Chrysler Dealer |
| J-TEC Blowby Meter | VF563AA | J-TEC |
| Blowby Canister | CCV6000 | J-TEC |

^A Alternatively an accelerator pedal position (APP) sensor simulator circuit may be used as described in Annex A.11.

^B Purchase PCM from local dealer and send to the test sponsor for installation of proper test calibration files.

Table 3 Engine Fluid Conditioning Module Control Parts

| <u>Control Parts</u> | <u>Supplier</u> | Part Number | Description |
|---|-------------------------------------|---|---|
| 2-way Coolant Flow Control Valve | Badger Meter Inc. ^{33,10} | 9003GCW36SV3A29L36 | 2" 2-way Air to close |
| Heat Exchanger | Kinetic Engineering Corp | | Elanco M-71-FL Heat Exchanger ^A |
| Coolant Micromotion Coriolis Flow Meter | Micro Motion, Inc. ^{34,10} | R200S418NCAMEZZZ ^B 1700I13ABMEZZZ | Flow meter Transmitter |
| Fuel Temp Heat Exchanger | | laboratory determined | |
| 3-way Coolant Temp Control Valve | Badger Meter Inc. ^{33,10} | 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. ^{33,10} | 1002GCN36SVCSALN36 | 1/2" 2-way Research valve, A-trim |
| Drive Shaft | | | Driveshaft w/1410 U-Joints |

^A Tube and shell heat exchanger is an acceptable alternative.

^B This model has been found satisfactory and is recommended¹⁰. Any other model used shall meet or exceed a mass flow accuracy of $\pm 0.50\%$ and mass flow repeatability of $\pm 0.05\%$.

³³ The sole source of supply of the apparatus known to the committee at this time is Badger Meter Inc. Tel: 1-800-616-3837. www.badgermeter.com.

³⁴ The sole source of supply of the apparatus known to the committee at this time is Emerson Process Management Micro Motion Americas, Boulder, Colorado, USA, 83010. www.emersonprocess.com.

Table 4 Test Parameters

| CONTROLLED PARAMETERS | | | |
|------------------------|------------|--------|------------------|
| Parameter | Units | Target | QI values |
| Speed | r/min | 3900 | ± 5 |
| Load | N·m | 250 | ± 0.98 |
| Oil Block Temp | ° C | 151 | ± 0.42 |
| Coolant Out Temp | ° C | 115 | ± 0.46 |
| Intake Air Temp | ° C | 35 | ± 0.37 |
| Fuel Temp | ° C | 30 | ± 0.70 |
| Dew Point | ° C | 16.1 | ± 2 |
| | | | |
| Intake Air Pressure | kPa (gage) | 0.05 | ± 0.009 |
| Right Exhaust Pressure | kPa (gage) | 4.5 | ± 0.08 |
| Left Exhaust Pressure | kPa (gage) | 4.5 | ± 0.08 |
| Coolant Flow | L/min | 170 | ± 1.43 |
| Fuel Pressure | kPa (gage) | 420 | ±20 ^A |
| Coolant Pressure | kPa | 200 | ±10 ^A |

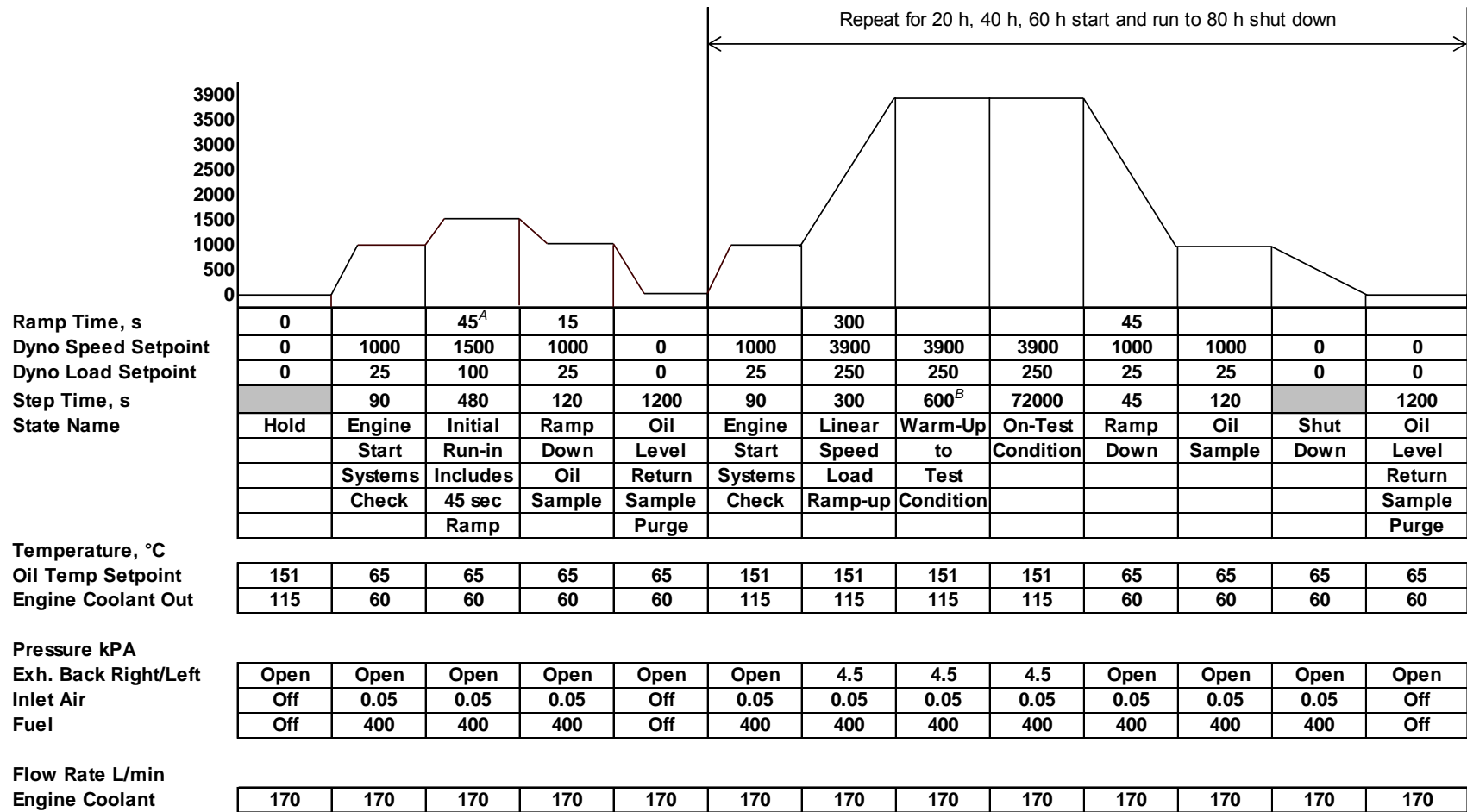
^AThis is a range rather than a QI value. QI calculations do not apply.

| UNCONTROLLED PARAMETERS | | |
|--|------------|---------|
| Parameter | Units | Average |
| Oil Pump Temp | ° C | Record |
| Oil Sump Temp | ° C | Record |
| Coolant In Temp | ° C | Record |
| Left Exhaust Temp | ° C | Record |
| Record Right Exhaust Temp | ° C | Record |
| Oil Pump Pressure | kPa (gage) | Record |
| Oil Gallery Pressure | kPa (gage) | Record |
| Manifold Pressure | kPaA () | Record |
| Fuel Pressure | kPa (gage) | Record |
| Crankcase Pressure | kPa (gage) | Record |
| Right bank AFR | | Record |
| Left bank AFR | | Record |
| Mass fraction right bank NO _x | mg/kg | Record |
| Mass fraction left bank NO _x | mg/kg | Record |
| Fuel flow | kg/hr | Record |

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 Chrysler IIIH Control States

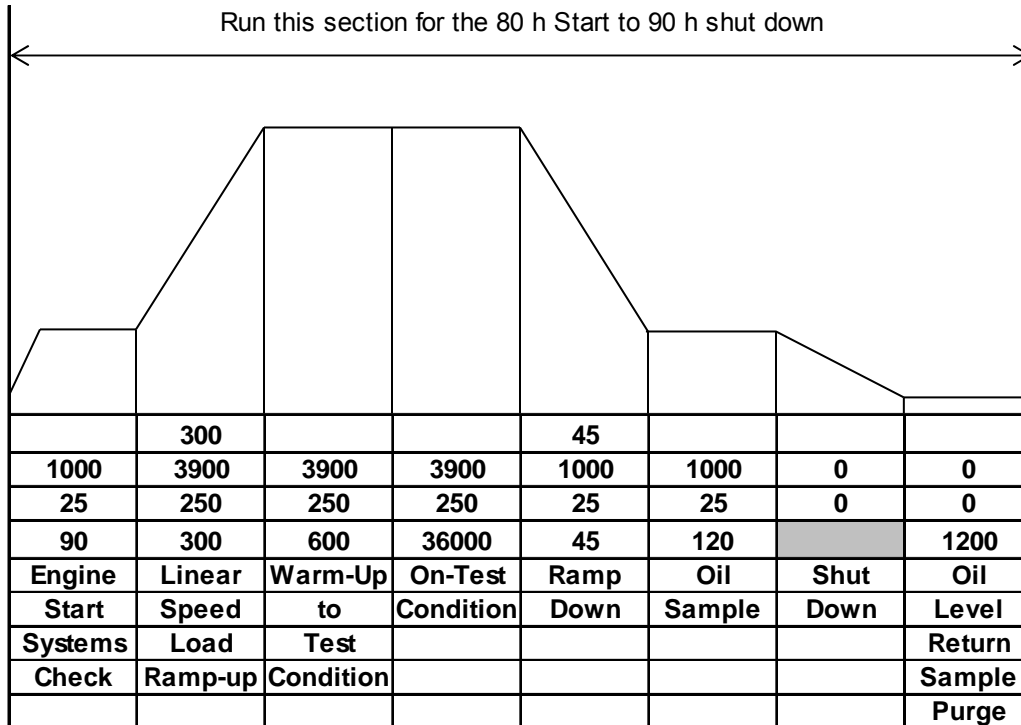


^A 45 s ramp included in step time 480 s for initial run-in.

^B 600 s minimum and greater than 151 °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.



| | | | | | | | |
|-----|-----|-----|-----|----|----|----|----|
| 151 | 151 | 151 | 151 | 65 | 65 | 65 | 65 |
| 115 | 115 | 115 | 115 | 60 | 60 | 60 | 60 |

| | | | | | | | |
|------|------|------|------|------|------|------|------|
| Open | 4.5 | 4.5 | 4.5 | Open | Open | Open | Open |
| 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | Off |
| 400 | 400 | 400 | 400 | 400 | 400 | 400 | Off |

| | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|
| 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 TMC 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.

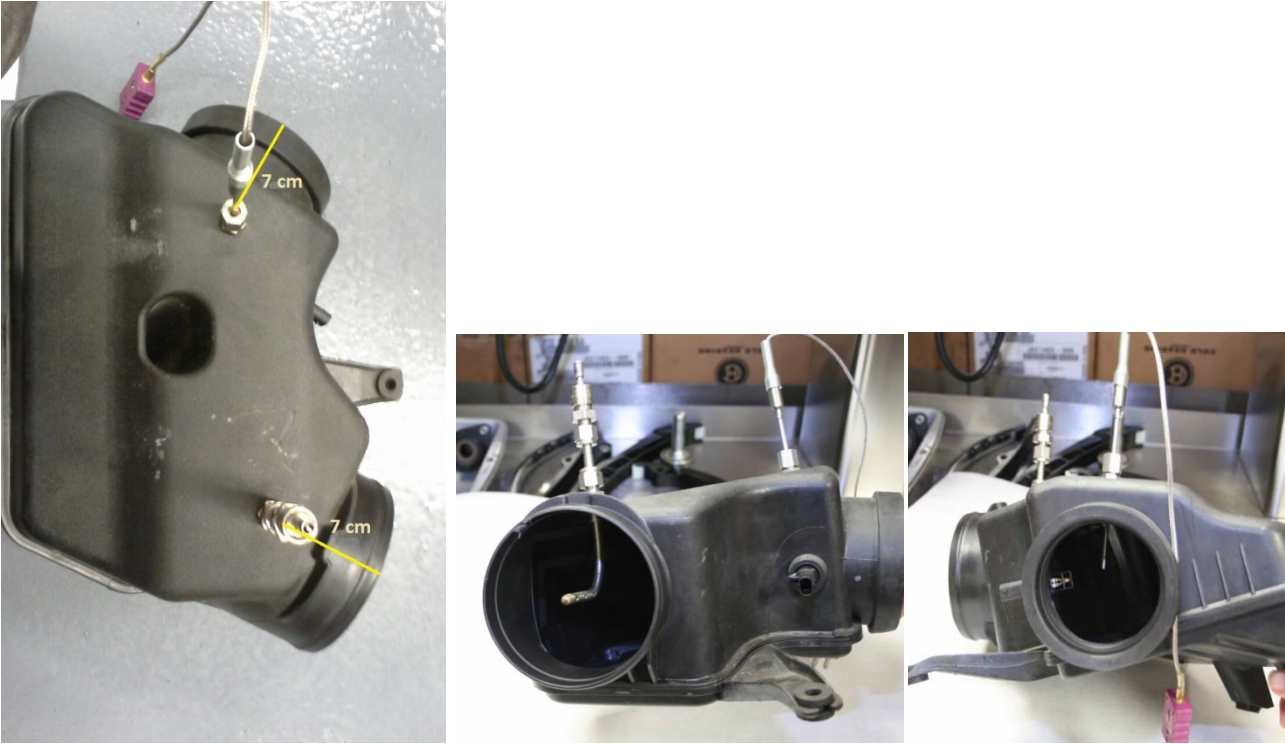


FIG. A2.1 to A2.3 Intake Air Temperature and Pressure – Air Resonator



FIG. A2.4 to A2.5 Fuel Temperature, Pressure and Supply

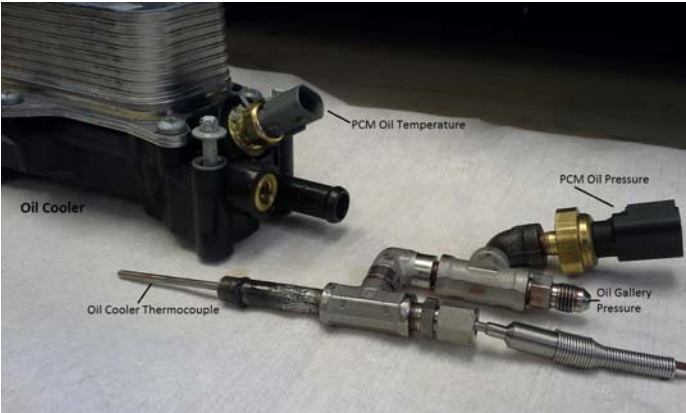


FIG. A2.6 to A2.7 Oil Cooler Temperature and Oil Gallery Pressure

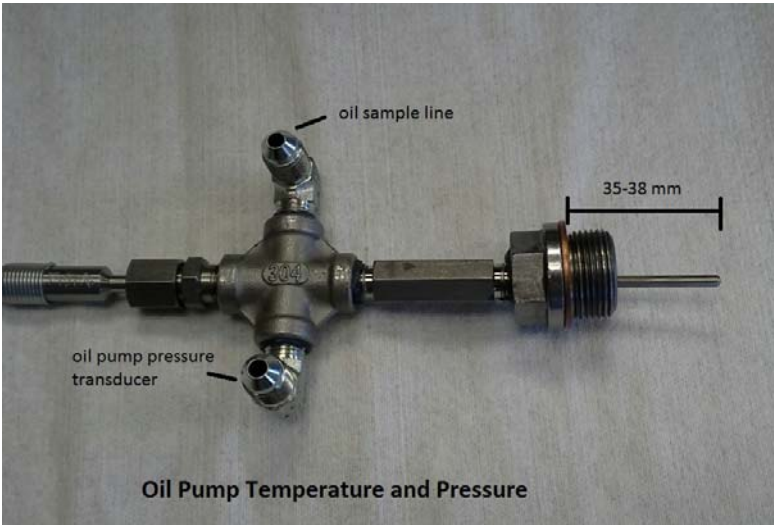


FIG. A2.8 Oil Pump Temperature and Pressure

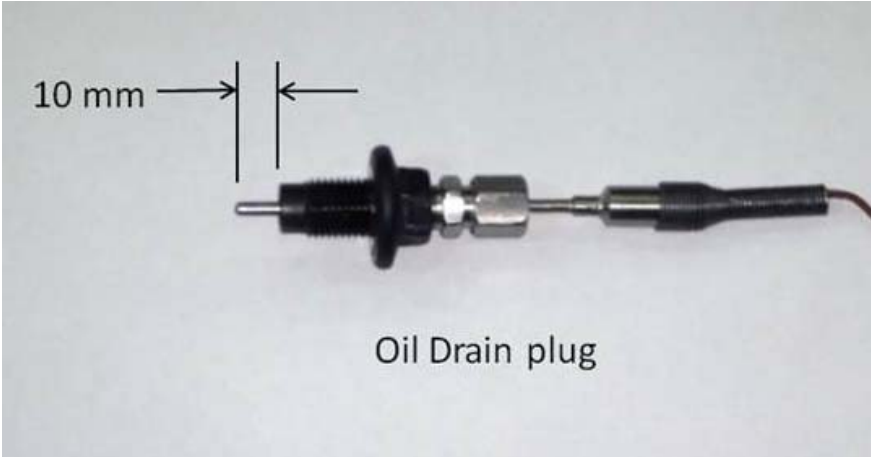


FIG. A2.9 Oil Sump Temperature

A3. BLOWBY VENTILATION SET UP

A3.1 The blowby ventilation set up is shown in Fig. A3.1

Figure A3.1 Blowby Ventilation Setup

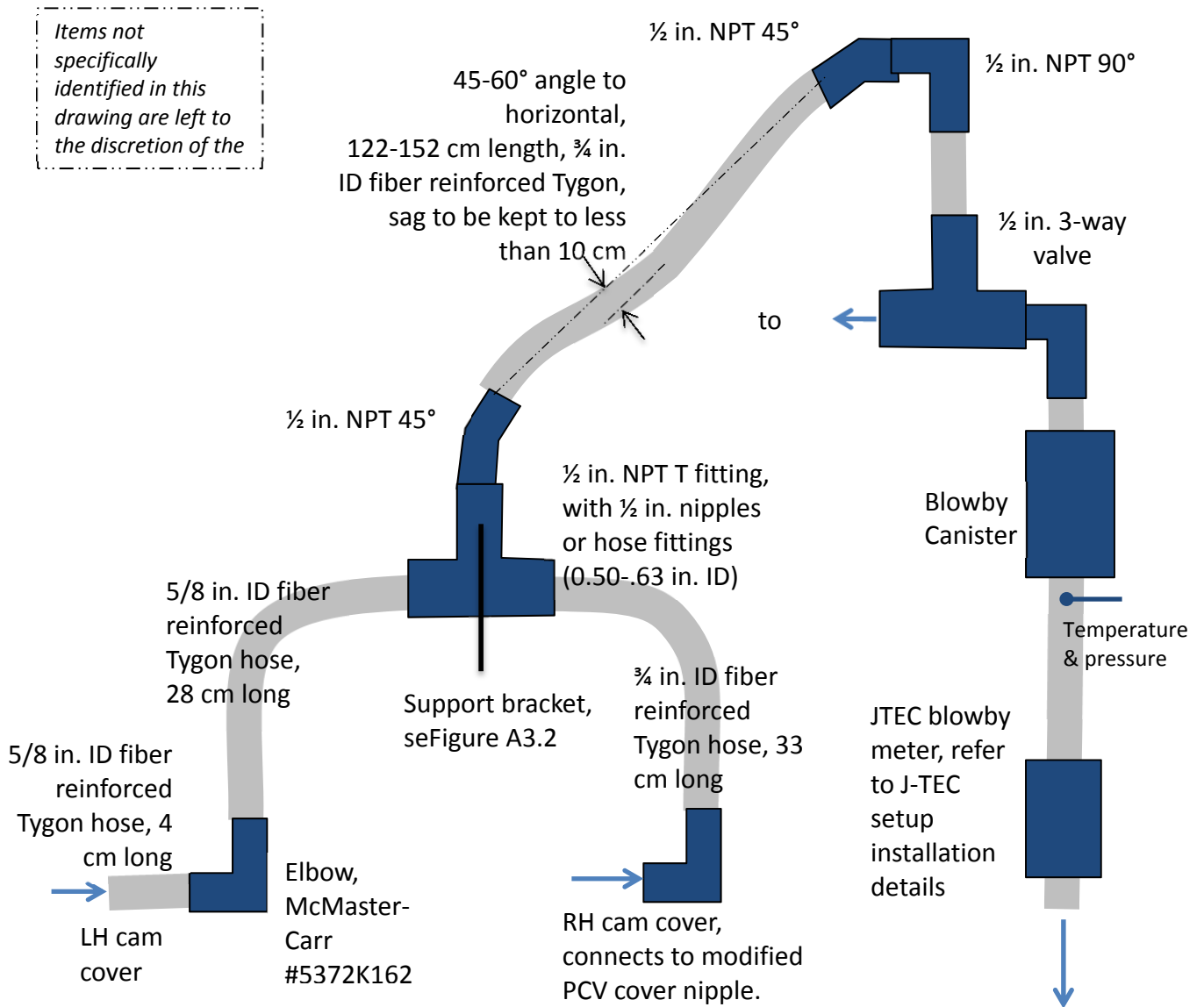
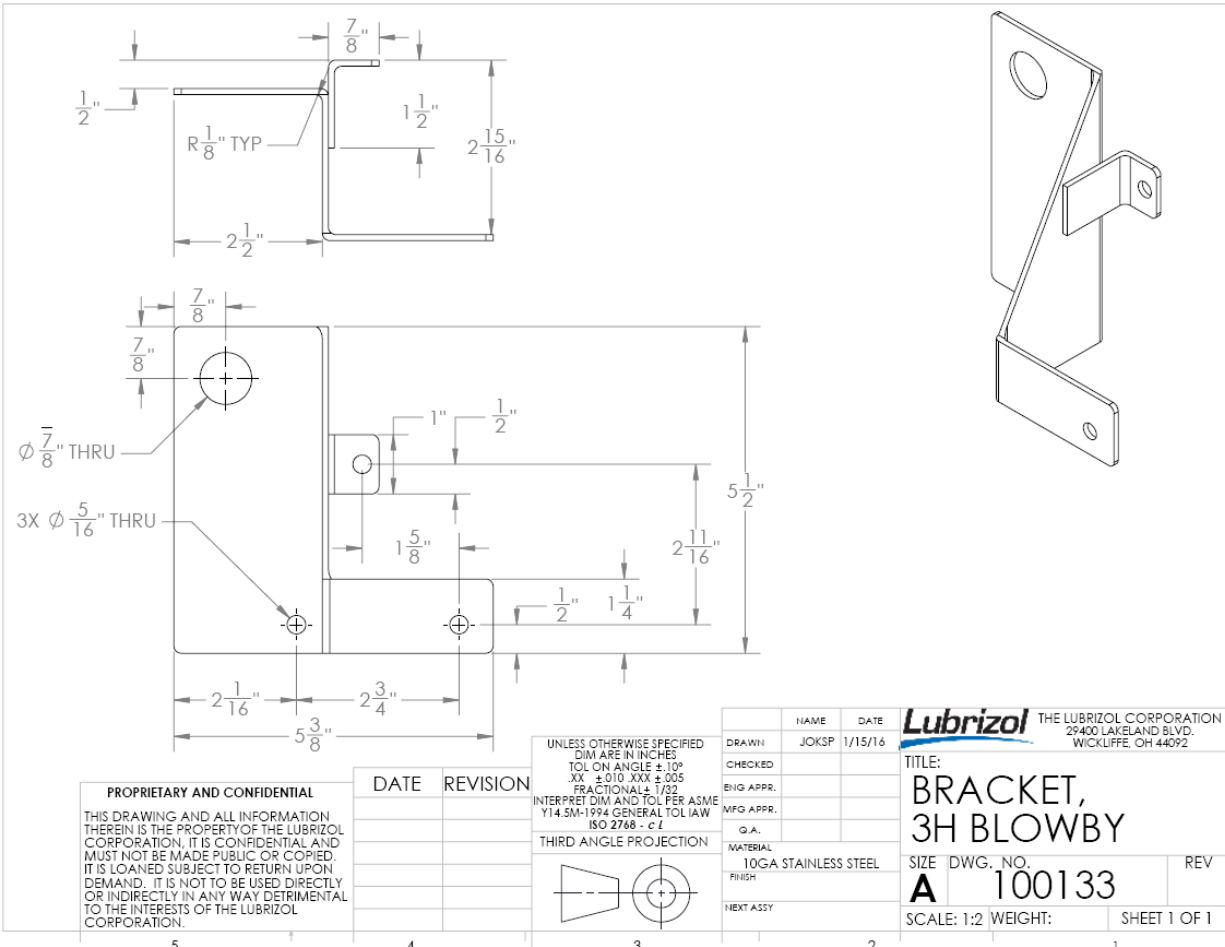


Figure A3.2 Blowby Ventilation Support Bracket



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. CHRYSLER PENTASTAR BUILD DATA WORKSHEET

A7.1 Record general engine build information in Table A7.1.

TABLE A7.1 General Build Data

| | |
|----------------------------|-----------------------------|
| Test #: _____ | Date: _____ |
| Block Assembled by: _____ | Build Completed Date: _____ |
| Lab Engine #: _____ | Crankshaft serial #: _____ |
| Right Head Number #: _____ | Chrysler Block |
| Left Head Number #: _____ | Code: _____ |

ID numbers

Micrometer: _____

Bore Gage: _____

Torque Wrench 3/8 in.:

Taper Gage: _____

Dial Indicator: _____

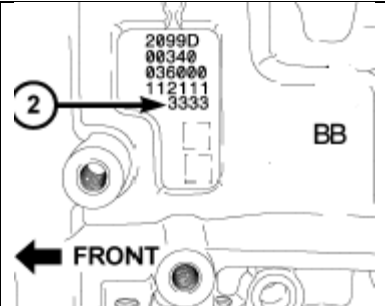
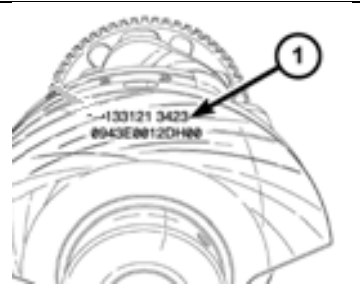
Torque Wrench 1/2 in.: _____

A7.2 Record main bearing size selection in Tables A7.2a and A7.2b.

TABLE A7.2a Main Bearing Selection

Engine #: _____
Run #: _____

Buildup Mechanic: _____
Date: _____

| | | | |
|--------|---|--|--|
| Bore # |  |  | Upper/Lower Main bearing selection from Table A7.2b ^A |
| | Engine Block Marking | Crankshaft Marking | |
| 1 | | | / |
| 2 | | | / |
| 3 | | | / |
| 4 | | | / |

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

Table A7.2b 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 to 0.050 mm Oil Clearance | | | | | |

A7.3 Record the connecting rod bore measurements in Table A7.3.

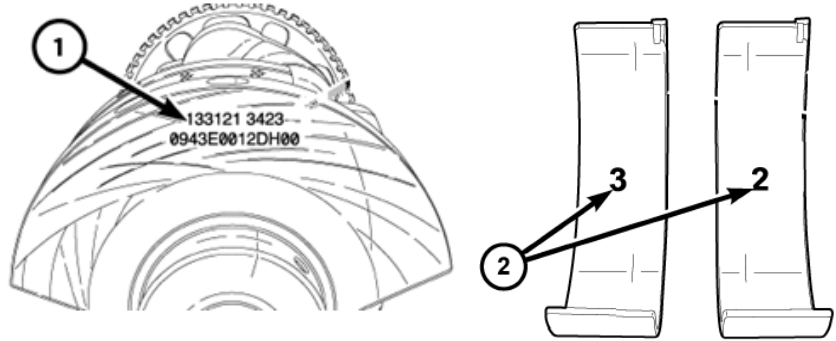
TABLE A7.3 Connecting Rod Bore Measurements

Engine #: _____
Run #: _____

Buildup Mechanic: _____
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 to 0.290 mm

A7.4 Record camshaft end play in Table A7.4

TABLE A7.4 Camshaft End Play

Engine #: _____
Run #: _____

Buildup Mechanic: _____
Date: _____

Camshaft End Play

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

A7.5 Record cylinder bore measurements in Table A7.5.

TABLE A7.5 Cylinder Bore Measurements

Engine No.: _____
 Bore Gage Set At: 95. _____

_____ Date Honed : _____
 Honed By : _____

Cylinder Bore Measurement

Transverse Diameter

| | Top: | Middle: | Bottom: | Taper ^A : |
|---|------|---------|---------|----------------------|
| 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 ^A : |
|---|------|---------|---------|----------------------|
| 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 | |

^A Record taper as the difference between top and bottom positions.

Microfinish roughness parameters:

| | Rk | Rpk | Rvk | Rz | Mr2 |
|---|----|-----|-----|----|-----|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |

A7.6 Record the ring end gap in Table A7.6.

TABLE A7.6 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 0.023 to 0.027 in. |
| 2 | 0.0 | 0.0 | |
| 3 | 0.0 | 0.0 | |
| 4 | 0.0 | 0.0 | 2nd 0.033 to 0.037 in. |
| 5 | 0.0 | 0.0 | |
| 6 | 0.0 | 0.0 | |

A8. SEQUENCE IIIH TEST REPORT FORMS AND DATA DICTIONARY

A8.1 Download the standardized report form set and data dictionary from the ASTM Test Monitoring Center Web Page³²; or obtain them in hardcopy format from the TMC². The contents of the report form set are as follows:

| | | |
|-----|--|---------|
| 1. | Title / Validity Declaration Page | Form 1 |
| 2. | Table of Contents | Form 2 |
| 3. | Summary of Test Method | Form 3 |
| 4. | Test Result Summary | Form 4 |
| 5. | Operational Summary | Form 5 |
| 6. | Oil Consumption Data Plot | Form 6 |
| 7. | Used Oil Analysis | Form 7 |
| 8. | Used Oil Analysis | Form 7a |
| 9. | Summary of Ring Sticking | Form 8 |
| 10. | Summary of Piston Deposits | Form 9 |
| 11. | Blowby Values & Plot | Form 10 |
| 12. | Viscosity Increase Plot | Form 11 |
| 13. | Hardware Information | Form 12 |
| 14. | Downtime Report Form | Form 13 |
| 15. | Test Comments | Form 14 |
| 16. | American Chemistry Council Code Of Practice Test Laboratory Conformance Statement | Form 15 |

A9. SEQUENCE IIIH OIL LEVEL AND CONSUMPTION WORKSHEET

A9.1 Use this Table to record oil levels

Oil Level at end of initial run: _____ mL

| Initial Fill = 5.92 L | 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 | ^A | | | | | ^A | |
| Dipstick mark after drain down, mm | | | | | | | |
| Difference between new and current oil levels, mL | | | | | | | |
| New oil added – analysis sample | | 118 | 118 | 118 | 118 | -236 | |
| 20 h oil consumption, mL | | | | | | | |
| Performed by: | | | | | | | |

^A Purge only. No new oil added at initial and EOT oil levels.

TABLE A9.2 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 |

A10. SETUP AND MAINTENANCE OF THE J-TEC MODEL VF563AA BLOWBY FLOW METER

A10.1. General Installation Instructions

A10.1.1 Install the flow meter as shown in Fig A10.1 with a minimum straight-pipe length of 20-pipe diameters upstream and 10-pipe diameters downstream from the flow meter. For example, a 1 in. diameter tube or hose should have 20 in. of straight length immediately before the flow meter inlet tube. This condition provides a more symmetrical flow profile, which is necessary to obtain accurate and repeatable results.

A10.1.2 A typical connection to the flow meter is made by attaching flexible hose onto the outside of the inlet tube and outlet tube.

A10.1.3 Install the flow meter vertically with flow into the top and out the bottom to encourage liquids to drain out of the flow meter.

A10.1.4 As shown in Fig. A10.1, install a J-TEC VF563AA CCV6000³¹, **Error! Bookmark not defined.** filter canister in the pipe between the crankcase and the flow meter. This minimizes the effect of pulsating flows, and collects oil and water droplets to keep the flow meter cleaner.

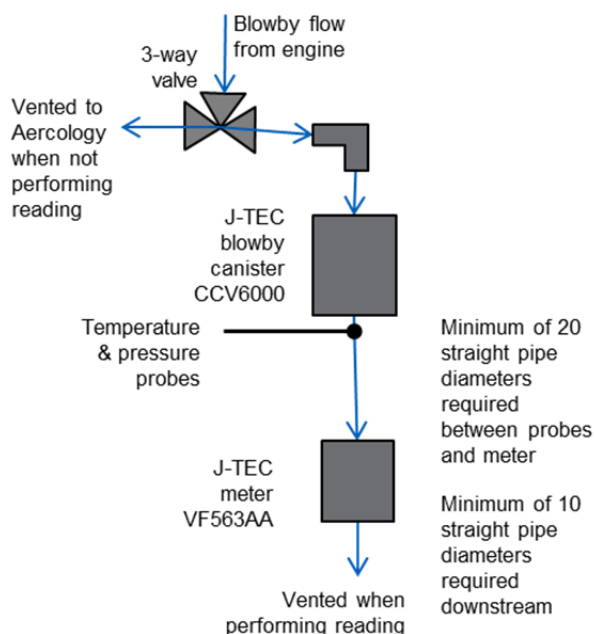


Fig. A10.1 Engine Blowby Measurement System

A10.2 Electrical Installation

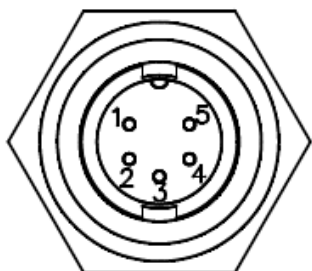
A10.2.1 Fig. A10.2 shows the recommended electrical connections for the flow meter.

A10.2.1.1 Provide a filtered direct current (DC) power supply to the blowby flow meter of at least 35 mA at +12 V to +24 V.

A10.2.1.2 Provide a DC analog output signal of 0 V to 5 V, proportional to the flow range. (Output impedance is 100 Ω).

A10.2.1.3 Make electrical connections to the flow meter with a four-conductor cable made of 26 to 22 AWG.

A10.2.1.4 Connect to the flow meter head using a Conxall cable connector P/N 6282-5SG-3XX³⁵ (available as P/N DRJ0720 from J-TEC^{31,10}). The contact pins of the connector are identified in Fig A10.2.

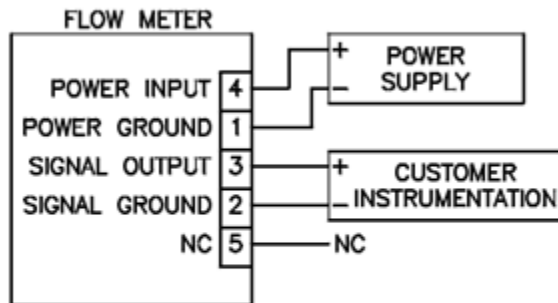


NOTE: Connector viewed from outside of flowmeter

| Pin | Color | Description |
|-----|-------|--------------------------------------|
| 5 | | Not Used |
| 4 | RED | DC Power Input (+12 V to +24 V) |
| 3 | WHT | DC Output(0 V to 5 V or Frequency) |
| 2 | BLK | Signal Ground |
| 1 | BLK | Power Ground |

Flowmeter Connector Pin-Outs

Recommended Electrical Connections
(separate grounds for lowest measurement error)



CIRCUIT BOARD OUTPUT JUMPERS

| | | |
|--------------|---------------------|--------------|
| DAA0XXX-0003 | ANALOG (0 V to 5 V) | P3-2 to P3-3 |
| DAA0XXX-0002 | FREQUENCY | P3-2 to P3-1 |

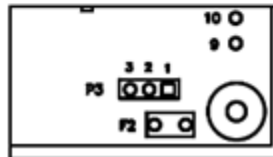


FIG. A10.2 Recommended Electrical Connections for the Flow Meter

A10.3 Cleaning and maintenance

³⁵ The sole source of supply of this connector known to the committee at this time is Conxall, 601 E Wildwood, Villa Park, IL 60181. Tel: 630-834-7504. www.conxall.com.

A10.3.1 To ensure the inside of the flow tube and strut remain in a clean condition, carry out the following cleaning procedure prior to every test start.

A10.3.1.1, Gently brush the strut and the inside of the tube with a soft brush or cotton swab. A solvent cleaner, such as a brake parts cleaner that degreases and leaves no residue, may be used to loosen deposits. Ensure the solvent is compatible with aluminum, fluorelastomers, and PTFE.

A10.3.1.2 DO NOT use wire brushes or use high-pressure liquids which may damage to the transducers.

A11. Accelerator Pedal Position Sensor Simulator Circuit

A11.1 The purpose of this circuit is to provide two voltages to the ECU that duplicate the output of the APP sensor (see Footnote A to Table 2).

A11.1.1 A block diagram of the circuit is shown in Fig A11.1.

A11.1.1.1 The items in the dashed box replace the OE pedal.

A11.1.1.2 The DC signal 1 (APP1) varies between 0.42 V and 4.55 V and the DC signal 2 (APP2) varies between 0.21 V and 2.27 V for accelerator positions 0 to 100 %. Note that APP2 is exactly half of APP1. This is accomplished by using 2 voltage output modules with one providing half the output of the other.

A11.1.1.3 Dataforth output modules SCM5B49 and SCM5B32³⁶, Error! Bookmark not defined. have been found to be acceptable for this application when the DAQ system control signal is voltage and current, respectively. Mount either module on a Dataforth dual channel backpanel SCMPB04-02^{36,10}. Use a DC power supply of 5 V.

A11.1.1.4 The minimum DC voltage provided through this circuit at 0 % throttle (idle) should correspond to APP1 = 0.42 V and APP2 = 0.21 V otherwise a “limp home” mode will be induced and the engine will be forced to 1500 r/min.

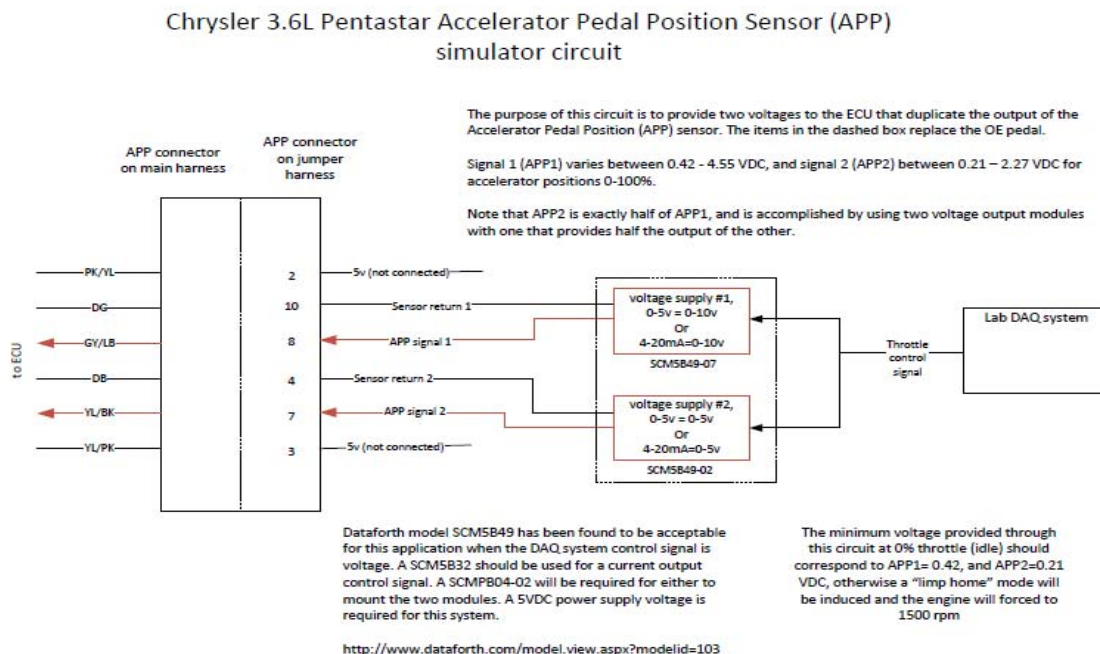


FIG. A11.1 Block Diagram for Chrysler 3.6 L Pentastar Accelerator Pedal Position Simulator Circuit

³⁶ The sole source of supply of this equipment known to the committee at this time is Dataforth Corporation, 3331 E Hemisphere Loop, Tuscon, AZ, 85706-5011, USA. Tel: 800 444 7644. www.dataforth.com.

