Sequence IVB

Test Procedure Draft

February 24, 2017

INTRODUCTION

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

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

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

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

Section 1

Scope

1. Scope *

1.1 This test method measures the ability of a crankcase oil to control valve-train wear for spark-ignition engines at low operating temperature conditions. This test method is designed to simulate extended engine cyclic vehicle operation. The Sequence IVB Test Method uses a Toyota 2NR-FE water cooled, 4 cycle, in-line cylinder, 1.5 liter engine. The primary result is bucket lifter wear. Secondary results include cam lobe nose wear and measurement of iron wear metal concentration in the used engine oil. Other determinations such as fuel dilution of the crankcase oil, non-ferrous wear metal concentrations, total fuel consumption, and total oil consumption, can be useful in the assessment of the validity of the test results.[12]

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 *Exceptions*—Where there is no direct SI equivalent such as pipe fittings, tubing, NPT screw threads/diameters, or single source equipment specified.

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.* See Annex A5 for specific safety precautions.

[1] The ASTM Test Monitoring Center will update changes in this test method by means of Information Letters. Information letters may be obtained from the ASTM Test Monitoring Center (TMC), 6555 Penn Ave., Pittsburgh, PA 15206-4489, Attention: Administrator. www.astmtmc.cmu.edu. This edition incorporates all Information Letters through No. 13–1.

Section 2

Reference Documents

NOTE: To be drafted, post-precision matrix, once necessary information is available.

Section 3

Terminology

NOTE: To be drafted, post-precision matrix, once necessary information is available.

Section 4

Summary of Test Method

4. Summary of Test Method

4.1 *Test Numbering Scheme*—Use the test numbering scheme shown below:

AAAAA–BBBBB–CCCCC

AAAAA represents the stand number. BBBBB represents the number of tests since the last calibration test on that stand. CCCCC represents the total number of Sequence IVB tests conducted on that stand. For example, 6-10-175 represents the 175th Sequence IVB test conducted on test stand 6 and the tenth test since the last calibration test. Consecutively number all tests. Number the stand calibration tests beginning with zero for the BBBBB field. Multiple-length Sequence IVB tests are multiple runs for test numbering purposes, such as double-length tests which are counted as two runs and triple-length tests which are counted as three runs. For example, if test 1-3-28 is a doubled-length test, number the next test conducted on that stand 1-5-30.

4.2 *Test Engine*—This procedure uses a Toyota 2NR-FE water cooled, 4 cycle, in-line four cylinder, 1.5 liter engine as the test apparatus. The engine incorporates dual overhead camshafts, four valves per cylinder (2 intake; 2 exhaust), and a direct acting mechanical bucket lifter valve-train design. The critical test parts (camshafts, direct acting mechanical bucket lifters) are replaced prior to each test. A 95 minute run-in schedule, followed by a 100 hour aging schedule, for Silicon (Si) pacification, is conducted whenever the long block or cylinder head are replaced with new components.

4.3 *Test Stand*—The complete test stand is available from the supplier listed in Annex Ax.x (TBD).

4.4 *Test Sequence*—After an engine run-in and aging schedule, or after the completion of a previous test, install new test camshafts and bucket lifters. Perform four engine flushes, using fresh oil charges for each flush. After completing the four flushes, drain the used oil from the 4th flush, and weigh and install the fresh test oil charge. Run the test for a total of 200 h, with no scheduled shutdowns. A single test cycle is composed of two 7-second steady-state stages separated by 8-second linear transitions. This test cycle (two steady-state stages and two linear transitions) is repeated 24,000 times.

4.5 *Analyses Conducted*—At the completion of the test, the camshaft lobes are measured for heel-to-toe wear and the bucket lifters are measured for maximum wear (z diff), area loss, volume loss and mass loss. Use these measurements to determine the summation, average, minimum and maximum wear for the intake and exhaust bucket lifters and the intake and exhaust camshaft lobes. Determine the oil consumption by calculating the difference between the mass of the used drain oil and the mass of the engine's initial oil charge. Analyze the end of test used oil for wear metals, fuel dilution, kinematic viscosity at 40°C, total acid number, total base number and oxidation and nitration by FTIR. Retain a final drain sample of 1 L for a minimum of 90 days. Retain the camshafts and bucket lifters for a minimum of 6 months.

Section 5

Significance and Use

5. Significance and Use

5.1 This test method was developed to evaluate automotive lubricant's effect on controlling camshaft lobe and bucket lifter wear for overhead camshaft engines with direct acting bucket lifters.

NOTE 2—This test method may be used for engine oil specifications, such as Specification D4485, API 1509, SAE J183, and ILSC GF 3.

NOTE 3—Coordination with the ASTM Committee D02, Subcommittee B, Sequence IVB Surveillance Panel is a prerequisite to the use of any equivalent apparatus. Figures are provided throughout the test method to suggest appropriate design details and depict some of the required apparatus.

Section 6

* Moved to Engine Assembly Manual *

Section 7

Reagents and Materials

NOTE: To be drafted, post-precision matrix, once necessary information is available.

Section 8

Oil Blend Sampling Requirements

NOTE: To be drafted, post-precision matrix, once necessary information is available.

Section 9

* Moved to Engine Assembly Manual *

Section 10

Data Acquisition,

Reference Oil Application,

Equipment Calibration and Maintenance

10. Data Acquisition, Reference Oil Application, and Equipment Calibration and Maintenance

10.1 *Data Acquisition:*

10.1.1 *Computer Data Acquisition*—The test stand should log operational data using a computer data acquisition system with sensor configurations process is described in 10.1.2 – 10.1.4.

10.1.2 *Frequency of Logged Test Cycle Data*—Log the test cycle data at a sampling rate of 1-Hz.

10.1.3 *Signal Conditioning*—Do not exceed the controlled operational parameters for system time response as shown in Table 2. The system time response includes the total system of sensor, transducer, analog signal attenuation, and computer digital filtering. Use single-pole type filters for attenuation. For temperature sensors only grounded thermocouples are acceptable.

10.1.3.1 *Isolated Inputs*—Use signal-conditioning modules to provide isolated inputs to the digital computer.

10.2 *Reference Oil Application:*

NOTE 9—10.2.6 and 10.2.7 and Annex A1 - 5 describe the involvement of the TMC in respect to calibration procedures and acceptance criteria for a testing laboratory and a test stand, and the issuance of Information Letters and memoranda affecting the test method.

10.2.1 *Testing of Reference Oils*—Periodically conduct tests on reference oils according to the following:

10.2.1.1 Conduct reference oil tests on each calibrated test stand within a laboratory according to TMC guidelines.

10.2.1.2 Obtain reference oils directly from the TMC. These oils are formulated or selected to represent specific chemical types 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 the test results. The TMC determines which specific reference oil the laboratory shall test.

10.2.1.3 Unless specifically authorized by the TMC, do not analyze reference oils, either physically or chemically. Identification of reference oils by such analyses could undermine the confidentiality required to operate an effective reference oil system. Therefore, reference oils are supplied with the explicit understanding that they will not be subjected to analyses other than those specified in this procedure, unless specifically authorized by the TMC. If so authorized, prepare a written statement of the circumstances involved, the name of the person authorizing the analysis, and the data obtained; furnish copies of this statement to the TMC.

10.2.2 *Reference Oil Test Frequency*—Conduct reference oil tests according to the following frequency requirements:

10.2.2.1 For a given, calibrated test stand, conduct an acceptable reference oil test after no more than XX test starts have been conducted, or after TBD have elapsed, whichever occurs first.

10.2.2.2 After starting a laboratory reference oil test, non-reference oil tests may be started on any other calibrated test stand.

10.2.2.3 Reference oil test frequency may be adjusted due to the following reasons:

10.2.3 *Procedural Deviations*—On occasions when a laboratory becomes aware of a significant deviation from the test method, such as might arise during an in-house review or a TMC inspection, the laboratory and the TMC shall agree on an appropriate course of action to remedy the deviation. This action may include the shortening of existing reference oil calibration periods.

10.2.4 *Parts and Fuel Shortages*—Under special circumstances, such as industry-wide parts or fuel shortages, the Surveillance Panel may direct the TMC to extend the time intervals between reference oil tests. These extensions shall not exceed one regular calibration period.

10.2.5 *Reference Oil Test Data Flow*—To ensure continuous severity and precision monitoring, calibration tests are conducted periodically throughout the year. There may be occasions when laboratories conduct a large portion of calibration tests in a short period of 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.

10.2.6 *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 is left in an excessively long pending status. 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.

10.2.7 *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.

10.2.8 *Reporting of Reference Oil Test Results*—Report the results of all reference oil tests to the TMC according to the following directives:

10.2.8.1 Transmit results to the TMC within five days of test completion by way of electronic data transfer protocol as outlined in the Data Communication Committee, Electronic Test Report Transmission Model (ETRTM). The ETRTM can be obtained from the TMC.

10.2.8.2 If the test was conducted during a time extension permitted by the TMC, so indicate in the Comments section of the test report.

10.2.8.3 For an acceptable reference oil test, conducted following an unacceptable reference oil test, provide sufficient information in the Comments section of the test report to indicate how the problem was identified and corrected, insofar as possible, and how it was related to non-reference oil tests conducted during the period of time that the problem was being solved.

10.2.9 *Evaluation of Reference Oil Test Results*—The TMC evaluates the reference-oil test results for both operational validity and statistical acceptability. The TMC may consult with the test laboratory in case of difficulty, as follows:

10.2.9.1 Immediately upon receipt of the reference-oil test results from the test laboratory, the TMC evaluates the laboratories decision on operational validity. For operationally valid tests, the TMC then evaluates the pass/fail parameters according to the Sequence IVB Lubricant Test Monitoring System (TBD). If the test is judged acceptable, the reference oil code is disclosed by the TMC to the test laboratory. The TMC conveys to the test laboratory its preliminary findings based on the limited information available to them.

10.2.9.2 Subsequently, upon receipt of the information detailed in 13.1.1 the TMC reviews all reference-oil test results and reports to determine final test acceptability.

10.2.9.3 In the event the reference oil test is unacceptable, the test laboratory shall provide an explanation of the problem relating to the failure. If the problem is not obvious, all test-related equipment shall be re-checked. Following this re-check, the TMC assigns another reference oil for testing by the laboratory.

10.2.9.4 The TMC decides, with consultation as needed with industry experts (testing laboratories, members of the ASTM Technical Guidance Committee and of the Surveillance Panel, and so forth), whether the reason for any failure of a reference oil test is a false alarm, testing stand, testing laboratory, or industry-related problem. The Sequence IVB Surveillance Panel shall adjudicate all industry problems.

10.2.10 *Status of Non-Reference Oil Tests Relative to Reference Oil Tests*—Non-reference oil tests may proceed within a given laboratory during reference oil testing based upon the following:

10.2.10.1 During the time of conducting a reference oil test on one test stand, non-reference oil tests may be conducted on other previously calibrated stands. If the reference oil test is acceptable to the TMC, the non-reference oil tests shall be considered to have been run in a satisfactorily calibrated laboratory.

10.2.10.2 If a reference oil test is unacceptable, and it is determined that the problem is isolated to an individual test stand, consider other test stands to remain calibrated, and testing of non-reference oils may proceed on those other stands.

10.2.10.3 If a reference oil test is unacceptable, and it is determined that the problem is laboratory related, non-reference tests running during the problem period shall be considered invalid unless there is specific evidence to the contrary for each test.

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

10.3 *Equipment Calibration:*

10.3.1 *Instrumentation Calibration*—Perform a thorough recalibration adjustment of all instrumentation and transducers, including computer channels, according to the requirements that follow. Perform additional calibration checks whenever operational data indicates an abnormality. Standards used for instrumentation calibration shall be traceable to that country's specific national standards organization. The accuracy of the standard shall be a minimum of four times better than the accuracy of the test stand instrumentation.

10.3.2 *Dynamometer Torque Measurement*—Scale the final readout of engine torque (N·m). Calibrate the force measurement and readout system with deadweights. Coolant flow through the dynamometer, reaction forces due to coolant plumbing, and brinnelled trunnion bearings of the dynamometer may affect calibration by temperature excursions of the dynamometer electronic force transducer. When calibrating, ensure the dynamometer coolant flow indicator is in the green (Refer to Figure 10 in Section E) and that the load cell temperature has been stabilized at 45°C ± 1°C for a minimum of one hour. The torque measurement accuracy shall be ± 0.2 N·m. Perform this calibration prior to every test start.

10.3.3 Instrument Calibration—Document all instrument calibrations. Retain all calibration documentation for a minimum of 3 years.

10.3.3 Upon initial stand installation and every six months thereafter perform a full instrumentation calibration according to **Table 6**.

TABLE 6 Sequence IVB Instrument Calibrations to be Performed every 6 Months

Temperatures
Intake Air Temperature, °C
Engine Oil Gallery Temperature, °C
Engine Oil Sump Temperature, °C
Coolant Temperature Into Engine, °C
Coolant Temperature Out of Engine, °C
Fuel Rail Temperature, °C
Exhaust Gas Temperature, °C
Rocker Cover Coolant In Temperature, °C
Rocker Cover Coolant Out Temperature, °C
Test Cell Air Temperature, °C
Load Cell Temperature, °C
Blowby Gas Temperature, °C
Blowby Coolant In Temperature, °C
Blowby Coolant Out Temperature, °C
Pressures
Crankcase Gas Pressure, kPa
Oil Gallery Pressure, kPa
Fuel Rail Pressure, kPa
Exhaust Pressure, kPa (absolute)
Intake Air Pressure, kPa
Intake Manifold Pressure, kPa (absolute)
Barometric Pressure, kPa (absolute)
Engine Coolant Pressure, kPa
Flows
Air Fuel Ratio, afr
Blowby Flow Rate, sl/min
Fuel Flow Rate, kg/h
Engine Coolant Flow, l/min
Rocker Cover Coolant Flow, l/min
General
Intake Air Humidity, grains/kg
Engine Speed, r/min
Engine Torque (N-m)

10.3.4 *Humidity of Induction Air Calibration:*

10.3.4.1 Calibrate the primary laboratory measurement system at each test stand every 6 months using a hygrometer with a minimum dew point accuracy of ± 0.55 °C at 16 °C. Locate the sample tap on the air supply line to the engine, between the main duct and 1000 mm upstream of the intake air cleaner. The calibration consists of a series of paired humidity measurements comparing the laboratory system with the calibration hygrometer. The comparison period lasts from 20 min to 2 h with measurements taken at intervals of (1 to 6) min, for a total of 20 paired measurements.

The measurement interval shall be appropriate for the time constant of the humidity measurement instruments.

10.3.4.2 Verify that the flow rate is within the equipment manufacturer's specification and that the sample lines are non-hygroscopic. Correct dew point hygrometer measurements to standard conditions (101.12 kPa) using the appropriate equation. Compute the difference between each pair of readings and calculate the mean and standard deviation of the twenty-paired readings. The absolute value of the mean difference shall not exceed 1.43 g/kg, and the standard deviation shall not be greater than 0.714 g/kg. If these conditions are not met, investigate the cause, make repairs, and recalibrate. Maintain calibration records for 2 years.

10.3.5 *Profilometer Calibration*—Follow the manufacturer's instruction for calibration and verification checks of the profilometer. Calibrate the profilometer at least annually.

10.3.6 *Keyence Measurement Device* —Confirm the calibration of the Keyence measurement device at least once every 6 months.

Section 11

Break-in and Aging Procedure

(Section D)

and

Engine Operation Procedure

(Section E)

Section D

Break-in and Aging Procedure

NOTE: Changes from the original to finalized test configuration are documented in the included lab instructions.

1. Configure the engine for run-in and silicone pacification as follows.
   1.1. First run engines have the correct engine break-in valve train components pre-installed. Install the components listed in Annex # ____ and in the engine assembly manual sections _____.
   1.2. If not a first run engine, then install stock intake camshaft, stock exhaust camshaft, and stock bucket lifters that have been designated for break-in use by the laboratory. Install the components listed in Annex # _____ and in the engine assembly manual sections _____

   Note: Pre-test measurements are not required on valve train components used for engine break-in purposes.

2. Configure the engine with stock valve train cover and active positive crankcase ventilation. Ensure the following connections are made. Affix all ends of hoses with hose clamps.
   2.1. Refer to Figure 1. Connect the stock PCV valve (A) to port (C) on the intake manifold (E) with the 19 mm diameter hose (B). This is the OEM supplied PCV hose.
   2.2. Refer to Figure 2. Connect the port (A) on the valve train cover to port (B) on the intake air filter housing with the 15.8 mm diameter Tygon hose (C).
   2.3. Refer to Figure 3. Connect the 8 mm steel-braided hose (B) to the quick-disconnect (A) on the modified oil fill cap.

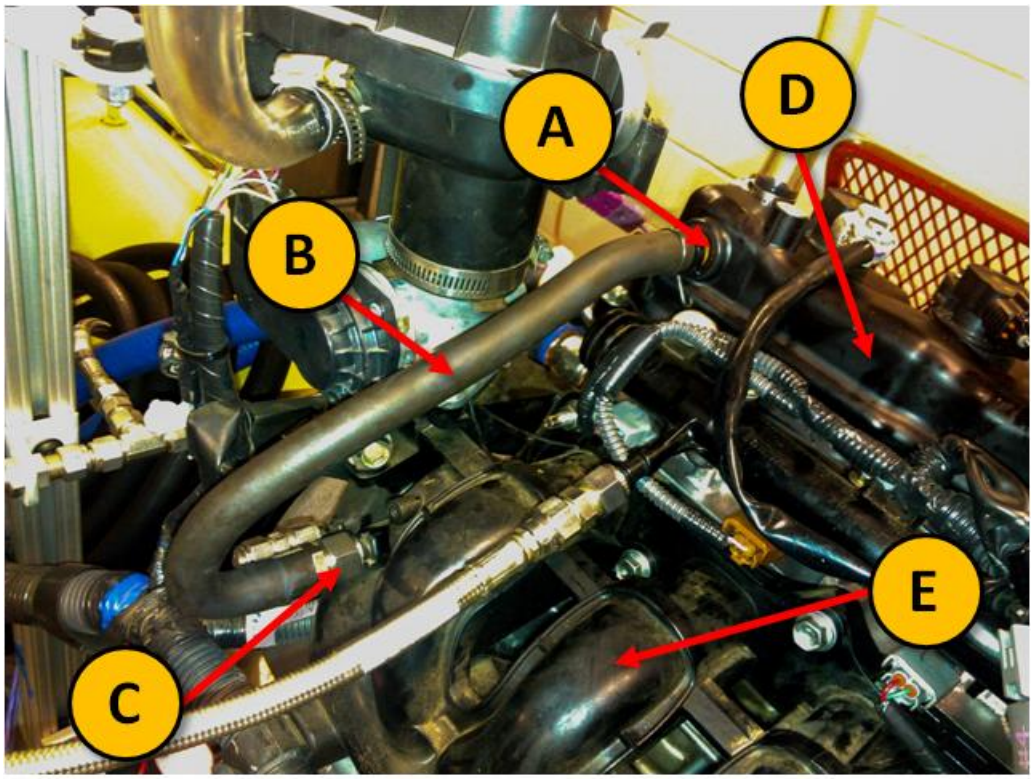

Figure 1: Routing of crankcase gases. (A) stock PCV valve, (B) 19 mm diameter hose, (C) hose adapter to intake manifold, (D) stock valve train cover, (E) intake manifold. The 19 mm diameter hose is the OEM provided crankcase ventilation hose which is installed on new engines.

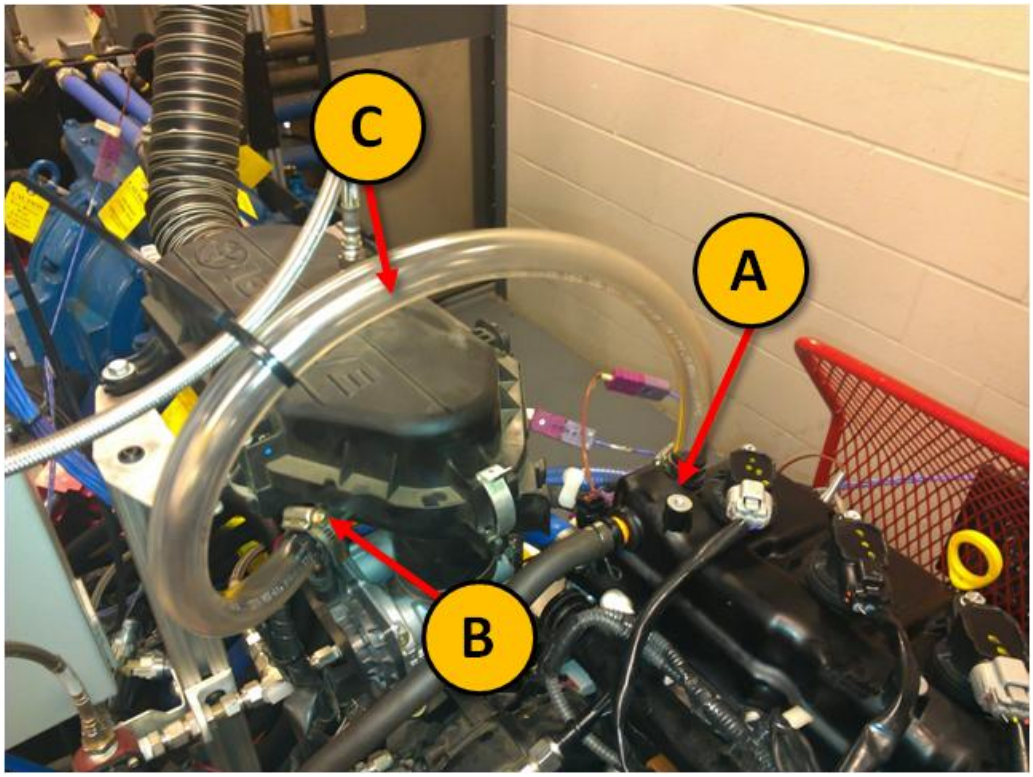

Figure 2: Routing of fresh air. (A) Port to valve train cover, (B) port from intake air filter housing, (C) 15 mm diameter Tygon hose

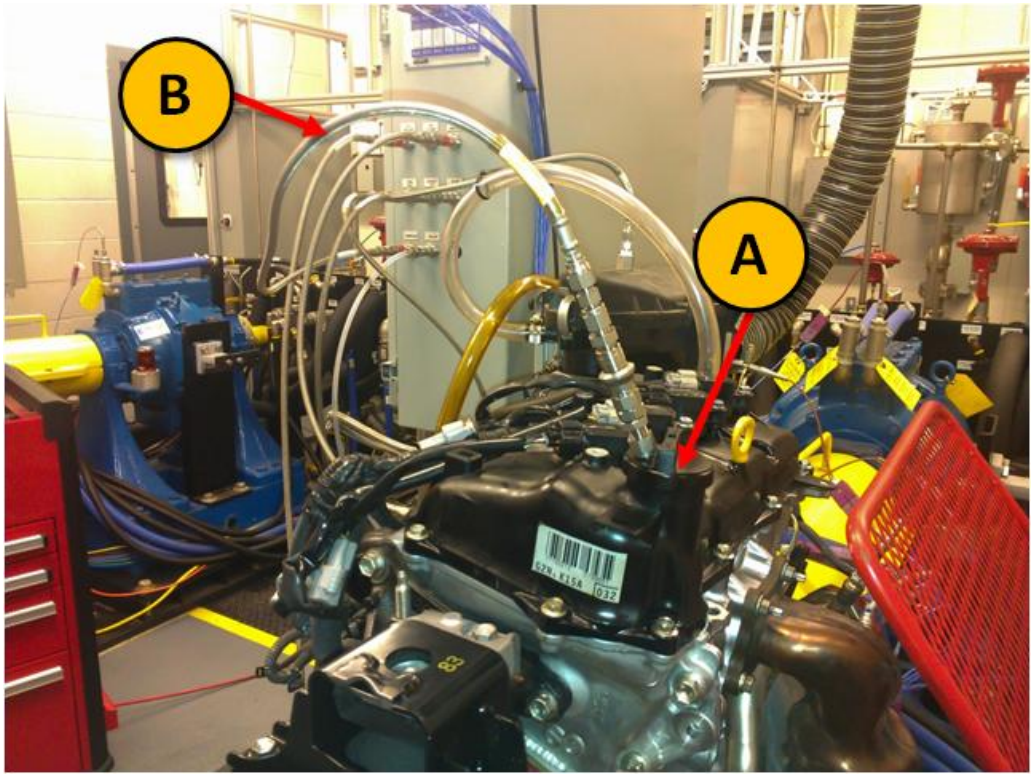

Figure 3: Crankcase pressure measurement point. (A) Oil fill cap modified with 5 mm diameter quick disconnect, (B) 8 mm diameter steel-braided hose to pressure transducer

3. Conduct the following external oil flush procedure.
   3.1. Refer to Figure 4. Disconnect the supply and return lines from the remote oil filter housing adapter that is mounted on the engine.

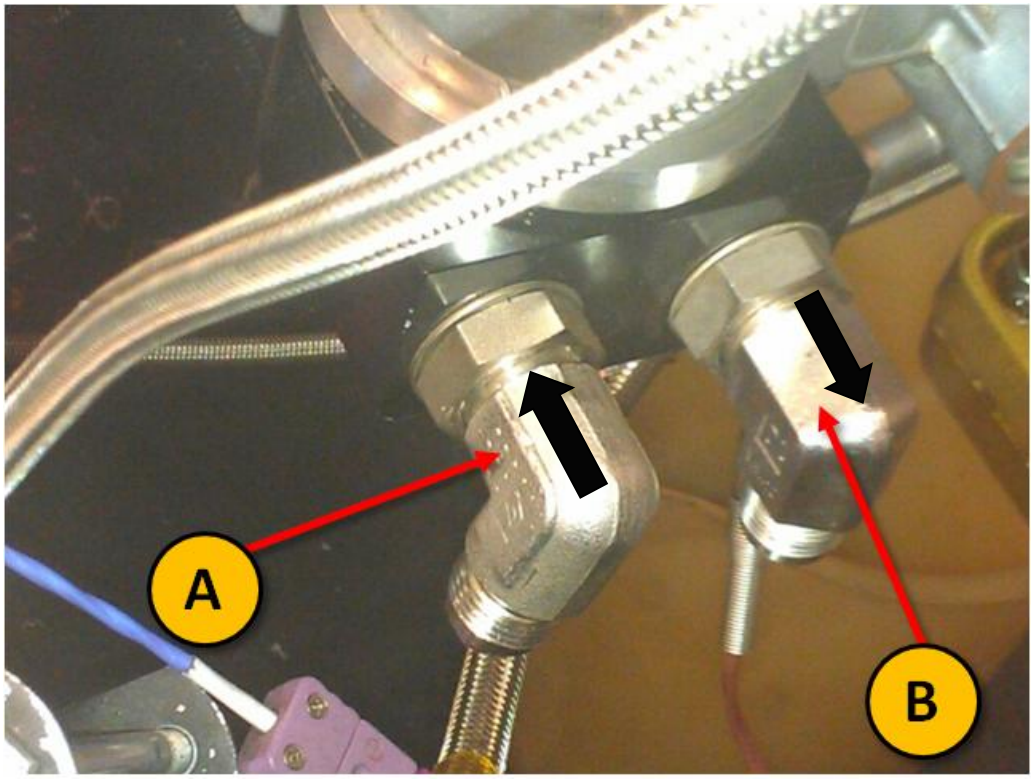

Figure 4: Engine-mounted oil filter housing adapter line connections.
(A) is return from oil cooler and (B) is supply to oil filter

   3.2. Connect the supply and return lines to a portable oil cleaning flush cart of minimum 3.8 L capacity that is equipped with a circulation pump. Charge the flush cart with mineral spirits meeting the requirements of Specification D235, Type II, Class C for Aromatic Content (0 to 2 vol)%, Flash Point (61 °C, min) and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale). Energize the flush cart pump and allow the mineral spirits to circulate for one (1) hour.
   3.3. At the end of one (1) hour, de-energize the flush cart pump. Open both engine oil heat exchanger drain valves (see Figure 5). Disconnect the supply and return lines from the flush cart.

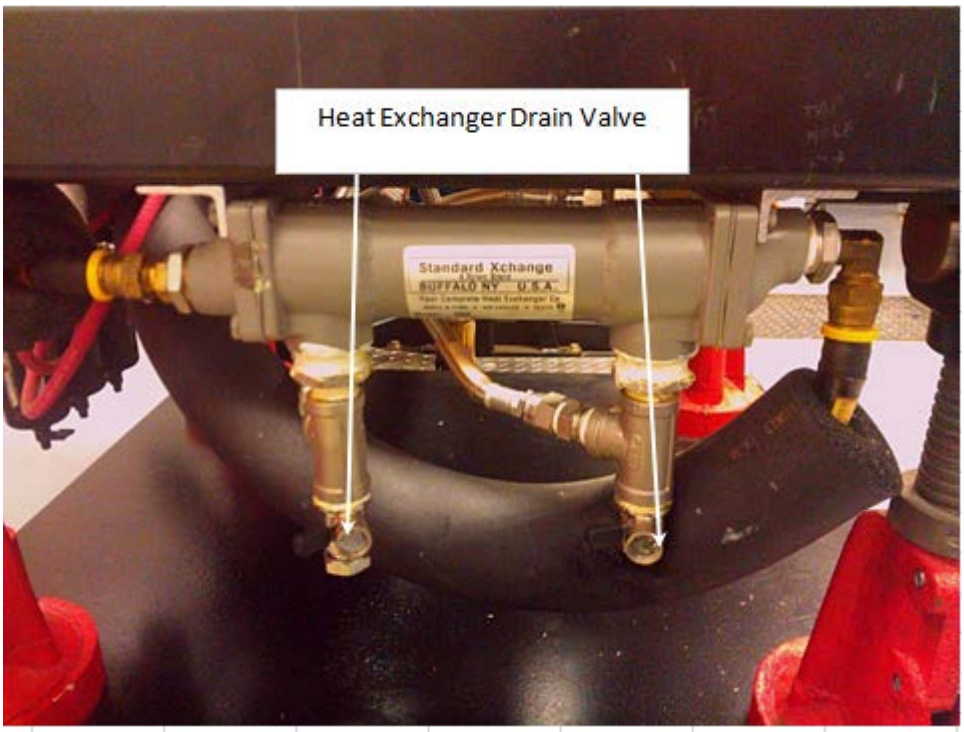

Figure 5: Engine Oil Heat Exchanger Drain Valve Locations

3.4. When the heat exchanger has completed draining, leave the heat exchanger drain valves open and connect both the supply and return lines to a clean, dry compressed air supply at 140 kPa. Allow compressed air to flow through the system for 15 minutes to dry the system.
3.5. Disconnect the supply and return lines from the compressed air source.
3.6. Connect the supply and return lines back to the engine-mounted oil filter housing adapter.
3.7. Close the heat exchanger drain valves, and remove the Oberg oil filter element for cleaning. Clear any debris retained in the Oberg oil filter element with mineral spirits and air dry. Re-install the Oberg oil filter element in the Oberg filter housing and secure the four retaining bolts.

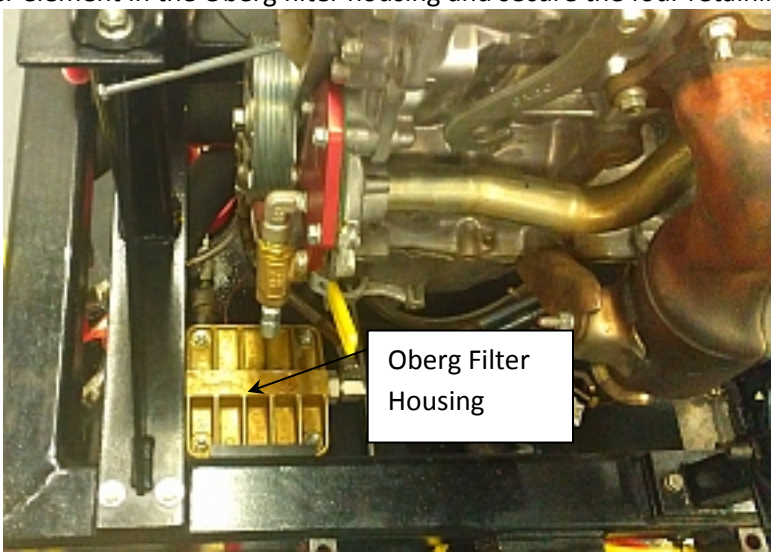

Figure 6: Oberg Filter Location

3.8. Dispose of the used mineral spirits following test laboratory practice.

4. Fill the engine with 3.0 L of break-in oil. The break-in oil is ASTM TMC reference oil 1006-2.

5. Fill the engine coolant system and the rocker cover coolant system with a 70/30 mixture of de-ionized or distilled water and Havoline Extended Life DEX-COOL® concentrated anti-freeze. Approximately 45 L of the 70/30 mixture is required to fill both systems.

6. With coolant flow control flow valve 50% open and the coolant system pressurized at 70 kPa, energize the engine coolant pump and allow the engine coolant to circulate for 5 minutes to remove air from the engine coolant system.

7. Using the coolant heater, gradually increase the coolant temperature to 50 °C over 15 minutes.

8. Soak the coolant temperature at 50 °C for 30 minutes.

9. With the dynamometer load control set point at 0 N·m and the throttle control set point at 10% , start the engine. As soon as the engine achieves 500 r/min increase the throttle control set point to 800 r/min while continuing to hold the dynamometer load control set point at 0 N·m.

10. When the engine achieves 800 r/min begin the engine break-in schedule provided in table 1.

Table 1 Engine Break-in Schedule

Break-in Step no.	Duration min	Engine Speed r/min	Engine Load N·m	Gallery Oil Temperature °C	Coolant Out Temperature °C
1	10	800	6.3	50	50
2	10	1600	6.3	55	50
3	10	2000	25.0	60	55
4	10	2400	25.0	65	60
5	10	2400	46.9	70	65
6	15	2800	46.9	75	70
7	15	3200	46.9	80	75
8	15	3200	46.9	85	80

10.1. The duration for each step includes the time to transition between set points. Engine load should achieve specified value within 45 seconds, and engine speed should achieve specified value within 60 seconds.

10.2. The following parameters should be controlled to the specified set points for all break-in steps:

- Fuel rail temperature 24 ± 3 ° C
- Coolant FLOW RATE 80 ± 1 lpm
- Exhaust back pressure 103.5 ± 1.0 kPaA
- Intake air pressure 0.25 ± 0.03 kPa
- Intake air temperature 32 ± 2 ° C
- Load cell temperature 45 ± 2 ° C

10.3. Following the completion of engine break-in step 8, establish the following oil sampling conditions.

Table 2 Oil Sampling Conditions

Oil Sampling Conditions	Duration min	Engine Speed r/min	Engine Load N·m	Gallery Oil Temperature °C	Coolant Out Temperature °C
	---	1000	10.0	50	50

10.4. When oil temperature has been reduced to 50°C, take a 240 mL purge sample immediately followed by a 30 mL oil sample. Conduct ASTM D5185 Metals by ICP on the oil sample. If the sample cannot be obtained within 10 minutes after achieving the 50 °C oil temperature stop the engine as excessive idling time can be detrimental to engine run-in.

11. When the oil sample has been obtained in step 10.4, stop the engine. Disconnect the conditioned intake air supply. Return the purge sample to the engine via the factory oil fill cap. Allow the engine to rest for ten minutes. Following the ten minute rest period, measure and record the oil level by removing the dipstick and measuring from the bottom of the dipstick to the top of the oil film. Record the length of the oil film in millimeters. Do not top off the oil level.

Figure 7: Engine Oil Level Measurement

12. Start the engine, and continue to run the engine at the following conditions for engine aging:

Table 3 Engine Aging Conditions

Aging Step no.	Duration (hrs)	Engine Speed r/min	Engine Load N·m	Gallery Oil Temp ° C	Coolant Out Temp ° C
Aging	50	3000	50	80	88
Sampling	---	1000	10	80	80

12.1. The duration for each step includes the time to transition between set points. Engine load should achieve specified value in 45 seconds, and engine speed should achieve specified value in 60 seconds.

12.2. After every 5 hours of aging, bring the engine down to the oil sampling conditions. If the sample cannot be obtained within 10 minutes after achieving the 50 °C oil temperature stop the engine as excessive idling time can be detrimental to engine run-in.

12.3. Take a 240 mL purge sample immediately followed by a 3 mL oil sample. Return the purge sample to the engine via the factory oil fill cap. Conduct ASTM D5185 Metals by ICP on the oil sample.

12.4. Stop the engine and allow the engine to rest for ten minutes. Measure and record the oil level by removing the dipstick and measuring from the bottom of the dipstick to the top of the oil film. Record the length of the oil film in millimeters. Do not top off the oil level.

12.5. Repeat steps 12 through 12.5 nine additional times for a total aging time of fifty (50) hours.

12.6. Drain oil charge after the aging runs have completed.

13. Examine the results of the ASTM D5185 for high wear anomalies using Fe, Cu, and Al and to ensure the Si levels have plateaued. Also examine values of K as an indicator of coolant leaks. K values exceeding 15 ppm are suspicious and the engine should be evaluated for an internal coolant leak. If an internal coolant leak is confirmed, make repairs and repeat the run-in and aging procedure. Note – the example graph below is that of a new engine. Used engines with fresh cylinder heads will provide lower results.

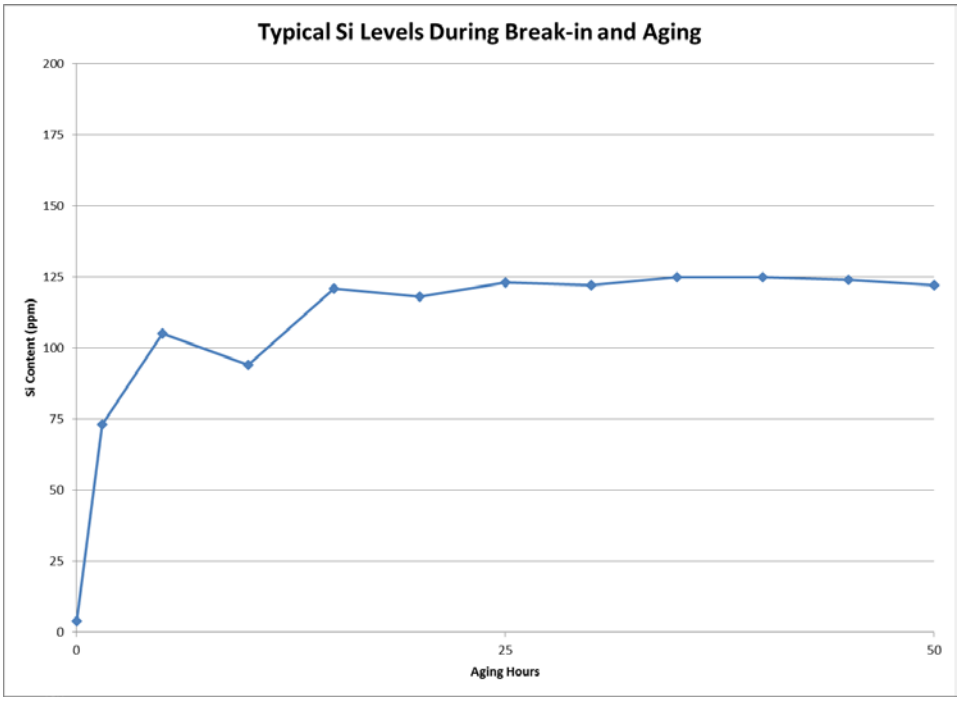

Figure 8: Example of Si Plateau (New Engine)

14. This completed the run-in and conditioning procedure.

Lubrizol

Break-in and Aging Lab Instructions

SEQUENCE IVB - NEW ENGINE OR CYLINDER HEAD BREAK-IN/AGING

GASW437

DOCUMENT REVISION LOG

REVISION LEVEL	DATE APPROVED	ISSUED BY	REVISION DESCRIPTION
0	03-19-2015	CHTM, OEWA	In service this date.
1	01-11-2016	CHTM	Added instructions for using dipstick measurement block and additional fields for operator initials. Also specifies new clutch and driveshaft with every break-in. Added oil circuit flush instructions and coolant temperature soak period.
2	01-12-2016	CHTM	Instructions to tap original coolant temperature sensor.
3	03-10-2016	CHTM	Added instructions to check the installation angles of the engine and to take post-test lifter clearance measurements.
4	03-21-2016	CHTM	Install new engine mounts prior to each engine break-in.
5	04-01-2016	CHTM	Added provisions for the new OHT oil pan design.
6	04-08-2016	CHTM	Added instructions to record serial number on engine block.
7	07-02-2016	CHTM	Added instructions to check engine mount orientation, instrument air pressure, and remove original cylinder head hardware.
8	09-09-2016	CHTM	Instructions have been modified to reflect differences between engine and cylinder head break-in.

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9	12-13-2016	CHTM	Added separate fields for rocker arm cover and oil pan dipstick measurements. Added fields for end-of-test lifter clearance measurements.
10	01-09-2017	CHTM	The lifter clearances and grades are now recorded for the engine/cylinder head prior to break-in. This information will allow the Metrology Lab to start preparations for the 1st test kit as soon as possible.

1. NOTES:

1.1. This work instruction form is to be completed any time a new Toyota engine or cylinder head is installed.

1.1.1. This completed form needs to be included in the test packet.

2. HARDWARE DOCUMENTATION:

2.1. TRN Number:

2.2. 5-Digit OHT Serial Number of Cylinder Head:

2.3. Number of Runs on Cylinder Head:

2.4. 5-Digit OHT Serial Number of Engine Block:

2.5. 7-Digit Serial Number at Back of Engine Block:

2.6. Number of Runs on Engine Block:

2.7. Oil Sample Number:

2.8. Date of Test Initiation:

2.9. Initials of Operator Performing Test Start-Up:

3. CONFIRM THE FOLLOWING ITEMS:

3.1. Specify the reason for running the break-in/aging cycle:

3.1.1. New engine and cylinder head ☐

3.1.2. New cylinder head only ☐

3.1.3. Other ☐

3.2. Confirm that the correct valve train components are installed for the type of break-in/aging that is being performed:

3.2.1. The stock intake camshaft and stock intake valve springs are only to be used with a completely new engine. **N/A:** ☐ **This Set-Up is Being Utilized:** ☐

3.2.2. The test intake camshaft and test intake valve springs are only to be used when a new cylinder head is installed on an existing engine. **N/A:** ☐ **This Set-Up is Being Utilized:** ☐

3.3. Confirm that the following hardware is installed in the engine:

3.3.1. Stock exhaust camshaft **Complete:** ☐

3.3.2. Engine's original bucket lifters or "flush" bucket lifters **Complete:** ☐

3.3.3. Stock rocker arm cover **Complete:** ☐

3.3.4. OHT front cover **Complete:** ☐

3.3.5. Stock active PCV system (Figure 1 and Figure 2) **Complete:** ☐

3.3.6. Throttle body without coolant fitting **Complete:** ☐

3.3.7. New spark plugs with a gap of 1.1mm or 0.043-inches **N/A:** ☐ **Complete:** ☐

3.3.8. New clutch (with associated bearings) **N/A:** ☐ **Complete:** ☐

3.3.9. New driveshaft **N/A:** ☐ **Complete:** ☐

3.3.10. OHT oil pan with dipstick **Complete:** ☐

3.4. Confirm that new engine mounts have been installed on the test stand. **N/A:** ☐ **Complete:** ☐

3.4.1. **NOTE:** The new exhaust-side engine mount will need to be modified (i.e. remove one of the metal tabs) so that there is no interference with the exhaust pipe.

3.5. Confirm that there is a small amount of silicone on the two junctions between the front cover, oil pan and engine block. **Complete:** ☐

3.5.1. **NOTE:** These junctions are located on either side of the harmonic balancer.

3.6. Confirm that the correct fuel hose is connected in the fuel shed and record the fuel batch number:

3.6.1. **Fuel Batch Number:** _____

3.7. Confirm that the location of the original equipment coolant temperature sensor (89422-33030) has been tapped to accommodate Lubrizol's thermocouple. **Complete:** ☐

3.7.1. **NOTE:** The original sensor uses a M12X1.5 thread.

3.8. Confirm that the PCM is plugged in. **Complete:** ☐

3.9. Confirm that the fuel injector wires are connected correctly. **Complete:** ☐

3.9.1. **NOTE:** The connector colors should be brown for Cylinder #1, gray for Cylinder #2, brown for Cylinder #3 and gray for Cylinder #4.

3.10. Confirm that the ignition coil wires are connected correctly. **Complete:** ☐

3.10.1. **NOTE:** The connector colors should be black for Cylinder #1, gray for Cylinder #2, black for Cylinder #3 and gray for Cylinder #4.

3.11. Open up the front door to the blue computer cabinet and confirm that the **Dynamometer** and **Throttle** indicator lights on the **DyneSystems** unit are both green. **Complete:** ☐

3.12. Connect the crankcase pressure transducer line to the modified oil fill cap (Figure 3). **Complete:** ☐

3.13. Use an inclinometer to confirm that the installation angles of the engine are within acceptable tolerances.

3.13.1. *Front-to-Back Angle = 0°±0.25°* (or *Flywheel Angle = 90°±0.25°*) **Complete:** ☐

3.13.2. *Side-to-Side Angle = 4.0°±0.5°* (with exhaust side lower than intake side) **Complete:** ☐

3.13.3. *Driveshaft Angle = 2.0°±0.25°* (with the driveshaft sloping down towards dyno) **Complete:** ☐

3.14. Confirm that the arrows molded on the top of the left-side and right-side engine mounts are both pointing towards the engine. **Complete:** ☐

3.15. Confirm that the instrument air pressure regulator is set at 20±2psi. **Complete:** ☐

OPERATOR INITIALS: ☐

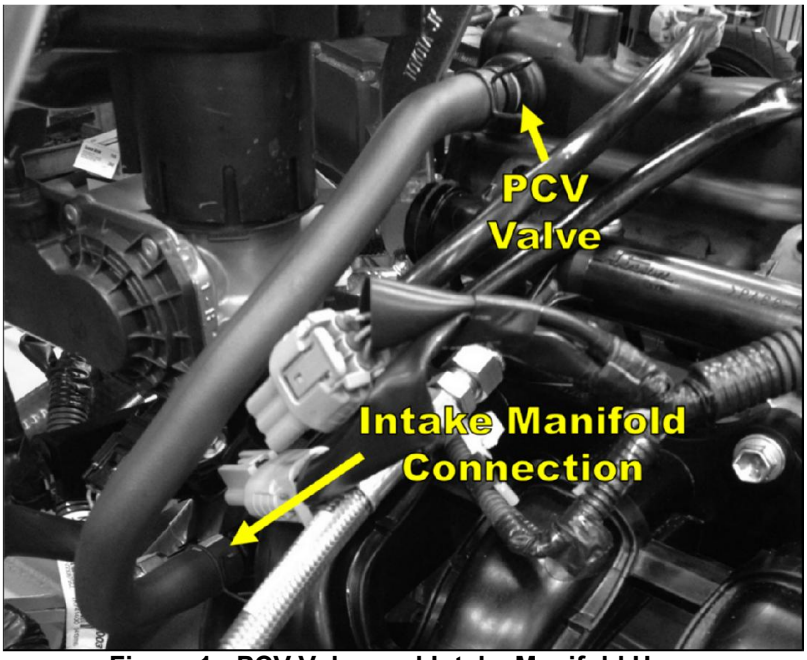


Figure 1 - PCV Valve and Intake Manifold Hose

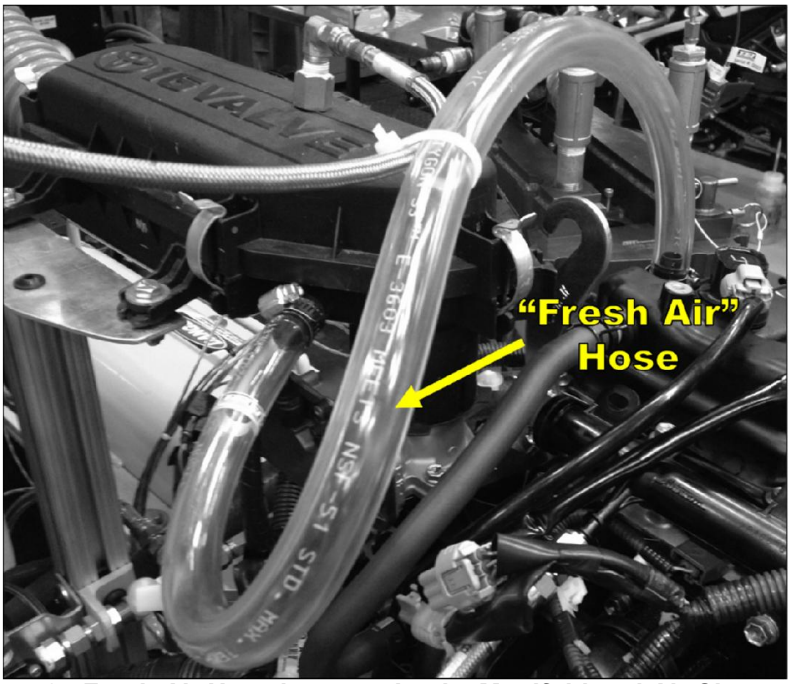


Figure 2 - Fresh Air Hose between Intake Manifold and Air Cleaner Box

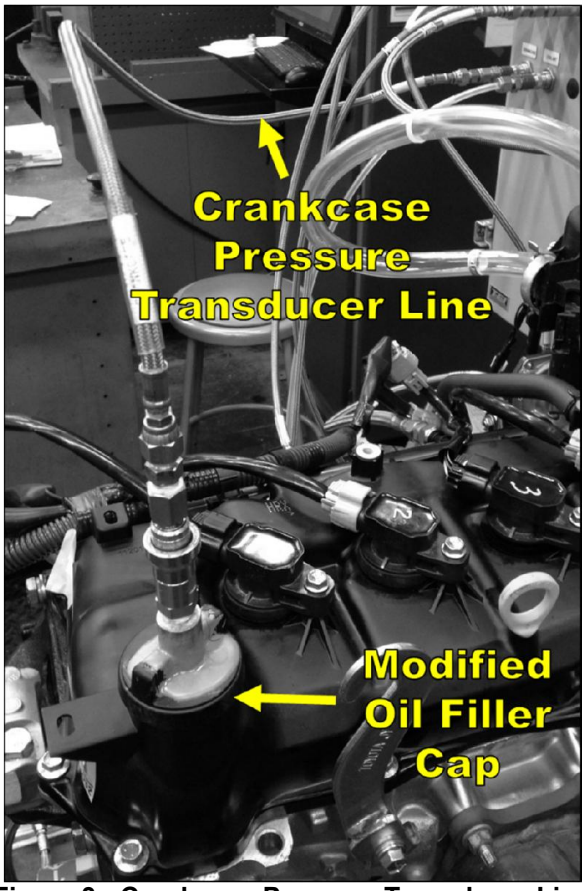


Figure 3 - Crankcase Pressure Transducer Line

4. CHARGE THE ENGINE COOLANT:

4.1. **NOTE:** The engine coolant must be changed after each engine replacement, cylinder head replacement, or any time the coolant system hardware was serviced (i.e. replacing a coolant pump).

4.2. Confirm that the test stand has the proper LO/TO equipment installed, and that none of the accessories on the **Accessories** tab of EasyTest are activated. **N/A:** ☐ **Complete:** ☐

4.3. Confirm that the coolant system is no longer pressurized. **N/A:** ☐ **Complete:** ☐

4.4. Remove the cap from the engine coolant reservoir. **N/A:** ☐ **Complete:** ☐

4.5. Set the engine coolant flow control valve to the fully open position and verify that all drains are closed and all hoses are connected. **N/A:** ☐ **Complete:** ☐

4.6. Prepare approximately **12-gallons** of 30% Havoline Extended Life Dex-Cool coolant and 70% deionized or distilled water. **N/A:** ☐ **Complete:** ☐

4.7. Charge the coolant by filling the system from the top or by pumping coolant into the system from the bottom drain of the heat exchanger. **N/A:** ☐ **Complete:** ☐

4.7.1. Fill the system until the coolant is 2-inches from the top of the vertical sight glass located on the side of the main coolant reservoir.

4.7.2. Secure the coolant reservoir cap once the system is full.

4.8. Adjust the system pressure to approximately 10psi. **N/A:** ☐ **Complete:** ☐

4.9. Select the **ac03_CoolPumps** accessory under the **Accessories** tab in EasyTest and allow the coolant to circulate for approximately 1-hour. **N/A:** ☐ **Complete:** ☐

4.10. After 1-hour, turn off the coolant pump and reduce the coolant pressure to 0psi.

4.10.1. Remove the reservoir cap and add additional coolant as needed to return the level to within 2-inches from the top of the vertical sight glass. **N/A:** ☐ **Complete:** ☐

4.11. Secure the coolant reservoir cap.

4.11.1. Pressurize the system to 10psi. **N/A:** ☐ **Complete:** ☐

5. CHARGE THE ROCKER ARM COVER COOLANT:

5.1. **NOTE:** The rocker arm cover coolant must be changed after each engine replacement, cylinder head replacement, or any time the coolant system hardware was serviced (i.e. replacing a coolant pump).

5.2. Confirm that the test stand has the proper LO/TO equipment installed, and that none of the accessories on the **Accessories** tab of EasyTest are activated. **N/A:** ☐ **Complete:** ☐

5.3. Verify that all drains are closed and all hoses are connected. **N/A:** ☐ **Complete:** ☐

5.4. Remove the pressure cap from the valve cover coolant reservoir. **N/A:** ☐ **Complete:** ☐

5.5. Prepare approximately **23-liters** of 30% Havoline Extended Life Dex-Cool coolant and 70% deionized or distilled water. **N/A:** ☐ **Complete:** ☐

5.6. Charge the coolant by filling the system from the top or by pumping coolant into the system from the bottom drain of the heat exchanger. **N/A:** ☐ **Complete:** ☐

5.6.1. Fill the system until the coolant is 2-inches from the top of the vertical sight glass located on the side of the main coolant reservoir.

5.6.2. Secure the coolant reservoir cap once the system is full.

5.7. Select the **ac03_CoolPumps** accessory under the **Accessories** tab in EasyTest and allow the coolant to circulate for approximately 1-hour. **N/A:** ☐ **Complete:** ☐

5.7.1. **NOTE:** Both the engine coolant and rocker arm cover coolant systems must be charged in order to run the coolant pumps

5.8. After 1-hour, turn off the coolant pump and reduce the coolant pressure to 0psi.

5.8.1. Remove the valve cover reservoir cap and add additional coolant as needed to return the level to within 2-inches from the top of the vertical sight glass. **N/A:** ☐ **Complete:** ☐

5.9. Secure the coolant reservoir cap. **N/A:** ☐ **Complete:** ☐

6. FLUSH THE EXTERNAL OIL SYSTEM:

6.1. **NOTE:** Use the Sequence IVB flush cart from the East Lab to perform this oil system flush.

6.2. Disconnect the supply and return lines from the remote oil filter housing adapter that is mounted on the engine. **Complete:** ☐

6.3. Connect the supply and return lines to a portable flush cart (with a minimum capacity of 1-gallon) that is equipped with a pump. **Complete:** ☐

6.3.1. Charge the flush cart with clean Stoddard solvent.

6.4. Activate the pump on the cart and allow Stoddard to circulate through the test stand's oil system for approximately 1-hour. **Complete:** ☐

6.5. After the solvent circulates through the oil circuit for 1-hour, deactivate the pump and place empty containers underneath the two oil heat exchanger drain valves.

6.5.1. Open the two heat exchanger drain valves.

6.5.2. Allow the heat exchanger to completely drain. **Complete:** ☐

6.6. Disconnect the supply and return lines from the portable flush cart. **Complete:** ☐

6.7. Connect the supply and return lines to a clean, dry compressed air source that is operating at approximately 20psi. **Complete:** ☐

6.7.1. Leave the two drain valves open and keep the Stoddard collection containers in place.

6.7.2. Allow compressed air to flow through the oil circuit for approximately 15-minutes to remove any residual Stoddard from the lines.

6.8. Disconnect the supply and return lines from the compressed air source. **Complete:** ☐

6.9. Connect the supply and return lines back on the remote oil filter housing adaptor located on the engine. **Complete:** ☐

6.10. Close the two heat exchanger drain valves. **Complete:** ☐

6.11. Remove the Oberg oil filter element for cleaning. **Complete:** ☐

6.11.1. **NOTE:** The Oberg oil filter housing is located underneath the front of the engine cradle.

6.11.2. Take the Oberg oil filter element to the Spray Room and remove any debris using Stoddard solvent and compressed air.

6.11.3. Confirm that the correct Oberg filter is being used (**OHT6A-013-2**, 28µm).

6.11.4. Once the Oberg oil filter element is dry, reinstall it in the Oberg oil filter housing and secure the four bolts.

6.12. Dispose of the used Stoddard and remove the two collection containers. **Complete:** ☐

6.13. Disconnect the oil sample and oil pressure transducer lines and take them to the Spray Room to clean them with Stoddard solvent. **Complete:** ☐

6.13.1. Dry the lines with compressed air.

6.14. Open the oil sample valve to allow any trapped oil to drain. **Complete:** ☐

6.14.1. Then close the valve and reconnect the oil sample and oil pressure transducer lines.

7. DOCUMENT THE LIFTER CLEARANCES AND GRADES:

7.1. Remove the rocker arm cover and measure the clearances between the lifters and camshaft lobes (Table 1). **Complete:** ☐

Table 1 – Lifter Clearances and Grades of New Cylinder Head

Intake Side of Engine								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Grade								
Clearance (in)								
Exhaust Side of Engine								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Grade								

Clearance (in)								

OPERATOR INITIALS:

DATE:

8. PRE-FLIGHT CHECKLIST:

8.1. Obtain and label each of the sample jars for the test. **Complete:** ☐

8.2. Lubricate the driveshaft. **Complete:** ☐

8.3. Drain the three pressure transducer condensation traps. **Complete:** ☐

8.4. Confirm that the DyneSystems PAU throttle controller is not in alarm. **Complete:** ☐

- 8.4.1. Press the red **RESET** button shown in Figure 4.
- 8.4.2. Then press the green **SATC ON** button shown in Figure 4.
- 8.4.3. Confirm that the display screen is not displaying an error.

Figure 4 - DyneSystems PAU Throttle Controls

9. ADD THE BREAK-IN OIL:

9.1. Confirm that the break-in oil is REO1006-2. **Complete:** ☐

9.2. Fill the engine with 3.0L of break-in oil. **Complete:** ☐

9.3. Confirm that the engine coolant system is charged with a mixture of 30% Dexcool and 70% deionized water. **Complete:** ☐

9.4. Confirm that the coolant system pressure cap is secure. **Complete:** ☐

9.5. Switch on the pressurized air valve to the coolant system pressure regulator and then apply 10-11psi of pressurized air to the coolant system. **Complete:** ☐

9.6. Turn on the **ac03_CoolPumps** and **ac02_HeaterENB** accessories and allow the coolant temperature (**TCLEO**) to reach its 50°C set point. **Complete:** ☐

9.6.1. **NOTE:** Allow the engine coolant temperature to remain at 50°C for 30-minutes before proceeding to the next step.

10.LOAD THE BREAK-IN MACRO:

10.1. Select **Begin/Resume Test** in the **Test** pull-down menu of EasyTest. **Complete:** ☐

10.2. Enter the correct TRN number in the **Run ID** field.

10.2.1. Press the **Begin/Resume Test** button. **Complete:** ☐

10.3. Select the **break-in** macro in the **Normal Pointers** pull-down menu of the **Sequencer** tab.

10.3.1. Press the **Load** button. **Complete:** ☐

10.4. Select the **Hold Sequencer** radial button on the Sequencer tab. **Complete:** ☐

10.5. Confirm that the dynamometer coolant flow indicator is green. **Complete:** ☐

10.6. Select the **ac02_HeaterENB** and **ac03_CoolPumps** accessories under the **Accessories** tab in EasyTest.

10.6.1. **NOTE:** The **ac03_CoolPumps** accessory must be selected for 60-seconds before the **ac02_HeaterENB** accessory can be selected. **Complete:** ☐

10.6.2. NOTE: The **ac00_HtrBloBy** accessory does not need to be turned on for break-in cycles.

10.7. Allow the load cell temperature parameter (**TLOADCELL**) to remain at a stable temperature of 45°±1°C for 1-hour before performing the calibration. **Complete:** ☐

10.8. Select the **TORQUE** parameter from the pull down menu on the **Calib/Tune** tab in EasyTest.

10.8.1. Add weight to the torque arm of the dynamometer until the **Value** field displays a measurement of approximately 40-50Nm. **Complete:** ☐

10.8.2. Once this measurement is achieved, remove all of the weights from the torque arm.
10.8.3. **NOTE:** This will remove any latent hysteresis from the load cell.

10.9. Press the **Slope and Offset Calculator** button. **Complete:** ☐
10.9.1. This will cause the **Slope and Offset Calculator** menu to appear.

10.10. Calibrate the dynamometer load cell at the four reference points shown in Table 2.
Complete: ☐

Table 2 - Dynamometer Load Cell Calibration

Calibration Point Description	Actual Mass (kg)	Actual Torque (Nm)	Permissible Error (%)
No Load	0	0	0.5%
Low Load	2.535	9.94	0.5%
Mid-Range Load	7.130	27.97	0.5%
Full Range Span	11.335	44.47	0.5%

10.10.1. Press the **Get Display Value** button on the **Slope and Offset Calculator** menu after each of these four calibration steps is completed and the **Actual Value** is inputted in the appropriate field.
10.10.2. Press the **Calculate** button.
10.10.3. Press the **Accept New Slope and Offset** button after the entire calibration is complete.

10.11. Record the calculated information displayed on the **Slope and Offset Calculator** menu in the fields listed below:

10.11.1. **Max Error, Old Calibration (Nm):** _____

10.11.2. **Max Error, New Calibration (Nm):** _____

10.12. Switch the **Dyno POT** and **Throttle POT** switches on the control panel to **POT**. **Complete:** ☐

10.13. Confirm that the **Dyno POT** knob is slightly above zero. **Complete:** ☐

10.14. Press the green **Reset** button and red **Dyno Reset** button on the control panel. **Complete:** ☐

10.15. Press and hold the yellow **Crank** button until the engine turns over. **Complete:** ☐

10.16. Once the engine stabilizes, select the **Run Sequencer** radial button.

10.16.1. Press the **Begin Break-In** button. **Complete:** ☐

10.17. **NOTE:** The break-in is 95-minutes long and includes a sequence of nine condition sets (as shown in Table 3).

10.17.1. **NOTE:** The engine load set point for each condition set should be achieved within the first 45-seconds.

10.17.2. **NOTE:** The engine speed set point for each condition set should be achieved within the first 60-seconds.

10.17.3. **NOTE:** The blowby temperature (TBBY) is not a critical parameter for break-in cycles.

Table 3 - Engine Break-In Condition Sets

Break-in Step No.	Duration (min)	Engine Speed (RPM)	Engine Load (N-m)	Gallery Oil Temp (°C)	Coolant Out Temp (°C)
1	10	800	6.3	50	50
2	10	1600	6.3	55	50
3	10	2000	25	60	55
4	10	2400	25	65	60
5	10	2400	46.9	70	65
6	15	2800	46.9	75	70
7	15	3200	46.9	80	75
8	15	3200	46.9	85	80
9	---	1000	10	50	50

11. MONITOR TEST STAND PERFORMANCE DURING BREAK-IN:

11.1. During Step 5, record the actual values of the controlled parameters in Table 4.

Table 4 - Record Break-In Step 5 Conditions

Parameter Name	Target Value	Actual Value
EngineSpeed	2400 RPM	**RPM**
PEXH	103.5±1.0 kPaa	**kPaa**
PAIRIN	0.07±0.03 kPag	**kPag**
TFUEL	24.0±3.0 °C	**°C**
TAIRIN	32.0±2.0 °C	**°C**

TOLGAL	70.0 °C	**°C**
TCLEO	65.0 °C	**°C**
TORQUE	46.9 N-m	**N-m**
FCLEO	80 LPM	**LPM**
FRAC	120 LPM	**LPM**

OPERATOR INITIALS:

11.2. During Step 8, record the actual values of the controlled parameters in Table 5.

Table 5 - Record Break-In Step 8 Conditions

Parameter Name	Target Value	Actual Value
EngineSpeed	3200 RPM	**RPM**
PEXH	103.5±1.0 kPaa	**kPaa**
PAIRIN	0.07±0.03 kPag	**kPag**
TFUEL	24.0±3.0 °C	**°C**
TAIRIN	32.0±2.0 °C	**°C**
TOLGAL	85.0 °C	**°C**
TCLEO	80.0 °C	**°C**
TORQUE	46.9 N-m	**N-m**
FCLEO	80 LPM	**LPM**
FRAC	120 LPM	**LPM**

OPERATOR INITIALS:

12.TAKE OIL SAMPLE AND MEAURE OIL LEVEL:

12.1. During Step 9, the engine will idle indefinitely at 1000RPM.

12.1.1. Once the **TOLGAL** and **TCLEO** parameters have reached their 50°C set points, take an 8-oz purge sample followed immediately by a 1-oz oil sample. **Complete:** ☐

12.2. Once the oil sample is taken, stop the engine. **Complete:** ☐

12.3. Disconnect the humidified air hose. **Complete:** ☐

12.4. Pour the 8-oz purge sample back into the engine. **Complete:** ☐

12.5. After the engine has sat for 10-minutes, measure and record the oil level by removing the dipstick from the rocker arm cover.

12.5.1. **NOTE:** Do not use the oil pan dipstick for these measurements.

12.5.2. Measure the length from the bottom of the dipstick to the top of the oil film in millimeters.

12.5.3. **ROCKER ARM COVER OIL LEVEL:** _____ **mm**

12.5.4. **OPERATOR INITIALS:** _____

12.5.5. **NOTE:** Use the dipstick measurement block for all oil level measurements (Figure 5):

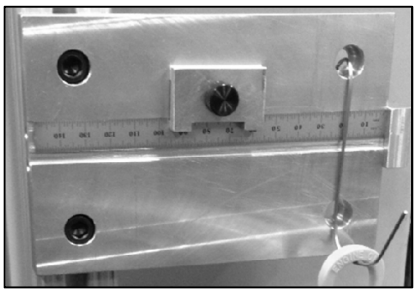


Figure 5 - Dipstick Measurement Block

13.LOAD THE AGING MACRO:

13.1. Reconnect the humidified air hose. **Complete:** ☐

13.2. Select the **Hold Sequencer** radial button on the **Sequencer** tab. **Complete:** ☐

13.3. Select the **bi-Aging** macro in the **Normal Pointers** pull-down menu of the **Sequencer** tab.

13.3.1. Press the **Load** button. **Complete:** ☐

13.4. Switch the **Dyno POT** and **Throttle POT** switches on the control panel to **POT**. **Complete:** ☐

13.5. Confirm that the **Dyno POT** knob is slightly above zero. **Complete:** ☐

13.6. Press the green **Reset** button and red **Dyno Reset** button on the control panel. **Complete:** ☐

13.7. Select the **Accessories** tab and click on all three check boxes, starting from the bottom. **Complete:** ☐

13.8. Press and hold the yellow **Crank** button until the engine turns over. **Complete:** ☐

13.9. Once the engine stabilizes, select the **Run Sequencer** radial button. **Complete:** ☐

13.9.1. Press the **Begin Aging** button.

13.10. **NOTE:** The aging cycle is 100-hours long and includes a sequence of four 25-hour cycles (the condition set for each cycle is shown in Table 6).

13.10.1. **NOTE:** The engine load set point for each condition set should be achieved within the first 45-seconds.

13.10.2. **NOTE:** The engine speed set point for each condition set should be achieved within the first 60-seconds.

Table 6 - Engine Aging Condition Set (Repeated 4 Times)

Aging Step No.	Duration (hour)	Engine Speed (RPM)	Engine Load (N-m)	Gallery Oil Temp (°C)	Coolant Out Temp (°C)
Aging	25	3000	50	90	88
Sampling	---	1000	10	90	90

14.AGING 0HR – 25HR:

14.1. Inspect the stand every 5-hours to confirm that there are no problems and record the inspection time in the log below (Table 7):

Table 7 – Stand Inspection Log for the 0Hr to 25Hr

Aging Time (Hr)	Time	Date	Operator Initials
05:00	**:**	**/ /**	
10:00	**:**	**/ /**	
15:00	**:**	**/ /**	

20:00	**:**	**/ /**	
25:00/Sampling	**:**	**/ /**	

14.2. After the 25-hour aging cycle is complete, the engine will idle indefinitely at 1000RPM.

14.2.1. Once the **TOLGAL, TCLEO** and **TORQUE** parameters have stabilized, take an 8-oz purge sample followed immediately by a 1-oz oil sample. **Complete:** ☐

14.2.2. Return the 8-oz purge sample to the engine while it is still running by utilizing the oil fill cap. **Complete:** ☐

14.3. Stop the engine. **Complete:** ☐

14.4. Disconnect the humidified air hose. **Complete:** ☐

14.5. After the engine has sat for 10-minutes, measure and record the oil level by removing the dipstick from the rocker arm cover. After the engine has sat for 10-minutes, measure and record the oil level by removing the dipstick from the rocker arm cover.

14.5.1. **NOTE:** Do not use the oil pan dipstick for these measurements.

14.5.2. Measure the length from the bottom of the dipstick to the top of the oil film in millimeters.

14.5.3. **ROCKER ARM COVER OIL LEVEL:** _____ **mm**

14.5.4. **OPERATOR INITIALS:** _____

14.6. Reconnect the humidified air hose. **Complete:** ☐

14.7. Restart the engine and press the **Resume Aging** button. **Complete:** ☐

15. AGING 26HR – 50HR:

15.1. Inspect the stand every 5-hours to confirm that there are no problems and record the inspection time in the log below (Table 8):

Table 8 – Stand Inspection Log for the 26Hr to 50Hr

Aging Time (Hr)	Time	Date	Operator Initials
30:00	**:**	**/ /**	
35:00	**:**	**/ /**	

40:00	**:**	**/ /**	
45:00	**:**	**/ /**	
50:00/Sampling	**:**	**/ /**	

15.2. After the 50-hour aging cycle is complete, the engine will idle indefinitely at 1000RPM.

15.2.1. Once the **TOLGAL, TCLEO** and **TORQUE** parameters have stabilized, take an 8-oz purge sample followed immediately by a 1-oz oil sample. **Complete:** ☐

15.2.2. Return the 8-oz purge sample to the engine while it is still running by utilizing the oil fill cap. **Complete:** ☐

15.3. Stop the engine. **Complete:** ☐

15.4. Disconnect the humidified air hose. **Complete:** ☐

15.5. After the engine has sat for 10-minutes, measure and record the oil level by removing the dipstick from the rocker arm cover.

15.5.1. **NOTE:** Do not use the oil pan dipstick for these measurements.

15.5.2. Measure the length from the bottom of the dipstick to the top of the oil film in millimeters.

15.5.3. **ROCKER ARM COVER OIL LEVEL:** _____ **mm**

15.5.4. **OPERATOR INITIALS:** _____

15.6. Reconnect the humidified air hose. **Complete:** ☐

15.7. Restart the engine and press the **Resume Aging** button. **Complete:** ☐

16. AGING 51HR – 75HR:

16.1. Inspect the stand every 5-hours to confirm that there are no problems and record the inspection time in the log below (Table 9):

Table 9 – Stand Inspection Log for the 51Hr to 75Hr

Aging Time (Hr)	Time	Date	Operator Initials
55:00	**:**	**/ /**	

60:00	**:**	**/ /**	
65:00	**:**	**/ /**	
70:00	**:**	**/ /**	
75:00/Sampling	**:**	**/ /**	

16.2. After the 75-hour aging cycle is complete, the engine will idle indefinitely at 1000RPM.

16.2.1. Once the **TOLGAL, TCLEO** and **TORQUE** parameters have stabilized, take an 8-oz purge sample followed immediately by a 1-oz oil sample. **Complete:** ☐

16.2.2. Return the 8-oz purge sample to the engine while it is still running by utilizing the oil fill cap. **Complete:** ☐

16.3. Stop the engine. **Complete:** ☐

16.4. Disconnect the humidified air hose. **Complete:** ☐

16.5. After the engine has sat for 10-minutes, measure and record the oil level by removing the dipstick from the rocker arm cover.

16.5.1. **NOTE:** Do not use the oil pan dipstick for these measurements.

16.5.2. Measure the length from the bottom of the dipstick to the top of the oil film in millimeters.

16.5.3. **ROCKER ARM COVER OIL LEVEL:** _____ **mm**

16.5.4. **OPERATOR INITIALS:** _____

16.6. Reconnect the humidified air hose. **Complete:** ☐

16.7. Restart the engine and press the **Resume Aging** button. **Complete:** ☐

17.AGING 76HR – 100HR:

17.1. Inspect the stand every 5-hours to confirm that there are no problems and record the inspection time in the log below (Table 10):

Table 10 – Stand Inspection Log for the 76Hr to 100Hr

Aging Time (Hr)	Time	Date	Operator Initials

80:00	**:**	**/ /**	
85:00	**:**	**/ /**	
90:00	**:**	**/ /**	
95:00	**:**	**/ /**	
100:00/Sampling	**:**	**/ /**	

17.2. After the 100-hour aging cycle is complete, the engine will idle indefinitely at 1000RPM.

17.2.1. Once the **TOLGAL, TCLEO** and **TORQUE** parameters have stabilized, take an 8-oz purge sample followed immediately by a 1-oz oil sample. **Complete:** ☐

17.2.2. Return the 8-oz purge sample to the engine while it is still running by utilizing the oil fill cap. **Complete:** ☐

17.3. Stop the engine. **Complete:** ☐

17.4. Disconnect the humidified air hose. **Complete:** ☐

17.5. After the engine has sat for 10-minutes, measure and record the oil level by removing the dipstick from the rocker arm cover.

17.5.1. **NOTE:** Do not use the oil pan dipstick for these measurements.

17.5.2. Measure the length from the bottom of the dipstick to the top of the oil film in millimeters.

17.5.3. **ROCKER ARM COVER OIL LEVEL:** _____ **mm**

17.5.4. **OPERATOR INITIALS:** _____

17.6. Secure the engine and drain the oil charge. **Complete:** ☐

17.7. Unplug the PCM. **Complete:** ☐

17.8. Disconnect the humidified air hose. **Complete:** ☐

17.9. Remove the rocker arm cover and measure the clearances between the lifters and camshaft lobes (Table 11). **Complete:** ☐

Table 11 - End of Test (E.O.T.) Lifter Clearances

Intake Side of Engine								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Grade								
Clearance (in)								
Exhaust Side of Engine								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Grade								
Clearance (in)								

OPERATOR INITIALS:

DATE:

18.REMOVE ORIGINAL CAMSHAFTS, LIFTERS AND INTAKE VALVE SPRINGS:

18.1. **NOTE:** Please contact the test engineer or facilitator to determine if the steps outlined in this section should be completed or skipped.

18.2. **NOTE:** Consult the *Sequence IVB Assembly Manual* as needed for specific instructions regarding the removal of test hardware.

18.3. Remove the intake and exhaust camshafts.

18.3.1. Discard the intake camshaft. **Complete:** ☐

18.3.2. Lightly lubricate the exhaust camshaft with utility oil or EF-411, wrap it in desiccant paper, and place it in one of the empty test kit trays in the black cabinet. **Complete:** ☐

18.4. Remove all (16) intake and exhaust bucket lifters.

18.4.1. Lightly lubricate these lifters with utility oil or EF-411 and place them in a blister carton with a sheet of desiccant paper (as shown in Figure 6). **Complete:** ☐

18.4.2. Place the carton in the black cabinet.
18.4.3. **NOTE:** Extra cartons are available in the Metrology lab.

Figure 6 - Blister Carton for Spare Lifters

18.5. Remove and discard the original intake valve springs. **Complete:** ☐

18.6. Install the test-specific high-load intake valve springs (OHTIVB-30034-1). **Complete:** ☐

Intertek

Break-in and Aging Lab Instructions

Sequence IVB Break-in/Aging Instructions

Test Number: IVB101-AGE-33 Oil Code: EG-0024/CMIR-118690

Pre-test Instructions	**Initials**
1) Verify that all work has been completed for the installation of engine/head **E0016/H0034**.	
1) Verify that all of the driveline bolts are tight and that the driveshaft has been lubricated, before starting Break-in.	
2) Verify that the external oil system has been cleaned before starting Break-in.	
3) Verify that the load calibration has been conducted before starting Break-in.	
4) Initilize a new test in LabVIEW. Click the **Test Initialization Screen** button on the Main Menu, enter the new test number in the Slot Number box, click the **INIT** button and click "Yes".	
5) Obtain and label the oil sample jars for the entire test.	
6) Drain all pressure traps and clean the dynamometer coolant strainer.	
7) Check the test screen for any unusual readings while the engine is down. Make repairs or have the instrumentation group recalibrate if necessary.	
8) Check the test scheduling for instructions on which test fuel/fuel tank/fuel line to run this test on. Verify that the test stand is connected to the correct fuel line at the Toyota patch panel and make changes if necessary. ***Please record the test fuel, fuel tank and fuel line in the space provided below.***	

Test Fuel _____

Fuel Tank _____

Fuel Line _____

NOTE: 5 HOUR OIL SAMPLING AND LEVEL DURING AGING FOR THIS TEST.

IVB BREAK-IN & AGING

Please follow attached instructions. Break-in will run the 9 steps, which is 1 hour and 35 minutes in duration. At the conclusion of break-in, leak down and compression will need to be done. When purging oil on step 9 and every 5 hours during aging, make sure the engine is at 1000 rpm, open the purge valve only half way to keep the engine from shutting down**. "Watch the oil pressure Gauge".** Obtain an 8oz purge each time then a 3ml sample each time. After the 3ml sample is obtained wait for engine to shut down on its own, then return the purge into the engine. Be sure to secure oil cap. Wait 10 minutes after sample has been returned then take a dip and record level as stated below. Please scan in samples promptly after obtaining. **Before starting check Engine Coolant and make sure rocker cover pump and coolant heater are off in the rear control box.**

TEST: IVB101-AGE-33

Cylinder #	Leak Down % At Start of Aging	Leak Down % At End of Aging	Compression At Start of Aging	Compression At End of Aging
1				
2				
3				
4				

TEST HOUR	TIME	DATE	DIP (Stock Dipstick)	DIP (OHT Dipstick)	Initial oil samples
BRK-IN					
5					
10					
15					
20					
25					
30					
35					
40					
45					
50					

When taking dips just indicate ¼, ½, ¾, or full.
If you have any questions please call me
Carlton Coker (210) 643-1817
PLEASE WRITE ANY NOTES BELOW:

IVB break in and aging oil sampling

The engine will come down to idle (every 5 hours per the step timer)

Take an 8 ounce purge then take the 3ml sample from the sample valve. Use the hose guide to ensure you are only taking 3ml.

The engine will then shut down for the oil level.

As soon as the engine shuts down turn “off” the stand starter switch and fuel “cut off” valve at the rail. Only on stand 165 turn off the combustion air using the intake air.

Remove the oil fill cap on the valve cover then return the purge to the engine.

Replace the oil fill cap and ensure the crankcase pressure line is connected to the Quick connect.

Wait 10 minutes and perform the oil level using the red dipstick and then stock dipstick.

Remove the red plug on the oil pan which is located below the intake manifold.

The red dipstick has a white line that needs to be “up” during the dip. Slowly insert the dipstick to help get a more accurate reading.

Record the measurement in the test packet.

Inspect the O-rings on the red plug (replace if necessary). Then reinstall the red plug.

Dip the engine using the stock dipstick. Record the measurement in the test packet.

Turn on the fuel valve at the rail and turn on the stand starter cut off switch.

When the program is ready, Go to the Test initialization screen and ensure the “Run aging” button is selected. Then return to the Test screen and start the stand.

Deliver the 3ml sample to the Chem lab

1. Configure the engine for run-in and silicone pacification as follows.
   1.1. First run engines have the correct engine break-in valve train components pre-installed. Install the components listed in Annex # ____ and in the engine assembly manual sections _____.
   1.2. If not a first run engine, then install stock intake camshaft, stock exhaust camshaft, and stock bucket lifters that have been designated for break-in use by the laboratory. Install the components listed in Annex # _____ and in the engine assembly manual sections _____

   Note: Pre-test measurements are not required on valve train components used for engine break-in purposes.

2. Configure the engine with stock valve train cover and active positive crankcase ventilation. Ensure the following connections are made. Affix all ends of hoses with hose clamps.
   2.1. Refer to Figure 1. Connect the stock PCV valve (A) to port (C) on the intake manifold (E) with the 19 mm diameter hose (B). This is the OEM supplied PCV hose.
   2.2. Refer to Figure 2. Connect the port (A) on the valve train cover to port (B) on the intake air filter housing with the 15.8 mm diameter Tygon hose (C).
   2.3. Refer to Figure 3. Connect the 8 mm steel-braided hose (B) to the quick-disconnect (A) on the modified oil fill cap.

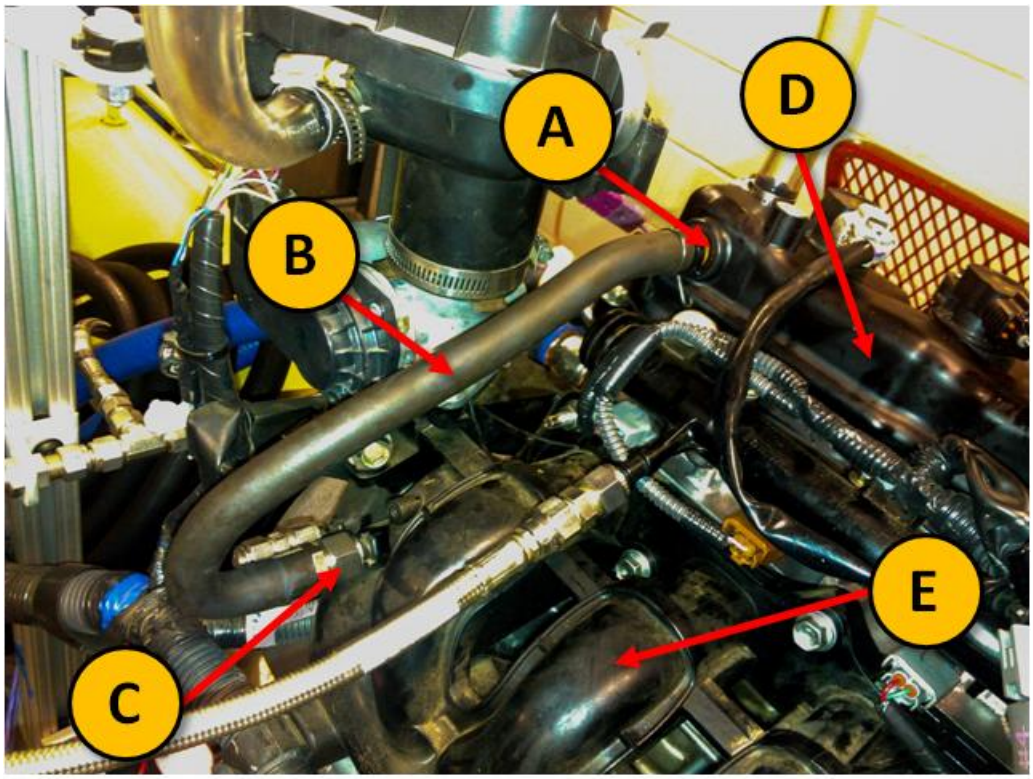


Figure 1: Routing of crankcase gases. (A) stock PCV valve, (B) 19 mm diameter hose, (C) hose adapter to intake manifold, (D) stock valve train cover, (E) intake manifold. The 19 mm diameter hose is the OEM provided crankcase ventilation hose which is installed on new engines.

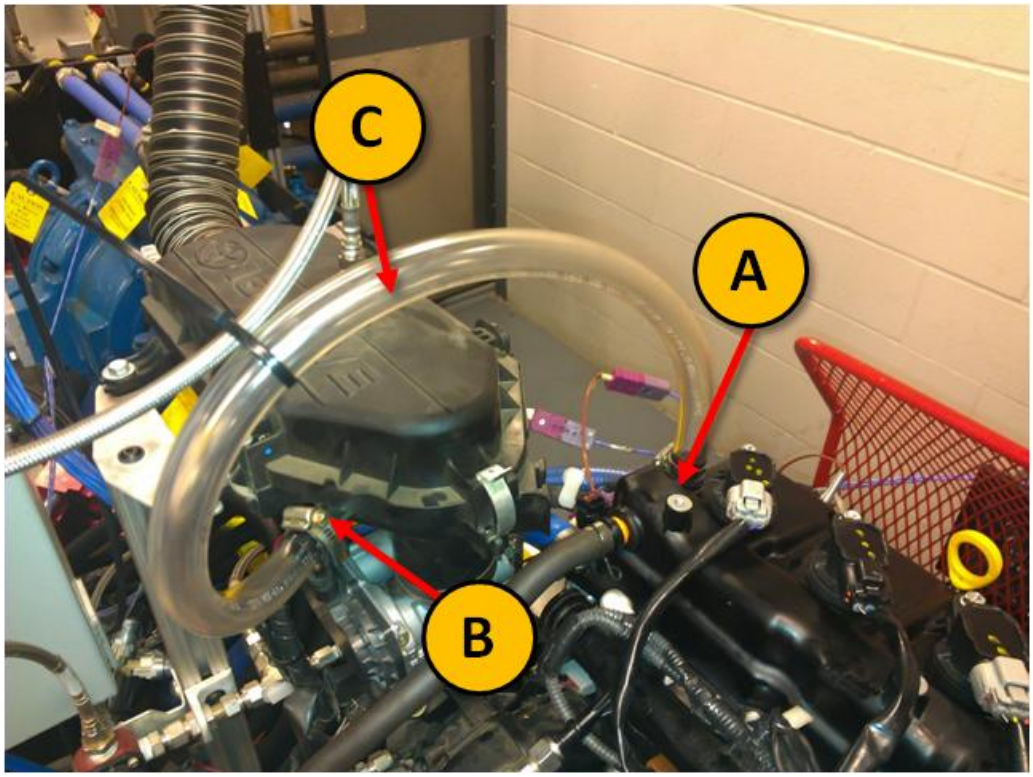


Figure 2: Routing of fresh air. (A) Port to valve train cover, (B) port from intake air filter housing, (C) 15 mm diameter Tygon hose

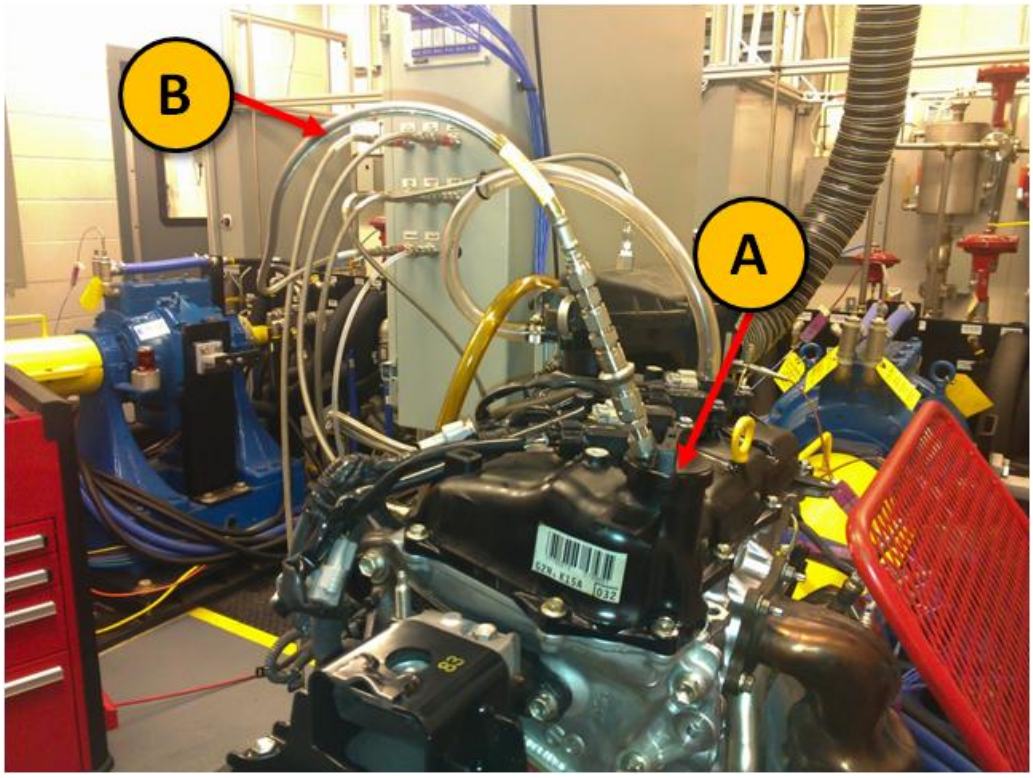


Figure 3: Crankcase pressure measurement point. (A) Oil fill cap modified with 5 mm diameter quick disconnect, (B) 8 mm diameter steel-braided hose to pressure transducer

3. Conduct the following external oil flush procedure.
   3.1. Refer to Figure 4. Disconnect the supply and return lines from the remote oil filter housing adapter that is mounted on the engine.

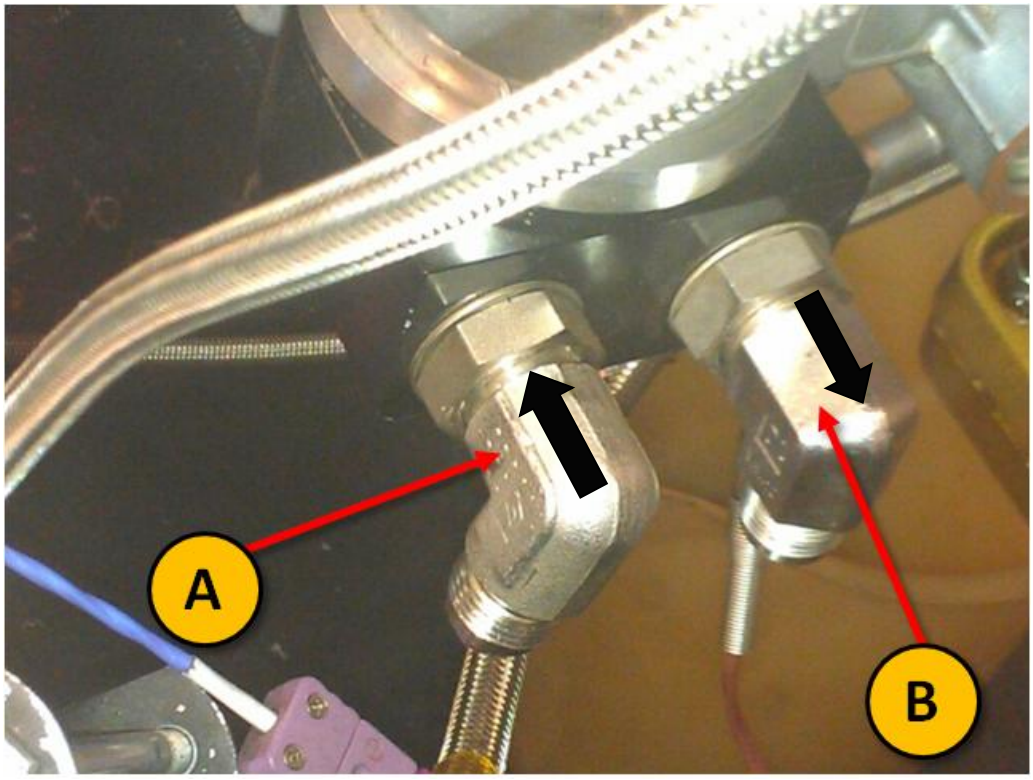


Figure 4: Engine-mounted oil filter housing adapter line connections.
(A) is return from oil cooler and (B) is supply to oil filter

   3.2. Connect the supply and return lines to a portable oil cleaning flush cart of minimum 3.8 L capacity that is equipped with a circulation pump. Charge the flush cart with mineral spirits meeting the requirements of Specification D235, Type II, Class C for Aromatic Content (0 to 2 vol)%, Flash Point (61 °C, min) and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale). Energize the flush cart pump and allow the mineral spirits to circulate for one (1) hour.
   3.3. At the end of one (1) hour, de-energize the flush cart pump. Open both engine oil heat exchanger drain valves (see Figure 5). Disconnect the supply and return lines from the flush cart.

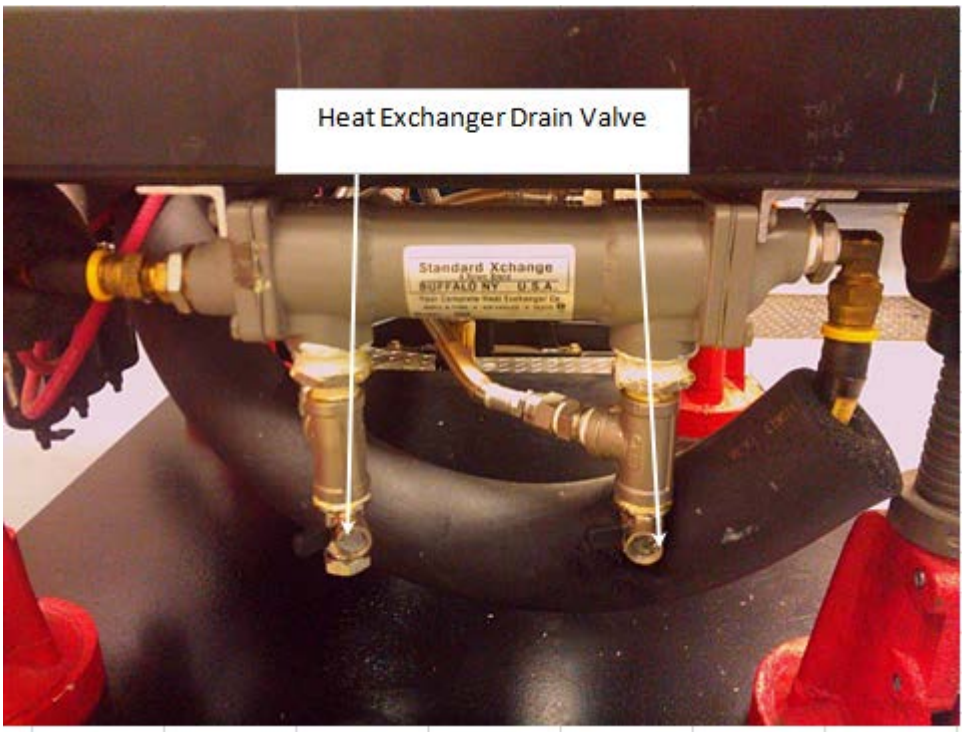


Figure 5: Engine Oil Heat Exchanger Drain Valve Locations

3.4. When the heat exchanger has completed draining, leave the heat exchanger drain valves open and connect both the supply and return lines to a clean, dry compressed air supply at 140 kPa. Allow compressed air to flow through the system for 15 minutes to dry the system.
3.5. Disconnect the supply and return lines from the compressed air source.
3.6. Connect the supply and return lines back to the engine-mounted oil filter housing adapter.
3.7. Close the heat exchanger drain valves, and remove the Oberg oil filter element for cleaning. Clear any debris retained in the Oberg oil filter element with mineral spirits and air dry. Re-install the Oberg oil filter element in the Oberg filter housing and secure the four retaining bolts.

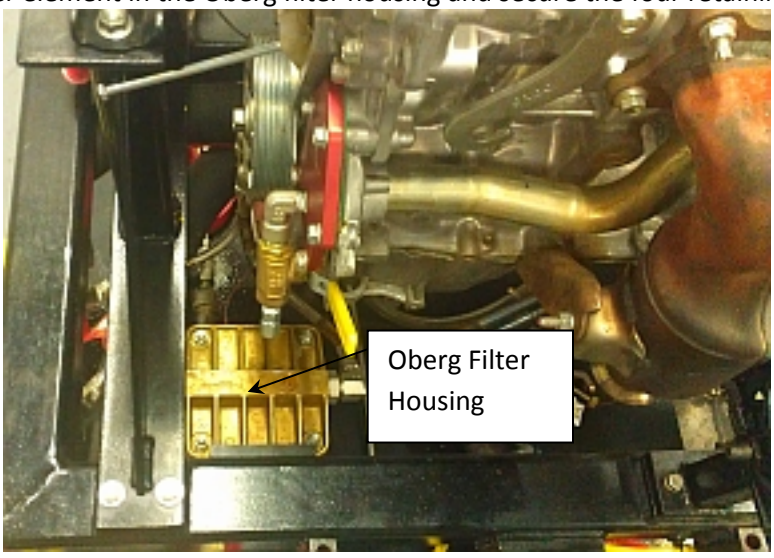


Figure 6: Oberg Filter Location

3.8. Dispose of the used mineral spirits following test laboratory practice.

4. Fill the engine with 3.0 L of break-in oil. The break-in oil is ASTM TMC reference oil 1006-2.

5. Fill the engine coolant system and the rocker cover coolant system with a 70/30 mixture of de-ionized or distilled water and Havoline Extended Life DEX-COOL® concentrated anti-freeze. Approximately 45 L of the 70/30 mixture is required to fill both systems.

6. With coolant flow control flow valve 50% open and the coolant system pressurized at 70 kPa, energize the engine coolant pump and allow the engine coolant to circulate for 5 minutes to remove air from the engine coolant system.

7. Using the coolant heater, gradually increase the coolant temperature to 50 °C over 15 minutes.

8. Soak the coolant temperature at 50 °C for 30 minutes.

9. With the dynamometer load control set point at 0 N·m and the throttle control set point at 10% , start the engine. As soon as the engine achieves 500 r/min increase the throttle control set point to 800 r/min while continuing to hold the dynamometer load control set point at 0 N·m.

10. When the engine achieves 800 r/min begin the engine break-in schedule provided in table 1.

Table 1 Engine Break-in Schedule

Break-in Step no.	Duration min	Engine Speed r/min	Engine Load N·m	Gallery Oil Temperature °C	Coolant Out Temperature °C
1	10	800	6.3	50	50
2	10	1600	6.3	55	50
3	10	2000	25.0	60	55
4	10	2400	25.0	65	60
5	10	2400	46.9	70	65
6	15	2800	46.9	75	70
7	15	3200	46.9	80	75
8	15	3200	46.9	85	80

10.1. The duration for each step includes the time to transition between set points. Engine load should achieve specified value within 45 seconds, and engine speed should achieve specified value within 60 seconds.

10.2. The following parameters should be controlled to the specified set points for all break-in steps:

- Fuel rail temperature 24 ± 3 ° C
- Coolant FLOW RATE 80 ± 1 lpm
- Exhaust back pressure 103.5 ± 1.0 kPaA
- Intake air pressure 0.25 ± 0.03 kPa
- Intake air temperature 32 ± 2 ° C
- Load cell temperature 45 ± 2 ° C

10.3. Following the completion of engine break-in step 8, establish the following oil sampling conditions.

Table 2 Oil Sampling Conditions

Oil Sampling Conditions	Duration min	Engine Speed r/min	Engine Load N·m	Gallery Oil Temperature °C	Coolant Out Temperature °C
	---	1000	10.0	50	50

10.4. When oil temperature has been reduced to 50°C, take a 240 mL purge sample immediately followed by a 30 mL oil sample. Conduct ASTM D5185 Metals by ICP on the oil sample. If the sample cannot be obtained within 10 minutes after achieving the 50 °C oil temperature stop the engine as excessive idling time can be detrimental to engine run-in.

11. When the oil sample has been obtained in step 10.4, stop the engine. Disconnect the conditioned intake air supply. Return the purge sample to the engine via the factory oil fill cap. Allow the engine to rest for ten minutes. Following the ten minute rest period, measure and record the oil level by removing the dipstick and measuring from the bottom of the dipstick to the top of the oil film. Record the length of the oil film in millimeters. Do not top off the oil level.

Figure 7: Engine Oil Level Measurement

12. Start the engine, and continue to run the engine at the following conditions for engine aging:

Table 3 Engine Aging Conditions

Aging Step no.	Duration (hrs)	Engine Speed r/min	Engine Load N·m	Gallery Oil Temp ° C	Coolant Out Temp ° C
Aging	50	3000	50	80	88
Sampling	---	1000	10	80	80

12.1. The duration for each step includes the time to transition between set points. Engine load should achieve specified value in 45 seconds, and engine speed should achieve specified value in 60 seconds.

12.2. After every 5 hours of aging, bring the engine down to the oil sampling conditions. If the sample cannot be obtained within 10 minutes after achieving the 50 °C oil temperature stop the engine as excessive idling time can be detrimental to engine run-in.

12.3. Take a 240 mL purge sample immediately followed by a 3 mL oil sample. Return the purge sample to the engine via the factory oil fill cap. Conduct ASTM D5185 Metals by ICP on the oil sample.

12.4. Stop the engine and allow the engine to rest for ten minutes. Measure and record the oil level by removing the dipstick and measuring from the bottom of the dipstick to the top of the oil film. Record the length of the oil film in millimeters. Do not top off the oil level.

12.5. Repeat steps 12 through 12.5 nine additional times for a total aging time of fifty (50) hours.

12.6. Drain oil charge after the aging runs have completed.

13. Examine the results of the ASTM D5185 for high wear anomalies using Fe, Cu, and Al and to ensure the Si levels have plateaued. Also examine values of K as an indicator of coolant leaks. K values exceeding 15 ppm are suspicious and the engine should be evaluated for an internal coolant leak. If an internal coolant leak is confirmed, make repairs and repeat the run-in and aging procedure. Note – the example graph below is that of a new engine. Used engines with fresh cylinder heads will provide lower results.

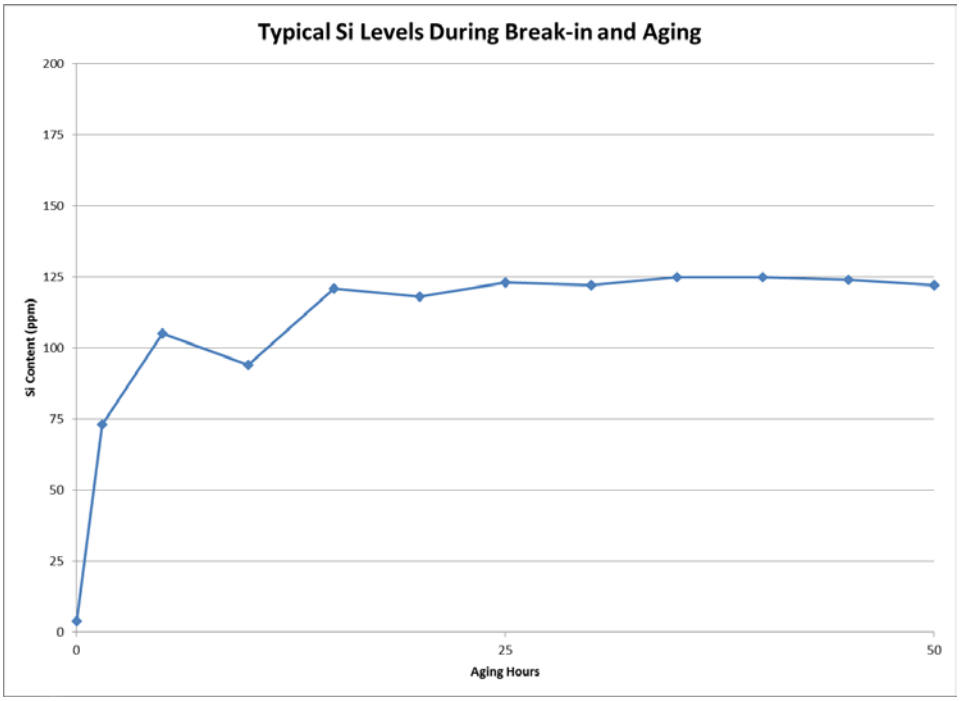


Figure 8: Example of Si Plateau (New Engine)

14. This completed the run-in and conditioning procedure.

Downtime Record

Sequence IVB

Test Number: IVB101-AGE-33

Oil Code: EG-0024/CMIR-118690

Unscheduled Shutdown	Stand Maintenance	Part Replacement	Operator	Date	Stage	Cycle	Test Time	Problem Statement/Action Taken/Comments	Shutdown Time	On-Test Time	Down Time
									IF SHUTDOWN		

If an extended shutdown, please Switch off the circuit breaker to the coolant heater and the pressurized air valve to the coolant system pressure regulator.

Down Time (hrs:min) = On-Test Time (hrs:min) - Shutdown Time (hrs:min)

Downtime Record

Sequence IVB

Test Number: IVB101-AGE-33

Oil Code: EG-0024/CMIR-118690

Unscheduled Shutdown	Stand Maintenance	Part Replacement	Operator	Date	Stage	Cycle	Test Time	Problem Statement/Action Taken/Comments	Shutdown Time	On-Test Time	Down Time
									IF SHUTDOWN		

If an extended shutdown, please Switch off the circuit breaker to the coolant heater and the pressurized air valve to the coolant system pressure regulator.

Down Time (hrs:min) = On-Test Time (hrs:min) - Shutdown Time (hrs:min)

Sequence IVB Oil Samples

Test Hour	Oil Sample Size	Oil Sample Jar
BREAK-IN: STEP 9	**1 ounce**	
AGING: 5	**3 ml** (fill to mark on bottle)	
AGING: 10	**3 ml** (fill to mark on bottle)	
AGING: 15	**3 ml** (fill to mark on bottle)	
AGING: 20	**3 ml** (fill to mark on bottle)	
AGING: 25	**3 ml** (fill to mark on bottle)	
AGING: 30	**3 ml** (fill to mark on bottle)	
AGING: 35	**3 ml** (fill to mark on bottle)	
AGING: 40	**3 ml** (fill to mark on bottle)	
AGING: 45	**3 ml** (fill to mark on bottle)	
AGING: 50	**3 ml** (fill to mark on bottle)	

Sequence IVB Aging Specifications

Stage	AGING
Time, hours	50
Controlled Parameters	
Dyno_Speed	3000 ± 25
Eng Load	50 ± 2
Oil Gallery T	80 ± 1
Load Cell T	45 ± 3
Eng Coolant In T	88 ± 1
Coolant Flow	80 ± 1
Inlet (Intake) Air T	32 ± 1
Fuel T	24 ± 1
Exh Gas Pr	103.5 ± 1
Inlet (Intake) Air Pr	0.25 ± 0.10
Humidity	11.5 ± 0.5
Uncontrolled Parameters (Typical Ranges)	
Eng Coolant Pr	70 ± 10
Fuel Pr	335 ± 10
Oil Gallery Pr	275 ± 25
Fuel Flow	4.5 ± 1.0
Air Fuel Ratio	14.5 ± 0.5

PLEASE CHECK AND DRAIN CONDENSATION TRAPS OCCASIONALLY

(Revision 3 (20170202)

Sequence IVB Stand Maintenance

Test Number: IVB101-AGE-33

Post-test Stand Maintenance

This stand maintenance checklist should stay at the test stand after the current test completes and then be added to the paperwork of the next test that runs on this test stand.

Load Calibration	Initials	Date
1) Submit a work request for the load calibration. **(Engineering Aid)**		
2) Perform the load calibration. **(Instrument Shop)**		
3) Verify that the load calibration has been completed. **(Lab Mechanic)**		
Driveline Inspection and Maintenance Procedure		
4) Remove driveshaft cover, inspect, and tighten if necessary, all driveline bolts. **Make sure that the engine does not rotate when tightening the driveline bolts, so that the camshafts do not jump time.**		
5) Inspect and lubricate driveshaft at all points, then reinstall driveshaft cover.		
External Oil System Cleaning Procedure		
6) Disconnect the supply and return lines from the remote oil filter housing adapter that is mounted on the engine.		
7) Connect the supply and return lines to a portable oil cleaning flush cart of minimum 1 gallon capacity that is equipped with a circulation pump. Charge the flush cart with Stoddard solvent (mineral spirits meeting the requirements of Specification D235, Type II, Class C for Aromatic Content ((0 to 2) vol %), Flash Point (61°C, min) and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale)).		
8) Energize the flush cart pump and allow the Stoddard solvent to circulate for one hour.		
9) At the end of one hour, de-energize the flush cart pump and open both heat exchanger drain valves. Then disconnect the supply and return lines from the flush cart.		

Test Number: IVB101-AGE-33

Post-test Stand Maintenance Cont'd

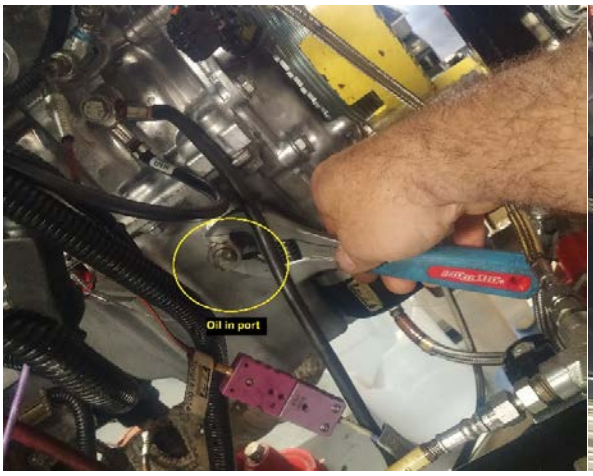
External Oil System Cleaning Procedure Cont'd	Initials	Date
10) When the heat exchanger has completed draining, leave the heat exchanger drain valves open and connect both the supply and return lines to a clean dry compressed air supply at 20 psi. Allow compressed air to flow through the system for 15 minutes to dry the system.		
11) Disconnect the supply and return lines from the compressed air source.		
12) Connect the supply and return lines back to the remote oil filter housing adapter that is mounted on the engine.		
13) Close the heat exchanger drain valves and remove the Oberg oil filter element for cleaning. Clear any debris retained in the Oberg oil filter element with Stoddard solvent and air dry. Re-install the Oberg oil filter element in the Oberg filter housing and secure the four retaining bolts.		
14) Dispose of the used Stoddard solvent following test laboratory practice.		
15) Disconnect the oil pressure sense line from the engine and from the oil sample valve. Rinse this line using Stoddard solvent and then air dry.		
16) Disconnect the oil pressure sense line from the oil sample valve and the oil pressure transducer. Rinse this line using Stoddard solvent. Then air dry.		
17) Open the oil sample valve and allow any trapped oil to drain. Then close the valve and reconnect both oil pressure/sample lines to their respective locations.		
Oil Pan Flush		
18) Ensure the oil drain has been completed.		
19) Ensure the flush bucket is clean.		
20) Pour 1 gallon of EF411 into bucket and install lid with pump assembly.		
21) Remove rear oil pan drain plug.		
22) Install the 3' x ¾" clear Tygon hose to the rear drain plug boss and tighten the hose clamp and install in filler neck on bucket lid.		

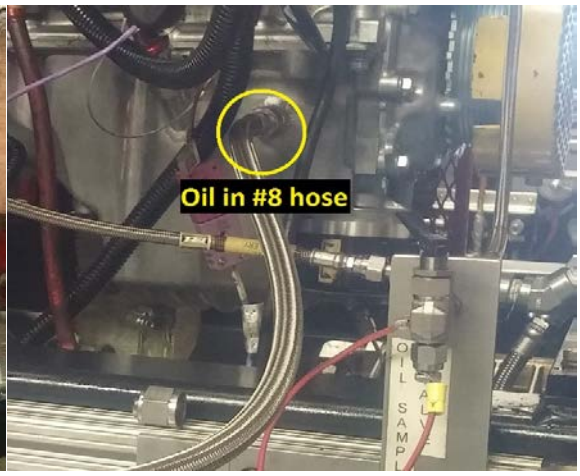
Test Number: IVB101-AGE-33

Post-test Stand Maintenance Cont'd

Oil Pan Flush Cont'd	Initials	Date

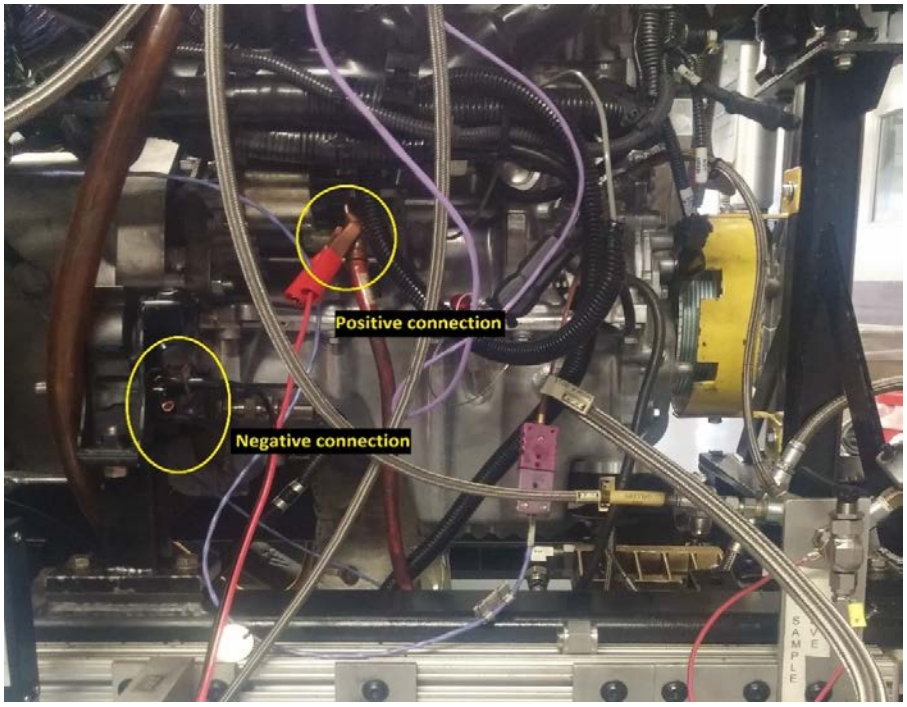
23) Remove the flush port cap then Install the #8 hose to the flush port on the side of the oil pan.





24) Connect the (Black) negative clamp to a suitable ground.

25) Connect the (Red) positive clamp to the starter wire.



26) Let pump run for 10 minutes.

Test Number: IVB101-AGE-33

Post-test Stand Maintenance Cont'd

Oil Pan Flush Cont'd	Initials	Date
27) Disconnect positive and negative clamps.		
28) Let oil pan drain for 5 minutes.		
29) Disconnect the #8 hose from the oil pan and reinstall the #8 cap.		
30) Remove the Tygon hose from the oil pan and reinstall the rear oil drain plug.		
31) Properly dispose of the EF411 and oil filter.		
32) Solvent wash the bucket and lid. Place on the cart in the lower IVB area.		

Sequence IVB Hourly Operational Checklist

Test Number: IVB101-AGE-33 Oil Code: EG-0024/CMIR-118690

Test Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Coolant Delta T & Eng Coolant Pr																				
Rocker Cover Coolant Out T																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling			**3 ml =**					**3 ml =**					**3 ml =**					**3 ml =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB101-AGE-33 Oil Code: EG-0024/CMIR-118690

Test Hour	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Coolant Delta T & Eng Coolant Pr																				
Rocker Cover Coolant Out T																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling			**3 ml =**					**3 ml =**					**3 ml =**					**3 ml =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB101-AGE-33

Oil Code: EG-0024/CMIR-118690

Test Hour	41	42	43	44	45	46	47	48	49	50
Operator Initials										
Time of Day, hr:min										
Scan the LabVIEW Test Screen										
Check for Alarms										
Check that the Following are Within Specification										
Dyno_Speed & Eng Load										
Oil Gallery T										
Eng Coolant In T, Coolant Delta T & Eng Coolant Pr										
Rocker Cover Coolant Out T										
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity										
Fuel T & Fuel Pr										
Exh Gas Pr										
Check that the Following are **Green**										
DAQ Enabled										
Visual Inspection of Test Stand										
Check for Oil Leaks										
Check for Coolant Leaks										
Check for Fuel Leaks										
Check for Process & Chilled Water Leaks										
Check for Exhaust System Leaks										
Check Dynamometer Oil Level (Add Oil if Low)										
Check Fuel Pressure at Fluid Rack & at Engine										
Check for Unusual Vibration & Noises										
Oil Sampling			**3 ml =**					**3 ml =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

SwRI

Break-in and Aging Lab Instructions

Section E

Engine Operation Procedure

NOTE: Changes from the original to finalized test configuration are documented in the included lab instructions.

Engine Coolant Charge Procedure

The following engine coolant charge procedure must be followed in the following circumstances:

- Engine replacement
- Cylinder head replacement
- Coolant system is serviced (i.e. pump replacement)
- Golden Stand is used for the first time

Warning: Do not activate the engine coolant heater at any time during this procedure.

1. Ensure that the engine coolant system pressure has been reduced to zero and then remove the pressure cap from the engine coolant reservoir. Verify all drains are closed and hoses are connected.
2. Set the engine coolant flow control valve to the fully-open position.
3. Prepare a mixture of 30% Havoline Extended Life Dex-Cool coolant and 70% de-ionized or distilled water (see Figure 1). Approximately 46 liters of coolant solution is required to fill an empty system.

Figure 1. Havoline Extended Life Dex-Cool Coolant

4. Fill the system to within 50 mm of the top of the vertical level indicator located on the side of the main coolant reservoir. The coolant system may be charged by either by filling the system from the top or by forced charging from the bottom drain of the heat exchanger.

5. Secure the engine coolant pressure cap, and adjust supplemental engine coolant system pressure to 70 kPa.
6. Turn on the coolant pump, and allow the coolant to circulate for one hour.
7. At the end of one hour, turn off the coolant pump. Reduce the coolant pressure to zero.
8. Remove engine coolant reservoir pressure cap, and top off coolant if necessary to fill within 50 mm from the top of the vertical level indicator located on the side of the main coolant reservoir.
9. Secure the engine coolant reservoir pressure cap. Pressurize engine coolant to 70 kPa.

Valve Cover Coolant Charge Procedure

The following valve cover coolant charge procedure must be followed in the following circumstances:

- Engine replacement
- Cylinder head replacement
- Coolant system is serviced (i.e. pump replacement)
- Golden Stand is used for the first time

1. Verify all drains are closed and hoses connected.

Note: The valve cover coolant system does not have supplemental pressure applied.

2. Remove the pressure cap from the valve cover coolant reservoir.
3. Prepare a mixture of 30% Havoline Extended Life Dex-Cool coolant and 70% de-ionized or distilled water. Approximately 23 liters of coolant solution is required to fill an empty system.
4. Fill the system to within 50 mm of the top of the vertical level indicator located on the side of the main coolant reservoir. Then secure the coolant pressure cap. The coolant system may be charged by either by filling the system from the top or by forced charging from the bottom drain of the heat exchanger.
5. Turn on the coolant pump and allow the coolant to circulate for one hour.
6. At the end of one hour, turn off the coolant pump and then reduce the engine coolant pressure to zero.
7. Remove valve cover coolant reservoir pressure cap, and top off coolant if necessary to achieve the desired level of 50 mm from the top of the vertical level indicator located on the side of the main coolant reservoir.
8. Secure the valve cover coolant reservoir pressure cap.

Fuel Supply Procedure

The Sequence IVB test uses HF-0008 KA24E Green Fuel as test fuel. Approximately 750 liters are required for a test. The fuel supply pressure from the test laboratory bulk fuel supply must be a minimum of 124 kPa (18 psi) at the fuel inlet connection to the Golden Stand Fluid Conditioning Module. The following procedure must be conducted prior to the first use of the Golden Stand Fluid Conditioning Module, or any time that the fuel system is serviced.

1. Ensure all fuel lines, thermocouple ports, and fuel pressure ports are connected and secured prior to connecting the Golden Stand Fluid Condition Module to the test laboratory bulk fuel supply.
2. Refer to Figure 2. Disconnect injector rail main fuel supply line. Connect the injector rail main fuel supply line directly to the test laboratory approved fuel purge container (not provided with Golden Stand).

3. Refer to Figure 3. Open fuel manual shutoff valves.

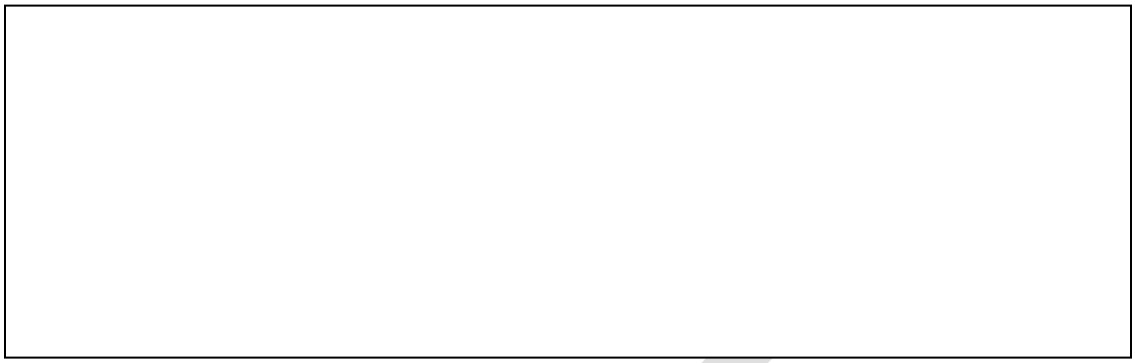


Figure 2. Injector Rail Main Fuel Supply and Purge Container

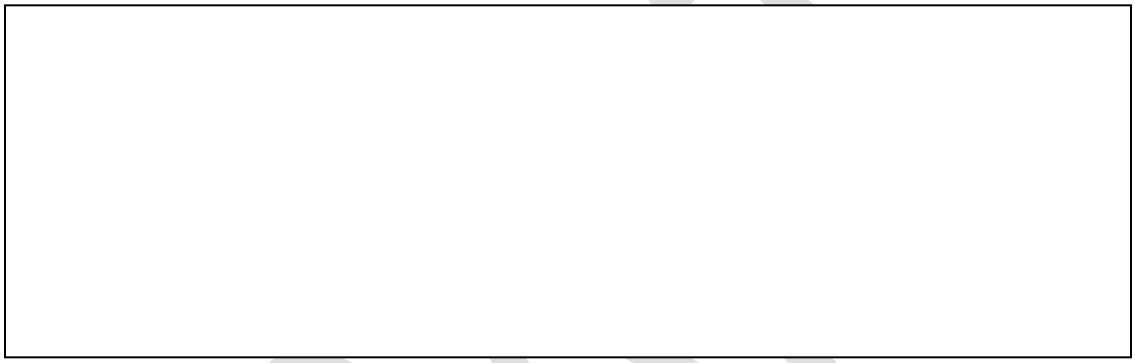


Figure 3. Manual Fuel Shutoff Valves

4. Energize electric fuel solenoid shutoff valve and electric fuel pump.
5. Purge 75 liters of fuel through the system while observing test stand for leaks.
6. De-energize electric fuel solenoid shutoff valve and electric fuel pump.
7. Disconnect the injector rail main fuel supply line from the fuel purge container and connect the injector rail main fuel supply line to the fuel injector rail fuel input.
8. Dispose of the fuel purge following test laboratory procedure for purged fuel disposal.

Engine Oil Flush Preparation Procedure

1. Refer to Figure 4. Disconnect the supply and return lines from the remote oil filter housing adapter that is mounted on the engine.

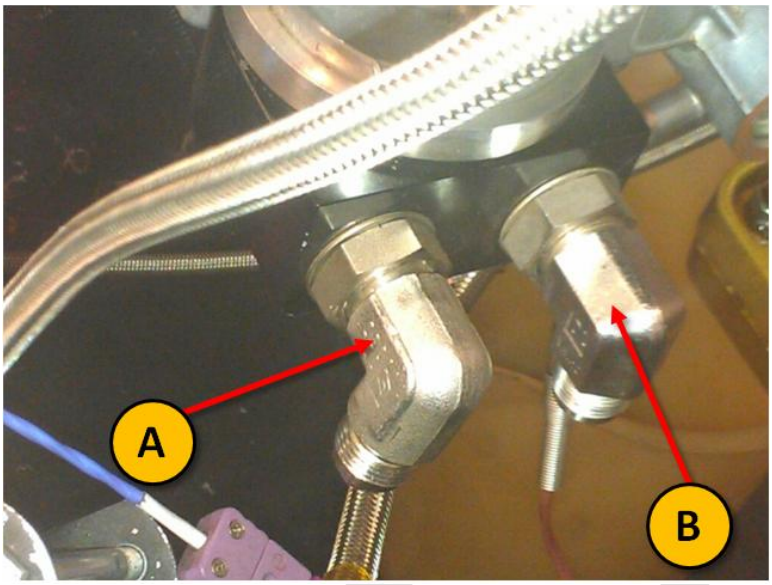


Figure 4. Engine-mounted oil filter housing adapter return to engine (A) and supply to oil filter (B) line connections

2. Connect the supply and return lines to a portable oil cleaning flush cart of minimum 4 liters capacity that is equipped with a circulation pump. Charge the flush cart with mineral spirits meeting the requirements of Specification D235, Type II, Class C for Aromatic Content (0 to 2 vol%), Flash Point (61°C, min.) and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale).
3. Energize the flush cart pump and allow the mineral spirits to circulate for one hour.
   Refer to Figure 5. At the end of one hour, de-energize the flush cart pump, and open both heat exchanger drain valves to allow mineral spirits to drain out from the heat exchanger.

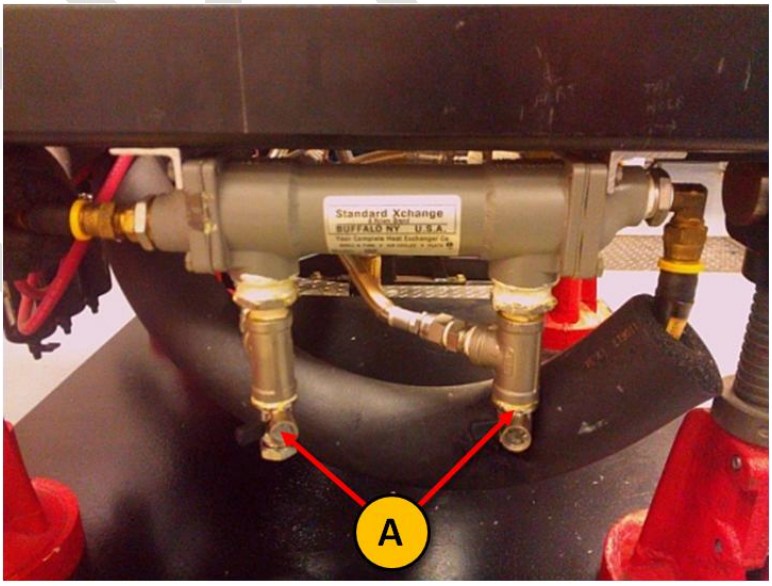


Figure 5. Oil heat exchanger drain valves (A)

4. Disconnect the supply and return lines from the flush cart.

5. When the heat exchanger has completed draining, leave the heat exchanger drain valves open, and connect both the supply and return lines to a clean, dry compressed air supply at 138 kPa. Allow compressed air to flow through the system for 15 minutes to dry the system.
6. Disconnect the supply and return lines from the compressed air source.
7. Connect the supply (A or B) and return (A or B) lines back to the remote oil filter housing adapter that is mounted on the engine (see Figure 6). Close the heat exchanger drain valves.
8. Refer to Figure 6. Remove the Oberg oil filter element (OHT p/n OHT6A-013-2, 28 MICRON) for cleaning. Clear any debris retained in the Oberg oil filter element with mineral spirits and air dry. Re-install the Oberg oil filter element in the Oberg filter housing and secure the four retaining bolts.
9. Dispose of the used mineral spirits following test laboratory practice.

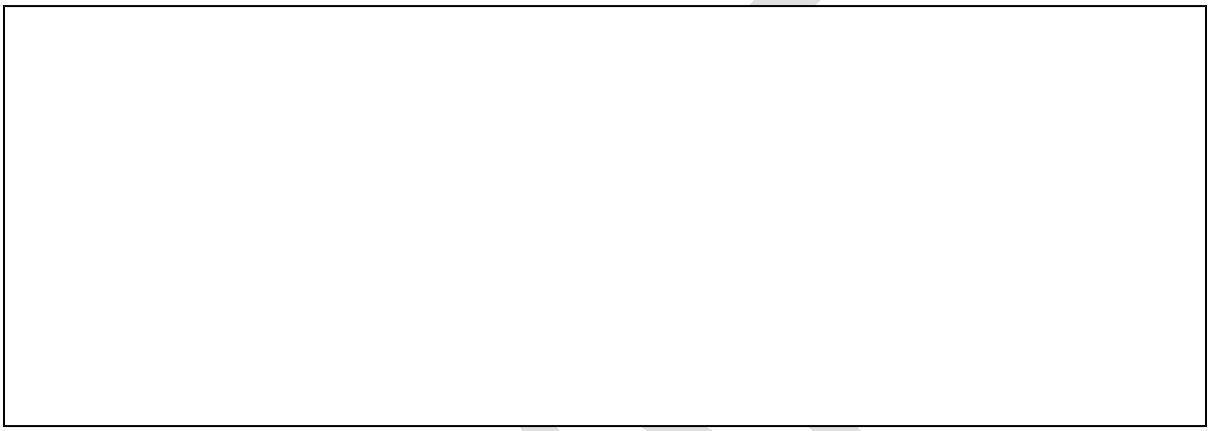


Figure 6. Disassembled Oberg Filter

Engine Pre-Start Checklist

- ☑ Manual fuel shutoff valves are open
- ☑ Starter disconnect switch is off
- ☑ Emergency stop switch is on
- ☑ Dynamometer bearing oil supply is adequate
- ☑ All machine guards are in place
- ☑ Engine and valve cover coolant levels are within 50 mm of the top of the vertical level indicators
- ☑ Engine oil drains at the oil sump and heat exchangers are closed (see Figures 5 and 7)

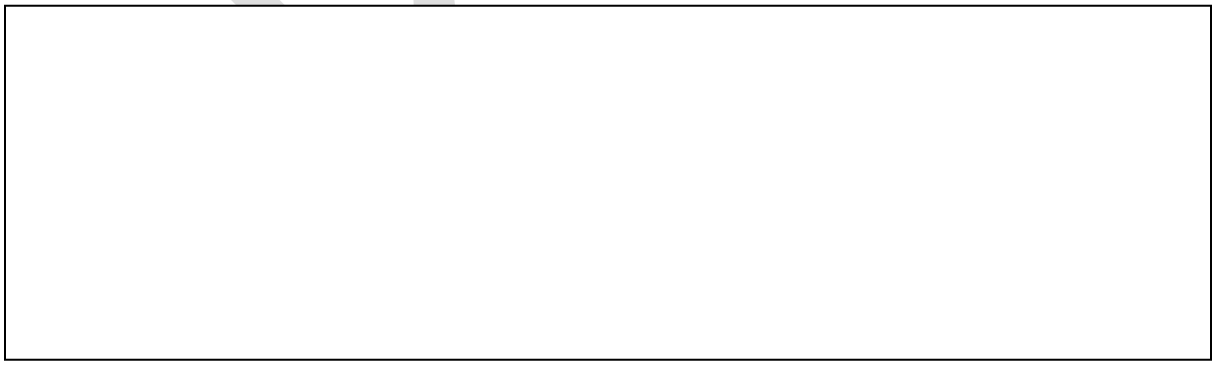


Figure 7. Engine Oil Drain

- ☑ Oberg filter housing is secure, and filter is installed correctly.

- ☑ Dynamometer process water is on and flowing.
- ☑ Load cell temperature is 45°C ± 1°C. If not, allow the load cell temperature to reach the required temperature and maintain for 60 minutes before load cell calibration is attempted.
- ☑ Verify with engine build technician that test engine is released for test

Dynamometer Load Cell Calibration Procedure

1. The IVB Golden Test Stand requires the use of the Midwest 1014 dry gap eddy current dynamometer equipped with Midwest Dynamometer Torque Arms. Spacers or modifications to the Midwest dynamometer torque arms are not permitted. Do not use any torque arm multipliers for performing dynamometer load cell calibration.
2. Refer to Figure 8. Ensure the Dynamometer coolant flow Indicator is in the green.

Figure 8. Dynamometer coolant flow indicator

3. Ensure that the load cell temperature has been stabilized at 45°C ± 1°C for a minimum of one hour.
4. Refer to Figure 9. Calibrate the dynamometer load cell by applying certified weights to the dynamometer calibration check arm so that the dynamometer load cell is in tension. Calibration reference values should be within ±0.2 kilogram of the target mass in Table 1, below.

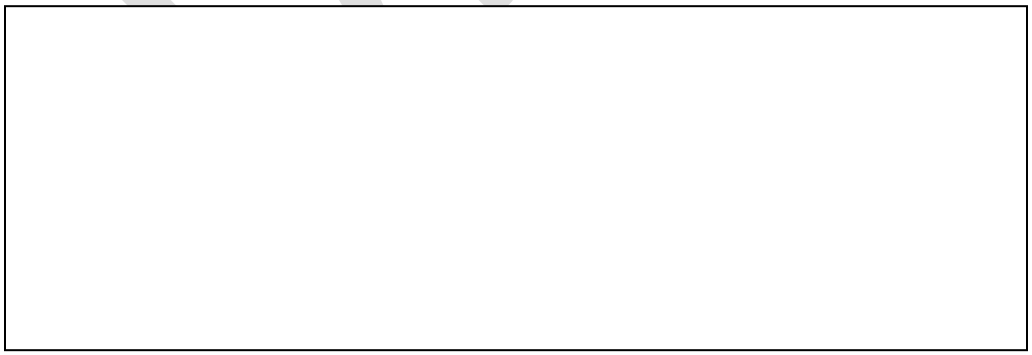


Figure 9. Applying Weights for Dyno Calibration

5. Calibrate the dynamometer load cell using the following reference table.

Table 1. Dynamometer Load Cell Reference Table

Calibration Point	Reference Calibration Target Mass, kg	Resulting Reference Torque, N-m	Permissible Percent Error
Zero	2.535	9.94	0.5 %
Mid-range	7.130	27.97	0.5%
Span	11.335	44.47	0.5%

Note: Hanger and certified weights are available from DyneSystems, Inc. (p/n TBD)

Engine Start Procedure

Note: Engine operation during the engine start routine does not count as accumulated test time.

1. Verify the following before starting engine:
   - ☑ Configure dynamometer to control torque and throttle to control engine speed.
   - ☑ Intake air box is disconnected from laboratory conditioned intake air supply.
   - ☑ Engine coolant is pressurized to 70 kPa.
   - ☑ Engine coolant flow control valve set at fully open position.
   - ☑ Oil temperature control valve set at fully closed position.
   - ☑ Coolant temperature control valve set at fully closed position.
   - ☑ Intake air temperature heater turned off.
   - ☑ Intake air pressure control valve set to fully closed position.
   - ☑ Exhaust back pressure control valve set to fully open position.
   - ☑ Check DyneSystems PAU status and, if necessary, perform reset procedure (see Figure 10).
   - ☑ Manual fuel shutoff valves are open
   - ☑ Starter disconnect switch is off,
   - ☑ All emergency stop switches are off.
2. Set DyneSystems PAU throttle position to a set percent opened to achieve > 500 rpm (typical range is 5 – 15%).
3. Set DyneSystems PAU dynamometer excitation to 0%.

Figure 10. DyneSystems PAU

4. Turn on digital I/O for engine coolant pump and valve cover coolant pump.
5. Gradually increase engine coolant heater set point to 50°C, over 5 minutes.
6. Set coolant temperature control valve loop set point to closed loop control with set point of 50°C. Soak engine coolant outlet temperature at 50°C for 5 minutes.

7. Turn on digital I/O for engine ignition and electric fuel pump. This will in turn apply power to the Horiba AFR meter. Hold in this step until the Horiba AFR meter indicates an air-fuel-ratio (AFR) value greater than 13:1.
8. Turn on digital I/O for engine starter motor for 7 seconds or until engine speed is greater than 500 rpm, whichever comes first. Then, turn off digital I/O for engine starter motor. If engine speed is not greater than 500 rpm, then turn off digital I/O for engine ignition and electric fuel pump and repeat steps 7 and 8. If engine speed is still greater than 500 rpm then proceed to step 9.
9. Connect engine intake air box to laboratory conditioned intake air supply. Set the laboratory PID control loops for intake air pressure and intake air temperature into closed loop control with set points of 0.07 kPa and 32°C, respectively.
10. Set the laboratory PID loop for engine speed into closed loop control with a set point of 800 rpm. This will gradually increase the DyneSystems PAU throttle servo until 800 rpm is achieved. This step should be set for a 60-second duration.
11. Set the laboratory PID loop for torque in closed loop mode with a set point of 5 N-m, then, gradually increase the torque set point to 10 N-m over a 30-second period.

Non-Emergency Engine Shutdown Procedure

Note: Engine operation during the non-emergency engine shutdown procedure does not count as accumulated test time.

For any scheduled or unscheduled non-emergency shutdowns, conduct the following shutdown sequence.

1. Reduce speed and load by linearly ramping to targets provided in Table 2. The ramp durations for speed and load are 60 seconds and 45 seconds, respectively.

Table 2. Non-Emergency Shutdown Control Parameters

Process	Target
Engine Speed	800 rpm
Torque	25 N-m
Engine Coolant Out Temperature	50°C
Engine Oil Gallery Temperature	49°C
Exhaust Back Pressure	103.5 kPaA
Intake Air Pressure	0.07 kPa
Intake Air Temperature	32°C
Fuel Temperature	24°C
Rocker Cover Outlet Temperature	20°C
Coolant Temperature Differential (Out –In)	2°C
Load Cell Temperature	45°C
Coolant Temperature Heater	OFF

2. Turn off the digital I/O for the electric fuel pump, and allow the engine to run for 5 seconds. Then, turn off the digital I/O for the ignition circuit to stop the engine.
3. Manually open the starter disconnect switch (off position). Turn on the manual emergency stop switch.
4. If shutdown occurred during engine oil system flush mode or test mode, allow the engine coolant pump and the valve cover coolant pump to remain on with the engine coolant flow

control valve fully open and the engine coolant heater controlling engine coolant outlet temperature to 49°C.

5. During shutdown, the following settings should be applied:
   - ☑ Valve cover coolant outlet temperature controlled to 20°C
   - ☑ Exhaust backpressure control valve set to fully open position
   - ☑ Intake air heater turned off
   - ☑ Intake air pressure control valve set to fully closed position.
   - ☑ Load cell temperature controlled to 45°C
6. Disconnect the engine intake air box from the laboratory conditioned intake air supply.
7. In the event of shutdown lasting more than 30 minutes, it is permissible to turn off the engine coolant heater, the engine coolant pump, the rocker cover coolant pump in order to conserve power and place the test stand in a non-operative mode. The test laboratory may elect to turn off the load cell heater, as well.

Engine Oil System Flush Procedure

Note: Engine operation during the engine oil system flush procedure does not count as accumulated test time. However, data is still logged at 1 Hz for diagnostic aid.

1. Charge engine with 3000 ml of new test oil via the oil fill cap.
2. Conduct the Engine Start Procedure.
3. Gradually increase engine speed from 800 rpm to 1500 rpm over 90 seconds while maintaining torque at 10 N-m. Maintain the conditions specified in Table 3 for 6 minutes (for Flush 1) or 38 minutes (for Flushes 2, 3 and 4), which includes time to ramp to engine speed set point:

Table 3. Engine Oil Flush Operating Parameters

Process	Target
Engine Speed	1500 rpm
Torque	10 N-m
Engine Coolant Out Temperature	50°C
Engine Oil Gallery Temperature	49°C
Exhaust Back Pressure	103.5 kPaA
Intake Air Pressure	0.07 kPa
Intake Air Temperature	32°C
Fuel Temperature	24°C
Rocker Cover Outlet Temperature	20°C
Coolant Temperature Differential (Out –In)	2°C
Load Cell Temperature	45°C
Coolant Temperature Heater	OFF

4. When 6 minutes (for Flush 1) or 38 minutes (for Flushes 2, 3 and 4) have elapsed, conduct the non-emergency engine shutdown procedure.
5. Conduct cranking compression and cylinder leak-down tests for all four cylinders and record values.
6. Conduct the engine oil drain procedure.
   Note: Data logging is not required during the non-emergency engine shutdown procedure or during the oil drain procedure.
7. Take a 240 ml purge sample and a 30 ml sample of the flush oil (See sampling procedure in the Test Operation Procedure) for analysis using ASTM D5185 (ICP) for wear metals to check for

containments, such as engine coolant (sodium and potassium) and unusual levels of silicone, iron, copper, lead, or aluminum. Report the ICP data for each flush drain on Form 7 of the test report. Dispose of the remaining flush oil drain following laboratory disposal practices.

8. Repeat steps 1 through 6 three additional times for a total of 4 flush procedures.

Note: Flush 1 is 6 minutes in duration and Flushes 2, 3 and 4 are each 38 minutes in duration.

Test Operation Procedure

1. Charge the engine oil sump with 2400 ml of new test oil via the oil fill cap. Obtain a minimum of 60 ml of new test oil sample for analysis.
2. Conduct the engine start procedure.
3. Once the engine start procedure completes, immediately enter into the cyclic test operation specified in Table 4, below. Use a linear ramp for engine speed, differential coolant temperature, oil gallery temperature, and exhaust pressure to transition between stages. Examples of acceptable variations in engine speed during stage 1, stage 2, and transition ramps are shown in Figures 14 thru 17. Speed and load controllers should be monitored periodically during the test to ensure the engine speed and engine torque are within limits by the first second of each cycle for both Stage 1 and Stage 2. Log data continuously at 1Hz.

Note: The engine will not respond in a linear fashion to aggressive speed set point changes. Overly aggressive acceleration ramps will activate the engine control unit engine protection scheme which in turn will affect fuel dilution.

Table 4. Sequence IVB Test Conditions

Sequence IVB - Test Sequence					
Parameter	Units	Ramp to Stage 1	Stage 1	Ramp to Stage 2	Stage 2
Duration	s	8	7	8	7
Engine Speed	rpm	4300 to 800	800 ± 25	800 to 4300	4300 ± 25
Engine Torque	N-m	25 ± 2	25 ± 2	25 ± 2	25 ± 2
Coolant Temperature Into Engine	°C	49 ± 3	49 ± 3	49 ± 3	49 ± 3
Coolant Delta Temperature	°C	5 to 2	2 ± 1	2 to 5	5 ± 1
Engine Oil Gallery Temperature	°C	55 to 53	53 ± 3	53 to 55	55 ± 3
Intake Air Temperature	°C	32 ± 3	32 ± 3	32 ± 3	32 ± 3
Rocker Cover Coolant Out Temperature	°C	20 ± 2	20 ± 2	20 ± 2	20 ± 2
Fuel Rail Temperature	°C	24 ± 3	24 ± 3	24 ± 3	24 ± 3
Load Cell Temperature	°C	45 ± 3	45 ± 3	45 ± 3	45 ± 3
Intake Air Pressure	kPa	0.07 ± 0.07	0.07 ± 0.07	0.07 ± 0.07	0.07 ± 0.07
Intake Air Humidity	g/kg	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5
Exhaust Pressure	kPa-abs	104.5 to 103.5	103.5 ± 1	103.5 to 104.5	104.5 ± 1
Engine Coolant Pressure	kPa	70 ± 10	70 ± 10	70 ± 10	70 ± 10
Fuel Rail Pressure	kPa	335 ± 10	335 ± 10	335 ± 10	335 ± 10
Air Fuel Ratio	afr	record	14.5 ± 0.5	record	14.5 ± 0.5

4. Repeat the test cycle for a total test time of 200 hours.

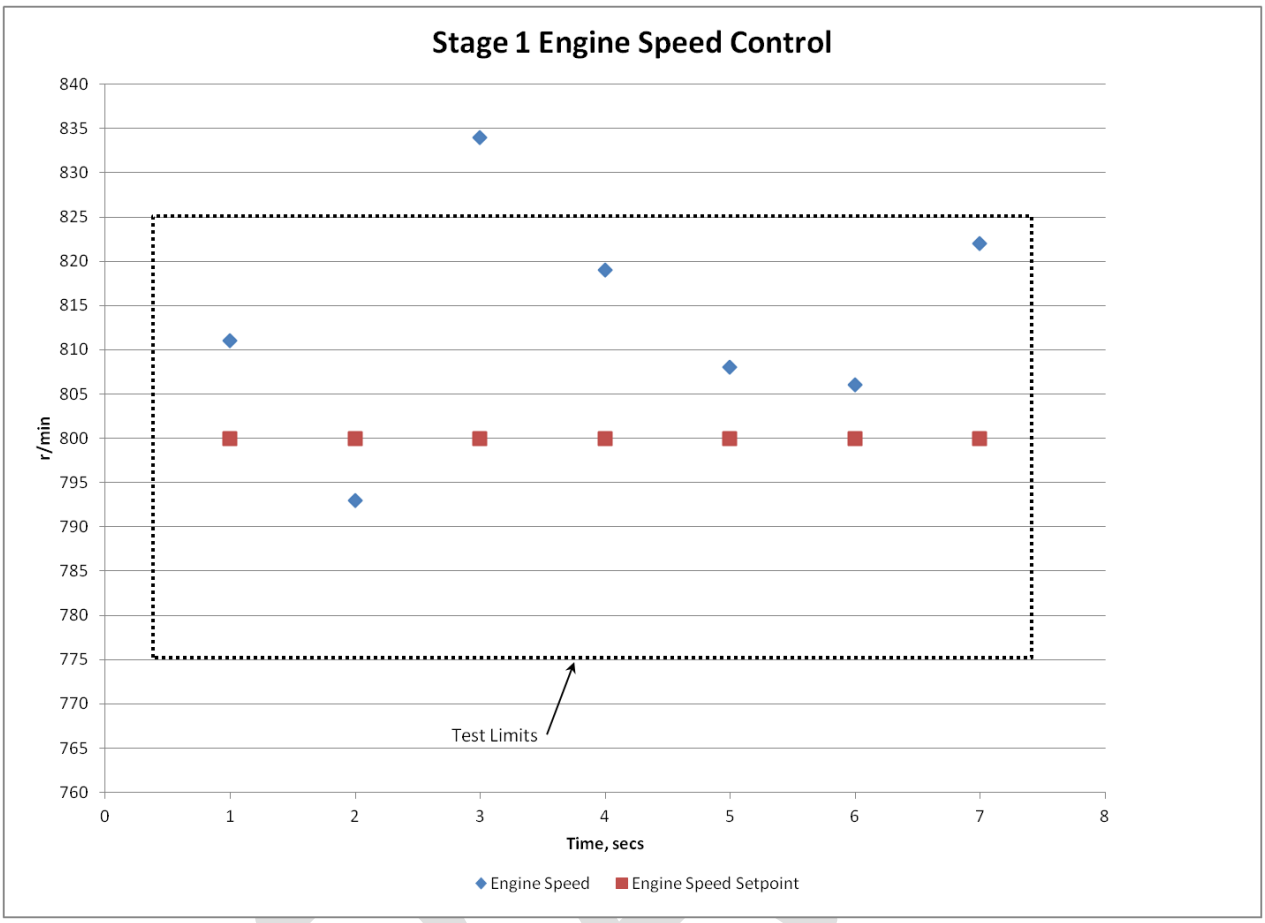


Figure 11. Stage 1 Engine Speed

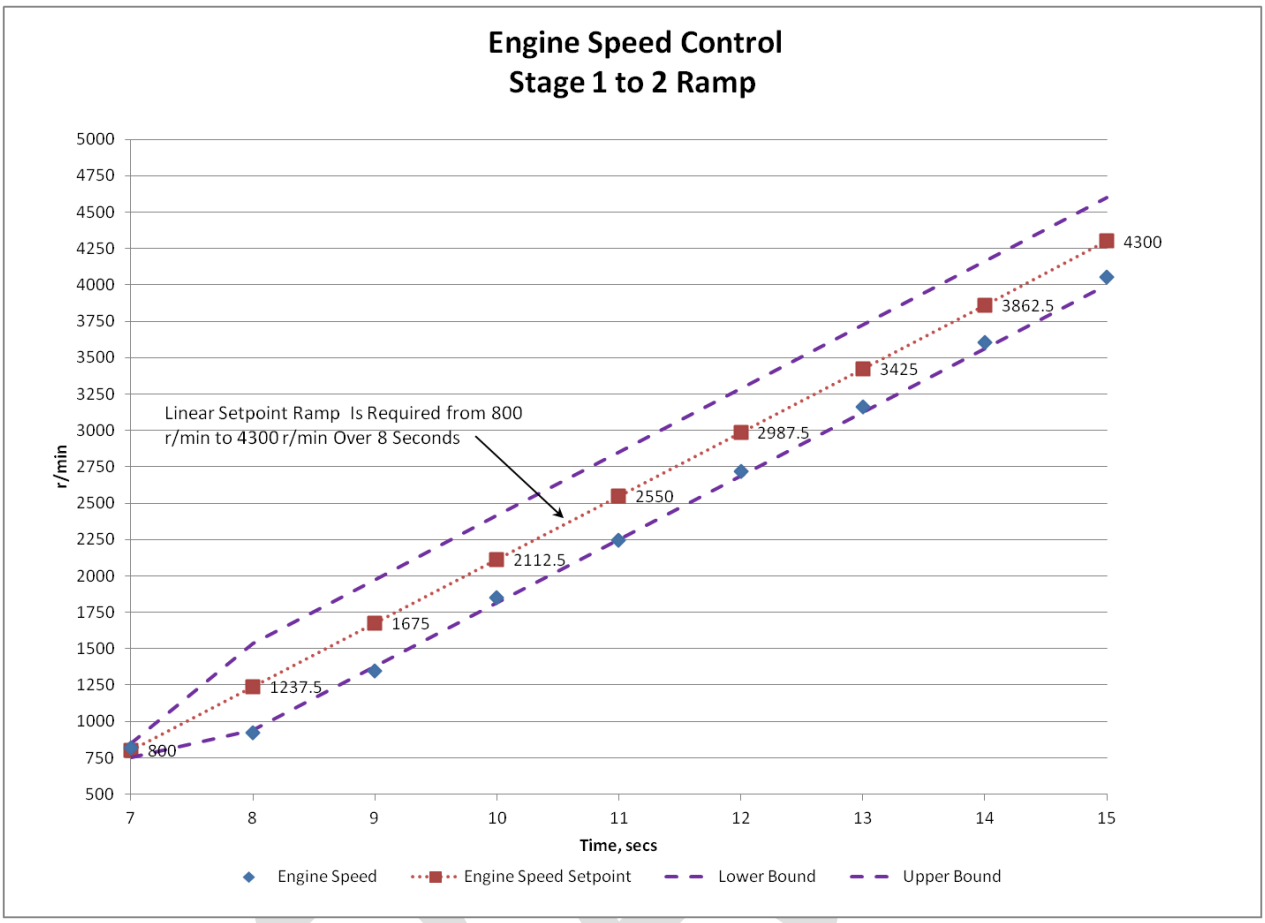


Figure 12. Stage 1 to Stage 2 Ramp of Engine Speed

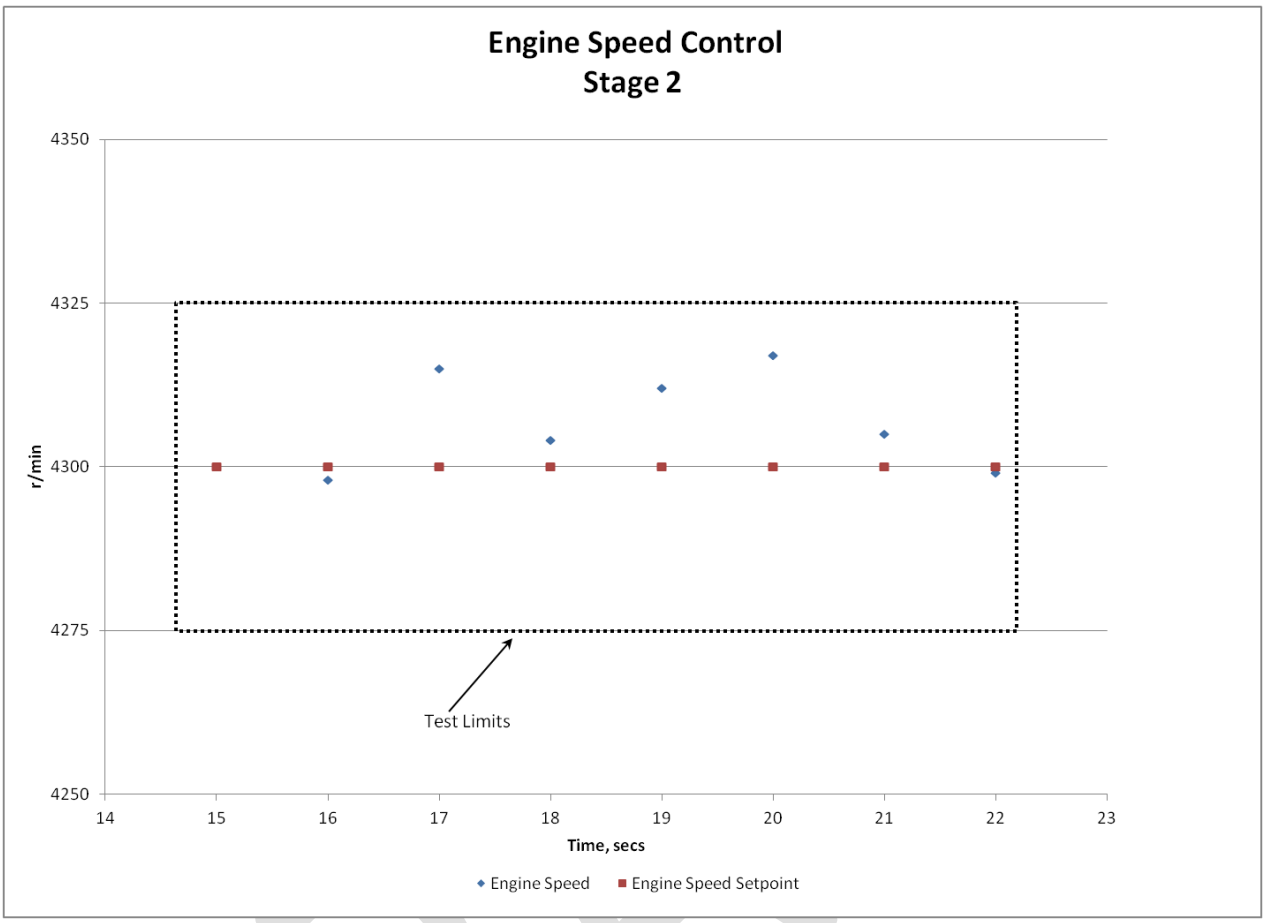


Figure 13. Stage 2 Engine Speed

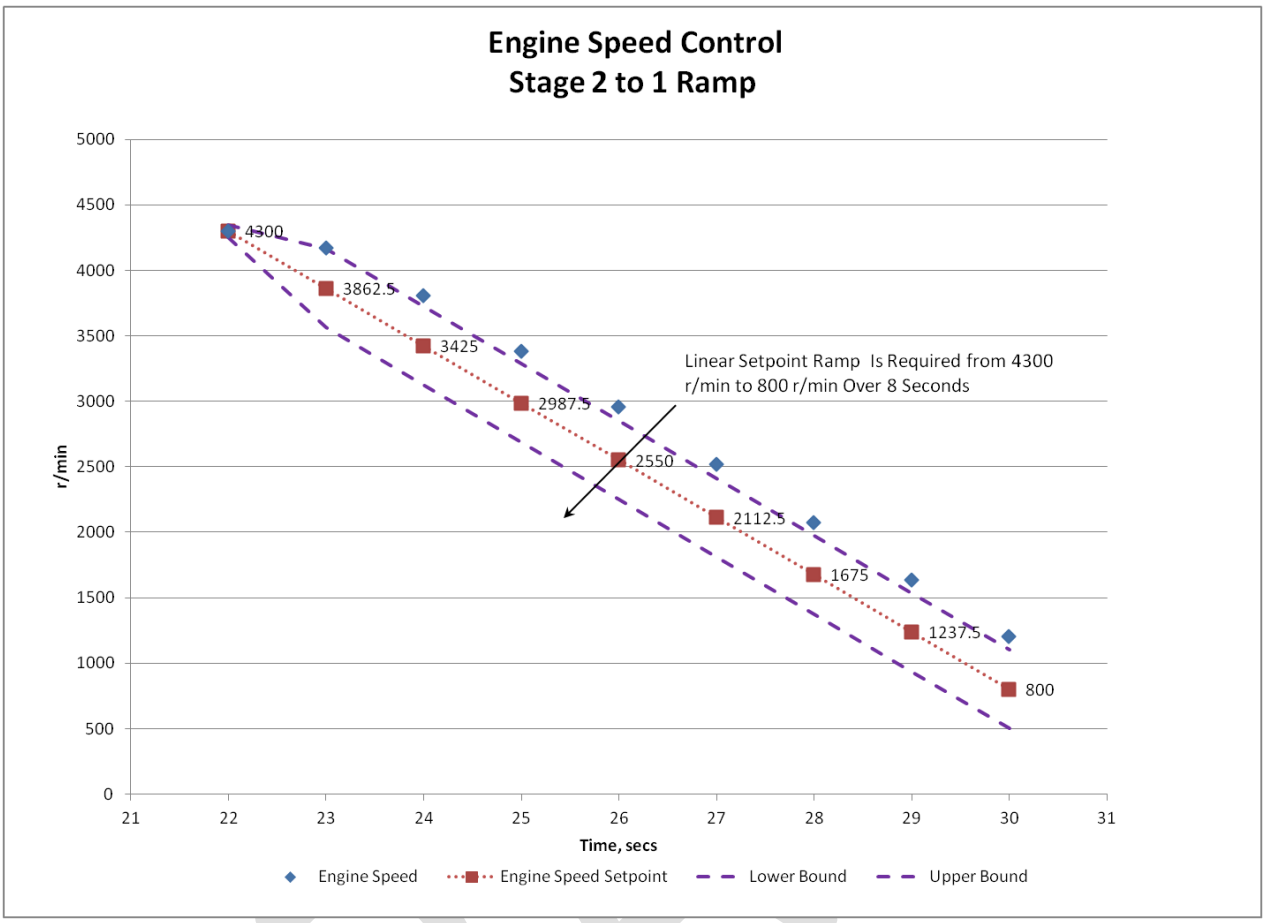


Figure 14. Stage 2 to Stage 1 Ramp of Engine Speed

5. Perform the following oil sample procedure. At test hours 25, 50, 75, 100, 125, 150, and 175, draw a 240 ml purge oil sample and a 30 ml oil sample for analyses.
   5.1. Wait until the engine is at Stage 1 conditions, and then place the computer control system in hold. Ensure test time is not incrementing.
   5.2. Refer to Figure 15. Uncap the oil sample port. Using a graduated cylinder, draw the 240 ml purge oil sample by pushing on the valve at the oil sample port.

   Caution: If the oil sample is obtained too quickly, the oil pressure safety shutoff trigger (if programmed in the engine control system) may shut down the test stand.

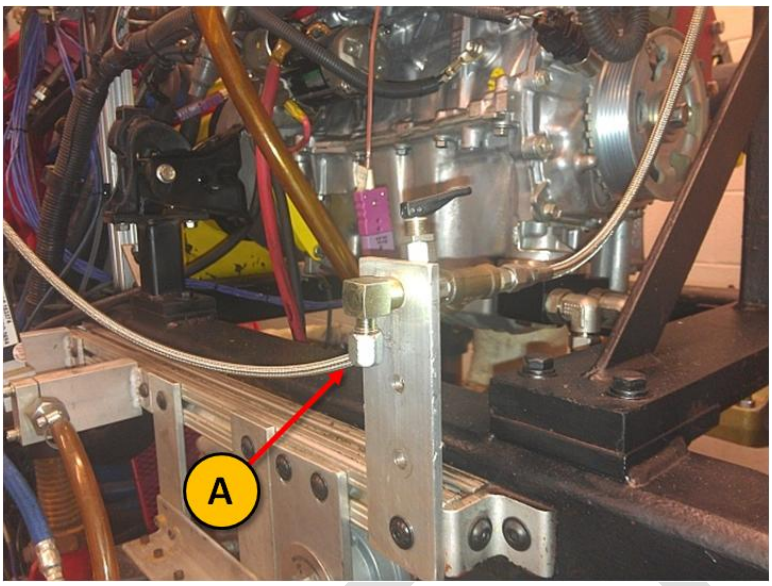


Figure 15. Oil sampling port

5.3. Obtain a 30 ml sample at the oil sample port.
5.4. Disconnect the crankcase pressure line at the jacketed valve cover.
5.5. Refer to Figure 16. Connect the oil return device to the crankcase pressure port located on top of the valve cover.
5.6. Pour the 240 ml purge sample into the oil return device. Secure the cap of the oil return device.

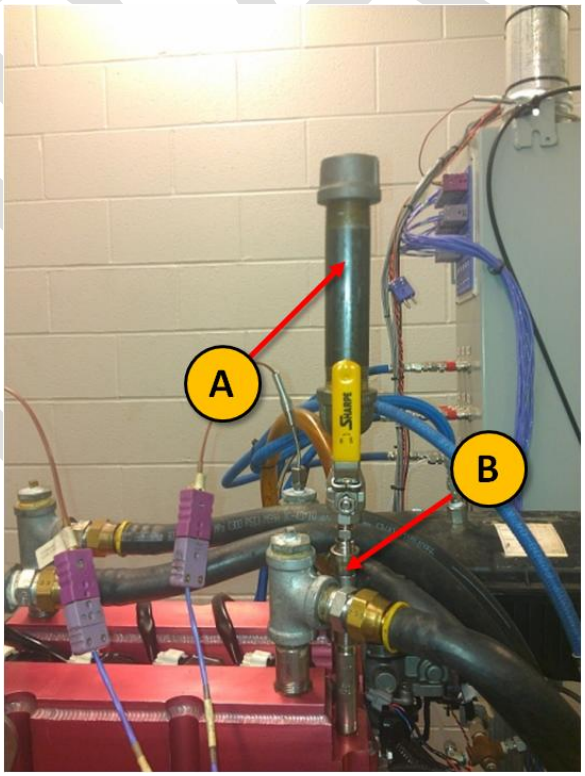


Figure 16. Oil return device (A) connected to the crankcase pressure sample port (B)

5.7. Open the ¼ turn valve on the oil return device to allow the 240 ml purge sample to return to the engine. Wait 2 minutes to ensure the purge sample has drained out of the oil return device.
5.8. Disconnect the oil return device, and reconnect the crankcase pressure line to the crankcase pressure port on top of the valve cover.
5.9. Return the computer control system to automatic cycling mode. Make sure test time is incrementing.
5.10. If the sample can't be obtained within 10 minutes, then shut down the engine.

6. When the test accumulates 200 hours of test time, stop the test using the non-emergency engine shutdown procedure.
7. Conduct cranking compression and cylinder leak-down tests for all four cylinders and record values.
8. Conduct the engine oil drain procedure.
9. Calculate the oil consumption.
10. Obtain a 60 ml sample for analysis directly from the test oil drain. Retain the test oil drain for a period of one year.
11. Remove test camshafts and bucket lifters for post-test metrology. See Engine assembly Manual-Section 1.

New and Used Oil Analytical Requirements

Perform the following analytical analysis on the new oil sample – ASTM D5185 (ICP), ASTM D445 at 40 °C (Kinematic Viscosity), ASTM D4739 (TBN), ASTM D664 (TAN), and ASTM E168 (FTIR) using fingerprint method to obtain oxidation and nitration.

Perform the following analytical analysis on all used oil samples and report result on Form 7 of the test report –ASTM D5185 (ICP), ASTM D3525 (Fuel Dilution for Gasoline), ASTM D4739 (TBN), ASTM D664 (TAN), and ASTM E168 (FTIR) using fingerprint method to obtain oxidation and nitration. ASTM D445 at 40 °C (Kinematic Viscosity) using micro tubes is optional, except for the 200-hour sample.

Lubrizol

Test Operation Lab Instructions

SEQUENCE IVB TEST INSTRUCTIONS

GASW438

DOCUMENT REVISION LOG

REVISION LEVEL	DATE APPROVED	ISSUED BY	REVISION DESCRIPTION
0	04-27-2015	CHTM	In-service on this date.
1	04-30-2015	CHTM	Removed instructions to turn the coolant heater breaker “on” and “off”. Added instructions for charging the engine coolant.
2	05-13-2015	CHTM	Modified document based on feedback from 1st Sequence IVB Prove-Out matrix test (TRNS9TF7C).
3	05-27-2015	CHTM	Added instructions to take E.O.T. lifter clearance measurements.
4	06-05-2015	CHTM	Modified document after feedback from 2nd Sequence IVB Prove-Out matrix test (TRNX713KB).
5	08-17-2015	CHTM	Continue to modify document based on revisions to ASTM procedure and experience gained from running prove-out matrix testing.
6	10-01-2015	CHTM	Includes updates to LTR and ET2 Data Viewer.
7	10-07-2015	CHTM	Changed E.O.T. oil sample volume to 4-oz.
8	12-17-2015	CHTM	Added instructions for resetting throttle control, operator initials for oil charge, disconnect ignition coils for compression checks, cleaning and LTR.

DOCUMENT REVISION LOG

REVISION LEVEL	DATE APPROVED	ISSUED BY	REVISION DESCRIPTION
9	03-10-2016	CHTM	Clarified the naming convention for the flush hours.
10	04-01-2016	CHTM	Added provisions for the new OHT oil pan.
11	04-12-2016	CHTM	Clarified instructions for calibrating load cell. Updated set points with new coolant flow control strategy.
12	05-18-2016	CHTM	Coolant flow set points updated (FRAC = 120 L/min, FCLEO = 50 L/min). Also added instructions to take pre-test and post-test dipstick measurements.
13	06-03-2016	CHTM	FCLEO set point changed to 80 L/min.
14	07-27-2016	CHTM	Added a field to record the official ACC start time. Also updated the test conditions to include blowby temperature.
15	08-12-2016	CHTM	Eliminate pre-test coolant warming procedure. Added additional engine flush (oil pan only).
16	11-22-2016	CHTM	Changed TBBY to 29C.
17	01-16-2017	CHTM	Remove “knock” sensor from engine.

DOCUMENT REVISION LOG

REVISION LEVEL	DATE APPROVED	ISSUED BY	REVISION DESCRIPTION
18	01-30-2017	CHTM	Mark the OHT front cover with strike marks to track usage.
19	02-08-2017	CHTM	Use KA24E fuel from tank G-11.
20	02-22-2017	CHTM	Updated instructions to clean condensation traps and external blowby control system per recommendations by Southwest Research.

1. NOTES:

1.1. This work instruction form is to be completed during the course of a Sequence IVB test.
  1.1.1. This completed form needs to be included in the test packet.

2. HARDWARE AND FUEL DOCUMENTATION:

2.1. TRN Number:

2.2. 5-Digit OHT Serial Number of Cylinder Head:

2.3. Number of Runs on Cylinder Head:

2.4. 5-Digit OHT Serial Number of Engine Block:

2.5. Number of Runs on Engine Block:

2.6. Oil Sample Number:

2.7. Date of Test Initiation:

2.8. S.O.T. Stand Hardware Time (XXXX:XX:XX):

2.9. Initials of Operator Performing Test Start-Up:

3. CONFIRM THE FOLLOWING ITEMS:

3.1. Confirm that the following hardware is installed in the engine:
  3.1.1. Test intake camshaft **Complete:** ☐
  3.1.2. Test exhaust camshaft **Complete:** ☐
  3.1.3. Test bucket lifters **Complete:** ☐
  3.1.4. High-tension intake valve springs (P/N DDU43-10535) **Complete:** ☐

3.1.5. OHT water-cooled rocker arm cover **Complete:** ☐
3.1.6. OHT front cover **Complete:** ☐
3.1.7. OHT rear cover **Complete:** ☐
3.1.8. OHT oil pan with dipstick **Complete:** ☐
3.1.9. New spark plugs (90919-01258) with a gap of 1.1mm or 0.043-inches **Complete:** ☐

3.2. Confirm that the fuel hose is connected to the G-11 fuel tank. **Complete:** ☐

3.2.1. **KA24E Fuel Batch Number:** _____

3.3. Confirm that the PCM is plugged in. **Complete:** ☐

3.4. Confirm that the "knock" sensor is unbolted from the engine block. **Complete:** ☐
3.4.1. *NOTE:* The "knock" sensor should be wrapped in insulation to isolate it from vibrations.

3.5. Confirm that the fuel injector wires are connected correctly. **Complete:** ☐
3.5.1. *NOTE:* The connector colors should be brown for Cylinder #1, gray for Cylinder #2, brown for Cylinder #3 and gray for Cylinder #4.

3.6. Confirm that the ignition coil wires are connected correctly. **Complete:** ☐
3.6.1. *NOTE:* The connector colors should be black for Cylinder #1, gray for Cylinder #2, black for Cylinder #3 and gray for Cylinder #4.

3.7. Open up the front door to the blue computer cabinet and confirm that the **Dynamometer** and **Throttle** indicator lights on the **DyneSystems** unit are both green. **Complete:** ☐

4. CHARGE THE ENGINE COOLANT:

4.1. *NOTE:* The engine coolant must be changed after each engine replacement, cylinder head replacement, or any time the coolant system hardware was serviced (i.e. replacing a coolant pump).

4.2. Confirm that the test stand has the proper LO/TO equipment installed, and that none of the accessories on the **Accessories** tab of EasyTest are activated. **N/A:** ☐ **Complete:** ☐

4.3. Confirm that the coolant system is no longer pressurized. **N/A:** ☐ **Complete:** ☐

4.4. Remove the cap from the engine coolant reservoir. **N/A:** ☐ **Complete:** ☐

4.5. Set the engine coolant flow control valve to the fully open position and verify that all drains are closed and all hoses are connected. **N/A:** ☐ **Complete:** ☐

4.6. Prepare approximately **12-gallons** of 30% Havoline Extended Life Dex-Cool coolant and 70% deionized or distilled water. **N/A:** ☐ **Complete:** ☐

4.7. Charge the coolant by filling the system from the top or by pumping coolant into the system from the bottom drain of the heat exchanger. **N/A:** ☐ **Complete:** ☐

4.7.1. Fill the system until the coolant is 2-inches from the top of the vertical sight glass located on the side of the main coolant reservoir.

4.7.2. Secure the coolant reservoir cap once the system is full.

4.8. Adjust the system pressure to approximately 10psi. **N/A:** ☐ **Complete:** ☐

4.9. Select the **ac03_CoolPumps** accessory under the **Accessories** tab in EasyTest and allow the coolant to circulate for approximately 1-hour. **N/A:** ☐ **Complete:** ☐

4.10. After 1-hour, turn off the coolant pump and reduce the coolant pressure to 0psi.

4.10.1. Remove the reservoir cap and add additional coolant as needed to return the level to within 2-inches from the top of the vertical sight glass. **N/A:** ☐ **Complete:** ☐

4.11. Secure the coolant reservoir cap.

4.11.1. Pressurize the system to 10psi. **N/A:** ☐ **Complete:** ☐

5. CHARGE THE ROCKER ARM COVER COOLANT:

5.1. *NOTE:* The rocker arm cover coolant must be changed after each engine replacement, cylinder head replacement, or any time the coolant system hardware was serviced (i.e. replacing a coolant pump).

5.2. Confirm that the test stand has the proper LO/TO equipment installed, and that none of the accessories on the **Accessories** tab of EasyTest are activated. **N/A:** ☐ **Complete:** ☐

5.3. Verify that all drains are closed and all hoses are connected. **N/A:** ☐ **Complete:** ☐

5.4. Remove the pressure cap from the valve cover coolant reservoir. **N/A:** ☐ **Complete:** ☐

5.5. Prepare approximately **23-liters** of 30% Havoline Extended Life Dex-Cool coolant and 70% deionized or distilled water. **N/A:** ☐ **Complete:** ☐

5.6. Charge the coolant by filling the system from the top or by pumping coolant into the system from the bottom drain of the heat exchanger. **N/A:** ☐ **Complete:** ☐

5.6.1. Fill the system until the coolant is 2-inches from the top of the vertical sight glass located on the side of the main coolant reservoir.
5.6.2. Secure the coolant reservoir cap once the system is full.

5.7. Select the **ac03_CoolPumps** accessory under the **Accessories** tab in EasyTest and allow the coolant to circulate for approximately 1-hour. **N/A:** ☐ **Complete:** ☐
5.7.1. *NOTE:* Both the engine coolant and rocker arm cover coolant systems must be charged in order to run the coolant pumps

5.8. After 1-hour, turn off the coolant pump and reduce the coolant pressure to 0psi.
5.8.1. Remove the valve cover reservoir cap and add additional coolant as needed to return the level to within 2-inches from the top of the vertical sight glass. **N/A:** ☐ **Complete:** ☐

5.9. Secure the coolant reservoir cap. **N/A:** ☐ **Complete:** ☐

6. FLUSH THE EXTERNAL OIL SYSTEM:

6.1. *NOTE:* Use the Sequence IVB flush cart from the East Lab to perform this oil system flush.

6.2. Disconnect the supply and return lines from the remote oil filter housing adapter that is mounted on the engine. **Complete:** ☐

6.3. Connect the supply and return lines to a portable flush cart (with a minimum capacity of 1-gallon) that is equipped with a pump. **Complete:** ☐
6.3.1. Charge the flush cart with clean Stoddard solvent.

6.4. Activate the pump on the cart and allow Stoddard to circulate through the test stand's oil system for approximately 1-hour. **Complete:** ☐

6.5. After the solvent circulates through the oil circuit for 1-hour, deactivate the pump and place empty containers underneath the two oil heat exchanger drain valves.
6.5.1. Open the two heat exchanger drain valves.
6.5.2. Allow the heat exchanger to completely drain. **Complete:** ☐

6.6. Disconnect the supply and return lines from the portable flush cart. **Complete:** ☐

6.7. Connect the supply and return lines to a clean, dry compressed air source that is operating at approximately 20psi. **Complete:** ☐
6.7.1. Leave the two drain valves open and keep the Stoddard collection containers in place.
6.7.2. Allow compressed air to flow through the oil circuit for approximately 15-minutes to remove any residual Stoddard from the lines.

6.8. Disconnect the supply and return lines from the compressed air source. **Complete:** ☐

6.9. Connect the supply and return lines back on the remote oil filter housing adaptor located on the engine. **Complete:** ☐

6.10. Close the two heat exchanger drain valves. **Complete:** ☐

6.11. Remove the Oberg oil filter element for cleaning. **Complete:** ☐

6.11.1. *NOTE:* The Oberg oil filter housing is located underneath the front of the engine cradle.

6.11.2. Take the Oberg oil filter element to the Spray Room and remove any debris using Stoddard solvent and compressed air.

6.11.3. Confirm that the correct Oberg filter is being used (**OHT6A-013-2**, 28µm).

6.11.4. Once the Oberg oil filter element is dry, reinstall it in the Oberg oil filter housing and secure the four bolts.

6.12. Dispose of the used Stoddard and remove the two collection containers. **Complete:** ☐

6.13. Disconnect the oil sample and oil pressure transducer lines and take them to the Spray Room to clean them with Stoddard solvent. **Complete:** ☐

6.13.1. Dry the lines with compressed air.

6.14. Open the oil sample valve to allow any trapped oil to drain. **Complete:** ☐

6.14.1. Then close the valve and reconnect the oil sample and oil pressure transducer lines.

7. CALIBRATE THE DYNAMOMETER LOAD CELL:

7.1. Initialize a new test in EasyTest. **Complete:** ☐

7.1.1. Select the **Begin/Resume Test** option from the **Test** pull-down menu.

7.1.2. Enter the correct TRN Number in the **Run ID** field.

7.1.3. Press the **Begin/Resume Test** button.

7.2. Confirm that the dynamometer coolant flow indicator is green. **Complete:** ☐

7.3. Load the **Toyota2NR_FE** macro in the **Sequencer Initialization** drop-down menu. **Complete:** ☐

7.3.1. This will load the **Dyno Cal** condition set.

7.3.2. **Run** the Sequencer.

7.3.3. Select the **ac02_HeaterENB** and **ac03_CoolPumps** accessories under the **Accessories** tab in EasyTest.

7.3.4. *NOTE:* The **ac03_CoolPumps** accessory must be selected for 60-seconds before the **ac02_HeaterENB** accessory can be selected.

7.4. Allow the load cell temperature parameter (**TLOADCELL**) to remain at a stable temperature of 45°±1°C for 1-hour before performing the calibration. **Complete:** ☐

7.5. Select the **TORQUE** parameter from the pull down menu on the **Calib/Tune** tab in EasyTest.

7.5.1. Add weight to the torque arm of the dynamometer until the **Value** field displays a measurement of approximately 40-50Nm. **Complete:** ☐

7.5.2. Once this measurement is achieved, remove all of the weights from the torque arm.

7.5.3. *NOTE:* This will remove any latent hysteresis from the load cell.

7.6. Press the **Slope and Offset Calculator** button. **Complete:** ☐

7.6.1. This will cause the **Slope and Offset Calculator** menu to appear.

7.7. Calibrate the dynamometer load cell at the four reference points shown in Table 1. **Complete:** ☐

Table 1 - Dynamometer Load Cell Calibration

Calibration Point Description	Actual Mass (kg)	Actual Torque (Nm)	Permissible Error (%)
No Load	0	0	0.5%
Low Load (Hanger and Small Weight)	2.535	9.94	0.5%
Mid-Range Load (Hanger and Medium Weight)	7.130	27.97	0.5%
Full Range Span (Hanger and Large Weight)	11.335	44.47	0.5%

7.7.1. Press the **Get Display Value** button on the **Slope and Offset Calculator** menu after each of these four calibration steps is completed and the **Actual Value** is inputted in the appropriate field.

7.7.2. Press the **Calculate** button.

7.7.3. Press the **Accept New Slope and Offset** button after the entire calibration is complete.

7.8. Record the calculated information displayed on the **Slope and Offset Calculator** menu in the fields listed below:

7.8.1. **Max Error, Old Calibration (Nm):** _____

7.8.2. **Max Error, New Calibration (Nm):** _____

8. PRE-FLIGHT CHECKLIST:

8.1. Obtain and label each of the sample jars for the test. **Complete:** ☐
- 8.1.1. Place yellow marks on the bottle caps of the appropriate samples as specified in Table 9.

8.2. Lubricate the driveshaft. **Complete:** ☐

8.3. Remove the three pressure transducer condensation traps. **Complete:** ☐
- 8.3.1. Clean each trap with solvent.
- 8.3.2. Replace the O-rings.

8.4. Confirm that the DyneSystems PAU throttle controller is not in alarm. **Complete:** ☐
- 8.4.1. Press the red **RESET** button.
- 8.4.2. Then press the green **SATC ON** button.
  - 8.4.2.1. *NOTE:* The green button should be illuminated.
- 8.4.3. Confirm that the display screen is not displaying an error.

8.5. Add a strike mark to the upper exhaust-side of the OHT front cover to track its number of runs (as shown in Figure 1. **Complete:** ☐

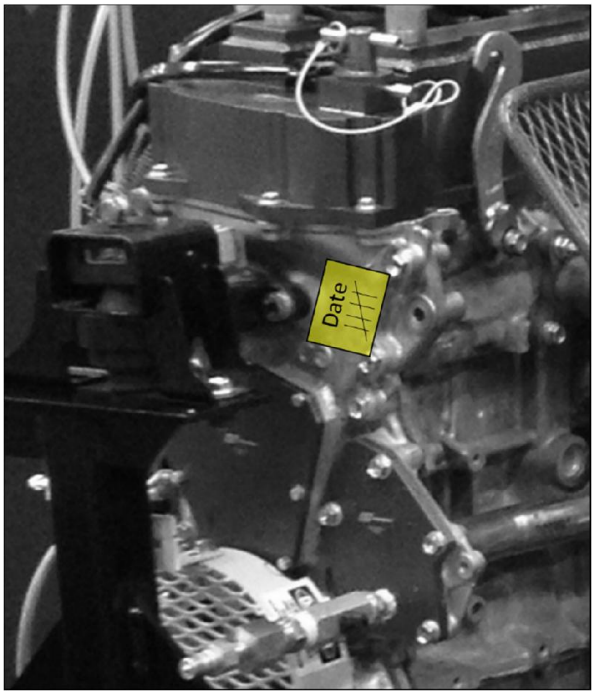


Figure 1 - Location for Strike Marks on OHT Front Cover

9. CONDUCT OIL PAN FLUSH:

9.1. *NOTE:* The oil pan flush is to be performed with the engine and all of the test stand accessories off.

9.2. *NOTE:* The oil pan flush must be performed using the dedicated IVB flush cart.

9.3. Install a new Motorcraft FL-1A oil filter on the flush cart. **Complete:** ☐

9.4. Remove the oil pan drain plug to confirm that there is no residual oil in the sump.
9.4.1. Reinstall the drain plug after any residual oil has drained from the pan. **Complete:** ☐

9.5. Confirm that the sump on the IVB flush cart is clean. **Complete:** ☐

9.6. Connect the wand (used to fill the sump) to the **outlet line** of the flush cart. **Complete:** ☐
9.6.1. Turn on the **outlet pump** of the flush cart.
9.6.2. Use the wand to transfer approximately 1-gallon of EF-411 into the flush cart sump.

9.7. Remove the rear oil pan drain plug. **Complete:** ☐
9.7.1. Connect the **outlet line** of the flush cart to the rear drain plug boss of the oil pan.

9.8. Remove the flush port cap on the side of the oil pan. **Complete:** ☐
9.8.1. Connect the **inlet line** of the flush cart to the flush port cap on the side of the oil pan.

9.9. Turn on the **inlet pump** of the flush cart.
9.9.1. Then turn on the **outlet pump** of the flush cart approximately 30-seconds later.
9.9.2. Let the flush cart run in this configuration for approximately 10-minutes. **Complete:** ☐
9.9.3. *NOTE:* Periodically monitor the oil level in the flush cart to make sure that the sump does not become fully drained.

9.10. After 10-minutes, turn of the **inlet pump**. **Complete:** ☐
9.10.1. Continue to run the **outlet pump** until oil stops flowing into the sump of the flush cart.

9.11. Disconnect flush cart from engine. **Complete:** ☐
9.11.1. Disconnect **outline line** of the flush cart and replace the rear drain plug.
9.11.2. Disconnect the **inlet line** of the flush cart and replace the cap on the side of the oil pan.

9.12. Properly dispose of the used EF-411 and oil filter. **Complete:** ☐

10. CONDUCT 1ST "FIRED" ENGINE OIL FLUSH (FL1 DR, 0.10 TEST HOURS):

10.1. Verify that the oil sump drain plug is tight. **Complete:** ☐

10.2. Measure 3000mL of new test oil and add this oil charge to the engine. **Complete:** ☐

10.2.1. **Enter the Time and Date:**

10.2.2. *NOTE:* This time and date is to be considered the official ACC start time of the test.

10.3. Confirm that the engine coolant system is charged with a mixture of 30% Dexcool and 70% deionized water. **Complete:** ☐

10.4. Confirm that the coolant system pressure cap is secure. **Complete:** ☐

10.5. Switch on the pressurized air valve to the coolant system pressure regulator and then apply 10-11psi of pressurized air to the coolant system. **Complete:** ☐

10.6. Remove the LO/TO equipment from the stand. **Complete:** ☐

10.7. Start the engine. **Complete:** ☐

10.7.1. Select all three checkboxes on the **Accessories** tab.
10.7.2. Press the **Begin Test** button.
10.7.3. This will bring the engine to **Start/Stop** conditions.
10.7.4. Start the engine.
10.7.5. Once the engine has stabilized press the **Begin Flush** button.

10.8. *NOTE:* The 1st engine flush is 6-minutes in duration and will utilize the following set points (Table 2):

Table 2 - Flush Operating Conditions

Engine Speed	1500 rpm
Torque	10 N*m
Engine Coolant In Temperature	49°C
Engine Oil Gallery Temperature	49°C
Exhaust Back Pressure	103.5 kPaa
Intake Air Pressure	0.07 kPag
Intake Air Temperature	32°C
Fuel Temperature	24°C
Rocker Cover Outlet Temperature	20°C
Coolant Flow Rate (Engine)	80 L/min
Coolant Flow Rate (Rocker Arm Cover)	120 L/min
Load Cell Temperature	45°C
Blowby Gas Temperature	29°C
Coolant Temperature Heater	OFF

10.9. Confirm that EasyTest is reading the critical PCM parameters ("can_XXX" parameter names) correctly via the CAN-Bus. **Complete:** ☐

10.10. At approximately 3-minutes into the 1st flush, please inspect the stand and record the actual values of the controlled parameters in Table 3:

Table 3 – 1st Engine Flush Inspection Sheet

Parameter Name	Target Value	Actual Value
AFR	14.7:1	**: 1**
EngineSpeed	1500 RPM	**RPM**
HUMID	11.5 ± 0.5	**g/kg**
PAIRIN	0.07±0.03 kPag	**kPag**
PCLEI	70±10 kPag	**kPag**
PEXH	103.5±1.0 kPaa	**kPaa**
PFUEL	325±75 kPag	**kPag**
POLGAL		**kPag**
TAIRIN	32.0±2.0 °C	**°C**
FCLEO	80±2 L/min	**L/min**
FRAC	120±2 L/min	**L/min**
TBBY	29.0±2.0 °C	**°C**
TCLEI	49.0 °C	**°C**
TFUEL	24.0±3.0 °C	**°C**
TLOADCELL	45.0 °C	**°C**
TOLGAL	49.0 °C	**°C**
TORQUE	10.0 N-m	**N-m**

TRCCLO	20.0 °C	**°C**

OPERATOR INITIALS:

DATE:

10.11. *NOTE:* EasyTest will bring the engine down to idle conditions (**Non-E shtdwn** condition set) and then it will stop the engine.

10.12. Once the engine has stopped, perform a compression and leak-down check on all four cylinders and record the measurements in Table 4.

10.12.1. Disconnect ignition coils. **Complete:** ☐

10.12.2. *NOTE*: When conducting the compression and leak-down check do not manually open the throttle body.

10.12.3. *NOTE*: Instead, remove the large rubber plug located near the rear of the intake manifold to provide adequate airflow through the engine.

Table 4 – S.O.T. Cylinder Compression and Leak-Down Results

Cylinder Number	Compression (kPa)	Leak-down Rate (%)
#1		
#2		
#3		
#4		

OPERATOR INITIALS:

DATE:

10.13. After the cylinder compression and leak-down checks are complete, use the appropriate LO/TO procedure to secure the stand. **Complete:** ☐

10.14. Remove both oil pan drain plugs and drain the engine's oil charge into a clean container.

10.14.1. Also, open both oil heat exchanger drain valves at the front of the stand and drain this oil into a clean container as well.

10.14.2. Allow all three locations to drain for 30-minutes. **Complete:** ☐

10.15. Take the 1-oz FL1 sample from this oil drain. **Complete:** ☐

11. CONDUCT 2nd "FIRED" ENGINE OIL FLUSH (FL2 DR, 0.20 TEST HOURS):

11.1. Verify that the sump drain plug is tight and the two heat exchanger valves are closed. **Complete:** ☐

11.2. Measure 3000mL of new test oil and add this oil charge to the engine. **Complete:** ☐

11.3. Remove the LO/TO equipment from the stand. **Complete:** ☐

11.4. Turn on the **ac02_HeaterENB** and **ac03_CoolPumps** accessories under the **Accessories** tab in EasyTest. **Complete:** ☐

11.4.1. *NOTE:* The **ac03_CoolPumps** accessory must be selected for 60-seconds before the **ac02_HeaterENB** accessory can be selected.

11.4.2. Press the **Begin Warming Sequence** button.

11.5. Select the **ac01_Ignition** accessory, press the **Begin Flush** button and start the engine.

11.5.1. Follow the prompts on the EasyTest screen. **Complete:** ☐

11.6. *NOTE:* The 2nd engine flush is 38-minutes in duration.

11.7. Approximately 5-minutes before the end of the flush, please inspect the stand and record the actual values of the controlled parameters in Table 5:

Table 5 – 2nd Engine Flush Inspection Sheet

Parameter Name	Target Value	Actual Value
AFR	14.7:1	**: 1**
EngineSpeed	1500 RPM	**RPM**
HUMID	11.5 ± 0.5	**g/kg**
PAIRIN	0.07±0.03 kPag	**kPag**
PCLEI	70±10 kPag	**kPag**

PEXH	103.5±1.0 kPaa	**kPaa**
PFUEL	325±75 kPag	**kPag**
POLGAL		**kPag**
TAIRIN	32.0±2.0 °C	**°C**
FCLEO	80±2 L/min	**L/min**
FRAC	120±2 L/min	**L/min**
TBBY	29.0±2.0 °C	**°C**
TCLEI	49.0 °C	**°C**
TFUEL	24.0±3.0 °C	**°C**
TLOADCELL	45.0 °C	**°C**
TOLGAL	49.0 °C	**°C**
TORQUE	10.0 N-m	**N-m**
TRCCLO	20.0 °C	**°C**

OPERATOR INITIALS: ☐

DATE: ☐

11.8. *NOTE:* EasyTest will bring the engine down to idle conditions and then it will stop the engine.

11.9. Use the appropriate LO/TO procedure to secure the stand. **Complete:** ☐

11.10. Remove both oil pan drains plug and drain the engine's oil charge into a clean container.

11.10.1. Also, open both oil heat exchanger drain valves at the front of the stand and drain this oil into a clean container as well.

11.10.2. Allow all three locations to drain for 30-minutes. **Complete:** ☐

11.11. Take the 1-oz FL2 sample from this oil drain. **Complete:** ☐

12.CONDUCT 3rd "FIRED" ENGINE OIL FLUSH (FL3 DR, 0.30 TEST HOURS):

12.1. Verify that the sump drain plug is tight and the two heat exchanger valves are closed. **Complete:** ☐

12.2. Measure 3000mL of new test oil and add this oil charge to the engine. **Complete:** ☐

12.3. Remove the LO/TO equipment from the stand. **Complete:** ☐

12.4. Turn on the **ac02_HeaterENB** and **ac03_CoolPumps** accessories under the **Accessories** tab in EasyTest. **Complete:** ☐

12.4.1. *NOTE:* The **ac03_CoolPumps** accessory must be selected for 60-seconds before the **ac02_HeaterENB** accessory can be selected.

12.4.2. Press the **Begin Warming Sequence** button.

12.5. Select the **ac01_Ignition** accessory, press the **Begin Flush** button and start the engine.

12.5.1. Follow the prompts on the EasyTest screen. **Complete:** ☐

12.6. *NOTE:* The 3rd engine flush is 38-minutes in duration.

12.7. Approximately 5-minutes before the end of the flush, please inspect the stand and record the actual values of the controlled parameters in Table 6:

Table 6 – 3rd Engine Flush Inspection Sheet

Parameter Name	Target Value	Actual Value
AFR	14.7:1	**: 1**
EngineSpeed	1500 RPM	**RPM**
HUMID	11.5 ± 0.5	**g/kg**
PAIRIN	0.07±0.03 kPag	**kPag**
PCLEI	70±10 kPag	**kPag**
PEXH	103.5±1.0 kPaa	**kPaa**
PFUEL	325±75 kPag	**kPag**
POLGAL		**kPag**

TAIRIN	32.0±2.0 °C	**°C**
FCLEO	80±2 L/min	**L/min**
FRAC	120±2 L/min	**L/min**
TBBY	29.0±2.0 °C	**°C**
TCLEI	49.0 °C	**°C**
TFUEL	24.0±3.0 °C	**°C**
TLOADCELL	45.0 °C	**°C**
TOLGAL	49.0 °C	**°C**
TORQUE	10.0 N-m	**N-m**
TRCCLO	20.0 °C	**°C**

OPERATOR INITIALS: ☐

DATE: ☐

12.8. *NOTE:* EasyTest will bring the engine down to idle conditions and then it will stop the engine.

12.9. Use the appropriate LO/TO procedure to secure the stand. **Complete:** ☐

12.10. Remove both oil pan drain plugs and drain the engine's oil charge into a clean container.

12.10.1. Also, open both oil heat exchanger drain valves at the front of the stand and drain this oil into a clean container as well.

12.10.2. Allow all three locations to drain for 30-minutes. **Complete:** ☐

12.11. Take the 1-oz FL3 sample from this oil drain. **Complete:** ☐

13.CONDUCT 4th "FIRED" ENGINE OIL FLUSH (FL4 DR, 0.40 TEST HOURS):

13.1. Verify that the sump drain plug is tight and the two heat exchanger valves are closed.
Complete: ☐

13.2. Measure 3000mL of new test oil and add this oil charge to the engine. **Complete:** ☐

13.3. Remove the LO/TO equipment from the stand. **Complete:** ☐

13.4. Turn on the **ac02_HeaterENB** and **ac03_CoolPumps** accessories under the **Accessories** tab in EasyTest. **Complete:** ☐

13.4.1. *NOTE:* The **ac03_CoolPumps** accessory must be selected for 60-seconds before the **ac02_HeaterENB** accessory can be selected.

13.4.2. Press the **Begin Warming Sequence** button.

13.5. Select the **ac01_Ignition** accessory, press the **Begin Flush** button and start the engine.

13.5.1. Follow the prompts on the EasyTest screen. **Complete:** ☐

13.6. *NOTE:* The 4th engine flush is 38-minutes in duration.

13.7. Approximately 5-minutes before the end of the flush, please inspect the stand and record the actual values of the controlled parameters in Table 7:

Table 7 – 4th Engine Flush Inspection Sheet

Parameter Name	Target Value	Actual Value
AFR	14.7:1	**: 1**
EngineSpeed	1500 RPM	**RPM**
HUMID	11.5 ± 0.5	**g/kg**
PAIRIN	0.07±0.03 kPag	**kPag**
PCLEI	70±10 kPag	**kPag**
PEXH	103.5±1.0 kPaa	**kPaa**
PFUEL	325±75 kPag	**kPag**
POLGAL		**kPag**
TAIRIN	32.0±2.0 °C	**°C**
FCLEO	80±2 L/min	**L/min**
FRAC	120±2 L/min	**L/min**

TBBY	29.0±2.0 °C	**°C**
TCLEI	49.0 °C	**°C**
TFUEL	24.0±3.0 °C	**°C**
TLOADCELL	45.0 °C	**°C**
TOLGAL	49.0 °C	**°C**
TORQUE	10.0 N-m	**N-m**
TRCCLO	20.0 °C	**°C**

OPERATOR INITIALS: ☐

DATE: ☐

13.8. *NOTE:* EasyTest will bring the engine down to idle conditions and then it will stop the engine.

13.9. Use the appropriate LO/TO procedure to secure the stand. **Complete:** ☐

13.10. Remove both oil pan drain plugs and drain the engine's oil charge into a clean container.

13.10.1. Also, open both oil heat exchanger drain valves at the front of the stand and drain this oil into a clean container as well.

13.10.2. Allow all three locations to drain for 30-minutes. **Complete:** ☐

13.11. Take the 1-oz FL4 sample from this oil drain. **Complete:** ☐

14. MEASURE THE INITIAL TEST OIL CHARGE:

14.1. *NOTE:* The next section will require the operator to record data on the **Oil Consumption Record.**

14.2. Take the 2-oz 0-HR oil drain. **Complete:** ☐

14.3. Obtain and weigh a clean container and record the value under **(A)** of the **Oil Consumption Record**. **Complete:** ☐

14.4. Measure 2400mL of new test oil using the clean container, weigh the container and oil charge, and record the value under **(B)** of the **Oil Consumption Record**. **Complete:** ☐

14.5. Calculate the initial oil charge weight and enter the value under **(C)** of the **Oil Consumption Record**. **Complete:** ☐

14.5.1. *IMPORTANT NOTE:* The weight of the test oil charge should never be less than 2000g.

14.6. Remove and clean the Oberg filter.

14.6.1. Replace the Oberg filter after it has dried. **Complete:** ☐

14.7. Verify that the engine oil sump drain plug is tight.

14.7.1. Add the oil charge to the engine. **Complete:** ☐

14.7.2. *IMPORTANT NOTE:* The operator that weighed and added the initial test oil charge must complete the fields below.

14.7.3. *IMPORTANT NOTE:* Allow the engine to sit for approximately 15-30 minutes before taking the dipstick measurement.

OIL PAN DIPSTICK (mm):	
OPERATOR INITIALS:	
DATE:	

14.8. Remove the LO/TO equipment from the stand. **Complete:** ☐

14.9. Turn on the **ac02_HeaterENB** and **ac03_CoolPumps** accessories under the **Accessories** tab in EasyTest. **Complete:** ☐

14.9.1. *NOTE:* The **ac03_CoolPumps** accessory must be selected for 60-seconds before the **ac02_HeaterENB** accessory can be selected.

14.10. Select the **ac01_Ignition** accessory and start the engine. **Complete:** ☐

14.11. Confirm that the Horiba unit is displaying a realistic AFR measurement. **Complete:** ☐

14.12. Proceed with the test macro. **Complete:** ☐

15.RUNNING THE TEST:

15.1. *NOTE:* EasyTest will run the following test program for 200-hours or 24,000 cycles (Table 8):

Table 8 - Sequence IVB Test Conditions

Parameter	Units	Stage 2→ 1	Stage1	Stage 1 →2	Stage 2
Duration	Sec.	8	7	8	7
Engine Speed	r/min	4300 to 800	800 ± 25	800 to 4300	4300 ± 25
Engine Torque	N-m	25 ± 2	25 ± 2	25 ± 2	25 ± 2
Coolant In Temperature	°C	49 ± 3	49 ± 3	49 ± 3	49 ± 3
Coolant Flow (Engine)	L/min	80 ± 2	80 ± 2	80 ± 2	80 ± 2
Coolant Flow (RAC)	L/min	120 ± 2	120 ± 2	120 ± 2	120 ± 2
Oil Gallery Temperature	°C	54 ± 3	54 ± 3	54 ± 3	54 ± 3
RAC Coolant Out Temperature	°C	20 ± 2	20 ± 2	20 ± 2	20 ± 2
Fuel Rail Temperature	°C	24 ± 3	24 ± 3	24 ± 3	24 ± 3
Load Cell Temperature	°C	45 ± 3	45 ± 3	45 ± 3	45 ± 3
Intake Air Temperature	°C	32 ± 3	32 ± 3	32 ± 3	32 ± 3
Blowby Gas Temperature	°C	29 ± 2	29 ± 2	29 ± 2	29 ± 2
Intake Air Pressure	kPa(g)	0.25	0.25	0.25	0.25
Intake Air Humidity	g/kg	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5
Exhaust Pressure	kPa(a)	Barometric	Barometric	104.5 ± 1	104.5 ± 1
Engine Coolant Pressure	kPa	70 ± 10	70 ± 10	70 ± 10	70 ± 10
Fuel Rail Pressure	kPa	335 ± 10	335 ± 10	335 ± 10	335 ± 10
Air-to-Fuel Ratio	:1	Record	14.5 ± 0.5	Record	14.5 ± 0.5

15.2. *NOTE:* At predetermined intervals, EasyTest will bring the engine down to idle conditions for intermediate oil sampling (Table 9).

15.2.1. The blue light on the test stand light stalk will illuminate.

Table 9 - Sequence IVB Oil Sampling Schedule

Test Hours	Sample Size	Comments or Special Instructions
FL1, FL2, FL3, FL4	1-oz	These are the oil flush samples.
0	2-oz	Take sample from oil can.
105, 110, 115, 120, 130, 135, 140, 145, 155, 160, 165, 170, 180, 185, 190, 195	3 ml	
25, 50, 75, 100, 125, 150, 175	1-oz	Place yellow mark on bottle cap.
200 (E.O.T.)	4-oz	Take sample while engine is running.

15.3. *NOTE:* Check the stand once an hour for mechanical problems, leaks or warning lights in EasyTest and complete the appropriate entry in the **Sequence IVB Hourly Log**.

15.4. *NOTE:* Record any problems or unscheduled downtime in the **Sequence IVB Downtime Record**.

16.OIL SAMPLING INSTRUCTIONS:

16.1. *NOTE:* Oil samples need to be taken during the test at 25-hour increments (3,000 cycles) between 0HR and 100HR.
16.1.1. Reference Table 9 to determine which oil samples require a yellow mark on the bottle cap.

16.2. *NOTE:* Oil samples need to be taken during the test at 5-hour increments (600 cycles) between 100HR and 200HR.

16.3. *NOTE:* Obtain these samples when EasyTest enters its oil sampling stage and the blue light illuminates.

16.4. Use the oil sample valve to remove an 8-oz purge sample from the engine. **Complete:** ☐

16.5. Once the purge is removed, draw the correct intermediate sample. **Complete:** ☐
16.5.1. *IMPORANT:* Review the Sequence IVB Oil Sampling Schedule to determine the correct sample volume.

16.6. Label the oil sample bottle.
16.6.1. If the sample was taken at a 25-hour interval (25HR, 50HR, 75HR, 100HR, 125HR, 150HR or 175HR), make sure that the sample bottle cap is clearly marked with yellow paint. **Complete:** ☐

16.7. Return the 8-oz purge sample to the engine through the rocker arm cover using the appropriate purge return device. **Complete:** ☐
16.7.1. The purge return port is located near the left-front corner of the rocker arm cover and is held in place with a removable pin.

16.8. Proceed with the test macro. **Complete:** ☐

17.END OF TEST INSTRUCTIONS:

17.1. *NOTE:* When the test cycle is complete, EasyTest will bring the test stand to idle conditions and then stop the engine.

17.2. Once the engine has stopped, perform a compression and leak-down check on all four cylinders and record the measurements in Table 10.
17.2.1. Disconnect ignition coils. **Complete:** ☐

17.2.2. *NOTE*: When conducting the compression and leak-down check do not manually open the throttle body.

17.2.3. *NOTE*: Instead, remove the large rubber plug located near the rear of the intake manifold to provide adequate airflow through the engine.

Table 10 – E.O.T. Cylinder Compression and Leak-Down Results

Cylinder Number	Compression (kPa)	Leak-down Rate (%)
#1		
#2		
#3		
#4		

17.3. Allow the engine to sit for approximately 15-30 minutes and then take the dipstick reading.

OIL PAN DIPSTICK (mm):	
OPERATOR INITIALS:	
DATE:	

17.4. Enter the pre-test and post-test compression and leak-down measurements (Table 4 and Table 10) in the appropriate fields of the **Engine Build** screen in the LTR system. **Complete:** ☐

17.5. Use the appropriate LO/TO procedure to secure the stand. **Complete:** ☐

17.6. Perform the necessary E.O.T. lifter clearance measurements (Table 11). **Complete:** ☐

Table 11 - End of Test (E.O.T.) Lifter Clearances

Intake Side of Engine								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Grade								

Clearance (in)								
Exhaust Side of Engine								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Grade								
Clearance (in)								

OPERATOR INITIALS:

DATE:

17.7. Obtain and weigh a clean container and record the value under **(E)** of the **Oil Consumption Record**. **Complete:** ☐

17.8. Remove the oil pan drain plug and drain the oil charge into the clean and weighed container.

17.8.1. Also, open both oil heat exchanger drain valves and allow any trapped oil to drain into the same container. **Complete:** ☐

17.9. Drain all three locations for 30-minutes. **Complete:** ☐

17.10. Weigh the final oil drain and container and record the value under **(F)** of the **Oil Consumption Record**. **Complete:** ☐

17.11. Calculate the weight of the E.O.T. drain oil and record the value under **(G)** of the **Oil Consumption Record**. **Complete:** ☐

17.12. Place the final drain in a 1-gallon container. **Complete:** ☐

17.13. Unplug the PCM. **Complete:** ☐

17.14. E.O.T. Stand Hardware Time (XXXX:XX:XX):

17.15. Remove the test camshafts and lifters and place them in a clean Sequence IVB test kit tray.

17.15.1. Record the intake and exhaust lifter sizes and ID numbers in the appropriate fields of the **Engine Build** screen in the LTR system. **Complete:** ☐

17.16. Clean the hardware and deliver it to the Metrology Lab. **Complete:** ☐

17.17. Confirm that the following written and completed documentation has been included in the test packet:

17.17.1. Completed **GASW438** checklist **Complete:** ☐

17.17.2. Completed **Sequence IVB Hourly Log** **Complete:** ☐

17.17.3. Completed **IVB Downtime Record** **Complete:** ☐

17.17.4. **Lifter Clearances and Grades – *Start of Test (S.O.T.)*** Sheet **Complete:** ☐

17.17.5. **Lifter Clearances and Grades – *End of Test (E.O.T.)*** Sheet **Complete:** ☐

17.17.6. **Sprocket Diameter and Camshaft End Play** Sheet **Complete:** ☐

17.18. Open the **ET2 DataViewer** icon on the desktop of the EasyTest screen. **Complete:** ☐

17.18.1. Choose the current test from the **Choose a Test** drop-down menu and hit the **Load Trace Data** button (Figure 2):

17.18.2. Close the **EasyTest2 Data Viewer** screen.

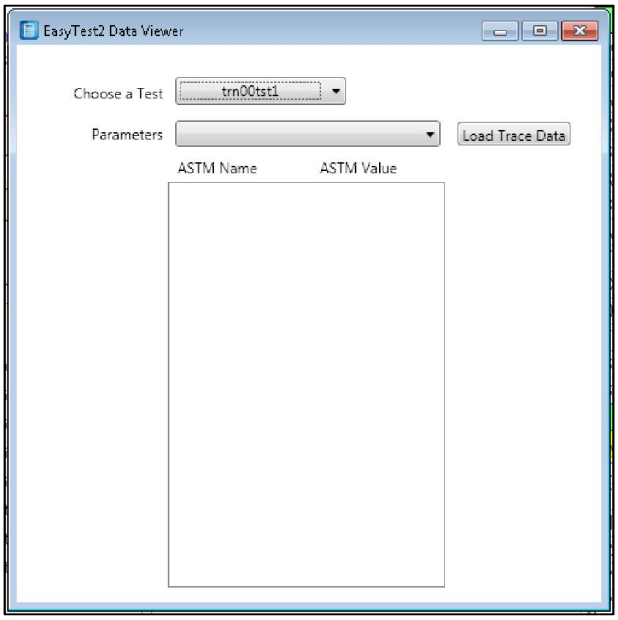


Figure 2 - ET2 DataViewer Pop-Up Menu

18. HOUSEKEEPING:

18.1. Clean the inside of the rocker arm cover to remove any emulsion or oil. **Complete:** ☐

18.2. Clean the oil sampling hardware and glassware. **Complete:** ☐

18.3. Drain all four condensation traps. **Complete:** ☐

18.4. Perform the necessary housekeeping around the stand. **Complete:** ☐

18.5. Return remaining new oil to storage. **Complete:** ☐

18.6. Clean the external blowby control system.

18.6.1. Remove and clean the blowby heat exchanger. **Complete:** ☐

18.6.2. Remove and clean the rocker arm cover oil separator. **Complete:** ☐

18.6.3. Replace the clear Tygon hoses. **Complete:** ☐

19. POPULATE REQUIRED LTR TEST REPORTING FIELDS:

19.1. Populate the required fields in the **LTR Test Reporting** system. **Complete:** ☐

19.1.1. *Link to LTR:* http://lz/ltr/

19.1.2. Select the correct test number.

19.1.3. Select the **Engine Build** screen (Figure 3).

19.1.4. Populate the lifter **size**, lifter **ID**, **compression** and **leak down** fields.

19.1.5. Press the **Save** button.

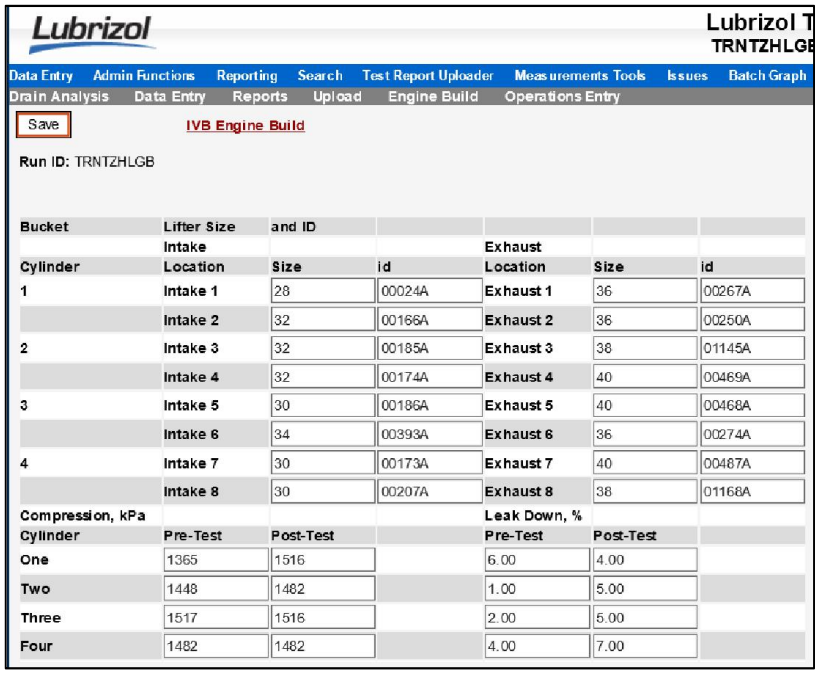


Figure 3 - LTR Engine Build Screen

20.OIL CONSUMPTION RECORD:

Description	Equation	Weight (g)

A. Clean and Empty Container Weight (S.O.T.)	**A**	
B. Oil Charge and Container Weight (S.O.T.)	**B**	
C. Initial Oil Charge (S.O.T.)	**C = B - A**	
IMPORTANT NOTE: **The initial oil charge should never weigh less than 2000g.**		
E. Clean and Empty Container Weight (E.O.T.)	**E**	
F. Drain Oil and Container Weight (E.O.T.)	**F**	
G. Drain Oil (E.O.T.)	**G = F - E**	

OPERATOR INITIALS:

DATE:

Intertek

Test Operation Lab Instructions

Sequence IVB Test Instructions

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Pre-test Instructions	**Initials**
1) Verify that all of the driveline bolts are tight and that the driveshaft has been lubricated, before starting Flush 1.	
2) Verify that the external oil system has been cleaned before starting Flush 1.	
3) Verify that the load calibration has been conducted before starting Flush 1.	
4) Initilize a new test in LabVIEW. Click the **Test Initialization Screen** button on the Main Menu, enter the test code, obtained from the CLTD start sheet, in the **Slot Number** box, click the **INIT** button and click "Yes".	
5) Make sure that the green indicators are **"OFF"** for **Run Break In**, **Run Flushes** and **Run Aging**.	
6) Enter **24000** in the **EOT Cycle** box.	
7) Enter **5** in the **> 100 Sample Rate in Hours** box.	
8) Click the green **Write Testsave File** button.	
9) **Obtain and label the oil sample jars for the entire test. Place all labeled sample jars in the aluminum sample jar rack located on the test stand's instrument cabinet door.**	
10) Take an 8 ounce sample of the new test oil. Deliver the new oil sample to the chem lab.	
11) Drain all pressure traps and clean the dynamometer coolant strainer.	
12) Check the test screen for any unusual readings while the engine is down. Make repairs or have the instrumentation group recalibrate if necessary.	

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Pre-test Instructions Cont'd **Initials**

13) Check the test scheduling for instructions on which test fuel/fuel tank/fuel line to run this test on. Verify that the test stand is connected to the correct fuel line at the Toyota patch panel and make changes if necessary. ***Please record the test fuel, fuel tank and fuel line in the space provided below.***

Test Fuel _____

Fuel Tank _____

Fuel Line _____

14) Record the Fuel Totalizer value at S.O.T. at **E** on the Oil and Fuel Consumption Record **(Page 13 of 21)**.

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct First Engine Oil Flush

Initials

1) Measure out **3000 ml** of new test oil. Verify the engine oil sump drain plug is tight and then add the oil charge to the engine. _____

2) Top off the engine coolant with a mixture of 30% Dexcool and 70% deionized water. Secure the coolant system pressure cap, switch on the pressurized air valve to the coolant system pressure regulator and then apply 10 - 11 psi of pressurized air to the coolant system. Switch on the coolant heater circuit breaker. Both are located in the fluid rack. _____

3) Turn the starter disconnect switch to the **"ON"** position and push the ESTOP switch **"IN"**. _____

4) Click the **Start** button on the Test Screen. LabVIEW will energize all systems and will start preheating the engine coolant to 50°C. _____

5) Once the engine coolant is above 35°C, start the engine. Turn on the main fuel supply which is located inside the 8020 rack and make sure the starter disconnect switch is in the **"ON"** position. Then using the starter button at the test stand (not the one in the control room), start the engine. Once the engine has started, check for coolant and oil leaks and start the first engine flush. _____

6) LabVIEW will increase the RPM to 1500 rpm and increase the LD to 10 Nm. Eng Coolant In T will be controlled to 50°C. LabVIEW will hold these conditions for **6 minutes**. ***At 3 minutes before the end of the flush please record the parameters listed below in the space provided.*** _____

Dyno_Speed	_____	Blowby Gas T	_____
Eng Load	_____	Exh Gas Pr	_____
Oil Gallery T	_____	Inlet (Intake) Air Pr	_____
Load Cell T	_____	Rocker Cover Coolant Out T	_____
Eng Coolant In T	_____	Humidity	_____
Coolant Flow	_____	Eng Coolant Pr	_____
Rocker Cover Flow	_____	Fuel Pr	_____
Inlet (Intake) Air T	_____	Oil Gallery Pr	_____
Fuel T	_____	Engine Speed	_____

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct First Engine Oil Flush Cont'd **Initials**

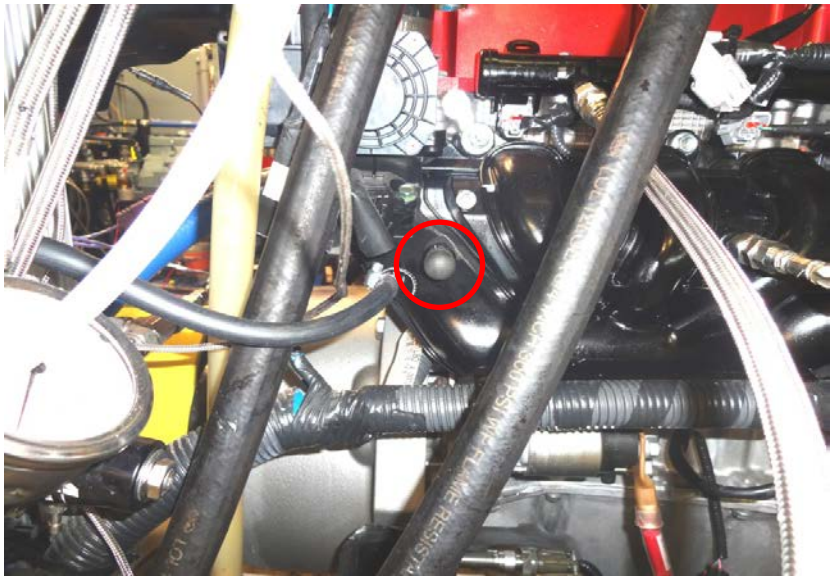
7) LabVIEW will bring the engine down to idle conditions and then stop the engine. Perform a cranking compression test and cylinder leakdown test for all four cylinders and record on the next page.

Cylinder #	Compression, psi	Leakdown Rate, %
1		
2		
3		
4		

Typical range for compression is 150 - 250 psi. If below 180 psi, recheck with a second gage. If below 140 psi after checking with two gages, contact engineer or engineering aide before proceeding.

Typical range for leakdown is 0 - 30 %. If above 20 %, recheck with a second gage. If above 40 % after checking with two gages, contact engineer or engineering aide before proceeding.

NOTE: When conducting the compression and cylinder leakdown tests **do not** manually open the throttle body. Instead, **remove the large rubber plug** located towards the rear of the intake manifold (see photo below). This will provide adequate airflow through the engine.



Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct First Engine Oil Flush Cont'd **Initials**

8) After the compression test and cylinder leakdowns are complete, turn the starter disconnect switch to the **"OFF"** position and pull the ESTOP switch **"OUT"**. Turn off the main fuel supply in the 8020 rack. Then remove the oil pan drain plug and drain the oil pan into a clean container. Also open both oil heat exchanger drain locations and drain both locations into a clean container. Drain all three oil drain locations for **30 minutes**. At the end of 30 minutes secure all drains. Then take a one ounce oil sample from the oil drain and label the drain with hours of FL1. Deliver the oil sample to the chem lab and then discard the oil drain.

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct Second Engine Oil Flush

Initials

1) Measure out **3000 ml** of new test oil. Verify the engine oil sump drain plug is tight and then add the oil charge to the engine. _____

2) Turn the starter disconnect switch to the **"ON"** position and push the ESTOP switch **"IN"**. _____

3) Click the **Start** button on the Test Screen. LabVIEW will energize all systems and will start preheating the engine coolant to 50°C. _____

4) Once the engine coolant reaches 50°C, start the engine. Turn on the main fuel supply which is located inside the 8020 rack and make sure the starter disconnect switch is in the **"ON"** position. Then using the starter button at the test stand (not the one in the control room), start the engine. Once the engine has started, check for coolant and oil leaks and start the first engine flush. _____

5) LabVIEW will increase the RPM to 1500 rpm and increase the LD to 10 Nm. Eng Coolant In T will be controlled to 50°C. LabVIEW will hold these conditions for **38 minutes**. ***At 5 minutes before the end of the flush please record the parameters listed below in the space provided.*** _____

Dyno_Speed	_____	Blowby Gas T	_____
Eng Load	_____	Exh Gas Pr	_____
Oil Gallery T	_____	Inlet (Intake) Air Pr	_____
Load Cell T	_____	Rocker Cover Coolant Out T	_____
Eng Coolant In T	_____	Humidity	_____
Coolant Flow	_____	Eng Coolant Pr	_____
Rocker Cover Flow	_____	Fuel Pr	_____
Inlet (Intake) Air T	_____	Oil Gallery Pr	_____
Fuel T	_____	Engine Speed	_____

6) LabVIEW will bring the engine down to idle conditions and then stop the engine. When the engine stops, turn the starter disconnect switch to the **"OFF"** position and pull the ESTOP switch **"OUT"**. Turn off the main fuel supply in the 8020 rack. Then remove the oil pan drain plug and drain the oil pan into a clean container. Also open both oil heat exchanger drain locations and drain both locations into a clean container. Drain all three oil drain locations for **30 minutes**. At the end of 30 minutes secure all drains. Then take a one ounce oil sample from the oil drain and label the drain with hours of FL2. Deliver the oil sample to the chem lab and then discard the oil drain. _____

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct Third Engine Oil Flush

Initials

1) Measure out **3000 ml** of new test oil. Verify the engine oil sump drain plug is tight and then add the oil charge to the engine. _____

2) Turn the starter disconnect switch to the **"ON"** position and push the ESTOP switch **"IN"**. _____

3) Click the **Start** button on the Test Screen. LabVIEW will energize all systems and will start preheating the engine coolant to 50°C. _____

4) Once the engine coolant reaches 50°C, start the engine. Turn on the main fuel supply which is located inside the 8020 rack and make sure the starter disconnect switch is in the **"ON"** position. Then using the starter button at the test stand (not the one in the control room), start the engine. Once the engine has started, check for coolant and oil leaks and start the first engine flush. _____

5) LabVIEW will increase the RPM to 1500 rpm and increase the LD to 10 Nm. Eng Coolant In T will be controlled to 50°C. LabVIEW will hold these conditions for **38 minutes**. ***At 5 minutes before the end of the flush please record the parameters listed below in the space provided.*** _____

Dyno_Speed	_____	Blowby Gas T	_____
Eng Load	_____	Exh Gas Pr	_____
Oil Gallery T	_____	Inlet (Intake) Air Pr	_____
Load Cell T	_____	Rocker Cover Coolant Out T	_____
Eng Coolant In T	_____	Humidity	_____
Coolant Flow	_____	Eng Coolant Pr	_____
Rocker Cover Flow	_____	Fuel Pr	_____
Inlet (Intake) Air T	_____	Oil Gallery Pr	_____
Fuel T	_____	Engine Speed	_____

6) LabVIEW will bring the engine down to idle conditions and then stop the engine. When the engine stops, turn the starter disconnect switch to the **"OFF"** position and pull the ESTOP switch **"OUT"**. Turn off the main fuel supply in the 8020 rack. Then remove the oil pan drain plug and drain the oil pan into a clean container. Also open both oil heat exchanger drain locations and drain both locations into a clean container. Drain all three oil drain locations for **30 minutes**. At the end of 30 minutes secure all drains. Then take a one ounce oil sample from the oil drain and label the drain with hours of FL3. Deliver the oil sample to the chem lab and then discard the oil drain. _____

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct Fourth Engine Oil Flush

Initials

1) Measure out **3000 ml** of new test oil. Verify the engine oil sump drain plug is tight and then add the oil charge to the engine. _____

2) Turn the starter disconnect switch to the **"ON"** position and push the ESTOP switch **"IN"**. _____

3) Click the **Start** button on the Test Screen. LabVIEW will energize all systems and will start preheating the engine coolant to 50°C. _____

4) Once the engine coolant reaches 50°C, start the engine. Turn on the main fuel supply which is located inside the 8020 rack and make sure the starter disconnect switch is in the **"ON"** position. Then using the starter button at the test stand (not the one in the control room), start the engine. Once the engine has started, check for coolant and oil leaks and start the first engine flush. _____

5) LabVIEW will increase the RPM to 1500 rpm and increase the LD to 10 Nm. Eng Coolant In T will be controlled to 50°C. LabVIEW will hold these conditions for **38 minutes**. ***At 5 minutes before the end of the flush please record the parameters listed below in the space provided.*** _____

Dyno_Speed	_____	Blowby Gas T	_____
Eng Load	_____	Exh Gas Pr	_____
Oil Gallery T	_____	Inlet (Intake) Air Pr	_____
Load Cell T	_____	Rocker Cover Coolant Out T	_____
Eng Coolant In T	_____	Humidity	_____
Coolant Flow	_____	Eng Coolant Pr	_____
Rocker Cover Flow	_____	Fuel Pr	_____
Inlet (Intake) Air T	_____	Oil Gallery Pr	_____
Fuel T	_____	Engine Speed	_____

6) LabVIEW will bring the engine down to idle conditions and then stop the engine. When the engine stops, turn the starter disconnect switch to the **"OFF"** position and pull the ESTOP switch **"OUT"**. Turn off the main fuel supply in the 8020 rack. Then remove the oil pan drain plug and drain the oil pan into a clean container. Also open both oil heat exchanger drain locations and drain both locations into a clean container. Drain all three oil drain locations for **30 minutes**. At the end of 30 minutes secure all drains. **Be sure to reinstall and tighten the plugs on the two heat exchanger drain valves.** Then take a one ounce oil sample from the oil drain and label the drain with hours of FL4. Deliver the oil sample to the chem lab and then discard the oil drain. _____

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct Engine Oil Test	**Initials**
1) Obtain and weigh a clean container and record the value at **A** on the Oil and Fuel Consumption Record (**Page 13 of 21**).	
2) Measure out **2400 ml** of new test oil in the **weighed** clean container, weigh the initial oil charge and container, and record the value at **B** on the Oil and Fuel Consumption Record (**Page 13 of 21**).	
3) Clean the Oberg oil filter and re-install the Oberg oil filter.	
4) Verify the engine oil sump drain plug is tight, the plugs on the two heat exchanger drain valves are installed and tight and then add the oil charge to the engine.	
5) Turn the starter disconnect switch to the **"ON"** position and push the ESTOP switch **"IN"**.	
6) In the "Test Initialization Screen" on the LabVIEW Main Menu, turn off **"Run Flushes"** and turn on **"Run Oil Level"**.	
7) Click the **Start** button on the Test Screen. LabVIEW will energize all systems and will start preheating the engine coolant to 50°C.	
8) Once the engine coolant reaches 50°C, start the engine. Turn on the main fuel supply which is located inside the 8020 rack and make sure the starter disconnect switch is in the **"ON"** position. Then using the starter button at the test stand (not the one in the control room), start the engine. Once the engine has started, check for coolant and oil leaks and start the first engine flush.	
9) LabVIEW will automatically run the engine for 10 minutes at 1000 rpms, then shut down the engine, allow it to soak down for 10 minutes then prompt to dip the engine. Dip the engine with the red OHT dipstick, and record the value at **G** on the Oil and Fuel Consumption Record (**Page 13 of 21**).	
10) In the "Test Initialization Screen" on the LabVIEW Main Menu, turn off **"Run Oil Level"**.	
11) Click the **Start** button on the Test Screen. LabVIEW will energize all systems and will start preheating the engine coolant to 50°C.	

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Conduct Engine Oil Test Cont'd **Initials**

12) Once the engine coolant reaches 50°C, start the engine. Turn on the main fuel supply which is located inside the 8020 rack and make sure the starter disconnect switch is in the **"ON"** position. Then using the starter button at the test stand (not the one in the control room), start the engine. Once the engine has started, check for coolant and oil leaks and start the first engine flush.

13) LabVIEW will automatically run the **7-8 Test Cycle** as defined below for **24,000 cycles / ≈ 200 hours**.

Stage	2 to 1 Ramp	1	1 to 2 Ramp	2
Time, seconds	8	7	8	7
Dyno_Speed	4300 to 800	800 ± 25	800 to 4300	4300 ± 25
Eng Load	25 ± 2	25 ± 2	25 ± 2	25 ± 2
Oil Gallery T	54 ± 2	54 ± 2	54 ± 2	54 ± 2
Load Cell T	45 ± 2	45 ± 2	45 ± 2	45 ± 2
Eng Coolant In T	49 ± 2	49 ± 2	49 ± 2	49 ± 2
Coolant Flow	80 ± 1	80 ± 1	80 ± 1	80 ± 1
Rocker Cover Flow	120 ± 1	120 ± 1	120 ± 1	120 ± 1
Inlet (Intake) Air T	32 ± 2	32 ± 2	32 ± 2	32 ± 2
Fuel T	24 ± 2	24 ± 2	24 ± 2	24 ± 2
Blowby Gas T	29 ± 2	29 ± 2	29 ± 2	29 ± 2
Exh Gas Pr	104.5 to baro	≈ baro	baro to 104.5	104.5 ± 1
Inlet (Intake) Air Pr	0.25 ± 0.10	0.25 ± 0.10	0.25 ± 0.10	0.25 ± 0.10
Rocker Cover Coolant Out T	20 ± 2	20 ± 2	20 ± 2	20 ± 2
Humidity	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5
Eng Coolant Pr	70 ± 10	70 ± 10	70 ± 10	70 ± 10
Fuel Pr	335 ± 10	335 ± 10	335 ± 10	335 ± 10

LabVIEW will bring the engine down to idle (Stage 1 conditions) for intermediate oil samples every 25 hours or 3,000 cycles for test hours 0 - 100 hours and every 5 hours or 600 cycles for test hours 100 - 200 hours. See the oil sample section for oil sample instructions. Manual data logging and cell checks are hourly.

14) Since there are no fresh oil additions during test operation, once the test is on-test, deliver the new oil container(s) with any retains to the upper loading dock for pick-up by oil inventory.

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

End of Test Instructions

Initials

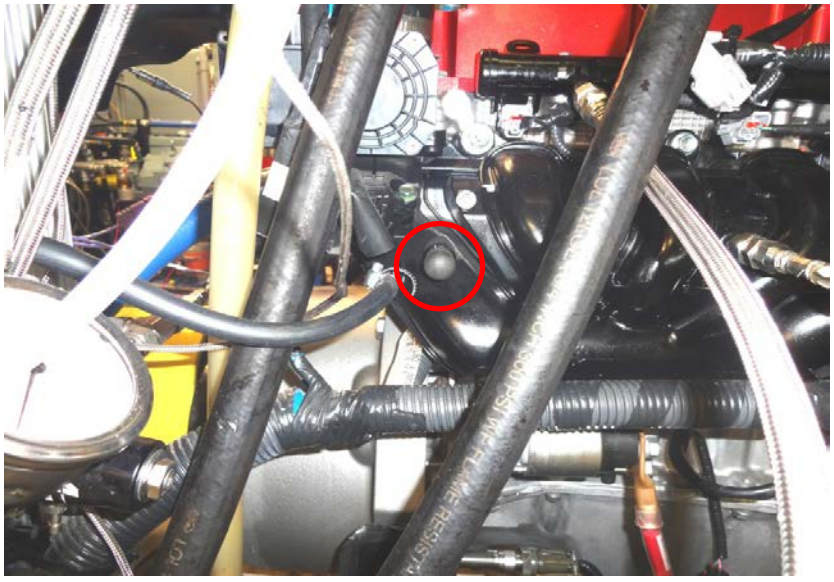
1) LabVIEW will run the test for **24,000 cycles / ≈ 200 hours** and then bring the engine down to idle conditions and then stop the engine. When the engine stops, perform a cranking compression test and cylinder leakdown test for all four cylinders and record the values below. Perform these two tests ASAP after the engine shuts down at 200 hours. They **must be performed within 30 minutes of the engine shut down** so that the engine and oil are still warm.

Cylinder #	Compression, psi	Leakdown Rate, %
1		
2		
3		
4		

Typical range for compression is 150 - 250 psi. If below 180 psi, recheck with a second gage. If below 140 psi after checking with two gages, contact engineer or engineering aide before proceeding.

Typical range for leakdown is 0 - 30 %. If above 20 %, recheck with a second gage. If above 40 % after checking with two gages, contact engineer or engineering aide before proceeding.

NOTE: When conducting the compression and cylinder leakdown tests **do not** manually open the throttle body. Instead, **remove the large rubber plug** located towards the rear of the intake manifold (see photo below). This will provide adequate airflow through the engine.



Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

End of Test Instructions Cont'd

Initials

2) After the compression and cylinder leakdown tests have been conducted, allow the engine soak down for 10 minutes then dip the engine with the red OHT dipstick, and record the value at **H** on the Oil and Fuel Consumption Record (**Page 13 of 21**). _____

3) Obtain and weigh a clean container and record the value at **C** on the Oil and Fuel Consumption Record (**Page 13 of 21**). _____

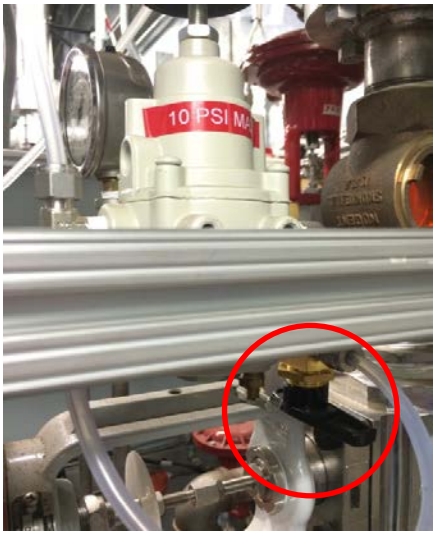
4) After the end of test cranking compression tests and cylinder leakdowns are complete, turn the starter disconnect switch to the **"OFF"** position and pull the ESTOP switch **"OUT"**. Turn off the main fuel supply in the 8020 rack. Then remove the oil pan drain plug and drain the oil pan into the **weighed** clean container. Also open both oil heat exchanger drain locations and drain both locations into the **weighed** clean container. Drain all three oil drain locations for 30 minutes. At the end of 30 minutes secure all drains. _____

5) Weigh the final oil drain and container and record the value at **D** on the Oil and Fuel Consumption Record (**Page 13 of 21**). _____

6) Place the final drain in a one gallon can and deliver to oil storage. _____

7) Record the Fuel Totalizer value at E.O.T. at **F** on the Oil and Fuel Consumption Record (**Page 13 of 21**). _____

8) Switch off the circuit breaker to the coolant heater and the pressurized air valve to the coolant system pressure regulator. Both are located in the fluid rack. _____



Oil and Fuel Consumption Record

Sequence IVB

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

A: Clean and Empty Container Weight (g)

A = _____ g

B: Initial Oil Charge & Container Weight (g)

B = _____ g

C: Clean and Empty Container Weight (g)

C = _____ g

D: Final Oil Drain & Container Weight (g)

D = _____ g

E: Fuel Totalizer Value at S.O.T. (lbs)

E = _____ lbs

F: Fuel Totalizer Value at E.O.T. (lbs)

F = _____ lbs

G: Test Oil Charge - Initial Dipstick Reading (mm)

G = _____ mm ***(use OHT dipstick top scale)***

H: Test Oil Charge - Final Dipstick Reading (mm)

H = _____ mm ***(use OHT dipstick top scale)***

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Oil Sample Instructions

Oil samples need to be drawn during the test every 25 hours or 3,000 cycles for test hours 0 - 100 hours and every 5 hours or 600 cycles for test hours 100 - 200 hours. Obtain these samples when LabVIEW goes to the Oil Sampling stage, by following the instructions below.

1) Use the oil sample valve to remove the purge sample and draw the intermediate oil sample.

2) Remove an 8 ounce purge sample from the engine.

3) **Look at the Oil Samples Chart and/or Operations Checklist to determine the size of the oil sample required.** Obtain the oil sample and label with the appropriate information, including test hour. Make sure that the oil sample is obtained from a separate container other than the purge oil.

4) Return the 8 ounce purge sample to the engine.

5) Press button on LabVIEW Test Screen to return to test conditions.

6) Deliver the oil sample to the chem lab.

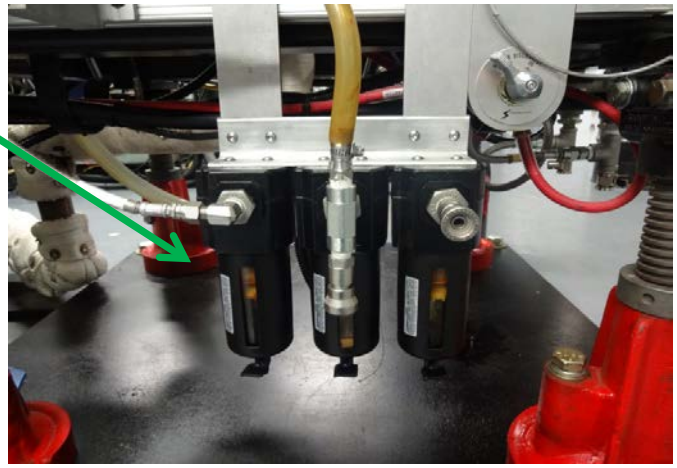
Use this jar for the 3 ml oil samples.

Use this jar for the 1 oz oil samples.

Sequence IVB

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

TEST CYCLE	Stage	SOT	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
Torque Calibration																						
Manual Data Logging			ONCE EVERY HOUR																			
Oil Consumption																						
Record Fuel Totalizer Value																						
3 ml Oil Sample	1																					
1 Ounce Oil Sample	1																					
Drain Condensation Traps		CHECK AND DRAIN IF NEEDED ONCE PER SHIFT																				

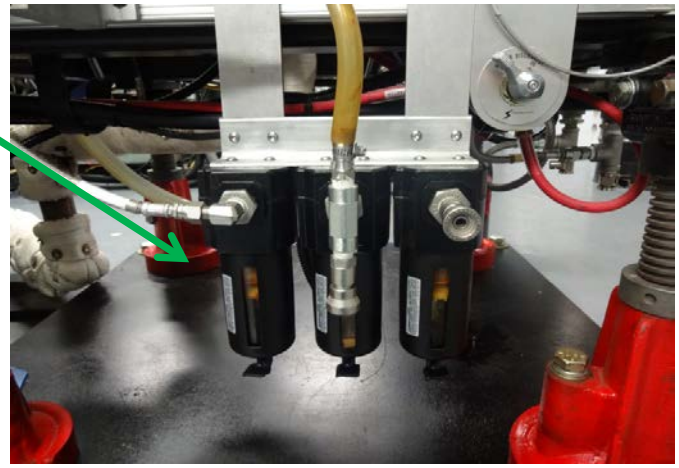


Condensate traps are located under the left side of the engine frame when looking at the stand from the front.

Sequence IVB

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

TEST CYCLE	Stage	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200
Torque Calibration																						
Manual Data Logging		ONCE EVERY HOUR																				
Oil Consumption																						
Record Fuel Totalizer Value																						
3 ml Oil Sample	1																					
1 Ounce Oil Sample	1																					
Drain Condensation Traps		CHECK AND DRAIN IF NEEDED ONCE PER SHIFT																				



Condensate traps are located under the left side of the engine frame when looking at the stand from the front.

Downtime Record

Sequence IVB

Test Number: IVB100-0-54

Oil Code: EG-0034/CMIR-123245

Unscheduled Shutdown	Stand Maintenance	Part Replacement	Operator	Date	Stage	Cycle	Test Time	Problem Statement/Action Taken/Comments	Shutdown Time	On-Test Time	Down Time
									IF SHUTDOWN		

If an extended shutdown, please Switch off the circuit breaker to the coolant heater and the pressurized air valve to the coolant system pressure regulator.

Down Time (hrs:min) = On-Test Time (hrs:min) - Shutdown Time (hrs:min)

Downtime Record

Sequence IVB

Test Number: IVB100-0-54

Oil Code: EG-0034/CMIR-123245

Unscheduled Shutdown	Stand Maintenance	Part Replacement	Operator	Date	Stage	Cycle	Test Time	Problem Statement/Action Taken/Comments	Shutdown Time	On-Test Time	Down Time
									IF SHUTDOWN		

If an extended shutdown, please Switch off the circuit breaker to the coolant heater and the pressurized air valve to the coolant system pressure regulator.

Down Time (hrs:min) = On-Test Time (hrs:min) - Shutdown Time (hrs:min)

Downtime Record

Sequence IVB

Test Number: IVB100-0-54

Oil Code: EG-0034/CMIR-123245

Unscheduled Shutdown	Stand Maintenance	Part Replacement	Operator	Date	Stage	Cycle	Test Time	Problem Statement/Action Taken/Comments	Shutdown Time	On-Test Time	Down Time
									IF SHUTDOWN		

If an extended shutdown, please Switch off the circuit breaker to the coolant heater and the pressurized air valve to the coolant system pressure regulator.

Down Time (hrs:min) = On-Test Time (hrs:min) - Shutdown Time (hrs:min)

Sequence IVB Oil Samples

Test Hour	Oil Sample Size	Oil Sample Jar
FL1	1 ounce	
FL2	1 ounce	
FL3	1 ounce	
FL4	1 ounce	
0 (NEW OIL)	1 ounce	
25	1 ounce	
50	1 ounce	
75	1 ounce	
100	1 ounce	
105	3 ml (fill to mark on bottle)	
110	3 ml (fill to mark on bottle)	
115	3 ml (fill to mark on bottle)	
120	3 ml (fill to mark on bottle)	
125	1 ounce	
130	3 ml (fill to mark on bottle)	
135	3 ml (fill to mark on bottle)	
140	3 ml (fill to mark on bottle)	
145	3 ml (fill to mark on bottle)	
150	1 ounce	
155	3 ml (fill to mark on bottle)	
160	3 ml (fill to mark on bottle)	
165	3 ml (fill to mark on bottle)	
170	3 ml (fill to mark on bottle)	
175	1 ounce	
180	3 ml (fill to mark on bottle)	
185	3 ml (fill to mark on bottle)	
190	3 ml (fill to mark on bottle)	
195	3 ml (fill to mark on bottle)	
200	1 ounce	

Sequence IVB Test Specification

Stage	1	1.1	2	2.1
Time, seconds	7	8	7	8
Controlled Parameters				
Dyno_Speed	800 ± 25	700 to 4400	4300 ± 25	700 to 4400
Eng Load	25 ± 2	22 to 28	25 ± 2	22 to 28
Oil Gallery T	54 ± 2	54 ± 2	54 ± 2	54 ± 2
Load Cell T	45 ± 2	45 ± 2	45 ± 2	45 ± 2
Eng Coolant In T	49 ± 2	49 ± 2	49 ± 2	49 ± 2
Coolant Flow	80 ± 1	80 ± 1	80 ± 1	80 ± 1
Rocker Cover Flow	120 ± 1	120 ± 1	120 ± 1	120 ± 1
Inlet (Intake) Air T	32 ± 2	32 ± 2	32 ± 2	32 ± 2
Fuel T	24 ± 2	24 ± 2	24 ± 2	24 ± 2
Blowby Gas T	29 ± 2	29 ± 2	29 ± 2	29 ± 2
Exh Gas Pr	≈ baro	98 to 118	104.5 ± 1	98 to 118
Inlet (Intake) Air Pr	0.25 ± 0.10	-0.05 to 0.20	0.25 ± 0.10	-0.05 to 0.20
Rocker Cover Coolant Out T	20 ± 2	20 ± 2	20 ± 2	20 ± 2
Humidity	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5	11.5 ± 0.5
Uncontrolled Parameters (Typical Ranges)				
Eng Coolant Pr	70 ± 10	70 ± 10	70 ± 10	70 ± 10
Fuel Pr	335 ± 10	335 ± 10	335 ± 10	335 ± 10
Oil Gallery Pr	125 ± 25	100 to 350	325 ± 25	100 to 350
Rocker Cover Gas Flow	10 ± 3	1 to 20	10 ± 3	1 to 20
Fuel Flow	0.75 ± 0.25	0.5 to 7.0	4.50 ± 0.25	0.5 to 7.0
Air Fuel Ratio	14.5 ± 0.5	12 to 17	14.5 ± 0.5	12 to 17

PLEASE CHECK AND DRAIN CONDENSATION TRAPS OCCASIONALLY

Sequence IVB Stand Maintenance

Test Number: IVB100-0-54

Post-test Stand Maintenance

This stand maintenance checklist should stay at the test stand after the current test completes and then be added to the paperwork of the next test that runs on this test stand.

Load Calibration	Initials	Date
1) Submit a work request for the load calibration. **(Engineering Aid)**		
2) Perform the load calibration. **(Instrument Shop)**		
3) Verify that the load calibration has been completed. **(Lab Mechanic)**		
Driveline Inspection and Maintenance Procedure		
4) Remove driveshaft cover, inspect, and tighten if necessary, all driveline bolts. **Make sure that the engine does not rotate when tightening the driveline bolts, so that the camshafts do not jump time.**		
5) Inspect and lubricate driveshaft at all points, then reinstall driveshaft cover.		
External Oil System Cleaning Procedure		
6) Disconnect the supply and return lines from the remote oil filter housing adapter that is mounted on the engine.		
7) Connect the supply and return lines to a portable oil cleaning flush cart of minimum 1 gallon capacity that is equipped with a circulation pump. Charge the flush cart with Stoddard solvent (mineral spirits meeting the requirements of Specification D235, Type II, Class C for Aromatic Content ((0 to 2) vol %), Flash Point (61°C, min) and Color (not darker than +25 on Saybolt Scale or 25 on Pt-Co Scale)).		
8) Energize the flush cart pump and allow the Stoddard solvent to circulate for one hour.		
9) At the end of one hour, de-energize the flush cart pump and open both heat exchanger drain valves. Then disconnect the supply and return lines from the flush cart.		

Test Number: IVB100-0-54

Post-test Stand Maintenance Cont'd

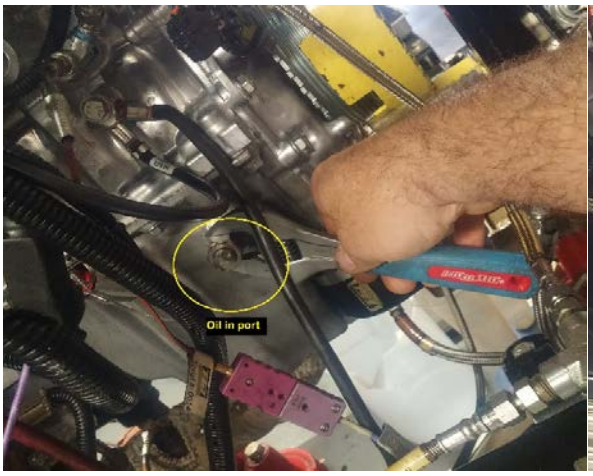
External Oil System Cleaning Procedure Cont'd	Initials	Date
10) When the heat exchanger has completed draining, leave the heat exchanger drain valves open and connect both the supply and return lines to a clean dry compressed air supply at 20 psi. Allow compressed air to flow through the system for 15 minutes to dry the system.		
11) Disconnect the supply and return lines from the compressed air source.		
12) Connect the supply and return lines back to the remote oil filter housing adapter that is mounted on the engine.		
13) Close the heat exchanger drain valves and remove the Oberg oil filter element for cleaning. Clear any debris retained in the Oberg oil filter element with Stoddard solvent and air dry. Re-install the Oberg oil filter element in the Oberg filter housing and secure the four retaining bolts.		
14) Dispose of the used Stoddard solvent following test laboratory practice.		
15) Disconnect the oil pressure sense line from the engine and from the oil sample valve. Rinse this line using Stoddard solvent and then air dry.		
16) Disconnect the oil pressure sense line from the oil sample valve and the oil pressure transducer. Rinse this line using Stoddard solvent. Then air dry.		
17) Open the oil sample valve and allow any trapped oil to drain. Then close the valve and reconnect both oil pressure/sample lines to their respective locations.		
Oil Pan Flush		
18) Ensure the oil drain has been completed.		
19) Ensure the flush bucket is clean.		
20) Pour 1 gallon of EF411 into bucket and install lid with pump assembly.		
21) Remove rear oil pan drain plug.		
22) Install the 3' x ¾" clear Tygon hose to the rear drain plug boss and tighten the hose clamp and install in filler neck on bucket lid.		

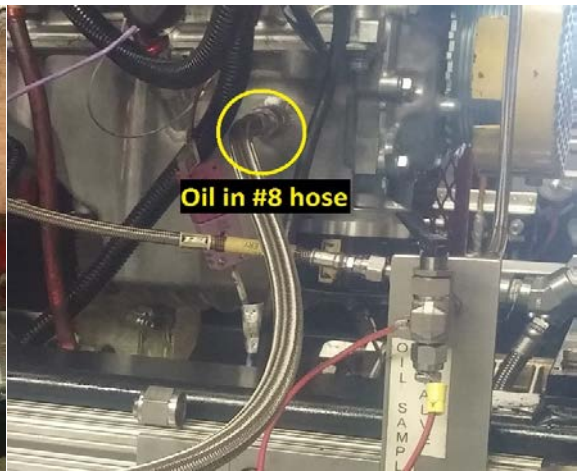
Test Number: IVB100-0-54

Post-test Stand Maintenance Cont'd

Oil Pan Flush Cont'd	Initials	Date

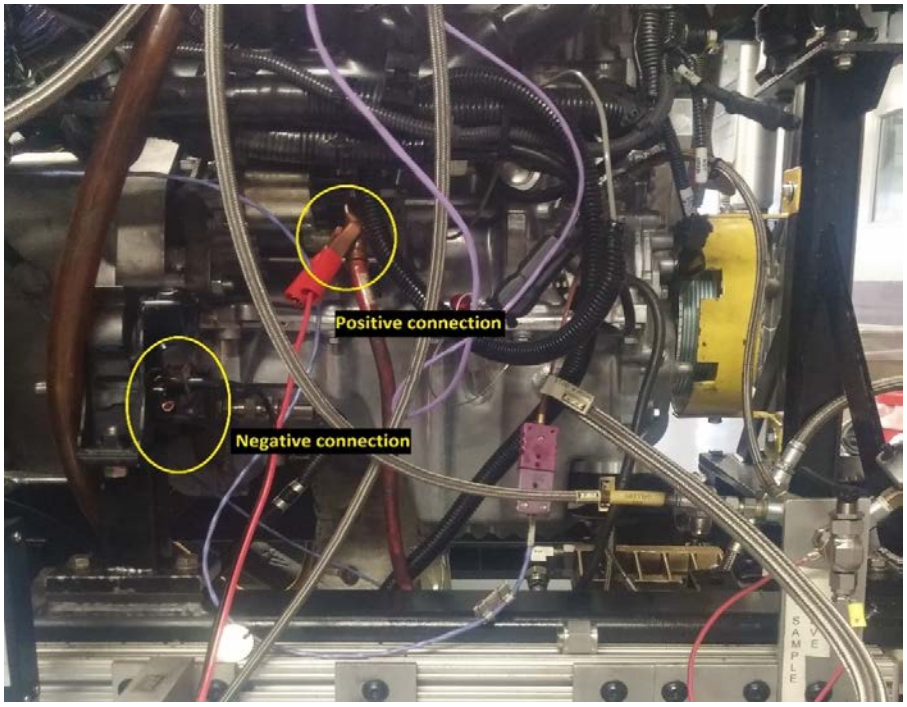
23) Remove the flush port cap then Install the #8 hose to the flush port on the side of the oil pan.





24) Connect the (Black) negative clamp to a suitable ground.

25) Connect the (Red) positive clamp to the starter wire.



26) Let pump run for 10 minutes.

Test Number: IVB100-0-54

Post-test Stand Maintenance Cont'd

Oil Pan Flush Cont'd	Initials	Date
27) Disconnect positive and negative clamps.		
28) Let oil pan drain for 5 minutes.		
29) Disconnect the #8 hose from the oil pan and reinstall the #8 cap.		
30) Remove the Tygon hose from the oil pan and reinstall the rear oil drain plug.		
31) Properly dispose of the EF411 and oil filter.		
32) Solvent wash the bucket and lid. Place on the cart in the lower IVB area.		

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling																				

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling			**1 oz =**																	

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling								**1 oz =**												

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling														**1 oz =**						

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling																		**1 oz =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling			**3 ml =**					**3 ml =**					**3 ml =**					**3 ml =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling				**1 oz =**					**3 ml =**					**3 ml =**					**3 ml =**	

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling			**3 ml =**					**1 oz =**					**3 ml =**					**3 ml =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling			**3 ml =**					**3 ml =**					**1 oz =**					**3 ml =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

Sequence IVB Hourly Operational Checklist

Test Number: IVB100-0-54 Oil Code: EG-0034/CMIR-123245

Test Hour	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
Operator Initials																				
Time of Day, hr:min																				
Scan the LabVIEW Test Screen																				
Check for Alarms																				
Check that the Following are Within Specification																				
Dyno_Speed & Eng Load																				
Oil Gallery T																				
Eng Coolant In T, Eng Coolant Flow & Eng Coolant Pr																				
Rocker Cover Coolant Out T, Rocker Cover Flow																				
Inlet (Intake) Air T, Inlet (Intake) Air Pr & Humidity																				
Fuel T & Fuel Pr																				
Blowby Gas T, RAC GAS Out T & Exh Gas Pr																				
Check that the Following are **Green**																				
DAQ Enabled																				
Visual Inspection of Test Stand																				
Check for Oil Leaks																				
Check for Coolant Leaks																				
Check for Fuel Leaks																				
Check for Process & Chilled Water Leaks																				
Check for Exhaust System Leaks																				
Check Dynamometer Oil Level (Add Oil if Low)																				
Check Fuel Pressure at Fluid Rack & at Engine																				
Check for Unusual Vibration & Noises																				
Oil Sampling			**3 ml =**					**3 ml =**					**3 ml =**					**1 oz =**		

NOTE: PLEASE INITIAL AT TOP OF COLUMN AND CHECK BOX WHEN TASK HAS BEEN COMPLETED

SwRI

Test Operation Lab Instructions

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

1.0 SAFETY

PERSONAL PROTECTIVE EQUIPMENT: All PPE should be worn when the appropriate hazard exists. Consult your supervisor or the Material Safety Data Sheet (MSDS) for additional information regarding protective equipment for the hazardous chemical or product being used.

- Body Protection: A rubber apron to protect clothing and exposed parts of the body shall be worn during parts cleaning operations. PCV sleeves shall be used on exposed arms.

- Eye/Face Protection: Safety glasses, ANSI Z87 approved, with side-shields shall be worn in laboratory testing and build areas. Face shields shall be worn during parts cleaning operations.

- Hearing Protection: Ear plugs or muffs with a NRR rating equal to or greater than 29 shall be worn when testing is in progress or other noise hazard exists.

- Foot Protection: Steel-toe safety shoes must be worn in the laboratory and build areas. Rubber boots or boot covers worn when cleaning parts.

- Hand/Arm Protection: Disposable nitrile gloves shall be worn during activities involving oil/fuel residue. Leather or Kevlar® gloves should be worn when handling sharp objects. Heavy rubber or neoprene gloves should be worn during parts cleaning operations. Heat resistant or Kevlar® gloves shall be worn when handling hot substance. Kevlar® sleeves should be worn when arms are exposed to hot and/or sharp objects.

2.0 SCOPE

This procedure provides the instructions for running of a standard IVB Valve Train Wear test. The procedures herein describe preparing the stand and engine for test, running of the engine, and monitoring of the engine during test.

3.0 PURPOSE

To provide a work order that can be used during every test. To ensure the test is conducted properly each line item should be initialed as soon as it is completed.

4.0 RECORDS

This laboratory procedure is filed online on the Division 08 home page under TIPs 1.08.02.12 001-031.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Test Number: XX-X-XX
PRISM Test Type: ***2NR_VTWT***

Test Stand: XX
Test Length: 200 Hrs

Engine Block Number: SR XX
Runs on Engine:

Cylinder Head Number: SR XX
Runs on Cylinder Head

Sponsor Oil Code: XXXXXXX
SwRI Oil Code: LO-XXXXXX

Test Fuel: KA24E Green

Fuel Tank: XX
Fuel Batch Code:

Labor Charge Number:

Notice: Please read all instructions carefully, the instructions must be followed precisely. If you have any questions, contact the following in the order provided. **Sign off each step in the work order as completed.**

Contacts	SwRI Ext	Cell Phone
Khaled Rais	3842	210-633-7935
Chris Peyton	5921	210-260-9645

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Test Packet Table of Contents

Test Number: XX-X-XX

SwRI Oil Code: LO-XXXXX

Calibrated Tools Record

Please verify calibration status for the tools listed below.

Item #	Asset #	Tool Description	Is Calibration Current? Circle either yes or no for each item	Initials
1	N/A	Test Stand Instruments Cal Good?	Yes / No	
2		Laboratory Oil Weight Scale	Yes / No	
3		Compression Gauge	Yes / No	
4		Leakdown Tester	Not Applicable	
5		Torque Wrench	Yes / No	
6	FH	Load Cell Calibration Weight FH	Yes / No	
7	FH4	Load Cell Calibration Weight FH4	Yes / No	
8	FH5	Load Cell Calibration Weight FH5	Yes / No	
9	FH6	Load Cell Calibration Weight FH6	Yes / No	

If any item has an expired calibration, hold the test and notify the operations supervisor.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Fuel and Oil Cross-check

Date: _____

1) The test sponsor, sponsor oil code, and LO code from the scheduling packet is listed below. *Write in the information listed on the tag on the candidate oil can and ensure that it EXACTLY matches the information listed from the scheduling packet.* If a discrepancy is found, contact the project leader beofre proceeding.

	Scheduling Packet	Candidate Oil Can
Sponsor		
Sponsor Oil Code		
LO Code		

2) Go to the fuel tank patch panel at the fuel farm ("Aggieland") and note which line the tank listed is connected to. Write this below.

3) Go to the laboratory patch panel located outside, at the southeast corner of A-Wing, and note which line is connected to the test stand for this test. Write this below ("Line1", "Line 4", etc.)

Fuel Tank Patch Panel		Laboratory Patch Panel	
Tank Number		**Test Stand**	
Line Connection		**Line Connection**	

4) The two "Line Connection" boxes above must match EXACTLY. If a change needs to be made, make the appropriate connection at the laboratory patch panel, and flush 15 gallons of fuel at the test stand. If the stand was already connected correctly, a flush is not necessary. Initial here if a fuel flush was necessary to indicate the flush was performed: _____

5) From the bulk fuel inventory report available on your PC, note the fuel description and batch ID which corresponds to that fuel tank below. *Ensure this information matches EXACTLY with the information listed from the scheduling sheet.* If a discepancy is found, contact the project leader before proceeding.

	Scheduling Sheet	Bulk Inventory Report
Description		
Fuel Batch ID		

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Test Stand Initiation

1. _____ Verify that the cylinder head is tagged with a note from the build-up mechanic stating that the test springs have been installed. The note should include the name of build-up mechanic and the date the test springs were installed. If not present, please contact the lab supervisor and the project engineer.

2. _____ Two people verify codes on test oil can match oil codes on Vista Scheduling

3. _____ Two people verify fuel information on Vista Scheduling sheet matches bulk fuel inventory report and that the test stand is connected to the correct fuel tank.

4. _____ Complete Calibrated Tools Record on page 2 of this document.

5. _____ Using information from the Vista Scheduling sheet, schedule a new test in the PRISM system. When scheduling the test, be sure to **select PRISM test type 2NR_VTWT** and to make sure all information is entered into the PRISM system to ensure correct fuel charges and an accurate daily status sheet. Initialize the scheduled test.

6. _____ Remove driveshaft guards and lubricate driveshaft at all points. Then reinstall and secure both inner and outer driveshaft guards

7. _____ Remove and clean all pressure traps using solvent and air dry. Obtain new O rings from B75 stock room and then re-install pressure traps using the new O rings.

Figure 1 Pressure Trap Locations

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Test Stand Initiation (cont. from previous page)

8. _____ Ensure the coolant system is depressurized by adjusting the manual pressure regulator until the pressure is reading zero.

Figure 2 Coolant System Pressure Adjustment

9. _____ Top off the engine coolant with a mixture of 30% Havoline Extended Life Anti-freeze and 70% deionized water. Also top off the rocker cover coolant with a mixture of 30% Havoline Extended Life Anti-freeze and 70% deionized water. Please measure out the appropriate mixture volume using a 5000 ml beaker and filling with 1500 ml of anti-freeze and 3500 ml of deionized water. Secure the all pressure caps and then apply 7 psi of pressurized air to the coolant system. Turn the coolant pump circuit breaker and coolant heater circuit breaker to the "ON" position.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Test Stand Initiation (cont. from previous page)

Figure 3 Havoline Extended Life Anti-freeze

10. _____ Remove blowby flow meter and clean using solvent and then air dry. Re-install blowby meter and ensure that all hose on the blow-by system is new.

11. _____ Record value of PRISM Fuel Used Channel in the space to the right. Fuel Used at SOT _____ gal

12. _____ Turn off tower water supply and return at back of wall and then clean dynamometer coolant strainer.

13. _____ Turn on tower water supply and return at back of wall and observe dynamometer coolant flow switch. If the flow indicator is red or yellow hold the test and notify supervisor or lead technican that the test is on hold.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

External Oil System Flush Procedure

1. _____ Disconnect the external oil supply and oil return lines from the remote oil filter housing adapter that is mounted on the engine.

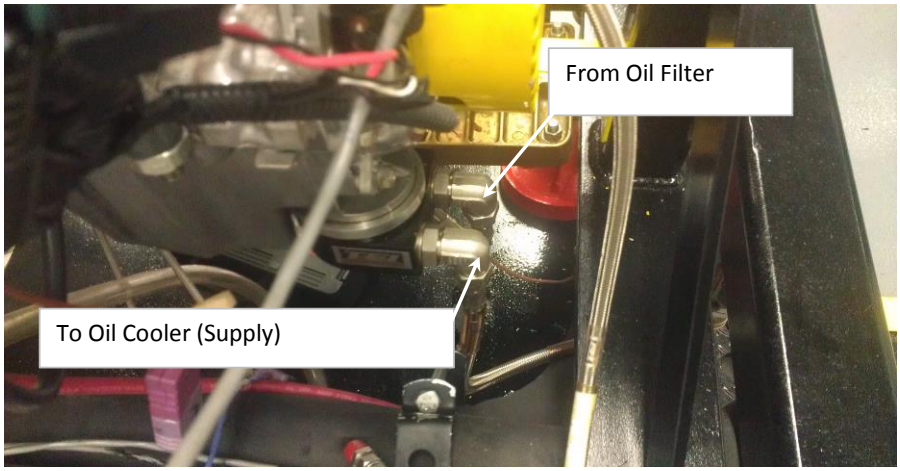


Figure 4 Remote Oil Filter Housing Adapter

2. _____ Connect the external oil supply and external oil return lines to a portable oil cleaning flush cart of minimum 1 gallon capacity that is equipped with a circulation pump. Charge the flush cart with solvent and energize the flush cart pump. Allow the solvent to circulate for one hour.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

External Oil System Flush Procedure (cont. from previous page)

3. _____ At the end of one hour, de-energize the flush cart pump and open both heat exchanger drain valves and allow the external oil system to drain. Then disconnect the external oil supply and external oil return lines from the flush cart.

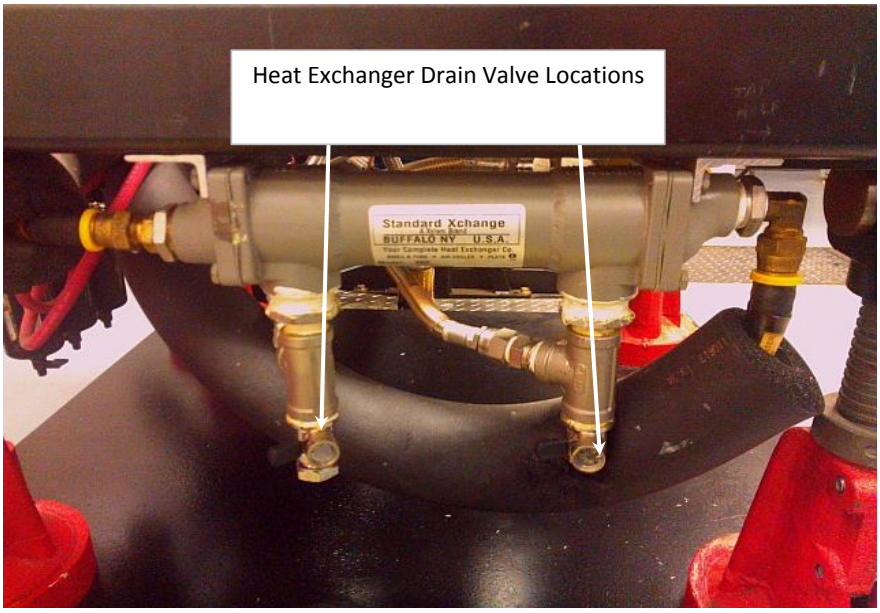


Figure 5 External Oil Heat Exchanger

4. _____ When the external oil system has completed draining, leave the heat exchanger drain valves open and connect both the external oil supply and external oil return lines to clean dry compressed air supply at 20 psi. Allow compressed air to flow through the system for 15 minutes to dry the system.

5. _____ Disconnect the supply and return lines from the compressed air source and Connect the external oil supply and external return lines back to the remote oil filter housing adapter that is mounted on the engine. Close the heat exchanger drain valves.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

External Oil System Flush Procedure (cont. from previous page)

6. _____ Remove the Oberg oil filter element for cleaning. Clear any debris retained in the Oberg oil filter element with solvent and air dry. Re-install the Oberg oil filter element in the Oberg filter housing and secure the four retaining bolts.

7. _____ Dispose of the used solvent following test laboratory practice.

8. _____ Disconnect the oil pressure sense line from the engine and from the oil sample valve. Rinse this line using clean solvent and then air dry.

9. _____ Disconnect the oil pressure sense line from the oil sample valve and the oil pressure transducer. Rinse this line using clean solvent and then air dry.

10. _____ Open the oil sample valve and allow any trapped oil to drain. Then close the valve and reconnect both oil pressure/sample lines to their respective locations.

EF-411 Oil Flush

1. _____ Remove the engine oil sump drain plug and place a clean 5000 ml beaker under the drain.

2. _____ In a separate beaker, measure out 3000 ml of new EF-411 solvent and pour it into the engine through the oil fill cap.

3. _____ Allow the EF-411 to drain for 10 minutes.

4. _____ Pour the EF-411 that drained out of the engine back through it and allow it to drain once again for 10 minutes.

5. _____ Repeat step 4 two more times so that the EF-411 drains through the engine a total of four times.

Dynamometer Load Cell Calibration

1. _____ Double check that PRISM test type 2NR-VTWT is selected

2. _____ Select F9 "Calibrate" from the PRISM Menu and select the "LD" channel

3. _____ Follow the on-screen instructions

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

First Engine Flush

1. _____ Verify the engine oil sump drain plug is tight and that both oil heat exchanger drain valves are closed. Then measure out 2400 ml of new test oil and add the oil charge to the engine.

2. _____ Turn the starter disconnect switch to the "ON" position and pull both ESTOP switches to the "OUT" position. Turn on the main fuel supply which is located inside the 8020 rack

3. _____ Press Shift F-5 to Start the PRISM Program. When prompted input the scheduled test length in hours that is on the official scheduling sheet. Then when the menu appears select Run Oil Flush.

4. _____ Press the F12 key when prompted to allow PRISM to start preheating the engine coolant.

5. _____ When the engine coolant reaches 50°C, PRISM will prompt you to start the engine. Use the cranking switch located above the PRISM console to start the engine. Once the engine has started, check for coolant and oil leaks before pressing the F12 key to begin the first engine flush.

6. _____ PRISM will increase the RPM to 1500 rpm and increase the LD to 10 Nm. TCO will be controlled to 50°C. PRISM will hold these conditions for 6 minutes. At 3 minutes before the end of the flush record the parameters listed below in the space provided.

Parameter Values Observed During Flush Conditions

Parameter	Value
TLS	
TLG	
TCI	
TCO	
TEX	
PLG	
PIM	
PEX	

Parameter	Value
PIA	
PCK	
PCO	
FFA	
RPM	
LD	
FFT	

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

First Engine Flush (continued from previous page)

7. _____ After 6 minutes of flush condition operation, PRISM will automatically bring the engine down to idle conditions and then automatically stop the engine.

8. _____ When the engine stops, turn off the starter disconnect switch and disconnect the condition intake air supply hose that is connected to the intake air filter housing.

9. _____ Use compressed air to disperse any water accumulation around the coil packs. Mark the position of the coil packs and then remove them with the wiring harness connected.

10. _____ Disconnect the electrical connectors for the fuel injectors and remove the ½ in. swage lock plug from the lower left port on the intake manifold.

11. _____ Remove all 4 spark plugs and mark their positions.

12. _____ Install the compression gauge into spark plug hole for cylinder number 1.

13. _____ Turn the battery disconnect switch to on. Using a remote starter cranking device or control software then crank engine for 8 seconds

14. _____ Record the compression pressure reading in the data entry table below. Repeat steps 12 through 14 for cylinder 2, 3, and 4.

Cylinder Number	1	2	3	4
Pressure, psi				

15. _____ Connect the electrical connectors for the fuel injectors and install the ½ in. swage lock plug from the lower left port on the intake manifold.

16. _____ Rotate the engine clockwise as viewed from the front of the engine until the cylinder that is being tested is at TDC compression stroke.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

First Engine Flush (continued from previous page)

17. _____ Connect the leak down tester to shop air and calibrate the leak down detector.

18. _____ Install the leak down tester adapter hose in the cylinder that is being tested.

19. _____ Connect the leak down detector to the adapter hose.

20. _____ Record the cylinder leak down percentage in the data entry area below.

Cylinder Number	1	2	3	4
Leakdown, %				

21. _____ Repeat steps 18 thru 20 for cylinders 2, 3, and 4.

22. _____ If the leak down percentages are 10% or less and if all four cylinder cranking compression readings are greater than 200 psi then proceed to step 23. Otherwise notify the laboratory supervisor that the engine has not passed the cranking compression and cylinder leak down checks and hold the test.

23. _____ Re-install spark plugs for cylinders 1 through 4. When installing a spark plug, start the spark plug by hand and then continue to turn the spark plug using a ratchet until the spark plug bottoms out. Tighten the spark plug to 18 N*m using a 3/8 drive calibrated torque wrench.

24. _____ ***Install the coil packs and take great care when tightening the coil pack hold down bolt as the threads are easy to damage. If a coil pack hold down bolt will not tighten make repairs before continuing. The coil pack hold down bolt and thread are the electrical ground connection for the coil pack and the engine will not run properly if the coil pack hold down bolt is not tightened correctly.***

25. _____ After the compression test and cylinder leak downs are complete, turn the starter disconnect switch to the "OFF" position and push the test stand ESTOP switch "IN".

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

First Engine Flush (continued from previous page)

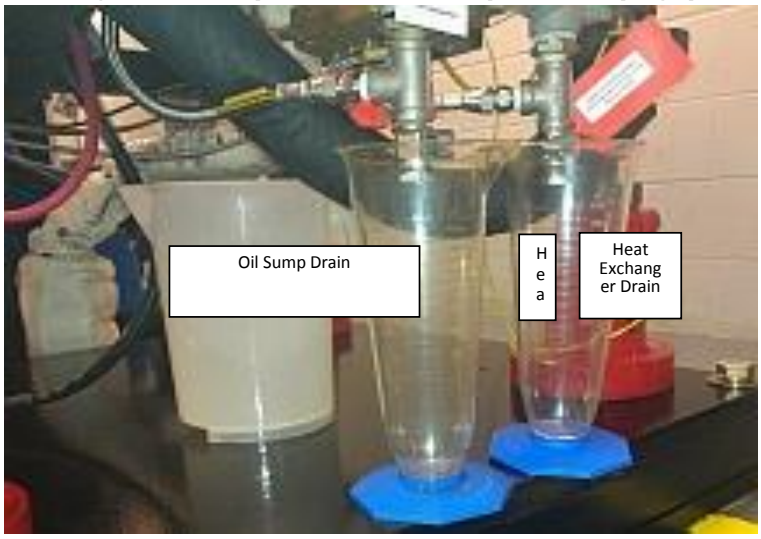


Figure 6 Oil Drain Locations

26. _____ Remove the oil pan drain plug and drain the oil pan into a clean 5000 ml beaker. Also open both oil heat exchanger drain locations and drain each location into a individual clean 1000 ml graduated cylinder.

27. _____ Press F12 to start the oil drain interval timer and allow all three oil drain locations to drain for 30 minutes. At the end of 30 minutes secure all drains. Then take a one ounce oil sample of the oil drain and label the drain with hours of FL1. Send the sample to the chem. lab for analysis and then discard the oil drain.

28. _____ Press F12 to end the oil drain interval and return to the menu.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Second Engine Flush

1. _____ Verify the engine oil sump drain plug is tight and that both oil heat exchanger drain valves are closed. Then measure out 2400 ml of new test oil and add the oil charge to the engine.

2. _____ Turn the starter disconnect switch to the "ON" position and pull both ESTOP switches to the "OUT" position. Turn on the main fuel supply which is located inside the 8020 rack

3. _____ Press Shift F-5 to Start the PRISM Program. When prompted input the scheduled test length in hours that is on the official scheduling sheet. Then when the menu appears select Run Oil Flush.

4. _____ Press the F12 key when prompted to allow PRISM to start preheating the engine coolant.

5. _____ When the engine coolant reaches 50°C, PRISM will prompt you to start the engine. Use the cranking switch located above the PRISM console to start the engine. Once the engine has started, check for coolant and oil leaks before pressing the F12 key to begin the second engine flush.

6. _____ PRISM will increase the RPM to 1500 rpm and increase the LD to 10 Nm. TCO will be controlled to 50°C. PRISM will hold these conditions for 38 minutes. At 30 minutes into the flush record the parameters listed below in the space provided.

Parameter Values Observed During Flush Conditions

Parameter	Value
TLS	
TLG	
TCI	
TCO	
TEX	
PLG	
PIM	
PEX	

Parameter	Value
PIA	
PCK	
PCO	
FFA	
RPM	
LD	
FFT	

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Second Engine Flush (continued from previous page)

7. _____ After 38 minutes of flush condition operation, PRISM will automatically bring the engine down to idle conditions and then automatically stop the engine.

8. _____ When the engine stops, turn off the starter disconnect switch and disconnect the condition intake air supply hose that is connected to the intake air filter housing.

9. _____ Remove the oil pan drain plug and drain the oil pan into a clean 5000 ml beaker. Also open both oil heat exchanger drain locations and drain both locations into a clean 1000 ml graduated cylinder.

10. _____ Press F12 to start the oil drain interval timer and allow all three oil drain locations to drain for 30 minutes. At the end of 30 minutes secure all drains. Then take a one ounce oil sample of the oil drain and label the drain with hours of FL2. Send the sample to the chem. lab for analysis and then discard the oil drain.

11. _____ Press F12 to end the oil drain interval and return to the menu.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Third Engine Flush

1. _____ Verify the engine oil sump drain plug is tight and that both oil heat exchanger drain valves are closed. Then measure out 2400 ml of new test oil and add the oil charge to the engine.

2. _____ Turn the starter disconnect switch to the "ON" position and pull both ESTOP switches to the "OUT" position. Turn on the main fuel supply which is located inside the 8020 rack

3. _____ Press Shift F-5 to Start the PRISM Program. When prompted input the scheduled test length in hours that is on the official scheduling sheet. Then when the menu appears select Run Oil Flush.

4. _____ Press the F12 key when prompted to allow PRISM to start preheating the engine coolant.

5. _____ When the engine coolant reaches 50°C, PRISM will prompt you to start the engine. Use the cranking switch located above the PRISM console to start the engine. Once the engine has started, check for coolant and oil leaks before pressing the F12 key to begin the third engine flush.

6. _____ PRISM will increase the RPM to 1500 rpm and increase the LD to 10 Nm. TCO will be controlled to 50°C. PRISM will hold these conditions for 38 minutes. At 30 minutes into the flush record the parameters listed below in the space provided.

Parameter Values Observed During Flush Conditions

Parameter	Value
TLS	
TLG	
TCI	
TCO	
TEX	
PLG	
PIM	
PEX	

Parameter	Value
PIA	
PCK	
PCO	
FFA	
RPM	
LD	
FFT	

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Third Engine Flush (continued from previous page)

7. _____ After 38 minutes of flush condition operation, PRISM will automatically bring the engine down to idle conditions and then automatically stop the engine.

8. _____ Turn off the starter disconnect switch and disconnect the condition intake air supply hose that is connected to the intake air filter housing. Turn off the main fuel supply which is located inside the 8020 rack.

9. _____ Remove the oil pan drain plug and drain the oil pan into a clean 5000 ml beaker. Also open both oil heat exchanger drain locations and drain both locations into a clean 1000 ml graduated cylinder.

10. _____ Press F12 to start the oil drain interval timer and allow all three oil drain locations to drain for 30 minutes. At the end of 30 minutes secure all drains. Then take a one ounce oil sample of the oil drain and label the drain with hours of FL3. Send the sample to the chem. lab for analysis and then discard the oil drain.

11. _____ Press F12 to end the oil drain interval and return to the menu.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Fourth Engine Flush

1. _____ Verify the engine oil sump drain plug is tight and that both oil heat exchanger

2. _____ Turn the starter disconnect switch to the "ON" position and pull both ESTOP switches to the "OUT" position. Turn on the main fuel supply which is located inside the 8020 rack

3. _____ Press Shift F-5 to Start the PRISM Program. When prompted input the scheduled test length in hours that is on the official scheduling sheet. Then when the menu appears select Run Oil Flush.

4. _____ Press the F12 key when prompted to allow PRISM to start preheating the engine coolant.

5. _____ When the engine coolant reaches 50°C, PRISM will prompt you to start the engine. Use the cranking switch located above the PRISM console to start the engine. Once the engine has started, check for coolant and oil leaks before pressing the F12 key to begin the fourth engine flush.

6. _____ PRISM will increase the RPM to 1500 rpm and increase the LD to 10 Nm. TCO will be controlled to 50°C. PRISM will hold these conditions for 38 minutes. At 30 minutes into the flush record the parameters listed below in the space provided.

Parameter Values Observed During Flush Conditions

Parameter	Value
TLS	
TLG	
TCI	
TCO	
TEX	
PLG	
PIM	
PEX	

Parameter	Value
PIA	
PCK	
PCO	
FFA	
RPM	
LD	
FFT	

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Fourth Engine Flush (continued from previous page)

7. _____ After 38 minutes of flush condition operation, PRISM will automatically bring the engine down to idle conditions and then automatically stop the engine.

8. _____ Turn off the starter disconnect switch and disconnect the condition intake air supply hose that is connected to the intake air filter housing. Turn off the main fuel supply which is located inside the 8020 rack.

9. _____ Remove the oil pan drain plug and drain the oil pan into a clean 5000 ml beaker. Also open both oil heat exchanger drain locations and drain both locations into a clean 1000 ml graduated cylinder.

10. _____ Press F12 to start the oil drain interval timer and allow all three oil drain locations to drain for 30 minutes. At the end of 30 minutes secure all drains. Then take a one ounce oil sample of the oil drain and label the drain with hours of FL4. Send the sample to the chem. lab for analysis and then discard the oil drain.

11. _____ Press F12 to end the oil drain interval and return to the menu.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Zero Hour Oil Charge Procedure

1. _____ When the menu appears select Run Test Conditions Bravo.

2. _____ Remove the Oberg oil filter, clean with solvent, air dry, and re-install the Oberg oil filter.

3. _____ Using a 5000 ml beaker, measure out 2400 ml of new test oil and record in the space below. The mass of the zero charge should be between 2.05 to 2.13 kg. If the mass of the zero hour charge is outside this range do not put oil in the engine and hold the test start.

Zero Hour Oil Charge Mass

A. Mass of Container with 2400 ml of oil _____ kg

B. Mass of Clean and Empty Container _____ kg

(A-B) Mass of Initial Oil Charge _____ kg

Mass of zero hour charge (A-B) should be between 2.05 to 2.13 kg

4. _____ Verify the engine oil sump drain plug is tight and both oil heat exchanger drain valves are closed and then add the oil charge to the engine.

5. _____ The engine will run at idle for 10 minutes before turning off for measurement of the initial oil level. Once the engine is off, allow the oil level to stabilize for 10 minutes before recording it in the space below.

SOT Oil Level (mm):	

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Operation of 200 Hour Test

1. _____ Make sure the starter motor disconnect switch is in the “On” position and both emergency stop switches are in the “Out” position. Turn on the main fuel supply valve located in the 8020 fluid control rack. Then press the F12 key and PRISM will prompt you to start the engine. Use the cranking switch located above the PRISM console to start the engine. Once the engine has started, check for coolant and oil leaks before pressing the F12 key.

2. _____ PRISM will operate the engine at Bravo Idle conditions until the engine reaches test specs and then begin to automatically cycle the engine as defined below for 200 hours.

Stage	Bravo_Idle_Ramp	Bravo_Idle	Bravo_Acel_Ramp	Bravo_Acel
Time, seconds	8	7	8	7
RPM	4300 to 800	800	800 to 4300	4300
LD	25 ± 1	25 ± 1	25 ± 1	25 ± 1
TCO	46 to 52	46 to 52	46 to 52	46 to 52
TLG	52 to 57	52 to 57	52 to 57	52 to 57
TIA	32 ± 2	32 ± 2	32 ± 2	32 ± 2
TRA_OUT	20 ± 2	20 ± 2	20 ± 2	20 ± 2

3. _____ PRISM will bring the engine down to idle automatically for all Intermediate oil samples at 25, 50, 75, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, and 195 test hours. See the oil sample procedure for oil sample instructions.

4. _____ Manual data logs and cell checks for fluid leaks are required hourly.

Due to the transient nature of this test it can be difficult to understand if the engine is running correctly and if the critical parameters are within tolerance. Two Spectrum Macros have been written to help understand the test operation - IDLE CRITICAL PLOTS and PWR CRITICAL PLOTS. It is highly recommended that you run both the IDLE CRITICAL PLOT macro and the PWR CRITICAL PLOT macro every 5 hours.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

Oil Sample Procedure

Oil samples need to be drawn according to the Stand Check Schedule. **Obtain these samples when the engine is step Oil_Sample by following the instructions below.**

1) Use the oil sample valve to remove the purge sample and draw the intermediate oil sample.

2) Remove a 4 ounce purge sample from the engine. Return the 4 ounce purge sample to the engine and then take a second 4 four ounce purge sample. Return the second purge sample to

3) **Look at the Stand Check Schedule to determine the size of the oil sample required.** Obtain the oil sample and label with the appropriate information, including test hour. Make sure that the oil sample is obtained from a separate container other than the purge oil.

4) Press F12 to return to test conditions.

5) Log the sample into to the PPRD oil sample pickup log book.

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

End of Test Procedure

1. _____ At 200 hours, PRISM will automatically bring the engine down to idle conditions and then automatically stop the engine.

2. _____ Wait 10 minutes, then take the final oil level reading and record it below.

EOT Oil Level (mm):	

3. _____ Turn off the main fuel supply at the fluid control rack.

4. _____ Turn off the chilled water supply at the back wall.

5. _____ Use compressed air to disperse any water accumulation around the coil packs. Mark the position of the coil packs and then remove them with the wiring harness connected.

6. _____ Disconnect the electrical connectors for the fuel injectors and remove the ½ in. swage lock plug from the lower left port on the intake manifold.

7. _____ Remove all 4 spark plugs and mark their positions.

8. _____ Install the compression gauge into spark plug hole for cylinder number 1.

9. _____ Turn the battery disconnect switch to on. Using a remote starter cranking device or control software then crank engine for 8 seconds

10. _____ Record the compression pressure reading in the data entry table below. Repeat steps 7 through 9 for cylinders 2, 3, and 4.

Cylinder Number	1	2	3	4
Pressure, psi				

11. _____ Connect the electrical connectors for the fuel injectors and install the ½ in. swage lock plug from the lower left port on the intake manifold.

12. _____ Rotate the engine clockwise as viewed from the front of the engine until the cylinder that is being tested is at TDC compression stroke.

13. _____ Connect the leak down tester to shop air and calibrate the leak down detector.

14. _____ Install the leak down tester adapter hose in the cylinder that is being tested.

15. _____ Connect the leak down detector to the adapter hose.

16. _____ Record the cylinder leak down percentage in the data entry area below.

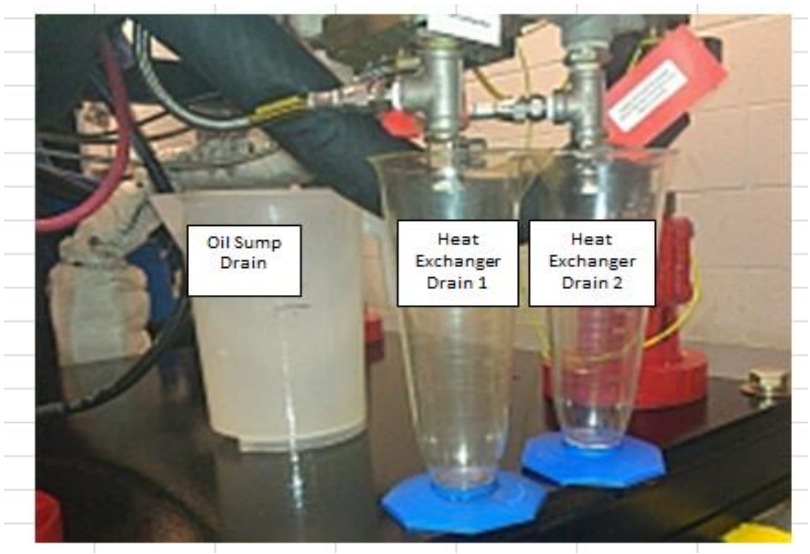
Cylinder Number	1	2	3	4
Leakdown, %				

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

End of Test Procedure (continued from previous page)

17. _____ Repeat steps 13 thru 15 for cylinders 2, 3, and 4.

18. _____ Obtain a clean 5000 ml beaker and two each clean 1000 ml graduated flasks. Record the mass of each in B below for each of the three containers.



Oil Sump Drain		
A. Mass of Container and oil sump drain	_____	kg
B. Mass of Clean and Empty Container ***(5000 ml beaker)***	_____	kg
(A-B) Mass of Oil Sump Drain	_____	kg
Heat Exchanger Drain 1		
A. Mass of Container and oil sump drain	_____	kg
B. Mass of Clean and Empty Container ***(1000 ml graduated cylinder)***	_____	kg
(A-B) Mass of Heat Exchanger Drain 1	_____	kg
Heat Exchanger Drain 2		
A. Mass of Container and oil sump drain	_____	kg
B. Mass of Clean and Empty Container ***(1000 ml graduated cylinder)***	_____	kg
(A-B) Mass of Heat Exchanger Drain 2	_____	kg

Test Number: XX-X-XX SwRI Oil Code: LO-XXXXX

End of Test Procedure (continued from previous page)

18. _____ Remove the oil pan drain plug and begin draining the oil pan into a clean 5000 ml beaker. Also open both oil heat exchanger drain locations and begin draining each location into individual clean 1000 ml graduated cylinders.

19. _____ Press F12 to start the oil drain interval timer and allow all three oil drain locations to drain for 30 minutes. At the end of 30 minutes secure all drains and press F12 to return to the main menu.

20. _____ Weigh and record each drain in the appropriate space on the previous page.

21. _____ Pour all three drains into a clean and labeled one gallon container. Then shake the container to ensure mixing. Lastly take an 8 ounce final drain sample. Label this sample with test hours of 200 and place into the chemical laboratory sample bin for pickup.

22. _____ Record value of PRISM Fuel Used Channel in the space to the right. Fuel Used at EOT _____ gal

23. _____ Place the one gallon container in the storage area for pickup to long term storage.

24. _____ Notify the building supervisor and the lead technician that the test stand is ready for end of test parts removal.

25. _____ Send this completed set of instructions to the laboratory supervisor.

26. _____ Laboratory supervisor review this set of instructions for completeness and then notify report processor completed instructions are ready for pickup.

27. _____ Spray out the blow-by heat exhanger and oil separator with solvent and air dry.

28. _____ Re-install the blow-by system with new short hose sections.

Section 12

Pre and Post-test Measurements Procedure

(Section H)

and

Keyence Measurements and Calibration Check Procedure

(Keyence)

Section H

Pre and Post-test Measurements Procedure

Section H - PDI Procedure | Draft

Revised Date *04/30/2015* | Revision *4.1* | Lubrizol Corporation

Test Name:	Sequence IVB
Revision By:	CHTM, MKKN, BSMA, PHAU
Comments:	This draft will eventually be incorporated into the Sequence IVB test procedure.

LIFTER MEASUREMENTS

1. Preparing Pre-Test Lifters for Measurement:

1.1. Record the following information for each lifter:
- 1.1.1. Unique ID number engraved on the inside
- 1.1.2. Lifter grade
- 1.1.3. Position in the engine (including intake or exhaust side)

1.2. This information needs to be properly documented and updated as needed throughout the course of the test.
- 1.2.1. An example of this documentation is shown in Table 1.

Table 1 - Example of Lifter Identification Documentation

Intake Side								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
ID No.								
Grade								
Exhaust Side								
Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
ID No.								
Grade								

1.3. Clean the lifters using pentane or heptane and allow the solvent to evaporate before taking any measurements.

2. Measure the Pre-Test Lifter Weights:

2.1. Use a calibrated scale to measure and record the weight of the lifters.

2.1.1.These weights are to be reported to (4) decimal places in units of grams.
2.1.2.A *Mettler AE200 Analytical Balance* is recommended for these measurements.

3. Confirm Center Position of OHT Fixture:

3.1. Place a dimpled reference lifter on the OHT fixture (Figure 1).

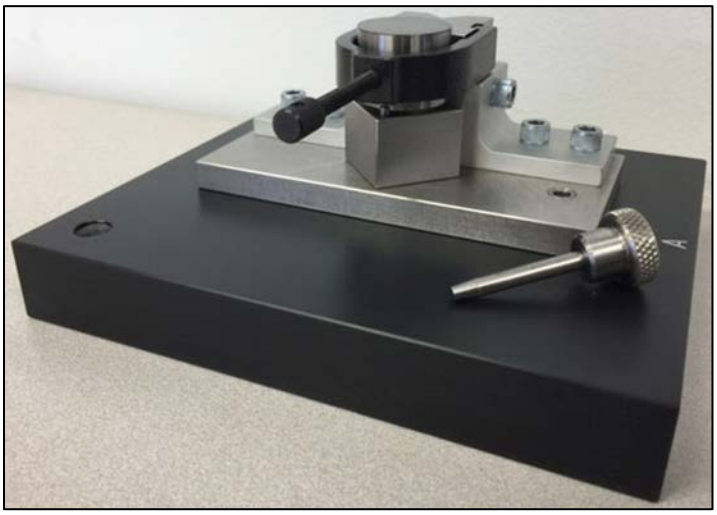


Figure 1 - OHT Lifter Fixture

3.2. Preload the PDI stylus on the dimpled reference lifter so that its trace path is aligned with the dimple.

3.3. Perform a trace of the dimpled reference lifter through the dimple.
3.3.1.Move the stage or fixture as needed to find the lowest spot of the dimple.
3.3.2.This will effectively center the OHT fixture.

3.4. Save the trace of the dimpled lifter (through the lowest spot of the dimple) for future reference.

4. Pre-Test Lifter Profile Traces:

4.1. Profile traces are to be performed using a *Precision Devices, Inc. (PDI) MicroAnalyzer 2000* profilometer that is using the *Windows XP Version 3.6.15* operational software.

4.2. Confirm that the **TOYOTA_BUCKET.NDT** template file is being used.

4.3. Confirm the following settings on the *Delimitation* tab (Figure 2):
4.3.1.The **Find** checkbox is selected and the filter width is set to **0.400mm** under the **(A)** *Left Edge* field.
4.3.2.The **Find** checkbox is selected and the filter width is set to **0.400mm** under the **(B)** *Right Edge* field.
4.3.3.The **(C) Fix Truncation to Part Edges** checkbox is selected.
4.3.4.The **(D) ASME B46.1-2002** standard is being used.

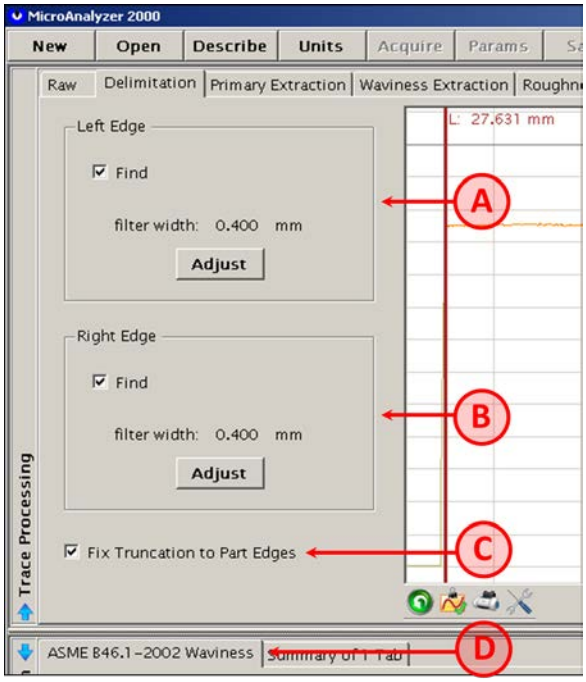


Figure 2 - Delimitation Tab Settings

4.4. Confirm the following settings on the *Primary Extraction* tab (Figure 3):

4.4.1. The **(E) Two-Point Line** radial button is selected under the *Form Removal* field.

4.4.2. The filter cutoff is set to **(F) 0.00µm** under the *Shortwave Cutoff* field.

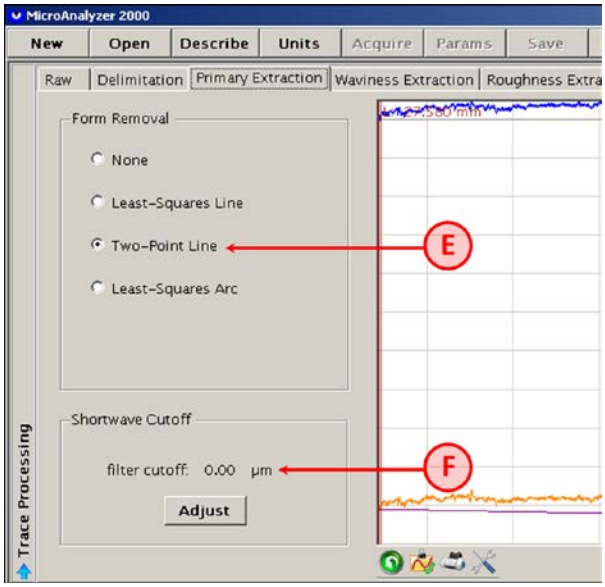


Figure 3 - Primary Extraction Tab Settings

4.5. Confirm the following settings on the *Waviness Extraction* tab (Figure 4):

4.5.1. The **(G) Gaussian w/o end removal** radial button is selected under the *Waviness Short Cutoff* field.

4.5.2. The filter cutoff is set to **(H) 0.800mm** under the *Waviness Short Cutoff* field.

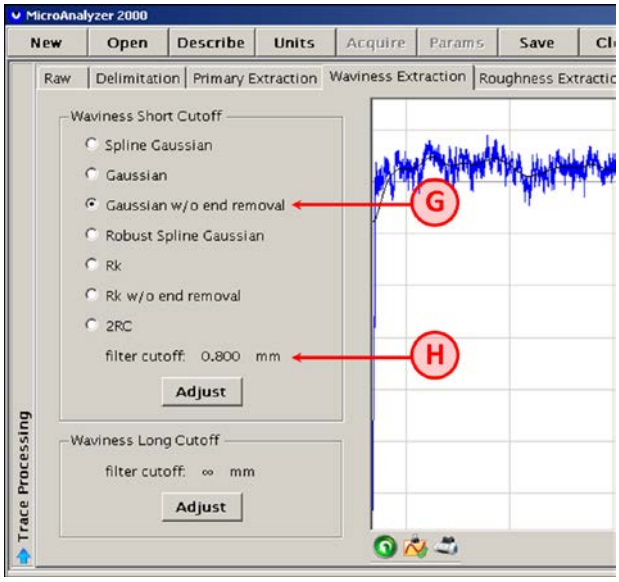


Figure 4 - Waviness Extraction Tab Settings

4.6. Confirm the following settings on the *Roughness Extraction* tab (Figure 5):

4.6.1.The **(I) Gaussian w/o end removal** radial button is selected under the *Roughness Cutoff* field.

4.6.2.The filter cutoff is set to **(J) 0.800mm** under the *Roughness Cutoff* field.

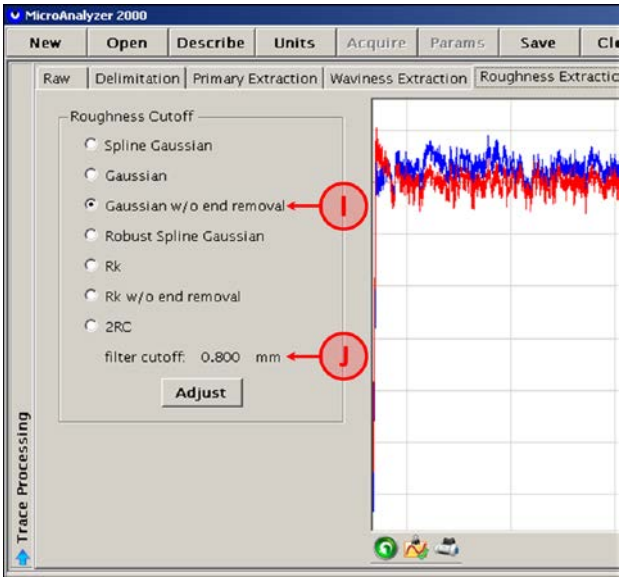


Figure 5 - Roughness Extraction Tab Settings

4.7. Place the notched lifter on the OHT fixture with the wear surface positioned upward :

4.7.1.Profile traces are taken on two orthogonal lines as shown in Figure 6.

4.7.1.1. The x-axis intersects the center of the lifter face near the middle of the ID number engraved on the inside of the lifter.

4.7.1.2. The y-axis also passes through the center of the wear surface and is perpendicular to the x-axis.

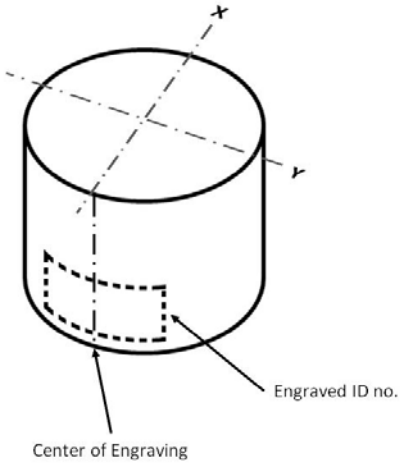


Figure 6 - Orthogonal Lines Used for Lifter Profile Measurements

4.8. Obtain a profile trace along one of the orthogonal lines by setting the OHT fixture in the **"A"** position.
- 4.8.1. *Important Note:* The current orthogonal axis of the OHT fixture can be easily identified by the position of the removable pin.
  - 4.8.1.1. For example, the OHT fixture is in the "A" position when the pin is near the "A" label on the black base plate.

4.9. Level the trace using the **two-point line** on the *Primary Extraction* tab.
- 4.9.1. Adjust the trace until its left and right edges are on the same horizontal level (as shown in Figure 7).

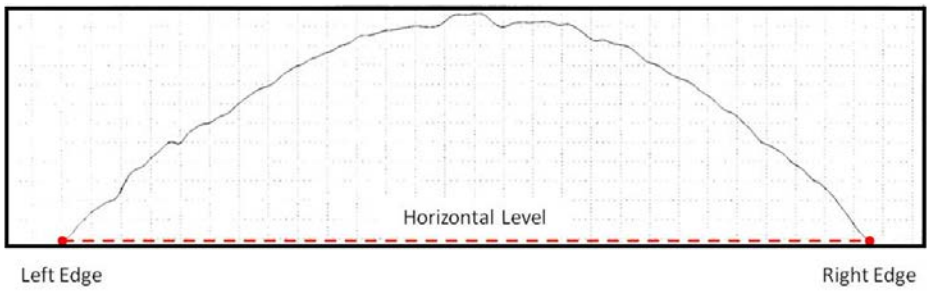


Figure 7 - Leveling the Lifter Profile Trace

4.10. Save the pre-test lifter traces using the unique file name that is assigned by the PDI software.
- 4.10.1. Each laboratory is responsible for correlating this unique file name to the unique ID number assigned to each lifter.
- 4.10.2. The laboratory must also correlate this file name to the orthogonal axis used for the trace ("A" or "B" as indicated on the OHT fixture).

4.11. Record the pre-test **Wt** (waviness total) measurement (µm) with the waviness evaluation lines set on the extreme left-side and right-side edges of the waviness profile trace.

4.12. Rotate the lifter 90-degrees and obtain a profile trace along the **"B"** position of the OHT fixture.
- 4.12.1. Repeat Steps 4.9 through 4.11.

4.13. Important Note:
- 4.13.1. The acceptable pre-test waviness total for intake lifters is **2µm < Wt < 15µm**.
- 4.13.2. The acceptable pre-test waviness total for exhaust lifters is **0µm < Wt**.

4.13.3. Reject any lifter with surface irregularities that prevent it from having a continuous and symmetric crowned profile (examples shown in Figure 8).

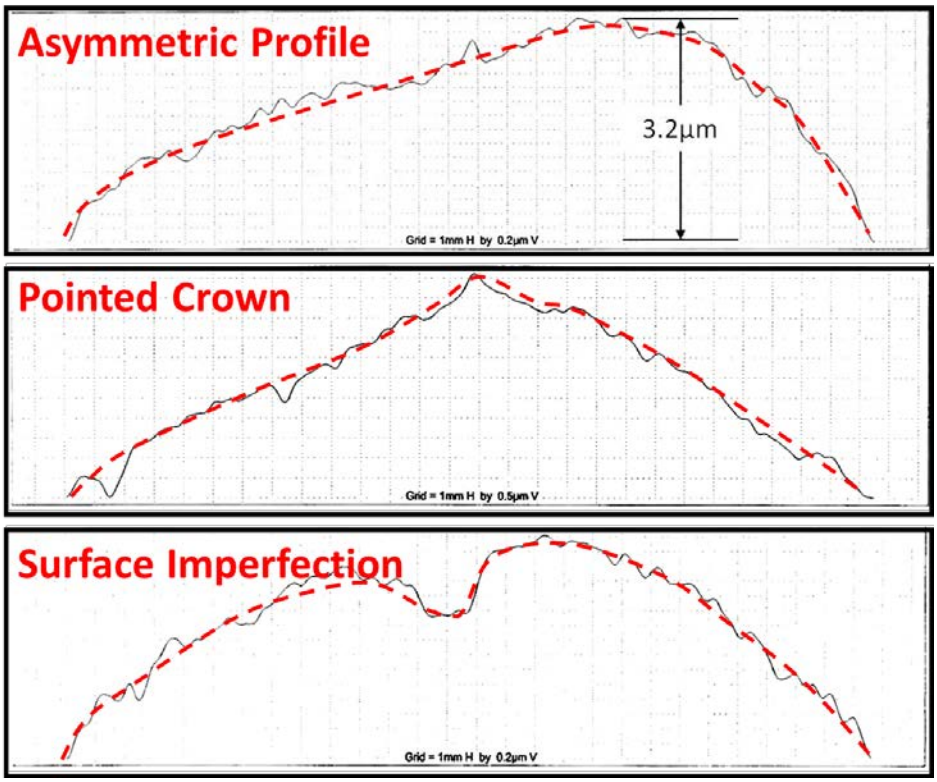


Figure 8 – Examples of Unacceptable Lifter Traces

4.13.4. An example of a profile trace from an acceptable lifter can be found in Figure 9.

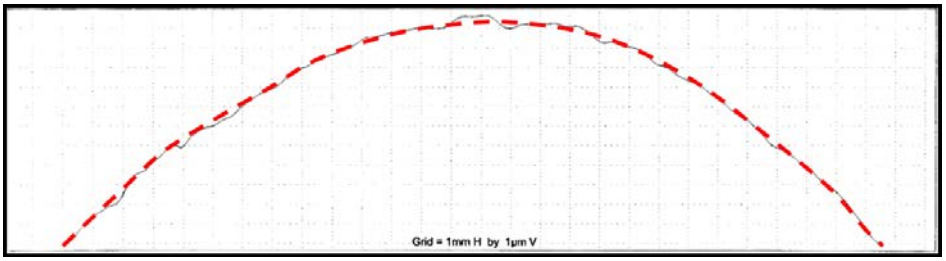


Figure 9 - Example of an Acceptable Lifter Trace

5. Preparing Post-Test Lifters for Measurement:

5.1. Clean the lifters using pentane or heptane and allow the solvent to evaporate before taking any measurements.

6. Measuring the Post-Test Lifter Weights:

6.1. Use a calibrated scale to measure and record the weight of the lifters.
6.1.1.These weights are to be reported to (4) decimal places in units of grams.
6.1.2.A *Mettler AE200 Analytical Balance* is recommended for these measurements.

7. Post-Test Lifter Profile Traces:

7.1. Confirm that the **TOYOTA_BUCKET.NDT** template file is being used.

7.2. Confirm the following settings on the *Delimitation* tab (Figure 2):
- 7.2.1. The **Find** checkbox is selected and the filter width is set to **0.400mm** under the *Left Edge* field.
- 7.2.2. The **Find** checkbox is selected and the filter width is set to **0.400mm** under the *Right Edge* field.
- 7.2.3. The **Fix Truncation to Part Edges** checkbox is selected.
- 7.2.4. The **ASME B46.1-2002** standard is being used.

7.3. Confirm the following settings on the *Primary Extraction* tab (Figure 3):
- 7.3.1. The **Two-Point Line** radial button is selected under the *Form Removal* field.
- 7.3.2. The filter cutoff is set to **0.00µm** under the *Shortwave Cutoff* field.

7.4. Confirm the following settings on the *Waviness Extraction* tab (Figure 4):
- 7.4.1. The **Gaussian w/o end removal** radial button is selected under the *Waviness Short Cutoff* field.
- 7.4.2. The filter cutoff is set to **0.800mm** under the *Waviness Short Cutoff* field.

7.5. Confirm the following settings on the *Roughness Extraction* tab (Figure 5):
- 7.5.1. The **Gaussian w/o end removal** radial button is selected under the *Roughness Cutoff* field.
- 7.5.2. The filter cutoff is set to **0.800mm** under the *Roughness Cutoff* field.

7.6. Obtain a profile trace along both of the lifter's orthogonal axes (identified as "A" and "B" on the OHT fixture).

7.7. Save the post-test lifter traces using the unique file name that is assigned by the PDI software.
- 7.7.1. Each laboratory is responsible for correlating this unique file name to the unique ID number assigned to each lifter.
- 7.7.2. The laboratory must also correlate this file name to the orthogonal axis used for the trace ("A" or "B" as indicated on the OHT fixture).

7.8. Open the Comparator software.
- 7.8.1. *Important Note:* All lifter profile comparisons are to be performed using *Version 3.0.3* of the Comparator software.

7.9. Press the **(K) Open Pre** button on the main Comparator screen (Figure 10).
- 7.9.1. Open the desired pre-test lifter trace document or documents.

7.10. Press the **(L) Open Post** button on the main Comparator screen (Figure 10).
- 7.10.1. Open the corresponding post-test lifter trace document or documents.

7.11. Use the **(N) vertical adjustment lines** and the **(O) adjustment arrow buttons** to level and align the pre-test and post-test traces (Figure 10).

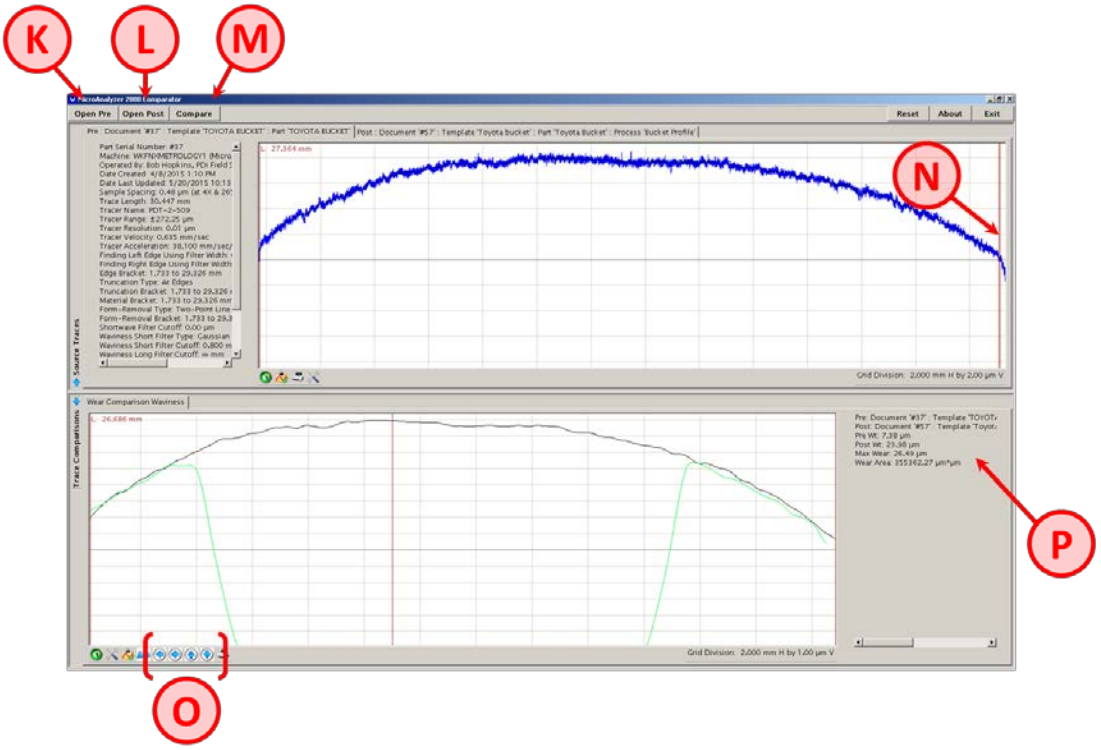


Figure 10 - Main Comparator Screen

7.12. Press the **(M) Compare** button on the main Comparator screen (Figure 10).

7.12.1. Select **(Q) Wear Comparison Waviness** from the *Comparison Type* pull down menu of the document selection screen (Figure 11).

7.12.2. Select the appropriate pre-test file **(R)** under the *Pre Documents* field.

7.12.3. Select the corresponding post-test file **(S)** under the *Post Documents* field.

7.12.4. Press the **OK** button.

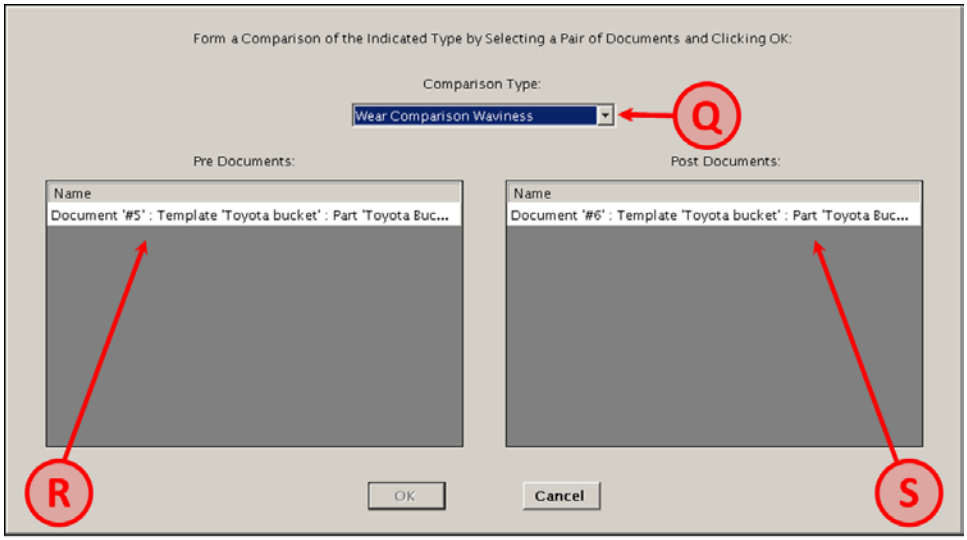


Figure 11 - Comparator Software Document Selection Screen

7.13. Record the required measurements (**P**, Figure 10).

7.13.1. *Important Note:* The **Max Wear** parameter is to be reported as **z-diff**.

CAMSHAFT MEASUREMENTS

8. Preparing Pre-Test Camshafts for Measurement:

8.1. Spray the camshafts with Stoddard solvent.
8.1.1. Use a non-metallic brush to thoroughly scrub the lobe surfaces.
8.1.2. Dry the camshaft with compressed air.

8.2. Visually inspect each camshaft lobe for defects or damage.
8.2.1. Examples of such defects or damage are shown in Figure 12.
8.2.2. Reject any camshafts that have these abnormalities.

8.3. Record the unique identification number for both the intake and exhaust camshafts.

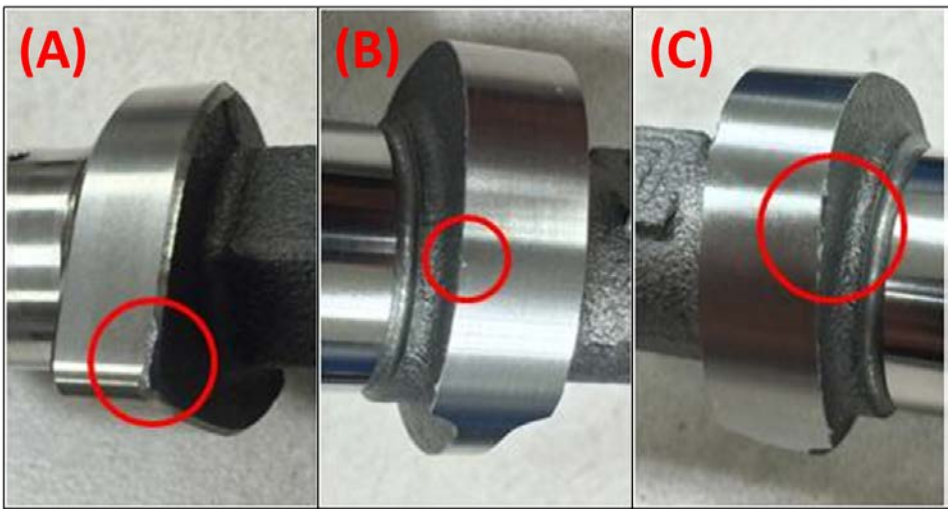


Figure 12 - **(A)** Grinding Damage, **(B)** Pitting and **(C)** Shipping Damage

9. Pre-Test Camshaft Diameter Measurements:

9.1. Use a pin gage set to measure and record the diameter of all five oil feed holes on the journals of both the intake and exhaust camshafts (Figure 13).

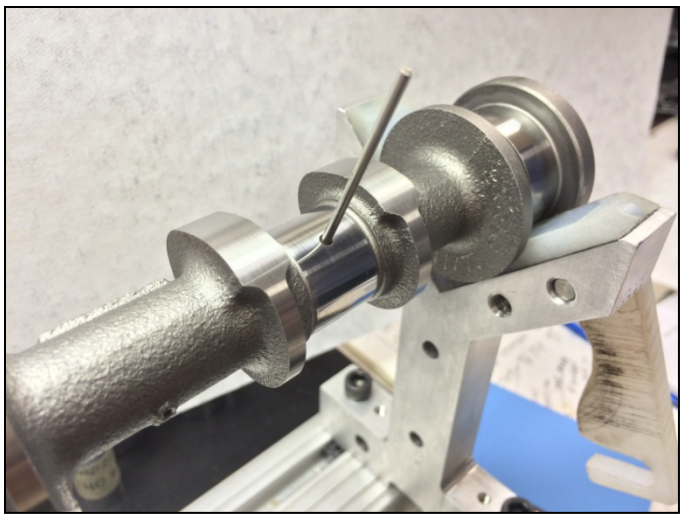


Figure 13 - Measuring Oil Feed Hole Diameters Using a Pin Gage

9.2. Place the camshaft on a V-Block fixture.
  9.2.1. The V-Blocks should be spaced so that each camshaft is supported on its 2nd and 5th journals.

9.3. Place a dial indicator next to the camshaft so that the spindle head is in contact with **Journal #3** and is orthogonal to the axis of the camshaft (Figure 14).
  9.3.1. Rotate the camshaft until the dial indicator reads a minimum value.
  9.3.2. Zero the dial indicator.
  9.3.3. Rotate the camshaft again until the dial indicator reads a maximum value.
  9.3.4. Record this dial indicator measurement as the run-out of **Journal #3**.
  9.3.5. Repeat these steps to obtain the run-out measurement for **Journal #4**.
  9.3.6. Average the run-out measurements of **Journal #3** and **Journal #4** to calculate the overall run-out of the camshaft.
  9.3.7. Repeat these steps for the second camshaft.

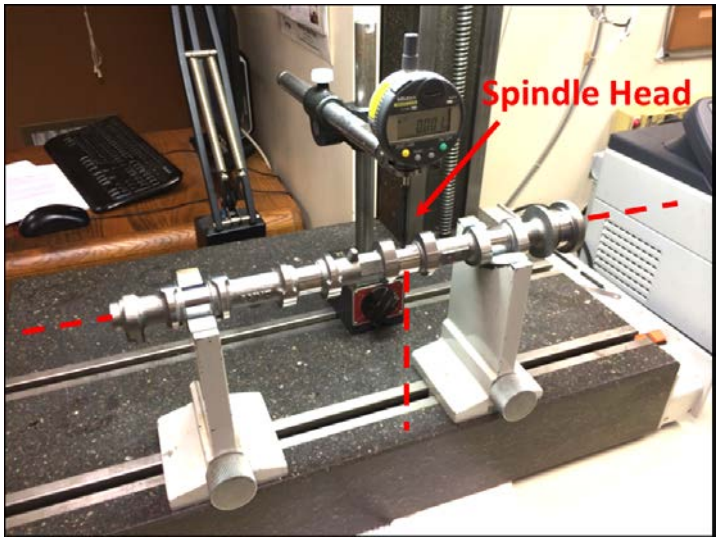


Figure 14 - Correct Positioning of Dial Indicator for Journal Run-Out Measurements

9.4. Reject any camshaft that has a run-out value that exceeds 0.04mm (0.00157-in).

9.5. Measure the diameter of **Journal #1** with a 1-2 inch digital micrometer.
  9.5.1. A *Mitutoyo Model #293-722-10 digital micrometer* is recommended for these measurements.

9.5.2.Measure the diameter of the journal along both its x-axis and y-axis (Figure 15).

9.5.3.Important Notes:

9.5.3.1. The x-axis passes through the center of the oil feed hole and intersects the center of the journal.

9.5.3.2. The y-axis is orthogonal to the x-axis.

9.5.4.Record the average of the x-axis and y-axis diameter measurements for **Journal #1**.

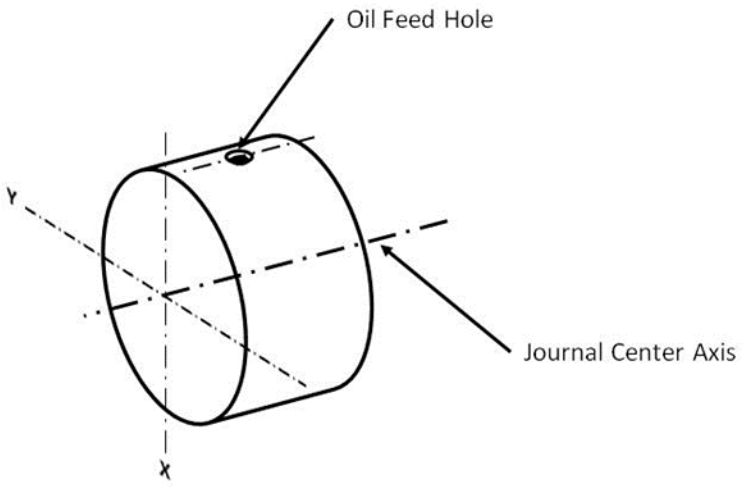


Figure 15 - X and Y-Axis of Camshaft Journal

9.6. Use a 0-1 inch digital micrometer to measure the diameter of **Journal #2** through **Journal #5**.

9.6.1.A *Mitutoyo Model #293-721-10 digital micrometer* is recommended for these measurements.

9.7. Reject any camshafts with journal diameters that exceed the following specifications (Table 2):

Table 2 - Camshaft Journal Diameter Specifications

Item	Specified Condition
Journal #1	33.949 - 33.968 mm (1.3366 – 1.3372 in)
Journal #2 - #5	22.949 – 22.965 mm (0.9035 – 0.9041 in)

10. Pre-Test Camshaft Lobe Heel-to-Toe Height:

10.1. Place the camshaft on a V-Block fixture.

10.1.1. The V-Blocks should be spaced so that each camshaft is supported on its 2nd and 5th journals.

10.2. Calibrate a 1-2 inch snap gage using a cylindrical measurement standard.

10.2.1. A *Mitutoyo Model #201-152 snap gauge* with a *Mitutoyo Model #ID-C112AEB digital indicator attachment* is recommended for these measurements.

10.2.2. The cylindrical measurement standard used for intake camshaft lobe heel-to-toe measurements has a diameter of 36.725mm.

10.2.3. The cylindrical measurement standard used for exhaust camshaft lobe heel-to-toe measurements has a diameter of 39.500mm.

10.3. Set the base circle of the camshaft lobe on the anvil of the snap gage and engage the spindle (Figure 16).

10.3.1. While keeping the snap gage centered on the lobe, slowly rotate the snap gage around the lobe until the digital indicator reads a maximum value.
10.3.2. Record this measurement as the heel-to-toe height for the specific camshaft lobe.
10.3.3. Repeat this measurement for the eight camshaft lobes on both the intake and exhaust camshafts.

Figure 16 - Positioning the Snap Gage to Measure the Camshaft Heel-to-Toe Height

10.4. Reject any exhaust camshafts that have heel-to-toe heights that exceed the following specifications (Table 3):
10.4.1. *Important Note:* There are currently no heel-to-toe height specifications for the intake camshafts.

Table 3 - Camshaft Heel-to-Toe Height Specifications

Item	Specified Condition
Standard Lobe Height	39.462-39.562 mm (1.554-1.558 in)
Minimum Lobe Height	39.362 mm (1.550 in)

11. Pre-Test Camshaft Lobe Surface Profile Traces:

11.1. Profile traces are to be performed using a *Precision Devices, Inc. (PDI) MicroAnalyzer 2000* profilometer that is using the *Windows XP Version 3.6.15* operational software.

11.2. Confirm that the **TOYOTA_CAM.NDT** template file is being used.

11.3. Confirm the following settings on the *Delimitation* tab:
11.3.1. The **Find** checkbox is selected and the filter width is set to **0.400mm** under the *Left Edge* field.
11.3.2. The **Find** checkbox is selected and the filter width is set to **0.400mm** under the *Right Edge* field.

11.3.3. The **Fix Truncation to Part Edges** checkbox is selected.
11.3.4. The **ASME B46.1-2002** standard is being used.

11.4. Confirm the following settings on the *Primary Extraction* tab:
11.4.1. The **Two-Point Line** radial button is selected under the *Form Removal* field.
11.4.2. The filter cutoff is set to **0.00µm** under the *Shortwave Cutoff* field.

11.5. Confirm the following settings on the *Waviness Extraction* tab:
11.5.1. The **Gaussian** radial button is selected under the *Waviness Short Cutoff* field.
11.5.2. The filter cutoff is set to **0.800mm** under the *Waviness Short Cutoff* field.

11.6. Confirm the following settings on the *Roughness Extraction* tab:
11.6.1. The **Gaussian** radial button is selected under the *Roughness Cutoff* field.
11.6.2. The filter cutoff is set to **0.800mm** under the *Roughness Cutoff* field.

11.7. Place the camshaft on a V-Block fixture.
11.7.1. The V-Blocks should be spaced so that each camshaft is supported on its 2nd and 5th journals.

11.8. Move the stylus until it is over the camshaft lobe that is to be measured.
11.8.1. Rotate the camshaft until the nose of the lobe is pointed toward the stylus.
11.8.2. Lower the stylus onto the surface of the camshaft lobe.
11.8.3. Slowly rotate the camshaft until the stylus reaches the point of highest displacement.

11.9. Obtain a trace that spans the width of the camshaft lobe.
11.9.1. Report the **roughness average (Ra)**, **skew (Rsk)** and **waviness (Wt)**.
11.9.2. Save the pre-test traces using the appropriate file naming convention.
11.9.3. Repeat the measurements for all eight camshaft lobes for both the intake and exhaust camshafts.

Revision Notes	Revision No.	Revision Date
SWRI document, ***Section H – Pre and After Measurement Procedure.doc***.	2.0	10-16-2014
Modified format and included setting changes agreed upon during 04-23-2015 conference call between three Metrology labs (IAR, SWRI and LZ).	3.0	04-30-2015
This revision reflects the feedback provided by the SWRI document, ***IVB Section H PDI Procedure – Revision 3 0_revEL.docx***. It also reflects suggestions made during 05/07/2015 conference call.	4.0	05-20-2015
Modified Figure 2 through Figure 5 based on feedback received during 05/22/2015 conference call.	4.1	05-22-2015

Keyence

Keyence Measurements and Calibration Check Procedure and Talc Application Procedure

Keyence VR-3000 Procedure | Draft

Revised Date *02-05-2016* | Revision *3.5* | Lubrizol Corporation

Test Name:	Sequence IVB
Revision By:	CHTM, MKKN
Comments:	This draft will eventually be incorporated into the Sequence IVB test procedure.

IMAGING PRE-TEST INTAKE AND EXHAUST LIFTERS (AUTO STITCHING)

1. Establish the Correct Viewer Software Settings:

1.1. Open the Keyence VR-3000 Viewer software.

1.2. Select **Options** from the *Tools* pull-down menu at the top of the screen.
1.2.1. This will cause the *Options* pop-up menu to appear.

1.3. Under the *Options* pop-up menu (Figure 1):
1.3.1. Select the **(A) 3D measurement – Auto stitching** option from the left-side of the pop-up menu.
1.3.2. Uncheck the **(B) Perform auto stitching after measurement and then automatically open stitched image** checkbox if needed.
1.3.3. Check the **(C) Auto-adjust position when stitching** checkbox.
1.3.4. Click the **(D) OK** button when complete.

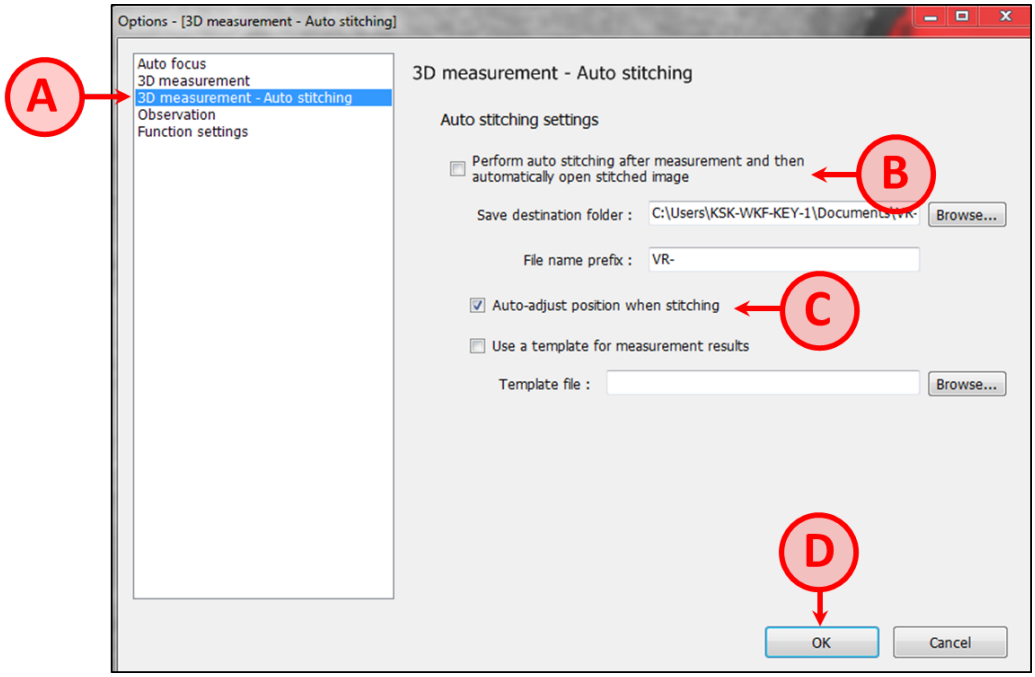


Figure 1 – Options [3D measurement – Auto stitching] Pop-Up Menu

1.4. Under the *Change Magnification* section located in the upper toolbar (Figure 2):
   1.4.1. Select **Low Mag Cam** from the left pull-down menu.
   1.4.2. Select **25x** from the *Magnification* pull-down menu.

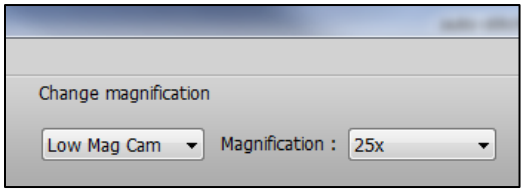


Figure 2 - Change Magnification Toolbar

1.5. Under the *Expert Mode* option of the *3D Measure* tab (Figure 3):
   1.5.1. Select the **(A) Meas settings** button.
   1.5.2. Select **(B) Standard** from the *Mode* pull-down menu.
   1.5.3. Select **(C) Both Sides** from the *Measurement direction* pull-down menu.
   1.5.4. Select the **(D) Auto** radial button under the *Adjust brightness for measurement* section.
   1.5.5. Select **(E) Auto** from the *Stitching* pull-down menu.
      1.5.5.1. *Important Note:* This should be set to **Manual** for Keyence units with a manual stage.
   1.5.6. Confirm that the **(F) Enable AF** checkbox is not selected.

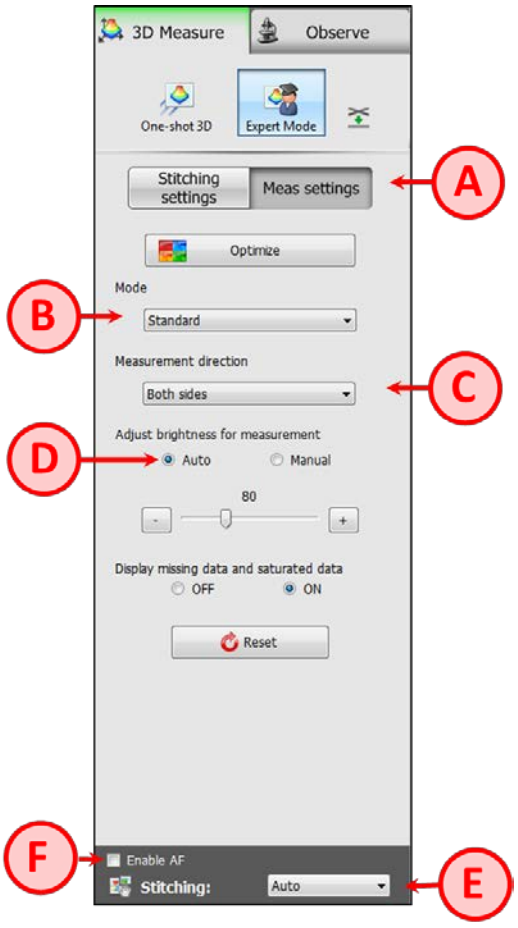


Figure 3 - Measurement Settings under 3D Measure Tab

1.6. Under the *Expert Mode* option of the *3D Measure* tab (Figure 4):

1.6.1. Select the **(A) Stitching settings** button.
1.6.2. Select the **(B) Simple** radial button under the *Area specification method* section.

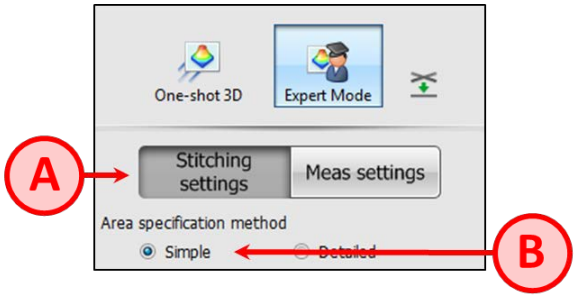


Figure 4 - Stitching Settings under 3D Measurement Tab

2. Take the Lifter Measurements:

2.1. *Important Notes:*
2.1.1. All pre-test lifter images must be captured and post-processed before the test can be started.
2.1.2. The macroscope must be warmed for approximately 1-hour in Expert Mode before any measurements are taken.
2.1.3. The OHT Keyence lifter fixture (P/N: IVB13751-KEY) must be used for all Sequence IVB measurements.
2.1.4. It is recommended that the OHT spacer (P/N: IVB13751-Spacer) is used in conjunction with the OHT fixture if the Keyence macroscope is configured with the optional spacer.

2.2. Wipe the top of the lifter until it is free of residue, smudges and dust.

2.3. Place the lifter in the OHT fixture with the wear surface facing upwards with the laser etching mark on the lifter aligned with one of the orthogonal axis marked on the OHT fixture.

2.4. Select an area on the image of the lifter and double-click the left mouse button to perform an auto focus.

2.5. Position the camera near the center of the lifter and then pan the camera down and to the right until the lower right-hand reference marks on the OHT fixture are aligned with the lower right-hand corner of the viewing area (Figure 5). Click and hold the right mouse button to drag the lifter image as needed, or use the arrows on the *XY stage* menu to move the camera.

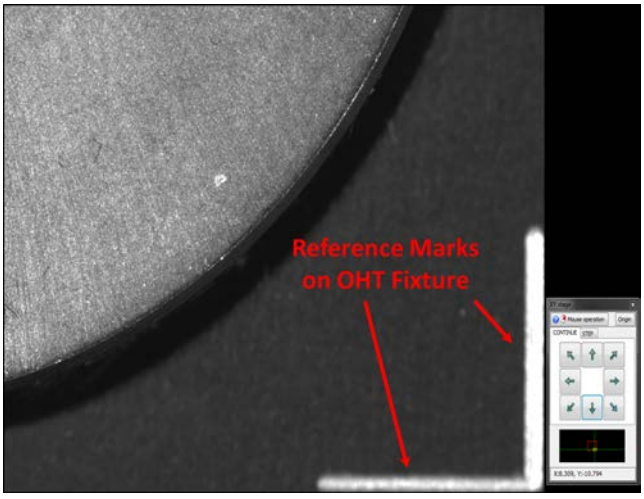


Figure 5 – Establishing Negative Space on the Screen Using Reference Marks on OHT Fixture

2.5.1. Press the **(A) Add** button to capture the image within the view of the *Stitching* area (Figure 6).
2.5.2. Repeat these steps to establish an image at the upper left-hand side of the lifter.
2.5.3. Capturing images of the upper left-hand and bottom right-hand corners of the lifter (as shown in Figure 6) are sufficient to establish the stitching area.

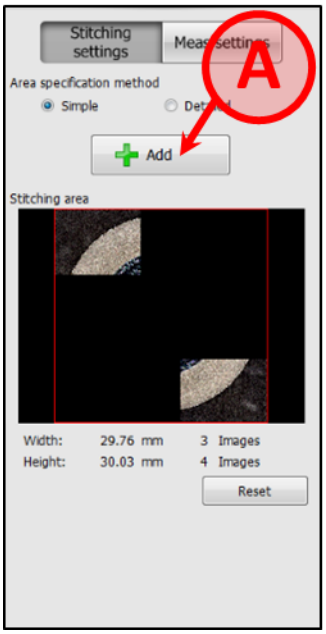


Figure 6 - Establishing the Stitching Area

2.6. Click the **Measure** button in the lower right-hand side of the screen once the boundaries of the lifter are established.

2.7. Click the **(A) Auto position adjustment** button that appears on the right of the *Stitching* screen after the image capture is complete (Figure 7).

2.8. Click the **(B) Execute Stitching** button that also appears on the right of the *Stitching* screen (Figure 7).

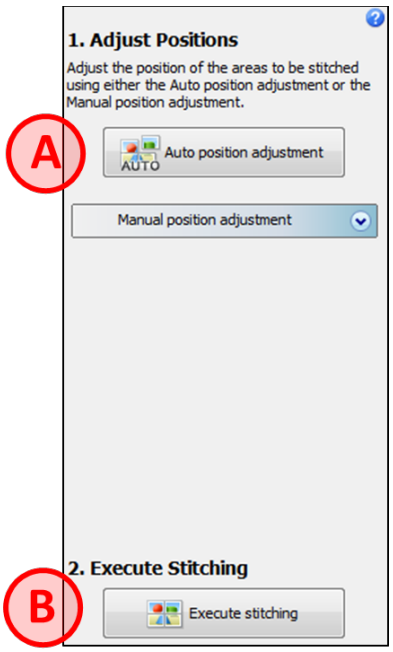


Figure 7 - Right-Side of Stitching Screen after Image Capture

2.9. Under the *Save Stitched Results* prompt, select **1200X1200** from the *Image size to save* pull-down menu (Figure 8).

2.9.1. The user may be required to select the option from the pull-down menu that is the closest to the 1200X1200 size.

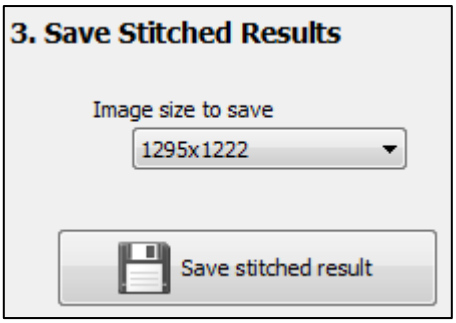


Figure 8 - Save Stitched Results Field

2.10. Click the **Save stitched result** button under the *Save Stitched Results* field (Figure 8).

2.10.1. Enter the desired file name in the *Save As* pop-up menu and press the **Save** button.

2.10.2. Use a different naming convention for the pre-test and post-test image files.

2.11. Select the **Use template file** checkbox on the *Open the stitched result, which was saved, in Analyzer* prompt.

2.11.1. Click the **Yes** button.

2.12. Select the **IVB Lifter Volume Temp_clr Exhaust_rev2.ztp** template file from the *Open* prompt.

2.12.1. Press the **Open** button on the *Open* prompt.

2.13. Important Note:

2.13.1. The user also has the option of collecting all of the images first, and then post-processing them at the same time using the *Analyzer* software.

2.13.2. This can be done in the *Analyzer* software by selecting the **Open with Template** option under the *File* pull-down menu.

2.13.3. Select **the IVB Lifter Volume Temp_clr Exhaust_rev2.ztp** template file from the *Open* prompt.

2.13.4. Use the **Shift** button to select all of the lifter images that are to have the template applied.

2.13.5. Click the **Ok** button.

3. Post-Process the Images Using the Analyzer Software:

3.1. Click the **Ref plane** button located in the upper toolbar of the main *Analyzer Software* screen (Figure 9).

Figure 9 - Reference Plane Button

3.2. Click the **(A) Area settings** button near the top of the *Reference plane settings* pop-up menu (Figure 10).

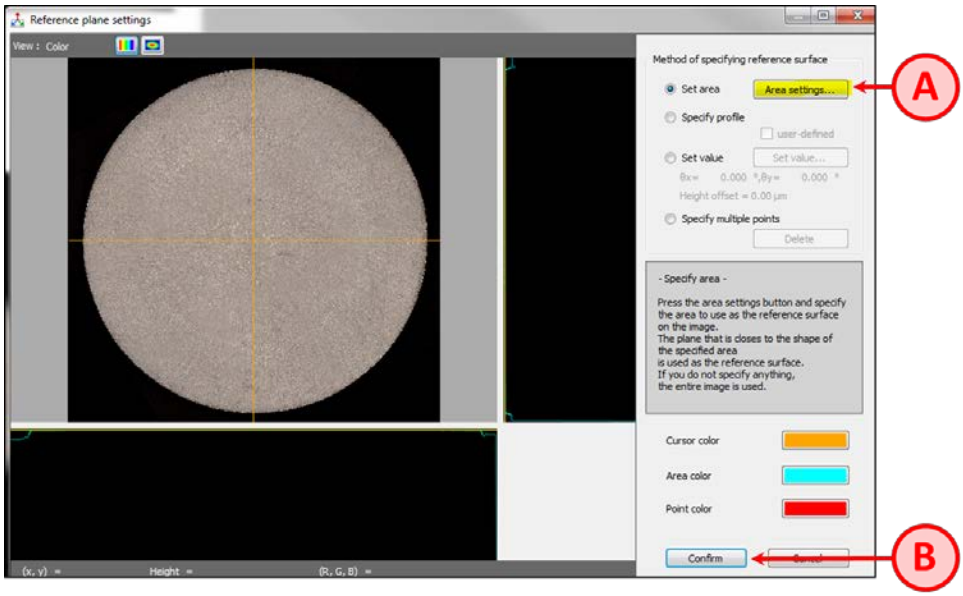


Figure 10 - Reference Plane Settings Pop-Up Menu

3.3. Click the **(A) Import area** button near the lower right-side corner of the *Area settings* pop-up menu (Figure 11).

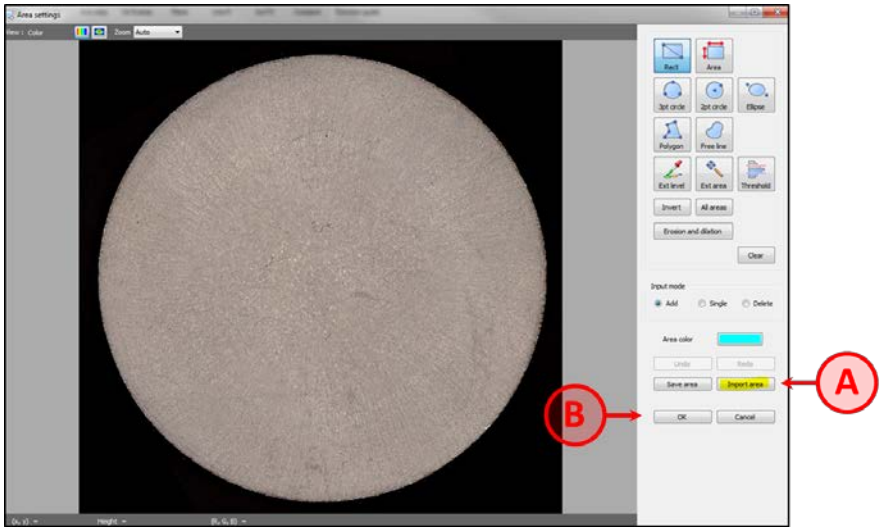


Figure 11 - Area Settings Pop-Up Menu

3.4. Select the **IVB leveling ring Exhaust_rev2.zri** file from the *Open* prompt.
   3.4.1. Press the **Open** button.

3.5. It is very important to confirm that the leveling ring is concentric with the lifter face.

3.6. Click the **(B) Ok** button (Figure 11) on the *Area settings* pop-up menu.

3.7. Click the **(B) Confirm** button (Figure 10) the *Reference plane settings* pop-up menu.

3.8. Click the **Ok** button on the *Reference plane settings (confirmation)* pop-up menu.

3.9. Select the **Volume & area 1** tab near the top of the *Analyzer Software* screen.
   3.9.1. *Important Note:* Please reference Addendum C for instructions on how to handle high-wear lifters.
   3.9.2. The volume data from the **Total** row of the *volume vs. area ratio* table (Figure 12) needs to be reported in the final test report as the pre-test volume.

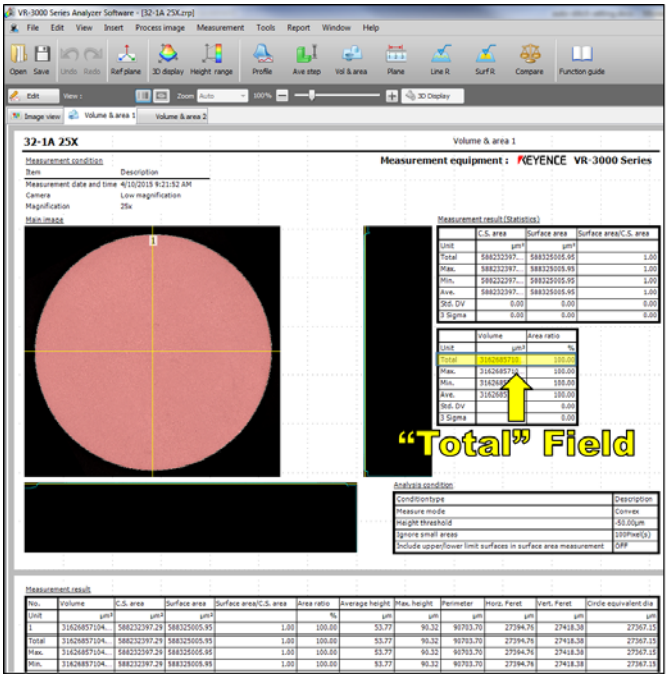


Figure 12 - Critical Data on Volume & Area 1 Tab

3.10. Select the **Save As** option from the *File* pull-down menu near the top of the screen.

3.10.1. Save this file using a different name than the original image in the event that the template application process is unsuccessful.

3.11. Click the **To Viewer** button.

3.12. Click the **Exit Stitching** button on the *Viewer Software* screen.

3.12.1. Click the **Yes** button at the *Ok to proceed* prompt.

3.13. Click the **Reset** button underneath the *Stitching area*.

3.13.1. Click the **Yes** button at the *Delete current stitch area settings* prompt.

IMAGING POST-TEST INTAKE AND EXHAUST LIFTERS (AUTO STITCHING)

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4. Establish the Correct Viewer Software Settings:

4.1. Repeat Steps 1.1 through 1.4.

4.2. Under the *Expert Mode* option of the *3D Measure* tab (reference Figure 3):

4.2.1. Select the **(A) Meas settings** button.

4.2.2. Select **Glare Removal** from the *Mode* pull-down menu (reference Item **B**).

4.2.3. Select **(C) Both Sides** from the *Measurement direction* pull-down menu.

4.2.4. Select the **Manual** radial button under the *Adjust brightness for measurement* section (reference Item **D**).

4.2.5. Select **(E) Auto** from the *Stitching* pull-down menu.

4.2.5.1. *Important Note:* This should be set to **Manual** for Keyence units with a manual stage.

4.2.6. Select the **(F) Enable AF** checkbox.

4.3. Set the **(A)** *Left side projection* and **(B)** *Right side projection* sliders to **300.0ms** (Figure 13).

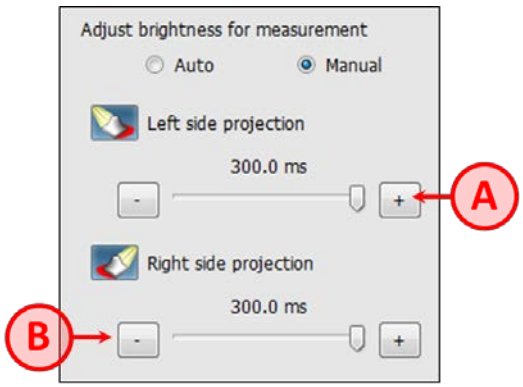

Figure 13 - Projection Sliders to Adjust Brightness

4.4. Under the *Expert Mode* option of the *3D Measure* tab:
  4.4.1. Select the **Stitching settings** button.
  4.4.2. Select the **Simple** radial button under the *Area specification method* section.

5. Take the Lifter Measurements:

5.1. Repeat Steps 2.2 through 2.13.

6. Post-Process the Images Using the Analyzer Software:

6.1. Repeat Steps 3.1 through 3.9.

6.2. Select the **Volume & area 2** tab near the top of the *Analyzer Software* screen.
  6.2.1. The volume data from the **Total** row of the *volume vs. area ratio* table (Figure 14) needs to be reported in the final test report as the post-test high spot volume.

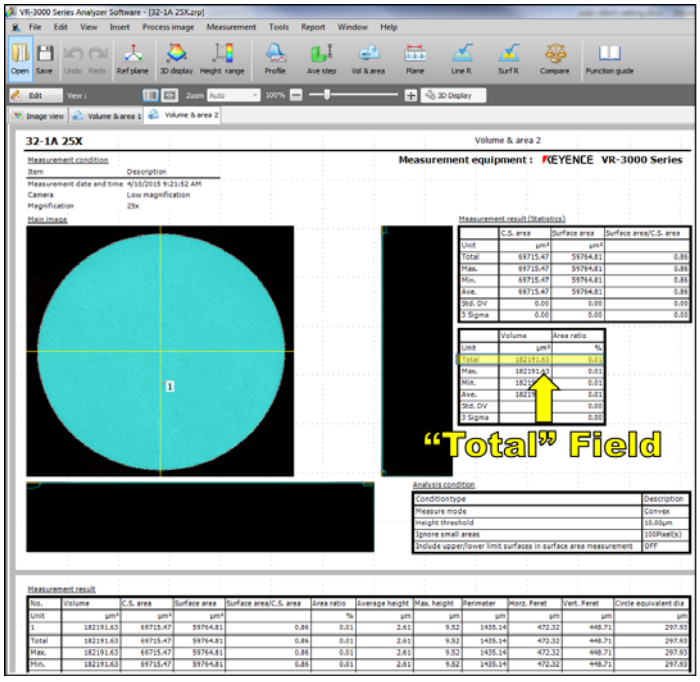

Figure 14 - Critical Data on Volume & Area 2 Tab

6.3. Select the **Save As** option from the *File* pull-down menu near the top of the screen.

6.3.1. Save this file using a different name than the original image in the event that the template application process is unsuccessful.

6.4. Click the **To Viewer** button.

6.5. Click the **Exit Stitching** button on the *Viewer Software* screen.
6.5.1. Click the **Yes** button at the *Ok to proceed* prompt.

6.6. Click the **Reset** button underneath the *Stitching area*.
6.6.1. Click the **Yes** button at the *Delete current stitch area settings* prompt.

CALCULATING LIFTER WEAR

7. Use the Following Equation to Calculate End of Test Wear for Each Lifter:

$$\textbf{Wear Volume} = (\text{Pre-Test Volume}) - (\text{Post-Test Volume}) + (\text{High Spot Volume})$$

ADDENDUM B – CALIBRATION INSTRUCTIONS

8. Recommended Calibration and Verification Frequencies:

8.1. The manufacturer recommends verifying the calibration every time the macroscope is used.

8.2. The manufacturer recommends updating the calibration approximately one time per month.

8.3. All of the manufacturer's calibration documentation can be found in the *Viewer Software Reference Manual VR-H1V*.

8.4. *Important Note:* The macroscope must be allowed to warm-up for 1-hour before performing a calibration or verification check.

9. XY-Calibration of Macroscope:

9.1. Place the calibration block on the stage plate.
9.1.1. *Important Note:* The calibration block is available through Keyence (P/N OP-87710).

9.2. Adjust the camera position until the right-side of the calibration block is in view on the screen.

9.3. Select **Calibration → XY calibration** from the *Maintenance* option in the *Tools* pull-down menu.
9.3.1. Follow the prompts on the screen to complete the calibration.

10. Z-Calibration of Macroscope:

10.1. Adjust the camera position until the left-side of the calibration block is in view on the screen.

10.2. Select **Calibration → Z calibration** from the *Maintenance* option in the *Tools* pull-down menu.

10.2.1. Follow the prompts on the screen to complete the calibration.

11. Verifying the Calibration:

11.1. Select **Verification → Measure width 20 times** from the *Maintenance* option in the *Tools* pull-down menu.

11.1.1. Follow the prompts on the screen to complete the calibration.

11.2. Select **Verification → Measure height 20 times** from the *Maintenance* option in the *Tools* pull-down menu.

11.2.1. Follow the prompts on the screen to complete the calibration.

ADDENDUM C – DEALING WITH HIGH-WEAR END OF TEST LIFTERS

12. Identifying a High-Wear Lifter:

12.1. A high-wear lifter is any lifter that has a wear depth that is below the standard evaluation depth of the Keyence software.

12.1.1. These high-wear lifters are identified by the presence of a large blue region near the center of the lifter image on the **Volume & area 2** tab (as shown in Figure 15).

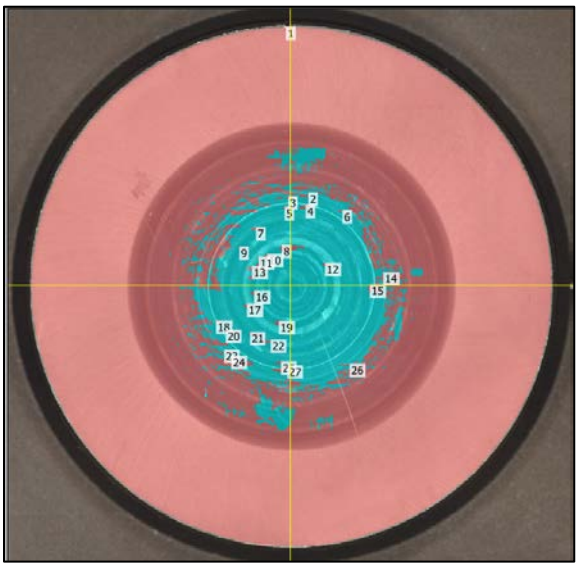

Figure 15 - Illustration of Region of Lifter below Standard Evaluation Depth

13. Lower the Evaluation Depth to Encapsulate the Entire Surface of the Lifter:

13.1. Select **Edit**.

13.2. Click the **(A) Settings** button directly under the **Height Threshold** field in Figure 16.

13.3. Change the value of the **(C) Height threshold** field of the **Set threshold** menu (Figure 17) to -100µm.

13.3.1. Click the **(D) OK** button.

13.4. Click the (**B) Create Report** button (Figure 16).

13.5. *Important Note:* These steps must be repeated for the pre-test image of this lifter.

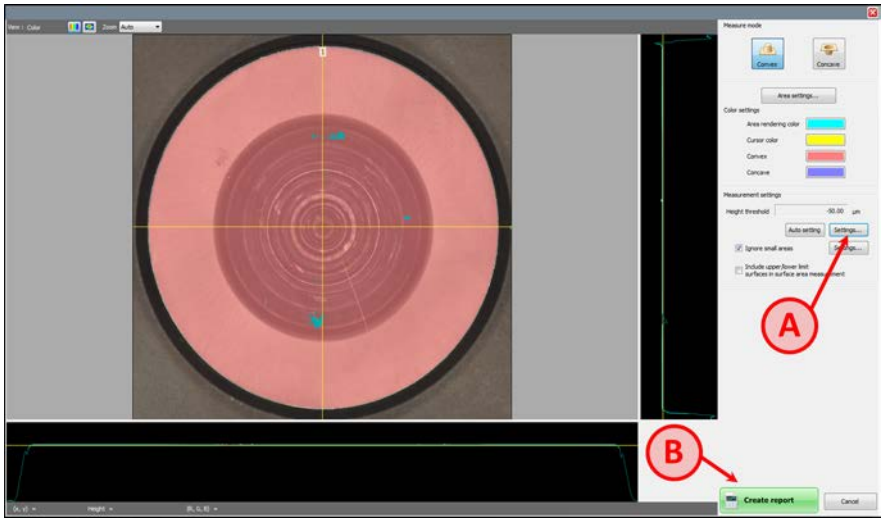

Figure 16 - Changing Height Threshold Setting

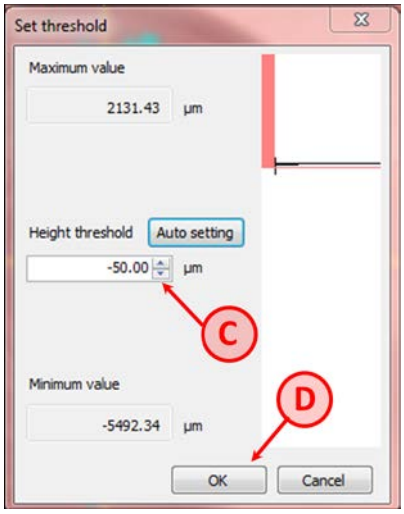

Figure 17 - Set Threshold Menu

Revision Notes	Revision No.	Revision Date
Lubrizol revised the format based on the original revision supplied by SWRI.	2.0	04-15-2015
Revision made based on feedback received by IAR and SWRI during 04-17-2015 conference call.	3.0	04-20-2015
Revision made based on feedback from SWRI (IVB Keyence Procedure – Revision3_revEL)	3.1	04-20-2015
Added *Addendum A – Additional Instructions for Keyence Units with Manual Stage*	3.2	04-29-2015

Revision Notes	Revision No.	Revision Date
Added *Addendum B – Calibration Instructions*	3.3	05-14-2015
Revision made based on feedback from SWRI document (IVB Keyence Procedure – Revision3 3_revEL) and also feedback received during 05-19-2015 conference call.	3.4	05-19-2015
Revision based on decisions made by three development laboratories during 07-30-2015 Keyence meeting in Cleveland, OH and 01-29-2016 conference call to discuss 2nd Keyence Round Robin.	3.5	02-05-2016

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Talc Application Procedure

The purpose of this document is to outline the procedure for applying talcum powder to post-test lifters in an effort to cancel the effects of high surface reflectivity and the resultant aberrations it causes on the repeatability and accuracy of Keyence VR-3200 scans. Human processes are of course inconsistent from technician to technician and from task to task. Care should be taken to follow the intent of the process with attention paid to the development of a technique that each technician will need to keep as repeatable as possible.

1. Tools

- ***PC compressed air duster***:

- ***Nextengine Extra Powderpen***: The powderpen can be purchased directly from Nextengine at a cost of $10. It is found on page 3 of the Nextengine store which can be accessed via the following link: https://www.nextengine.com/store.

2. Procedure

Prior to talc application, prepare the surface of the lifter by wiping it with a clean, lint-free cloth to clear away any smudges or residue from handling. If lifter surface is excessively soiled, clean with pentane. Once clean, proceed with talc application. It is important to note that it is ideal to use the minimum amount of talc required to achieve a good scan. Several application and scan cycles may be necessary for the technician to develop a good “feel” for the amount of talc required. To help control the amount of talc applied and the character of the application, the brush can be used with the bristles half or fully “nested” into the sleeve instead of extended. Images should always be reviewed when using talc powder to aid in scanning reflective surfaces.

2.1

Wipe the lifter clean. Refer to Figure 2.1.1 for an example of a clean lifter prior to the application of any talc.

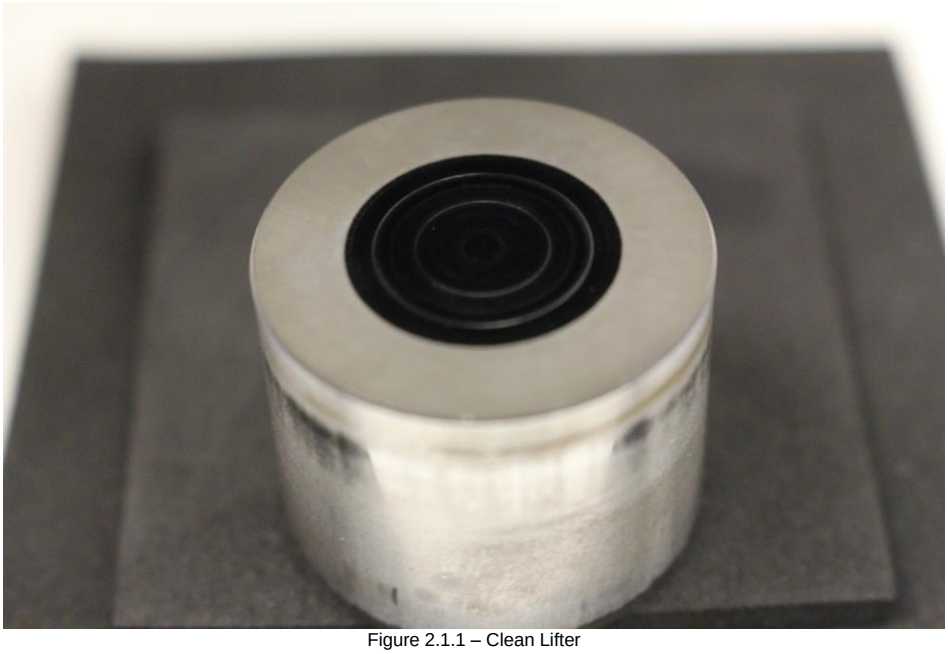


Figure 2.1.1 – Clean Lifter

2.2

There are two primary methods that can be employed to apply talc to the lifter surface. “Tamping” is a method in which the ends of the brush bristles are patted down onto the lifter surface perpendicular to the surface plane. Note in figure 2.2.1 that the talc characteristic is large spherical particles and smaller talc dust.

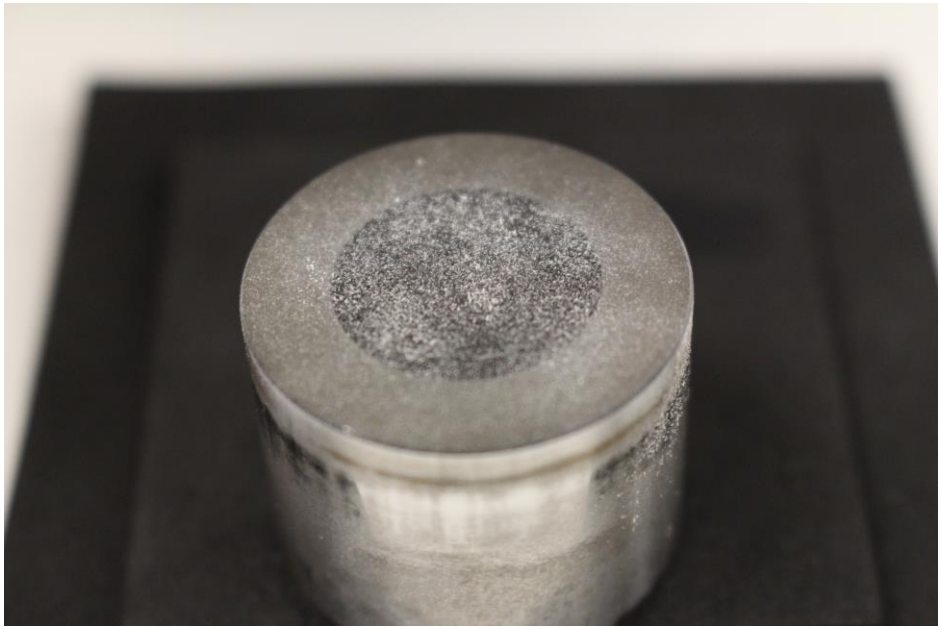


Figure 2.1 – Lifter after Tamping

2.3

"Brushing" is a method in which the bristles are swept across the lifter surface. Refer to Figure 2.3.1 for an example. Note that the characteristic is a swept pattern of talc dust. There are not very many large particles present.

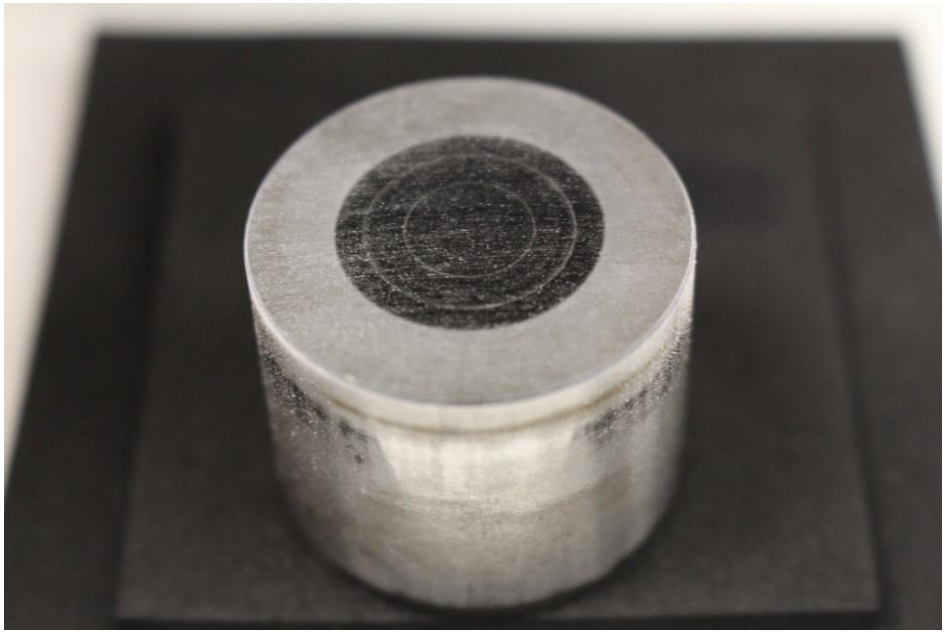


Figure 2.3.1 – Lifter after Brushing

2.4

Use a "tamping" method to first coat the lifter surface followed by a "brushing" method to wipe the larger particles away and create a light smearing affect. Then use the compressed air duster to blow away as much talc as possible when holding the duster approx. 10-12 inches from the lifter surface using the straw attachment. Use a sweeping motion when dusting the lifter surface; 2-3 pulsed blasts should be sufficient. Refer to Figure 2.4.1 for an example of what the lifter should look like after being dusted with the compressed air.

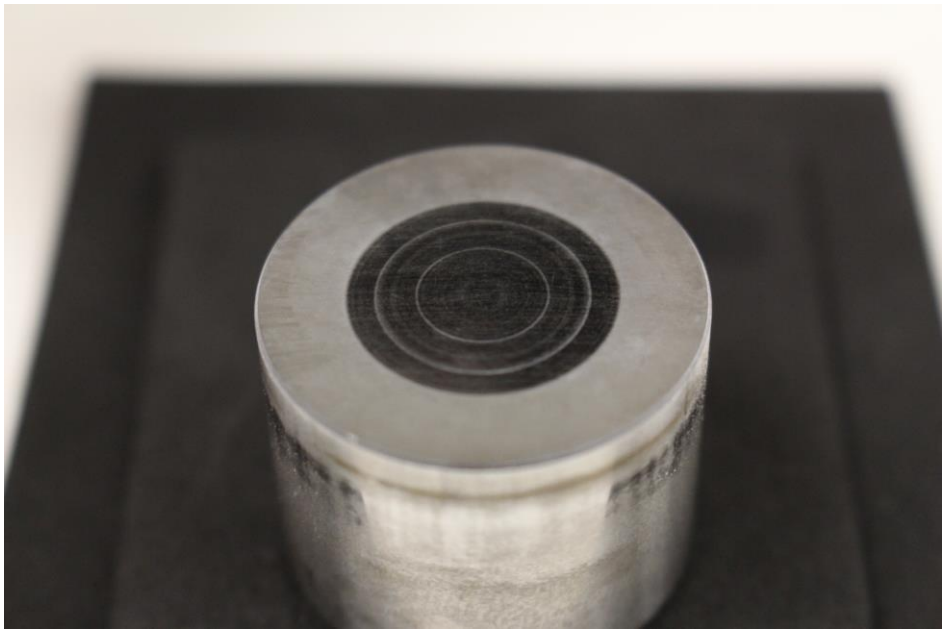


Figure 2.4.1 – Lifter after Dusting

3. Scan

Scan the lifter and proceed with the post-processing steps outlined in the current revision of the *Keyence VR-3000 Procedure.*

Section 13

Test Report

13. Test Report

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

NOTE X 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.

XY.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.

13.7 *Photographs*—The final test report does not require photographs.

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

Section 14

Precision and Bias

NOTE: To be drafted, post-precision matrix, once necessary information is available.

Section 15

Keywords

NOTE: To be drafted, post-precision matrix, once necessary information is available.

Annex A1

ASTM Test Monitoring Center:

Role

A1. ASTM TEST MONITORING CENTER: ROLE

A1.1 *Nature and Functions of the ASTM Test Monitoring Center (TMC)*—The TMC is a non-profit organization located in Pittsburgh, Pennsylvania and is staffed to: administer engineering studies; conduct laboratory inspections; perform statistical analyses of reference oil test data; blend, store, and ship reference oils; and provide the associated administrative functions to maintain the referencing calibration program for various lubricant tests as directed by ASTM Subcommittee D02.B0 and the ASTM Executive Committee. The TMC coordinates its activities with the test sponsors, the test developers, the surveillance panels, and the testing laboratories. Contact TMC through the TMC Director at:

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

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

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

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

Annex A2

ASTM Test Monitoring Center:

Calibration Procedures

A2. ASTM TEST MONITORING CENTER: CALIBRATION PROCEDURES

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

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

A2.2 *Calibration Testing:*

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

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

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

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

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

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

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

Annex A3

ASTM Test Monitoring Center:

Maintenance Activities

A3. ASTM TEST MONITORING CENTER: MAINTENANCE ACTIVITIES

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

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

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

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

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

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

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

A3.7 *TMC Memoranda*—In addition to the Information Letters, supplementary memoranda are issued. These are developed by the TMC and distributed to the appropriate surveillance panel and participating laboratories. They convey such information as batch approvals for test parts or materials, clarification of the test procedure, notes and suggestions of the collection and analysis of special data that the TMC may request, or for any other pertinent matters having no direct effect on the test performance, results, or precision and bias.

Annex A4

ASTM Test Monitoring Center:

Related Information

A4. ASTM TEST MONITORING CENTER: RELATED INFORMATION

A4.1 *New Laboratories*—Laboratories wishing to become part of the ASTM Test Monitoring System will be requested to conduct reference oil tests to ensure that the laboratory is using the proper testing techniques. Information concerning fees, laboratory inspection, reagents, testing practices, appropriate committee membership, and rater training can be obtained by contacting the TMC Director.

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

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

Annex A5

Safety Precautions

A5. SAFETY PRECAUTIONS

A5.1 *General Information*:

A5.1.1 The operating of engine tests can expose personnel and facilities to a number of safety hazards. It is recommended that only personnel who are thoroughly trained and experienced in engine testing should undertake the design, installation, and operations of engine test stands.

A5.1.2 Each laboratory conducting engine tests should have their test installation inspected and approved by their safety department. Personnel working on the engines should be provided with proper tools, be alert to common sense safety practices, and avoid contact with moving, or hot engine parts, or both. Guards should be installed around all external moving or hot parts. When engines are operating at high speeds, heavy-duty guards are required, and personnel should be cautioned against working alongside the engine and coupling shaft. Barrier protection should be provided for personnel. All fuel lines, oil lines, and electrical wiring should be properly routed, guarded, and kept in good order. Scraped knuckles, minor burns, and cuts are common, if proper safety precautions are not taken. Safety masks or glasses should always be worn by personnel working on the engines and no loose or flowing clothing, including long hair or other accessory to dress which could become entangled, should be worn near running engines.

A5.1.3 The external parts of the engines and the floor area around the engines should be kept clean and free of oil and fuel spills. In addition, all working areas should be free of tripping hazards. Personnel should be alert for leaking fuel or exhaust gas. Leaking fuel represents a fire hazard and exhaust gas fumes are noxious. Containers of oil or fuel cannot be permitted to accumulate in the testing area.

A5.1.4 The test installation should be equipped with a fuel shutoff valve, which is designed to automatically cut off the fuel supply to the engine when the engine is not running. A remote station for cutting off fuel from the test stand is recommended. Suitable interlocks should be provided so that the engine is automatically shut down when any of the following events occur: engine loses oil pressure, dynamometer loses field current, engine overspeeds, exhaust system fails, room ventilation fails, or the fire protection system is activated.

A5.1.5 Consider an excessive vibration pickup interlock if equipment operates unattended. Fixed fire protection equipment should be provided.

A5.1.6 Normal precautions should be observed whenever using flammable solvents for cleaning purposes. Make sure adequate firefighting equipment is immediately accessible.

Annex A6

Parts List

NOTE: Draft is currently in process and will be added post-precision matrix.

A6. PARTS LIST

A6.1 This annex illustrates the parts needed for the Sequence IVB test (Table A6.1).

TABLE A6.1 Parts List

Section	Description	Part Number	Contents			Supplier
			Part Name	Part Number	Quantity	
Engine Assembly Manual Section 3	KIT, CYLINDER HEAD REPLACEMENT AND MAINTENANCE[B]	OHTIVB-101-1	GASKET, CYLINDER HEAD	OHTIVB-11115-1	1	OH Technologies, Inc.
			GASKET, SPARKPLUG TUBE	OHTIVB-11193-1	4	
			SEAL, TYPE T OIL	OHTIVB-90311-1	1	
			GASKET	OHTIVB-12031-1	1	
			O-RING, FRONT COVER	OHTIVB-09031-1	1	
			RING, O	OHTIVB-19023-1	1	
			O-RING, FRONT COVER	OHTIVB-27014-1	1	
			SPRING, COMPRESSION	OHTIVB-30034-1	8	
			GASKET, CHAIN TENSIONER	OHTIVB-13552-1	1	
			GASKET, INTAKEMANIFOLD TO HEAD	OHTIVB-17177-1	1	
			GASKET, EXHAUST MANIFOLD	OHTIVB-17173-1	1	
			NUT	OHTIVB-08228-1	2	
			BOLT, FLANGE W/WASHER	OHTIVB-80825-1	2	
			GASKET, THROTTLE BODY	OHTIVB-22271-1	1	
			INSULATOR, INJECTOR VIBRATION	OHTIVB-23291-1	4	
			O-RING, INJECTOR	OHTIVB-07033-1	4	
			COVER ASSY, CLUTCH	OHTIVB-31210-1	1	
			DISC ASSY, CLUTCH	OHTIVB-31250-1	1	
			BOLT, W/WASHER	OHTIVB-08026-1	6	
			BEARING, RADIAL BALL	OHTIVB-90363-1	1	
			HEAD SUB-ASSY, CYLINDER	OHTIVB-11101-1	1	
			GASKET, CYLINDER HEAD	OHTIVB-11115-1	1	
			TUBE, SPARKPLUG	OHTIVB-11191-1	4	
			GASKET, SPARKPLUG TUBE	OHTIVB-11193-1	4	
			GASKET, CYLINDER HEAD COVER	OHTIVB-11213-1	1	
			SEAL, TYPE T OIL	OHTIVB-90311-1	1	
			O-RING, FRONT COVER	OHTIVB-09031-1	1	
			O-RING, FRONT COVER	OHTIVB-19023-1	1	
			O-RING, FRONT COVER	OHTIVB-27014-1	1	
			GASKET, CHAIN TENSIONER	OHTIVB-13552-1	1	
			VALVE, INTAKE	OHTIVB-13711-1	8	
			VALVE, EXHAUST	OHTIVB-13715-1	8	
			SEAT, VALVE SPRING	OHTIVB-13734-1	16	
			RETAINER, VALVE SPRING	OHTIVB-13741-1	16	
			SPRING, COMPRESSION	OHTIVB-30034-1	8	
			SPRING, COMPRESSION	OHTIVB-25063-1	8	
			LOCK, VALVE SPRING RETAINER	OHTIVB-03028-1	32	
			SEAL, VALVE STEM OIL	OHTIVB-02101-1	8	
			SEAL, VALVE STEM OIL	OHTIVB-02112-1	8	
			GASKET, WATER TEMP SENSOR	OHTIVB-90430-1	1	
			O-RING, WATER BYPASS PIPE	OHTIVB-90301-1	1	
			GASKET, INTAKEMANIFOLD TO HEAD	OHTIVB-17177-1	1	
			GASKET, EXHAUST MANIFOLD	OHTIVB-17173-1	1	
			NUT	OHTIVB-08228-1	2	
			BOLT, FLANGE W/WASHER	OHTIVB-80825-1	2	
			GASKET, THROTTLE BODY	OHTIVB-22271-1	1	
			INSULATOR, INJECTOR VIBRATION	OHTIVB-23291-1	4	
			O-RING, INJECTOR	OHTIVB-07033-1	4	
			STUD, HEXALOBULAR	OHTIVB-08052-1	2	
			STUD, HEXALOBULAR	OHTIVB-08060-1	2	
			NUT, FLANGE	OHTIVB-80800-1	2	
			BOLT, FLANGE W/WASHER	OHTIVB-80835-1	3	
			SPROCKET, CAMSHAFT TIMING	OHTIVB-13523-1	2	
			BOLT, W/WASHER	OHTIVB-10889-1	2	
			CHAIN SUB-ASSY	OHTIVB-13506-1	1	
			SPROCKET, CRANKSHAFT TIMING	OHTIVB-13521-1	1	
			TENSIONER ASSY, CHAIN	OHTIVB-13540-1	1	
			GUIDE, TIMING CHAIN	OHTIVB-13566-1	1	
			ARM, TIMING CHAIN TENSION	OHTIVB-13591-1	1	
Engine Assembly Manual Section 2	KIT, ENGINE TEST	OHTIVB-102-1	CAMSHAFT SUB- ASSY , NO.1	OHTIVB-13501-1	1	OH Technologies, Inc.
			CAMSHAFT SUB- ASSY , NO.2	OHTIVB-13502-1	1	
			GASKET	OHTIVB-12031-1	1	
			PLUG, SPARK	OHTIVB-01258-1	4	
Engine Assembly Manual Section 1	KIT, ENGINE ASSEMBLY AND INITIAL INSTALLATION[A]	OHTIVB-103-1	ENGINE ASSY, L/CLUTCH	OHTIVB-16000-1	1	OH Technologies, Inc.
			GASKET, SPARKPLUG TUBE	OHTIVB-11193-1	4	
			SEAL, TYPE T OIL, FRONT COVER	OHTIVB-90311	1	
			INSULATOR SUB-ASSY, ENGINE MOUNTING, RH	OHTIVB-12305-1	1	
			BOLT, FLANGE	OHTIVB-10469-1	1	
			BOLT, STUD	OHTIVB-90116-1	1	
			NUT, FLANGE	OHTIVB-21041-1	1	
			BRACKET, ENGINE MOUNTING, FR	OHTIVB-12311-1	1	
			BRACKET, ENGINE MOUNTING, RR	OHTIVB-12321-1	1	
			INSULATOR, ENGINE MOUNTING, FR	OHTIVB-12361-1	1	
			INSULATOR, ENGINE MOUNTING, RR	OHTIVB-12371-1	1	
			BOLT, WASHER BASED HEAD HEXAGON	OHTIVB-10426-1	1	

TABLE A6.1 Parts List

Section	Description	Part Number	Contents			Supplier
			Part Name	Part Number	Quantity	
			BOLT, WASHER BASED HEAD HEXAGON	OHTIVB-12054-1	1	
			BOLT, FLANGE	OHTIVB-81020-1	4	
			BOLT, FLANGE	OHTIVB-81025-1	4	
			NUT	OHTIVB-10016-1	1	
			GASKET, DRAIN PLUG	OHTIVB-12031-1	1	
			SPRING, COMPRESSION	OHTIVB-30034-1	8	
			SENSOR, OXYGEN	OHTIVB-89465-1	1	
			COVER ASSY, CLUTCH	OHTIVB-31210-1	1	
			DISC ASSY, CLUTCH	OHTIVB-31250-1	1	
			BOLT, W/WASHER	OHTIVB-08026-1	6	
			BEARING, RADIAL BALL	OHTIVB-90363-1	1	
Engine Assembly Manual Section 1	LIFTER, VALVE, GRADE 12	OHTIVB-23030-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 14	OHTIVB-23040-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 16	OHTIVB-23050-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 18	OHTIVB-23060-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 20	OHTIVB-23070-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 22	OHTIVB-23080-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 24	OHTIVB-23090-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 26	OHTIVB-23100-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 28	OHTIVB-23110-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 30	OHTIVB-23120-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 32	OHTIVB-23130-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 34	OHTIVB-23140-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 36	OHTIVB-23150-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 38	OHTIVB-23160-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 40	OHTIVB-23170-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 42	OHTIVB-23180-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 44	OHTIVB-23190-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 46	OHTIVB-23200-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 48	OHTIVB-23210-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 50	OHTIVB-23220-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 52	OHTIVB-23230-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 54	OHTIVB-23240-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 56	OHTIVB-23250-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 58	OHTIVB-23260-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	LIFTER, VALVE, GRADE 60	OHTIVB-23270-1	16 LIFTERS PER PACKAGE			OH Technologies, Inc.
	KIT, GOLDEN STAND SETUP HARDWARE	OHTIVB-100-1	INCLUDES THE ASSEMBLIES LISTED BELOW:			OH Technologies, Inc.
	HOUSING, BELL, ASSEMBLY	OHTIVB-001-1	HOUSING, BELL	IVB001-1	1	OH Technologies, Inc.
			SHAFT, OUTPUT	IVB001-3	1	
			PLATE, BEARING	IVB001-4	1	
			GUARD, FLYWHEEL	IVB001-5	1	
			RING RETAINER	VH006-3	1	
	Test Fuel	KA24E	KA24E (dyed green)			Haltermann
	Break-in Oil	TMC 1006-2	TMC 1006-2			ASTM Test Monitoring Center

[A] Can be used for 12 tests; cylinder head included with assembly can be used for 6 tests.

[B] Can be used for 6 tests.

Annex A7

Procedures for lab to properly install and set-up the TEI supplied Golden Stand

NOTE: Draft is currently in process and will be added post-precision matrix.

Golden Stand Installation and Setup

1. Golden Stand Installation
    a. Securing the Base plate
        i. Level
        ii. Four anchors
    b. Dynamometer installation and configuration
        i. Use of spacers allowed but specify center of dynamometer height
        ii. Allow use of strainers and other lab related items
        iii. Installation of torque arms
        iv. Installation of 60 tooth gear and magnetic pickup
        v. Installing load cell and load cell heater assembly
    c. Engine installation
        i. Specify install height for centerline of engine crankshaft
        ii. Installing OHT components
            1. Clutch
            2. Bellhousing
                a. Installation of engine speed safety magnetic pickup
                b. Installation of dummy input shaft
                c. Installation of drive shaft adapter
            3. Installation of Engine mounts
                a. Left
                b. Right
                c. Front
            4. Installation of Coolant Adapters
                a. Inlet
                b. Outlet
            5. Test specific throttle body
            6.
            7. Test specific intake air filter housing
                a. Intake air thermocouple installation
                b. Allow use of bypass air upstream of inlet to intake air filter housing.
                c. Intake air pressure tap
        iii. Install TEI components
            1. Coolant out thermocouple
                a. Remove OEM coolant temperature Sensor
                b. Install pipe fitting hardware
                c. Themocouple installation
            2. Coolant in thermocouple
                a. Install pipe fitting hardware
                b. Themocouple installation
            3. Oil gallery thermocouple
                a. Remove OEM oil pressure sensor
                b. Install pipe fitting hardware
                c. Themocouple installation
            4. Exhaust thermocouple
                a. Install pipe fitting hardware
                b. Themocouple installation
            5. Exhaust pressure tap

   a. Install pipe fitting hardware
   b. Connect pressure sense line to exhaust pressure moisture trap.
6. Install Horiba AFR sensor
7. AFR sample tap
   a. Install pipe fitting hardware
   b. Connect sample line to AFR moisture trap
8. Oil sample and oil pressure sense line
   a. Install
9. External oil temperature control system
   a. Remote oil filter adapter installation
   b. Oil hose routing
   c. Process water hose connection to oil heat exchanger
   d.

2. Driveline alignment
   a. 2 +- 0.5 degrees vertical offset between centerline of engine crankshaft and centerline of dynamometer.
   b. Horizontal offset is 0.
3. Hose routing
   a. Coolant inlet hose supply from fluid control rack
   b. Coolant outlet hose supply to fluid control rack
4. Installation of thermocouple extension wire harness
5. Installation of fuel line connections
   a. From fluid control rack to engine stand
   b. From engine stand to fuel rail
   c. Fuel pressure sense line
   d. Main fuel supply into fluid control rack

T/C	Location	Location	T/C Size	Depth	Comment
1	Engine Coolant In T	Rear of cylinder head	E type 1/8” x 4”	78mm	From rear of cylinder head
2	Engine Coolant Out T	Coolant pipe on exhaust side of engine	E type 1/8” x 4”	75 mm	From coolant pipe
3	Oil Gallery T	Under intake manifold	E type 1/8” x 4“	92-98mm	From engine block
4	Load Cell T	Top of load cell heated canister	E type 1/8 x 4”	9mm	Top of Swagelock nut
5	Inlet (Intake) Air T	Exhaust side of the air box	E type 1/8 x 4”	60mm	Aluminum adaptor
6	Test Cell T	Suspended from jack panel	E type 1/8” x 2”	N/A	Suspended from Jack panel
7	Fuel T	Fuel fitting on air box brace	E type 1/8” x 4”	98mm	Center of Tee
8	Oil Sump T	Oil pan in front hole	E type 1/8 “x 3”	5mm	Top of Swagelock nut
9	Blowby Gas T	Blowby gas out on top of blowby heat exchanger.	E type 1/8” x 4”	100mm	Center of the Tee
10	Rocker Cover Coolant In T	Front left rocker cover coolant “in” fittings	E type 1/8” x 4”	100mm	Center of the Tee
11	Rocker Cover Coolant Out T	Rear right rocker cover coolant “out” fittings	E type 1/8” x 4”	100mm	Center of the Tee
12	Exhaust Gas T	Down pipe below the exhaust manifold	E type 1/4” x 4”	21mm	Top of Swagelock nut
13	Dyno Coolant Out T	Left port on the dynamometer cooling head	E type 1/8” x 4”	100mm	Center of the Tee
14	Blowby Coolant Out T	Coolant “out” (top shell side) port on blowby heat exchanger	E type 1/8 “x 4”	54mm	Top of Swagelock nut
15	RAC Gas Out T	Blowby “out” port on rear of rocker cover	E type 1/8” x 4”	39mm	Center of Tee
16	Blowby Coolant In T	Coolant “in” (bottom shell side) port on blowby heat exchanger	E type 1/8” x 3”	2mm	Center of Tee

Annex A8

Fuels Specification Information

A8. FUELS SPECIFICATION INFORMATION

A8.1This annex provides information on the test fuel and engine coolant used in the Sequence IVA test procedure.

A8.1.1 KA24E Test Fuel (Fig.A8.1).

haltermannsolutions

Product Information

Telephone: (800) 969-2542 **FAX: (281) 457-1469**

PRODUCT: KA24E TEST FUEL **Batch No.:** EL3021LT10

PRODUCT CODE: HF0008 **Tank No.:** TK128

Date: 1/4/2017

TEST	METHOD	UNITS	SPECIFICATIONS MIN	SPECIFICATIONS TARGET	SPECIFICATIONS MAX	RESULTS
Distillation - IBP	ASTM D86[2]	°F	75		95	86
5%		°F				108
10%		°F	120		135	123
20%		°F				143
30%		°F				167
40%		°F				196
50%		°F	200		230	218
60%		°F				229
70%		°F				238
80%		°F				252
90%		°F	300		325	308
95%		°F				341
Distillation - EP		°F	385		415	400
Recovery		vol %		Report		97.3
Residue		vol %		Report		0.7
Loss		vol %		Report		2.1
Gravity	ASTM D4052[2]	°API	58.7		61.2	60.3
Density	ASTM D4052[2]	kg/l	0.734		0.744	0.738
Reid Vapor Pressure	ASTM D5191[2]	psi	8.8		9.2	9.1
Carbon	ASTM D5291[2]	wt fraction	0.8580		0.8667	0.8611
Carbon	ASTM D3343[2]	wt fraction		Report		0.8639
Sulfur	ASTM D2622[2]	wt %	0.01		0.04	0.02
Lead	ASTM D3237[2]	g/gal			0.05	None Detected
Oxygen	ASTM D4815[2]	wt %			0.2	None Detected
Composition, aromatics	ASTM D1319[2]	vol %			35.0	27.1
Composition, olefins	ASTM D1319[2]	vol %	5.0		10.0	5.7
Composition, saturates	ASTM D1319[2]	vol %		Report		67.2
Oxidation Stability	ASTM D525[2]	minutes	1440			1440+
Copper Corrosion	ASTM D130[2]				1	1a
Gum content, washed	ASTM D381[2]	mg/100ml			5	<0.5
Research Octane Number	ASTM D2699[2]		96.0		97.5	96.8
Motor Octane Number	ASTM D2700[2]			Report		88.0
R+M/2	D2699/2700[2]			Report		92.4
Sensitivity	D2699/2700[2]		7.5			8.8
Net Heat of Combustion	ASTM D240[2]	btu/lb		Report		18650
Color	Visual			Green		Green

APPROVED BY:

[1] Haltermann Solutions is accredited to ISO/IEC 17025 by A2LA for the tests referred to with this footnote.
[2]Tested by ISO/IEC 17025 accredited subcontractor.

Gasoline and diesel specialty fuels from Haltermann Solutions shall remain within specifications for a minimum of 3 years from the date on the COA so long as the drums are sealed and unopened in their original container and stored in a warehouse at ambient conditions. Specialty fuels that have been intentionally modified for aggressive or corrosive properties are excluded.

Main Lab, 15600 West Hardy,Houston TX 77060

FIG. A8.1 KA24E Test Fuel

Additional Material

Intertek

Camshaft and Lifter Replacement Procedure

Sequence IVB - Camshaft and Lifter Replacement Procedure

Test #:_____ Kit #:_____

_____ a. Ensure the starter has been disabled to ensure accidental cranking cannot happen.

_____ b. Remove the exhaust and front crankshaft pulley guards.

_____ c. Mark, then remove the 4 coil packs. Keep coil packs connected to the wiring harness. The spaces between the intake manifold runners are a good location to place the coil packs once removed.

_____ d. Remove the crankcase pressure transducer line and the line going to the oil separator.

_____ e. Swing the external blowby conditioning system to the rear of the engine.

_____ f. Remove jacketed rocker cover and place on the stainless storage tray or on the driveshaft guard. Do not remove the coolant hoses from the jacketed rocker cover.

_____ g. Remove the spark plugs.

_____ h. Rotate the crankshaft clockwise until the engine is on cylinder 1 TDC compression stroke. The intake and exhaust lobes for cylinder 1 will point away from each other. The camshaft sprockets will have rectangular marks that should be close to vertical and the timing marks on the balancer and timing cover will line up. Either mark the timing chain links that line up to these marks on the camshaft sprockets or rotate the crankshaft until the 2 gold links line up with these marks. There will be 8 links between the marks on the camshaft sprockets.

_____ i. If not present, scribe permanent reference marks on the camshaft sprockets and front crankshaft pulley to ensure proper reassembly. See Figure 1.

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

_____ j. Remove the timing chain tensioner access cover and insert a wedge between the timing chain and push down firmly. Wiggle the tensioner to make sure it will not pop out.

_____ k. Hold the exhaust camshaft in position by using the factory installed wrench flats (20 mm) and then loosen the camshaft sprocket bolt.

_____ l. Remove the exhaust camshaft sprocket.

_____ m. Remove the exhaust camshaft bearing caps from outside to inside in several loosening steps until no spring tension is on the camshaft. This procedure is to avoid damaging the caps or camshaft. This is the proper order **1**.) Front cap [all 3 bolts] then E5 **2**.) E2 then E4 **3**.) E3.

_____ n. Remove the intake camshaft bearing caps from outside to inside in several loosening steps until no spring tension is on the camshaft. This procedure is to avoid damaging the caps or camshaft. This is the proper order **1**.) Front cap [already removed] then I5 **2**.) I2 then I4 **3**.) I3.

_____ o. Secure the timing chain to the boss located on the front of the cylinder head on the exhaust side, using a retainer pin. This will keep the timing chin from falling into the engine.

_____ p. Place the intake camshaft with sprocket on a non-marring surface. Hold the intake camshaft on the factory installed wrench flats (20 mm) and then loosen the camshaft sprocket bolt with the help of a second person.

_____ q. Remove the intake camshaft sprocket.

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

_____ r. Remove the intake and exhaust valve lifters. Record the lifter size and position in the table below, to ease the measuring and reassembly process.

	1	2	3	4	5	6	7	8
Intake								
Exhaust								

Table 1 Lifter Size and Position

_____ s. If test parts are installed, deliver the parts to metrology for post-test measurements. If break-in parts are installed, store the parts in the cabinet to the right of stand IVB100.

_____ t. Clean the jacketed rocker cover.

_____ u. Clean the cylinder head valve deck, by vacuuming out the oil with the IVB vacuum cart.

_____ v. Inspect the camshaft bearing surfaces.

_____ w. Reinstall the used spark plugs to protect the engine from contamination.

_____ x. Place a fender cover over the valve deck to protect the engine from contamination.

<u>This completes disassembly and prep for reassembly!!!</u>

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

_____ y. Record the serial number of the new test camshafts and timing chain tensioner below.

Serial Numbers	
Intake Camshaft	
Exhaust Camshaft	
Timing Chain Tensioner	

Table 2 Serial Numbers

_____ z. Remove and store the fender cover.

_____ aa. Remove the used spark plugs and properly dispose of.

_____ bb. Remove the used timing chain tensioner, bolts and gasket. Save the timing chain tensioner and properly dispose of the bolts and gasket.

_____ cc. Install a new timing chain tensioner using new bolts and gasket.

_____ dd. Install new test camshafts, Plastigauge the camshaft bearing clearances and record the values in the table below.

Camshaft cap bearing clearances	0.035mm to 0.072mm

Table 3 Camshaft Bearing Clearance Specification

Bearing Clearances					
Position	Front	2	3	4	5
Intake					
Exhaust					

Table 4 Camshaft Bearing Clearance

_____ ee. Remove the camshafts and clean the Plastigauge material off of the camshaft journals and the camshaft bearing caps.

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

_____ ff. Measure the camshaft sprocket diameters, as per the procedure on page 16/63 of the Toyota 2NR-FE Engine Build-up Manual, and record the values in the table below.

Sprocket Diameter	
Intake	
Exhaust	

Minimum sprocket diameter (w/ chain) – 3.79 in.

Table 5 Camshaft Sprocket Diameter

_____ gg. Record the new lifter ID number and position in the table below.

	1	2	3	4	5	6	7	8
Intake								
Exhaust								

Table 6 Lifter ID Number and Position

_____ hh. Apply a light coat of EF-411 to the valve stem tips and camshaft bearing journals. Then install the new lifters in the positions from the chart above.

_____ ii. Install the intake camshaft sprocket on the intake camshaft. On a non-marring surface and with the help of a second person, hold the intake camshaft on the wrench flats. Torque the intake camshaft sprocket bolt to 54 Nm. Use a 14 mm socket and suitable calibrated torque wrench.

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

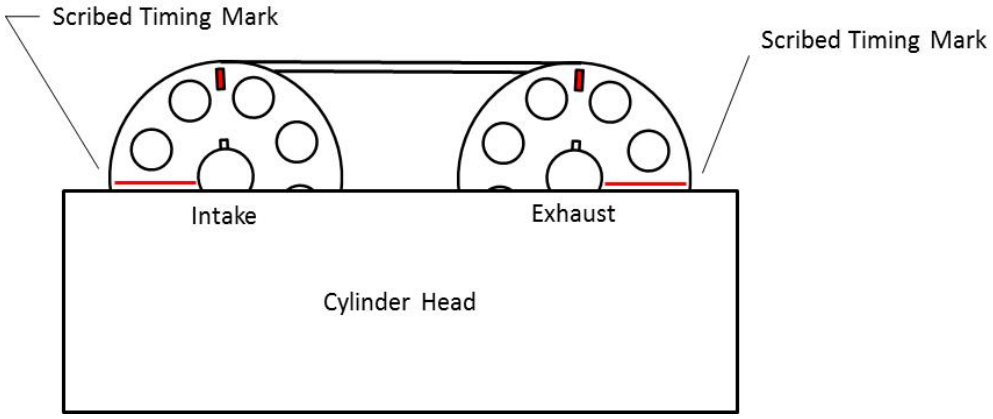


Figure 1 Timing Alignment

_____ jj. Remove the retainer pin and carefully lift the timing chain as not to dislodge the timing chain wedge. Then place the intake camshaft and sprocket into their installed position. Ensure that the marked link or gold link and the mark on the intake camshaft sprocket line up, and that the line marked on the sprocket is level with the cylinder head / valve cover mating deck. See Figure 1. Do not install the camshaft bearing caps at this time.

_____ kk. Place the exhaust camshaft into its installed position. Do not install the camshaft bearing caps at this time.

_____ ll. Carefully lift the timing chain and install the exhaust camshaft sprocket into its installed position. Ensure the chain slack between the crankshaft sprocket and the exhaust camshaft sprocket is taken out (exhaust side of engine). Ensure that the marked link or gold link and the mark on the exhaust camshaft sprocket line up, and that the line marked on the sprocket is level with the cylinder head / valve cover mating deck. See Figure 1. Install the exhaust camshaft sprocket bolt and hand tighten only.

_____ mm. Oil the camshaft and lifters with EF-411 then install the camshaft bearing caps in the positions indicated in Figure 2.

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

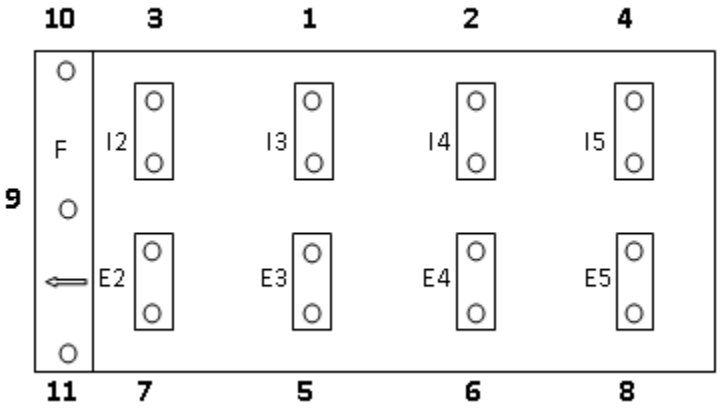


Figure 2 Camshaft Bearing Cap Installation and Torque Sequence

_____ nn. To prevent the camshaft from warping, tighten using several steps uniformly, in the sequence as outlined by the bold numbers in Figure 2.

_____ oo. Using the torque specifications in Table 6, torque each cap in the sequence as outlined by the bold numbers in Figure 2.

Thread diameter	Length	Torque
M6	40 mm	13 Nm
M8	40 mm	21 Nm

Table 7 Camshaft Cap Torque Specification

_____ pp. Utilizing the intake camshaft wrench flats, turn the intake camshaft counter-clockwise taking out the timing chain slack. Stop when the slack is removed between the intake and exhaust camshaft sprockets.

_____ qq. Ensure the timing marks on the crank pulley, intake camshaft sprocket and exhaust camshaft sprocket are in the appropriate positions as indicated in Figure 1.

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

_____ rr. If the timing marks are not in the proper position, remove the exhaust camshaft sprocket and reposition the camshafts to the correct positions.

_____ ss. Hold the exhaust camshaft on the wrench flats. Torque the exhaust camshaft sprocket bolt to 54 Nm. Use a 14 mm crows foot and suitable calibrated torque wrench.

_____ tt. Remove the timing chain wedge and verify the timing marks are correct.

_____ uu. Using a long handle ratchet wrench and 19 mm socket slowly turn the engine 2 full rotations. Verify the timing marks are correct.

_____ vv. Install the timing chain wedge inspection cover. Torque bolts to 5 Nm.

_____ ww. Measure the intake and exhaust valve clearance and record in the table below. If any valve clearances are out of specification notify Bill Buscher to get the correct lifter size.

	1	2	3	4	5	6	7	8
Intake								
Exhaust								

Intake valve clearance cold – 0.00571 to 0.00925 in.

Exhaust valve clearance cold – 0.0108 to 0.0144 in.

Table 8 Lifter Clearance and Position

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Test #:_____ Kit #:_____

_____ xx. Measure the camshaft end play and record the values in the table below.

End Play	
Intake	
Exhaust	

Camshaft end play (measure on cap) – Appx. 0.051mm

Table 9 Camshaft End Play

_____ yy. Inspect the spark plugs and install. If any irregularities are noted with the existing spark plugs, install new spark plugs and notify the project leader of the irregularities. Torque to 18 Nm.

_____ zz. Inspect the jacketed rocker cover and gasket. If serviceable, put a small dab of RTV sealant on the mating lines of the timing cover and cylinder head then install the jacketed rocker cover. Pay attention to the spark plug tube seals to insure they fit properly.

_____ aaa. First hand tighten the jacketed rocker cover bolts. Torque the jacketed rocker cover bolts in a cross pattern from the middle out. Torque bolts to 10 Nm.

_____ bbb. Install the coil packs. Torque the coil pack bolts to 5 Nm.

_____ ccc. Re-enable the starter.

Always utilize proper Personal Protection Equipment and appropriate safety practices to ensure safe working conditions. Contact the project leader with anything that will prevent a proper build and sign as you proceed.

Lubrizol

Engine Decommissioning

Procedure

DECOMMISSIONING SEQUENCE IVB ENGINES

GASW441

DOCUMENT REVISION LOG

REVISION LEVEL	DATE APPROVED	ISSUED BY	REVISION DESCRIPTION
0	01-27-2016	CHTM	Instructions for decommissioning a Toyota 2NR engine. Document placed in-service on this date.

1. BACKGROUND:

1.1. This document must be followed when a Sequence IVB (Toyota 2NR) engine is permanently decommissioned.

1.2. This documentation must also be retained for government traceability purposes.

2. ENGINE IDENTIFICATION:

2.1. Toyota Serial Number: | |

2.2. Lubrizol Engine Designation: | |

2.3. In-service date (Optional): | |

2.4. Out-of-Service Date: | |

2.5. Was this engine purchased by OHT? **Yes** ☐ **No** ☐

2.6. Was this engine obtained directly from Toyota? **Yes** ☐ **No** ☐

3. INSTRUCTIONS FOR LAB OPERATORS:

3.1. Confirm that Engineering has provided written notification that the engine in question is to be decommissioned. **Complete:** ☐

3.2. Print a copy of this checklist and place it in a clear plastic document sleeve. **Complete:** ☐

3.2.1. *NOTE:* This paperwork will remain with the engine block throughout the decommissioning process and must be returned to the test engineer upon completion.

3.3. Remove all hardware from the engine block. **Complete:** ☐

3.4. Take the engine block to the cleaning room and remove any residual oil. **Complete:** ☐

3.4.1. *NOTE:* Please use the most efficient cleaning method to accomplish this (Stoddard booth, parts washer, solvent tank and ultrasonic cleaner are all acceptable).

3.5. Submit a work order to have Maintenance destroy the engine block. **Complete:** ☐

3.6. Transfer the engine block (with this checklist) to the Maintenance department. **Complete:** ☐

OPERATOR INITIALS: _____

DATE: _____

4. INSTRUCTIONS FOR MAINTENANCE:

4.1. Cut a hole in the block near the serial number stamping at the back of the engine. **Complete:** ☐

4.1.1. *NOTE:* The hole must be large enough so that it cannot be repaired and the block is rendered unserviceable.

4.2. Photograph the damage and the serial number stamping so that both features are captured in the same frame (as shown in **Figure 1**). **Complete:** ☐

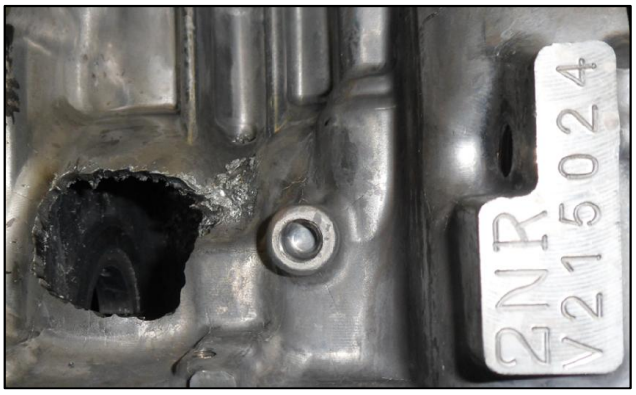


Figure 1 - Photograph of Engine Damage Required for Traceability

MAINTENANCE SIGNATURE:

DATE:

4.3. *NOTE:* Once the photograph is taken, the decommissioned engine block can be disposed of as Maintenance sees fit.

4.4. Return this documentation and photograph to Engineering (both paper and electronic forms are acceptable). **Complete:** ☐

5. INSTRUCTIONS FOR ENGINEER/FACILITATOR:

5.1. Sign this document and save an electronic copy in the appropriate directory (the link is provided below).

5.2. *LINK:* N:\Testing\Wickliffe\MET\MT Gas\Engineer\Ka24 E (Engr)\IVB\Engine Inventory\Government Traceability

5.3. Update the **IVB Test Bible** as needed. **Complete:** ☐

ENGINEERING SIGNATURE:

DATE:

5.4. Attach the photograph of the decommissioned engine below:

QI
Targets and Limits

Sequence IVB
Fixed Target and Limit QIs

Parameter	Target	± Limits	Units	Comment
Intake Air Humidity	11.5	0.50	g/kg	Exisiting parameter, exisiting QI, possible change from original values.
Engine Coolant In Temperature	49	0.75	°C	Exisiting parameter, new QI. Parameter and QI **are** included in the current report form and data dictionary (version 20161012).
Exhaust Backpressure *	104.5	3	kPa	Exisiting parameter, exisiting QI, possible change from original values.
Fuel Rail Temperature	24	0.50	°C	Exisiting parameter, exisiting QI, possible change from original values.
Intake Air Pressure	0.25	0.25	kPa	Exisiting parameter, exisiting QI, possible change from original values.
Intake Air Temperature	32	0.75	°C	Exisiting parameter, exisiting QI, possible change from original values.
Oil Gallery Temperature	54	4	°C	Exisiting parameter, exisiting QI, possible change from original values.
RAC Coolant Out Temperature	20	0.75	°C	Exisiting parameter, exisiting QI, possible change from original values.
Torque	25	1.50	N-m	Exisiting parameter, exisiting QI, possible change from original values.
Engine Coolant Flow Rate	80	0.40	L/min	Exisiting parameter, new QI. Parameter and QI **are** included in the current report form and data dictionary (version 20161012).
RAC Coolant Flow Rate	120	0.75	L/min	Exisiting parameter, new QI. Parameter and QI **are** included in the current report form and data dictionary (version 20161012).
Blowby Gas Temperature	29	0.50	°C	Exisiting parameter, new QI. Parameter and QI **are** included in the current report form and data dictionary (version 20161012).
Engine Speed (Dyno)	**see variable QI**			Exisiting parameter, exisiting QI, possible change from original values.
Load Cell Temperature	45	4	°C	New parameter, new QI. Parameter and QI **are not** included in the current report form and data dictionary (version 20161012).
Engine Coolant Pressure	70	10	kPa	Exisiting parameter, new QI. Parameter **is** included in the current report form and data dictionary (version 20161012), but will need to be moved from non-controlled to controlled parameters. QI **is not** included in the current report form and data dictionary (version 20161012).
Fuel Rail Pressure	335	10	kPa	Exisiting parameter, new QI. Parameter **is** included in the current report form and data dictionary (version 20161012), but will need to be moved from non-controlled to controlled parameters. QI **is not** included in the current report form and data dictionary (version 20161012).

*** NOTE: QI values are calculated on all 30 seconds of data from each test cycle for all parameters, except Exhaust Backpressure.**

*** NOTE: QI value for Exhaust Backpressure is only calculated on the 7 seconds of data from Stage 2 steady state from each test cycle.**

Sequence IVB
Variable Target and Limit QIs

Engine Speed (Dyno) QI

Cycle Time	Target	± Limits	Units	Comment
1	800	150	rpm	Possible change from original values.
2	800	100	rpm	Possible change from original values.
3	800	75	rpm	Possible change from original values.
4	800	50	rpm	Possible change from original values.
5	800	50	rpm	Possible change from original values.
6	800	50	rpm	Possible change from original values.
7	800	50	rpm	Possible change from original values.
8	927	150	rpm	Possible change from original values.
9	1357	250	rpm	Possible change from original values.
10	1888	400	rpm	Possible change from original values.
11	2300	400	rpm	Possible change from original values.
12	2731	400	rpm	Possible change from original values.
13	3168	400	rpm	Possible change from original values.
14	3610	400	rpm	Possible change from original values.
15	4041	400	rpm	Possible change from original values.
16	4300	100	rpm	Possible change from original values.
17	4300	75	rpm	Possible change from original values.
18	4300	50	rpm	Possible change from original values.
19	4300	25	rpm	Possible change from original values.
20	4300	25	rpm	Possible change from original values.
21	4300	25	rpm	Possible change from original values.
22	4300	25	rpm	Possible change from original values.
23	4136	100	rpm	Possible change from original values.
24	3734	250	rpm	Possible change from original values.
25	3283	400	rpm	Possible change from original values.
26	2829	400	rpm	Possible change from original values.
27	2382	400	rpm	Possible change from original values.
28	1946	400	rpm	Possible change from original values.
29	1523	400	rpm	Possible change from original values.
30	1116	400	rpm	Possible change from original values.

Golden Stand
Upgrade Information

These are from McMaster-Carr

1	4452K413	Type 316 Stainless Steel Threaded Pipe Fitting, 3/8 Pipe Size, 90 Degree Elbow, 150 PSI	4 ea.
2	4452K433	Type 316 Stainless Steel Threaded Pipe Fitting, 3/8 Pipe Size, Tee, 150 PSI	2 ea.
3	4548K381	Standard-Wall Type 316/316L Stainless Steel Thread Pipe Nipple, 3/8 Pipe Size X 1" Length, Fully Threaded	3 ea.
4	9110T32	Standard-Wall 316/316L Stainless Steel Thread One End Pipe Nipple, 3/8 Pipe Size X 2" Length	4 ea.
5	9110T22	Standard-Wall 316/316L Stainless Steel Thread One End Pipe Nipple, 3/8 Pipe Size X 1-1/2" Length	4 ea.
6	4452K169	Type 316 Stainless Steel Threaded Pipe Fitting, 3/4 Male X 3/8 Female, Hex Reducing Bushing, 150 PSI	2 ea.
7	4452K162	Type 316 Stainless Steel Threaded Pipe Fitting, 3/8 Male X 1/8 Female, Hex Reducing Bushing, 150 PSI	1 ea.
8	4830K152	Standard-Wall Type 304/304L Stainless Steel Thread Pipe Nipple, 3/8 Pipe Size X 1-1/2" Length	2 ea.
9	5182K804	Type 316 Stainless Steel Yor-Lok Tube Fitting, Straight Adapter for 1/8" Tube OD X 1/8 NPT Male	2 ea.

10	4452K175	Type 316 Stainless Steel Threaded Pipe Fitting, 1 Male X 1/2 Female, Hex Reducing Bushing, 150 PSI	2 ea.
11	4452K164	Type 304 Stainless Steel Threaded Pipe Fitting, 1/2 Male x 1/8 Female, Hex Reducing Bushing, 150 PSI	1 ea.
12	51205K129	Extreme-Pressure 316 Stainless Steel Threaded Pipe Fitting, 1/2 Pipe Size, Female x Female x Male Tee	1 ea.
13	4475K14	Thick-Wall 316/316L Stainless Steel Threaded Pipe Nipple, 1/2 Pipe Size x 1-1/8 Length, Fully Threaded	2 ea.

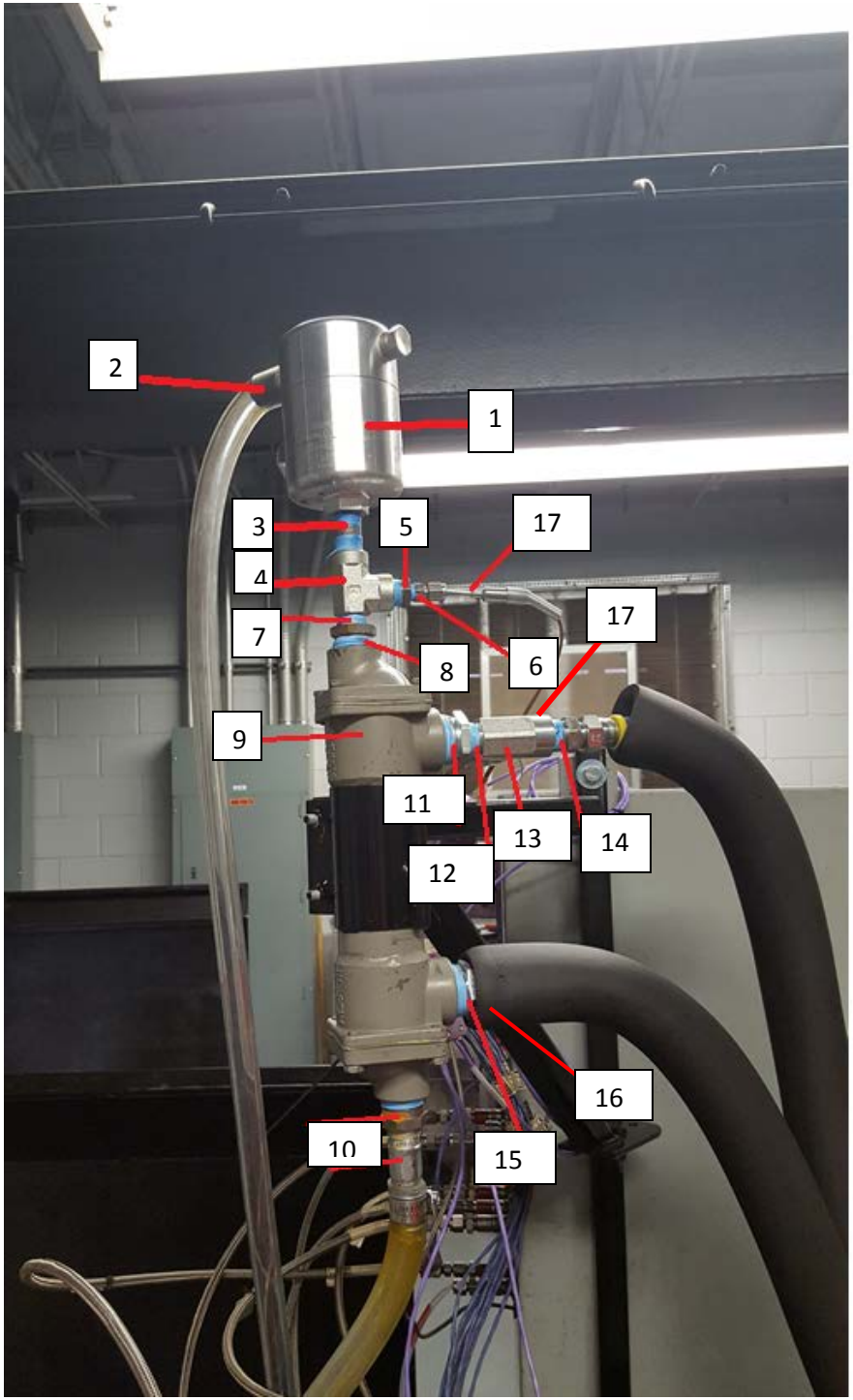
Below purchased from Taylor made hose.

14	NS-501-8FP	Parker QUICK COUPLING FEMALE COUPLER, NS SERIES, 1/2" Female	2 ea.
15	NS-501-8FP	Parker QUICK COUPLING FEMALE COUPLER, NS SERIES, 1/2" Male	2 ea.

Blow By temperature maintainer parts list

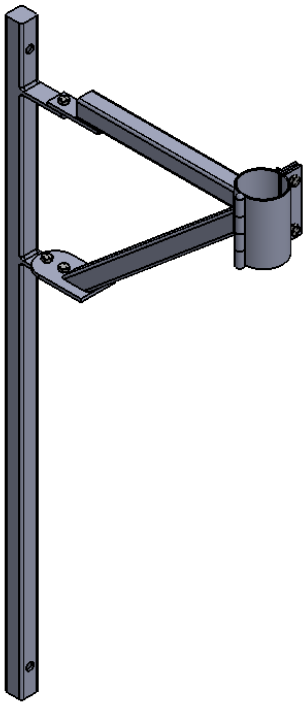
35185K42 Stainless Steel Heat Exchanger, 2.4 Square ft Surface Area, 32 GPM Flow Capacity	1 Each
4452K171 Type 316 Stainless Steel Threaded Pipe Fitting, 3/4 Male x 1/2 Female, Hex Reducing Bushing, 150 PSI	2 Each
4452K175 Type 316 Stainless Steel Threaded Pipe Fitting, 1 Male x 1/2 Female, Hex Reducing Bushing, 150 PSI	2 Each
50675K166 Brass 37 Degree Flared Tube Fitting, Straight Adapter for 1/2" Tube OD x 1/2 NPT Male	8 Each
99095K52 Heavy-Duty Extended-Life Plastic Pump, for Water/Coolants, 1/10 hp, 120V AC	1 Each
4452K175 Type 316 Stainless Steel Threaded Pipe Fitting, 1 Male x 1/2 Female, Hex Reducing Bushing, 150 PSI	1 Each
4452K114 Type 316 Stainless Steel Threaded Pipe Fitting, 1/2 Pipe Size, Coupling, 150 PSI	1 Each
4392T65 Stainless Steel Drum, 8 Gallon, Nut/Bolt Ring, Solid Cover, 20 Gauge, Type 304 Stainless Steel	1 Each
4452K213 Type 316 Stainless Steel Threaded Pipe Fitting, ¾” Pipe Size, Half Coupling, 150 PSI	1 Each
4452K217 Type 316 Stainless Steel Threaded Pipe Fitting, 2” Pipe Size, Half Coupling, 150 PSI	1 Each
4452K149 Type 316 Stainless Steel Threaded Pipe Fitting, 2 Pipe Size, Hex Head Plug, 150 PSI	1 Each
4452K212 Type 316 Stainless Steel Threaded Pipe Fitting, ½” Pipe Size, Half Coupling, 150 PSI	2 Each
4464K47 Type 316 Stainless Steel Threaded Pipe Fitting, 1/4 Pipe Size, Half Coupling, 150 PSI	1 Each
7981K14 Precision Programmable Temperature Controller, with Solid-State Relay, Water-Rst, 1/16 DIN	1 Each
7456K61 Long-Life Medium-Amp Relay, Touchsafe, SPST-NO, 3-32V DC, 25 Amp at 230V AC	1 Each
7456K29 Optional Heat Sink for 25 and 45 Amp, Long-Life Medium-Amp Relay	1 Each
4654T26 Compact Cartridge-Style Immersion Heater, Incoloy Element, 240 VAC, 3000 Watts, 7-7/8" Length	1 Each

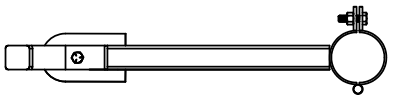
Number	Description	Part number	Vendor
1.	Moroso oil separator	85472	Summit racing
2.	Hose barb 5/8” to 3/8” NPT SS	RN 53	Amazon.com
3.	Hex nipple SS 3/8”	48805K581	McMASTER-CARR
4.	Female pipe T SS 3/8”	48805K49	McMASTER-CARR
5.	Reducer bushing 3/8” to 1/8” SS	48805k524	McMASTER-CARR
6.	Yor-LoK tube fitting 1/8” tube to 1/8” MPT SS	5182K405	McMASTER-CARR
7.	Hex nipple SS 3/8”	48805K581	McMASTER-CARR
8.	Bushing SS 3/4” to 3/8”	51205K357	McMASTER-CARR
9.	Heat exchanger shell and tube Model - SSCF	SN516002008002	TEI
10.	Hose barb 5/8” to 3/4” NPT SS	Dixon RN-56	Amazon.com
11.	Bushing SS 1” to 1/2”	4452K175	McMASTER-CARR
12.	F,F-M pipe T SS 1/2”	48805K611	McMASTER-CARR
13.	Reducer bushing 1/2” to 1/8” SS	4464K642	McMASTER-CARR
14.	1/2” x 1/2” 45 degree flare straight 48F	50635K387	McMASTER-CARR
15.	Bushing SS 1” to 1/2”	4452K175	McMASTER-CARR
16.	1/2” x 1/2” 45 degree flare straight 48F	50635K387	McMASTER-CARR
17.	2 ea. 1/8” x 3” E type T/C		TEI

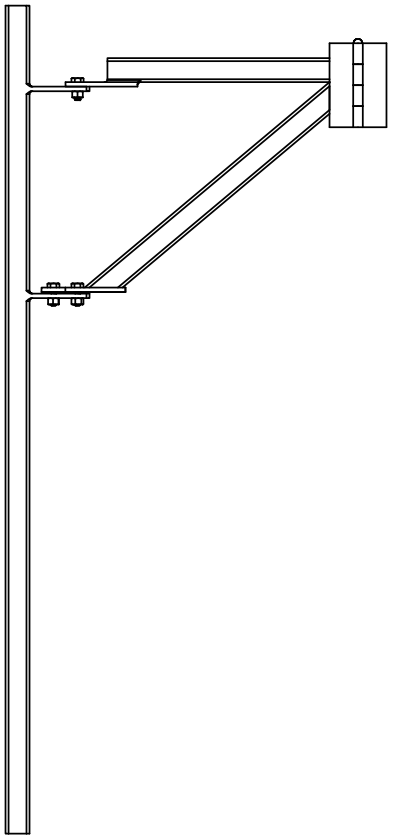


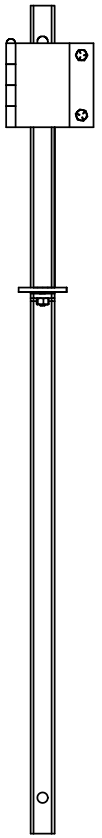
NOTE: Oil Separator has been relocated from above to below heat exchanger.

Materials List:
1) 3 Each 1/4 - 20 3/4"L Coarse Thread Bolts
2) 2 Each 1/4 - 20 1"L Coarse Thread Bolts
3) 5 each 1/4 - 20 Coarse Thread Hex Nuts









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			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

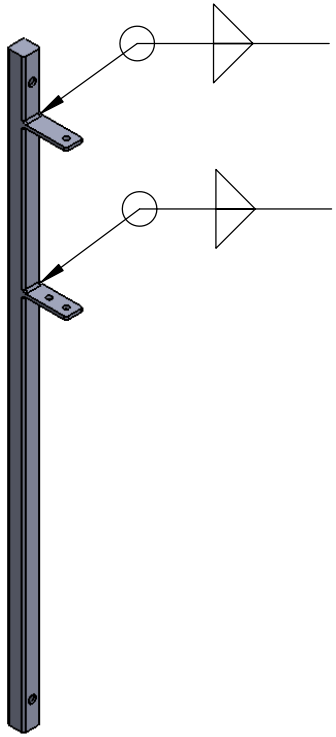
TITLE: IVB Blowby Condenser HX Support Assembly

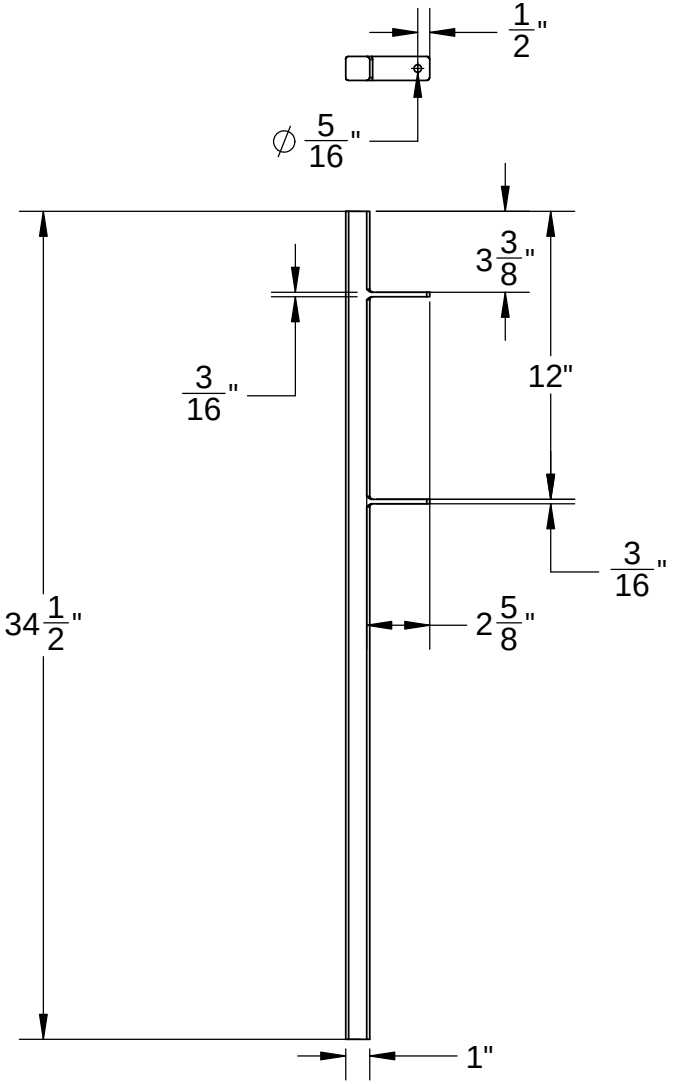
SIZE	DWG. NO.	REV
A		

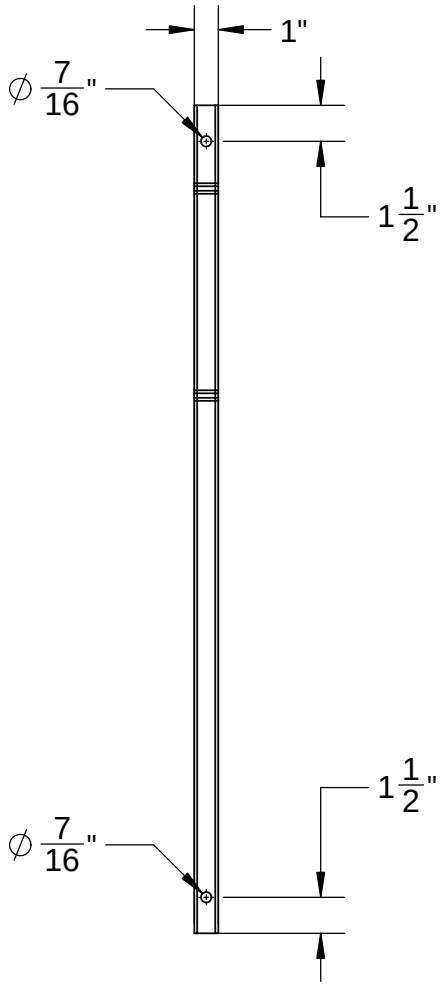
SCALE: 1:12	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

Materials List:
1) 1"Square Steel Tubing
2) 3/16" by 1" Steel Plate







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			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
			COMMENTS:		
		MATERIAL Cold Rolled Steel			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

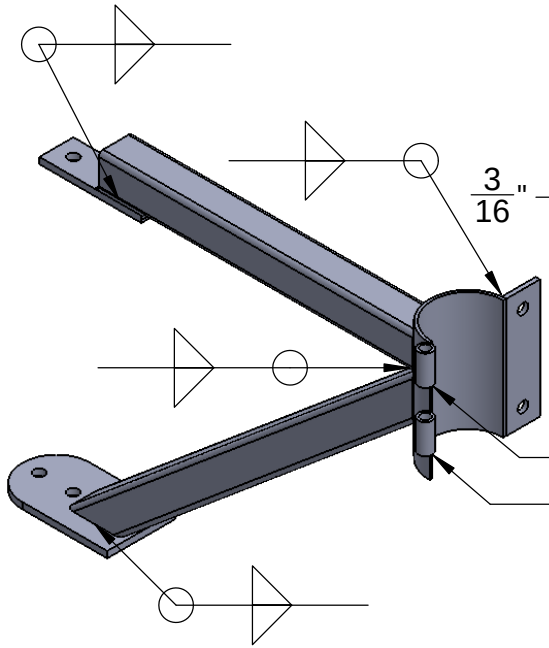
TITLE:
IVB Blowby HX Support Bracket

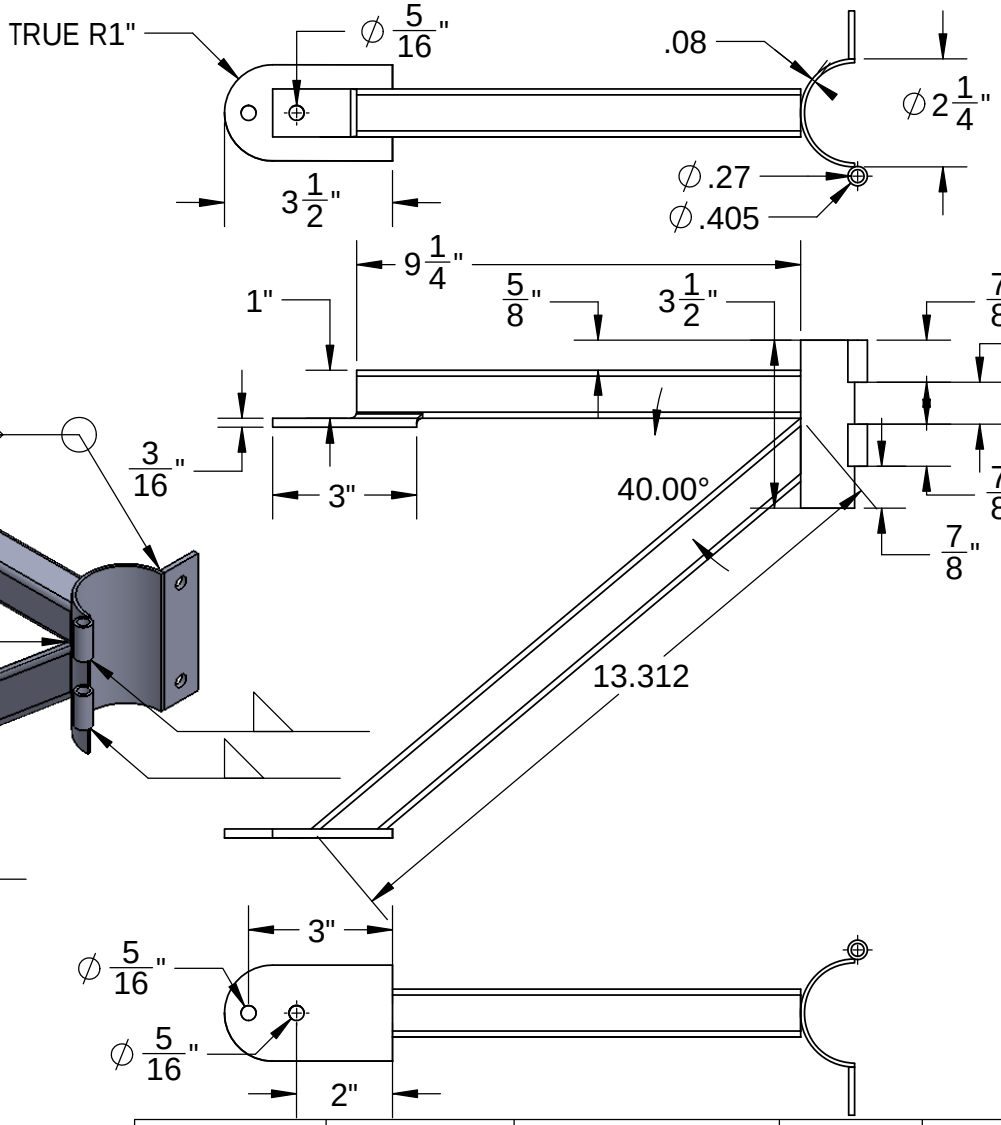
SIZE	DWG. NO.	REV
A		

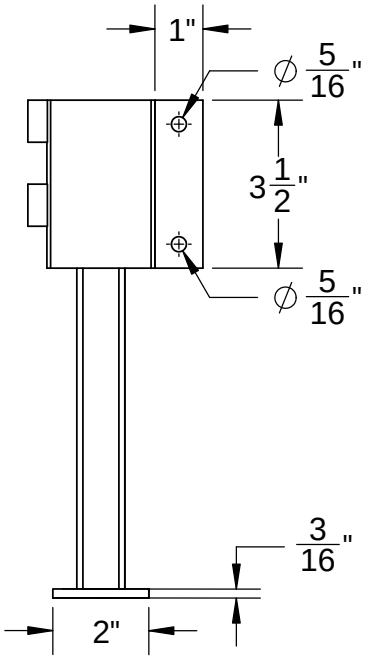
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

Materials List:
1) 1" Square Steel Tubing
2) 2 1/4" O.D. 14 Gauge Exhaust Pipe
3) 1/8" Steel Pipe
4) 1/8" by 1" Steel Plate
5) 3/16" by 1" Steel Plate
6) 3/16" by 2" Steel Plate







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			MFG APPR.		
			Q.A.		
		MATERIAL Cold Rolled Steel	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

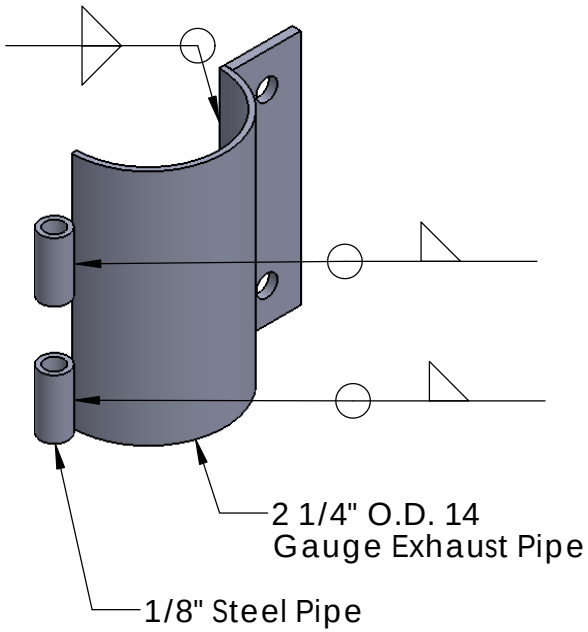
TITLE:
IVB Blowby HX Arm

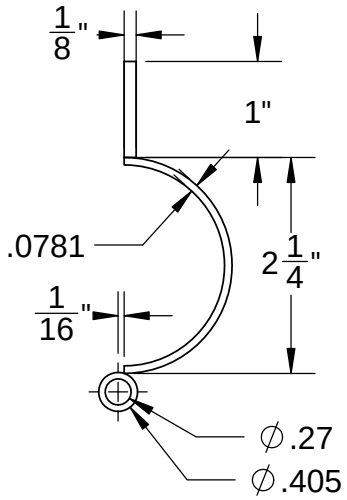
SIZE	DWG. NO.	REV
A		

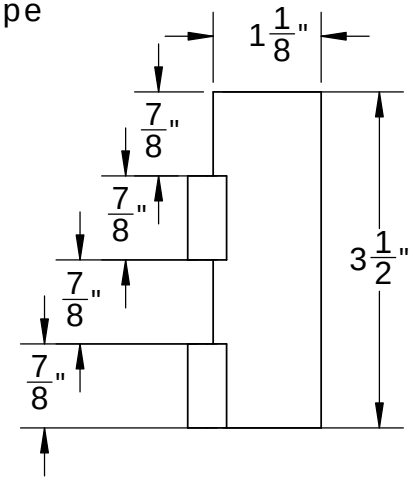
SCALE: 1:4	WEIGHT:	SHEET 1 OF 1

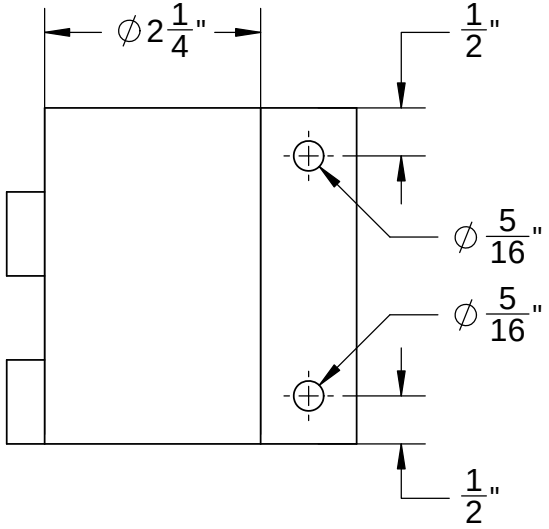
5 4 3 2 1

Materials List:
1) 2 1/4" O.D. 14 Gauge Exhaust Pipe
2) 1/8" Steel Pipe
3) 1/8" by 1" Steel Plate









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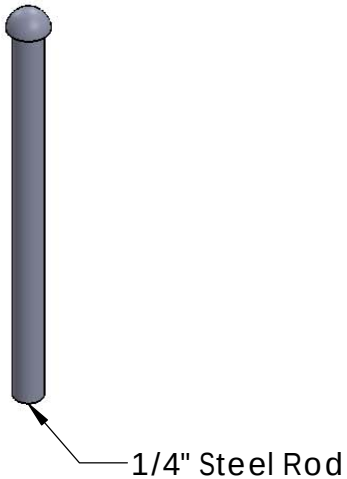
			MFG APPR.		
			Q.A.		
			COMMENTS:		
		MATERIAL Cold Rolled Steel			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

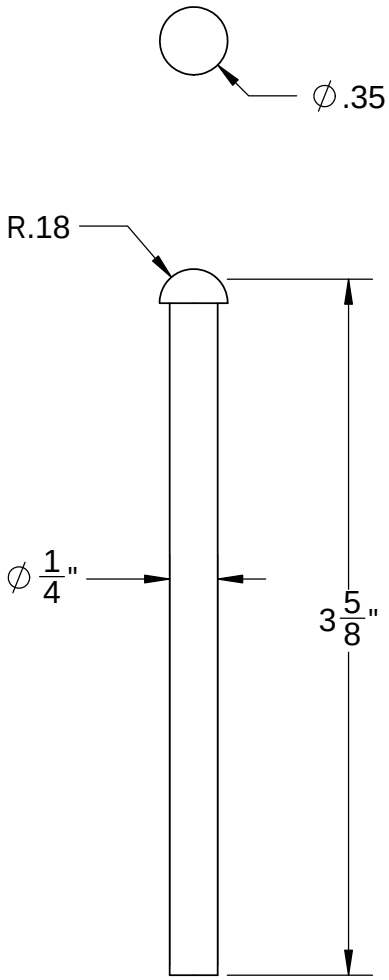
TITLE:
IVB Blowby HX Hinge

SIZE	DWG. NO.	REV
A		
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

Materials List:
1) 1/4" Steel Rod





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			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
			COMMENTS:		
		MATERIAL Cold Rolled Steel			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

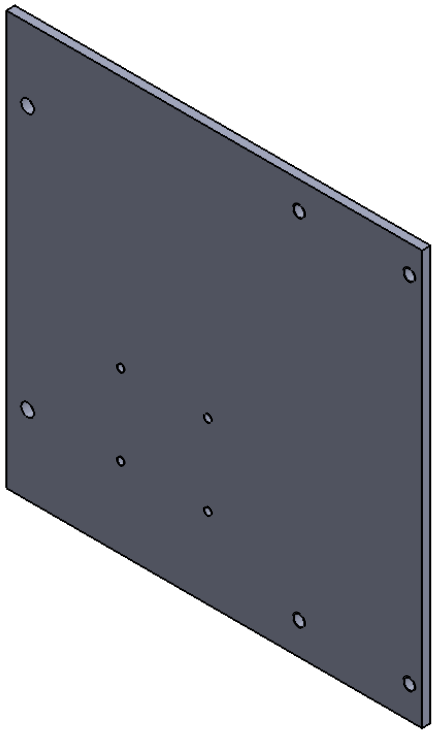
PROPRIETARY AND CONFIDENTIAL
SOLIDWORKS Drawing Provided by
Intertek Automotive Research

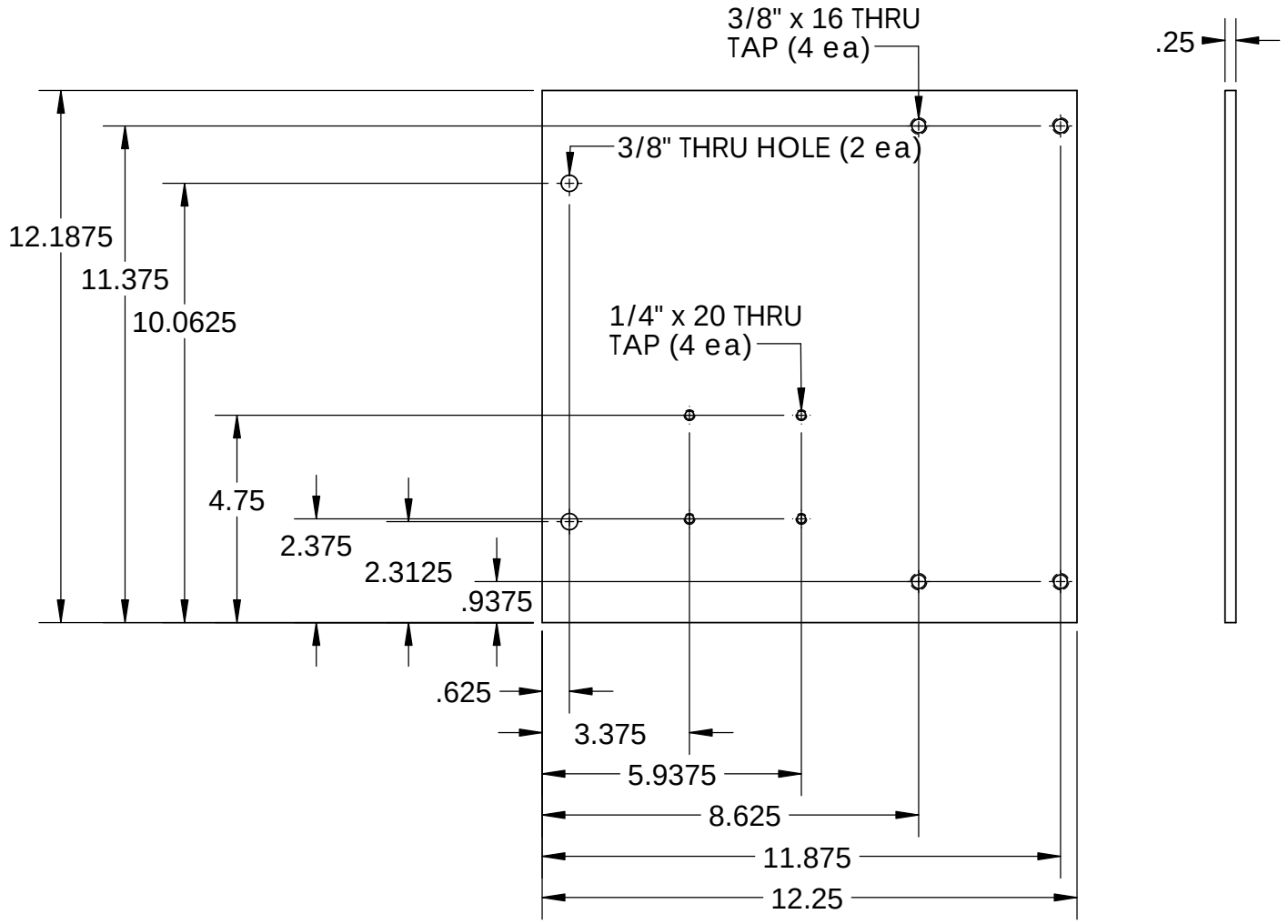
TITLE:
IVB Blowby HX Hinge Pin

SIZE	DWG. NO.	REV
A		

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1





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			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		MATERIAL Aluminum	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

PROPRIETARY AND CONFIDENTIAL
SOLIDWORKS Drawing Provided by
Intertek Automotive Research

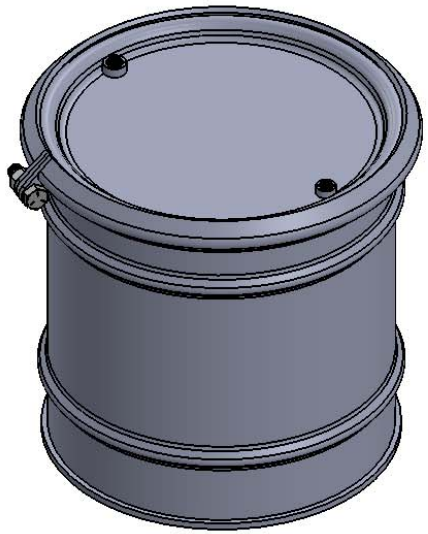
TITLE: IVB HX and Pump Mounting Plate

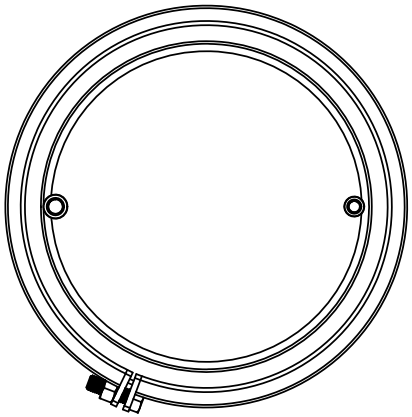
SIZE	DWG. NO.	REV
A		

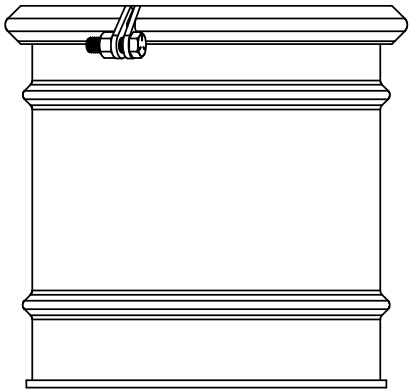
SCALE: 1:4	WEIGHT:	SHEET 1 OF 1

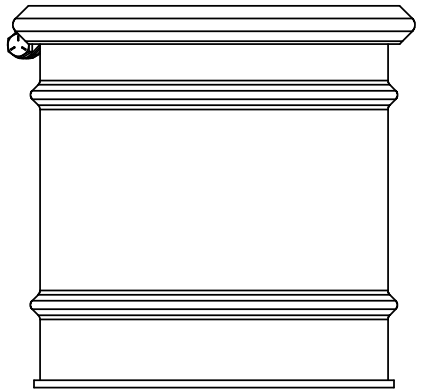
5 4 3 2 1

Materials List (From McMaster-Carr):
1) 4392T65 (1 ea)
2) 4452K139 (1 ea)
3) 4452K211 (1 ea)









		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: THREE PLACE DECIMAL ± 0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

PROPRIETARY AND CONFIDENTIAL

SOLIDWORKS Drawing Provided by Intertek Automotive Research

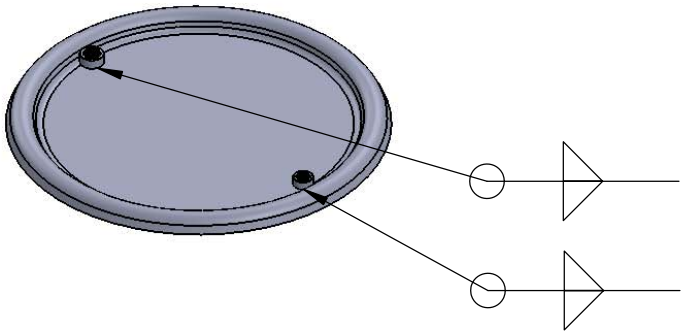
TITLE: IVB Blowby Surge Tank Assembly

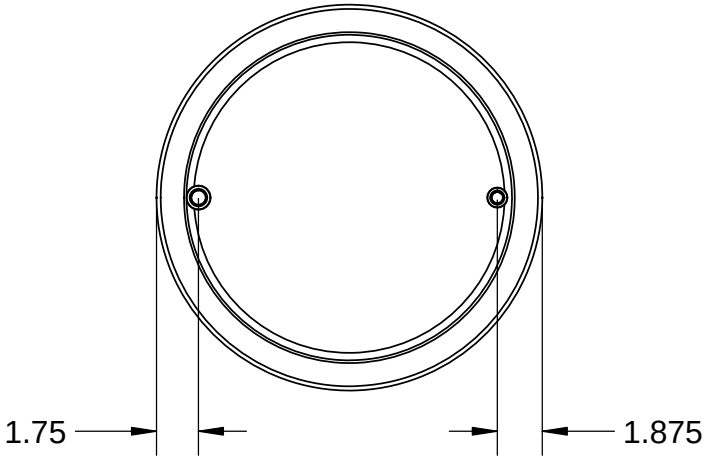
SIZE	DWG. NO.	REV
A		

SCALE: 1:12	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

Materials List (From McMaster-Carr):
1) 4392T65 (1 ea)
2) 4452K139 (1 ea)
3) 4452K211 (1 ea)





		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: THREE PLACE DECIMAL ± 0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
			COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

TITLE: IVB Blowby Surge Tank Lid Assembly

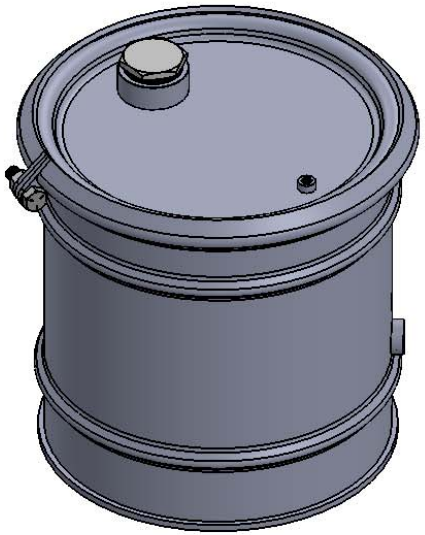
SIZE	DWG. NO.	REV
A		

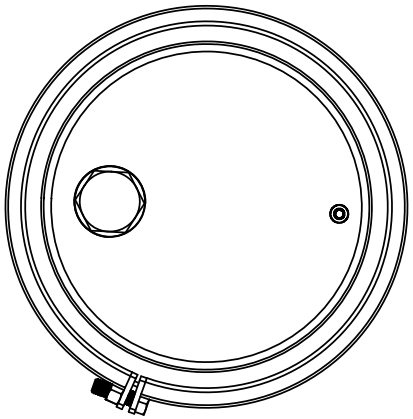
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

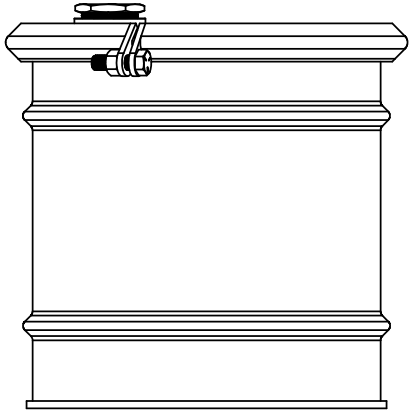
5 4 3 2 1

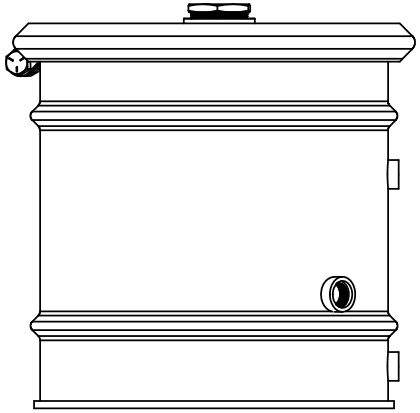
Materials List (From McMaster-Carr):

1) 4392T65 (1 ea)
2) 4452K138 (1 ea)
3) 4452K149 (1 ea)
4) 4452K212 (2 ea)
5) 4452K213 (1 ea)
6) 4452K217 (1 ea)









		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: THREE PLACE DECIMAL ± 0.005	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

IVB Blowby Heater Tank Assembly

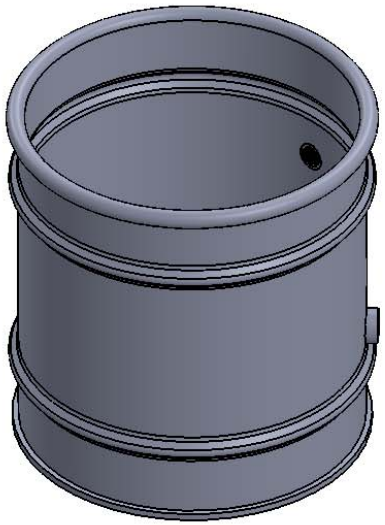
SIZE	DWG. NO.	REV
A		

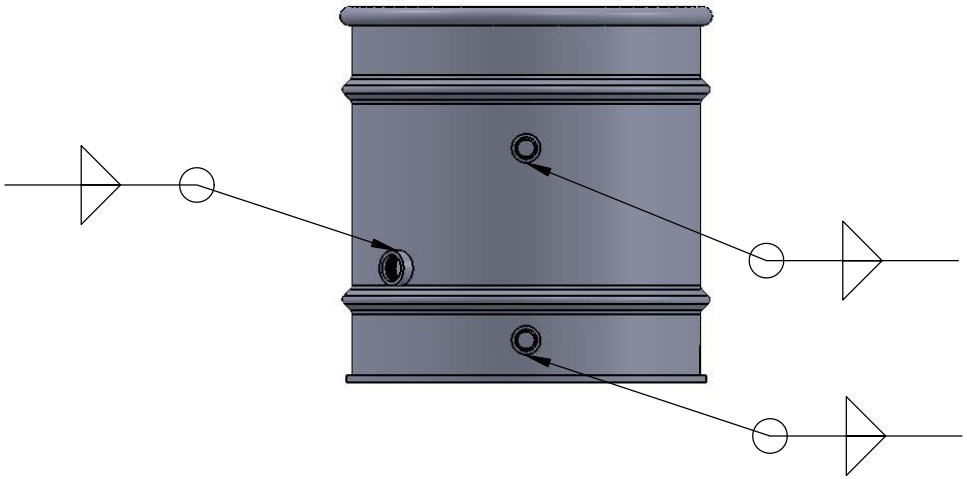
SCALE: 1:12	WEIGHT:	SHEET 1 OF 1

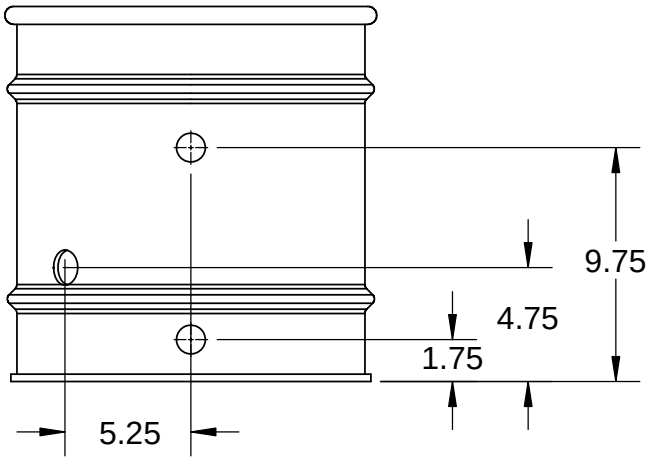
5 4 3 2 1

Materials List (From McMaster-Carr):

1) 4392T65 (1 ea)
2) 4452K212 (2 ea)
3) 4452K213 (1 ea)







		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
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			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

PROPRIETARY AND CONFIDENTIAL
SOLIDWORKS Drawing Provided by
Intertek Automotive Research

TITLE: IVB Blowby Heater Barrel

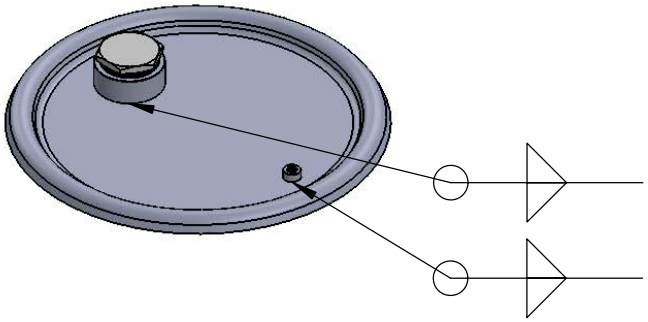
SIZE	DWG. NO.	REV
A		

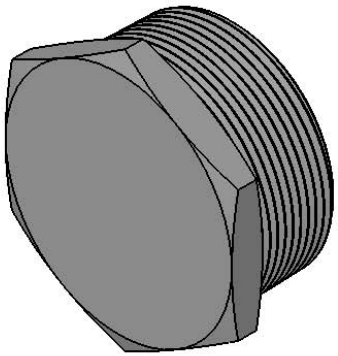
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

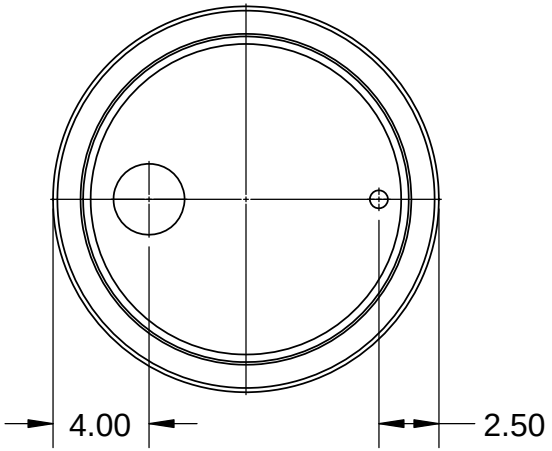
5 4 3 2 1

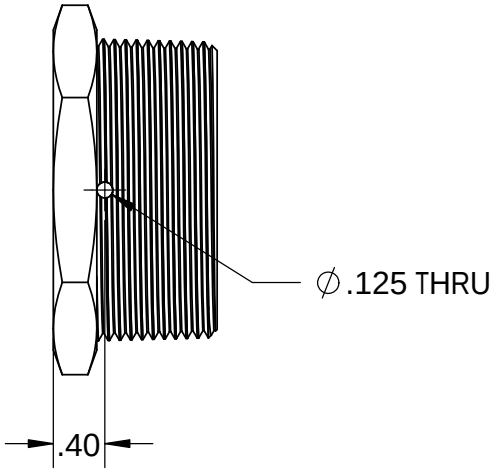
Materials List (From McMaster-Carr):

1) 4452K138 (1 ea)
2) 4452K149 (1 ea)
3) 4452K217 (1 ea)









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			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
			COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

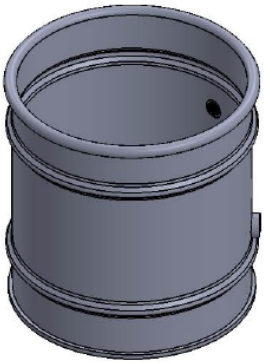
TITLE: IVB Blowby Heater Tank Lid

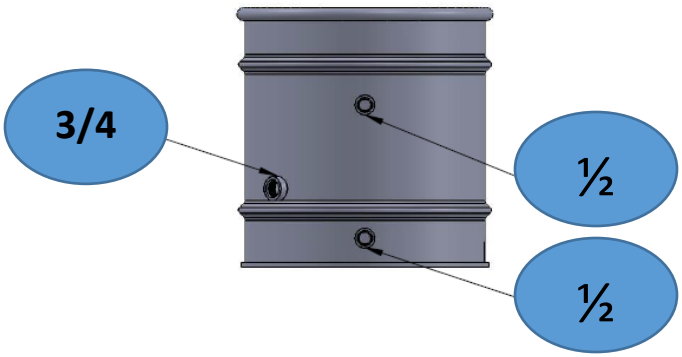
SIZE	DWG. NO.	REV
A		

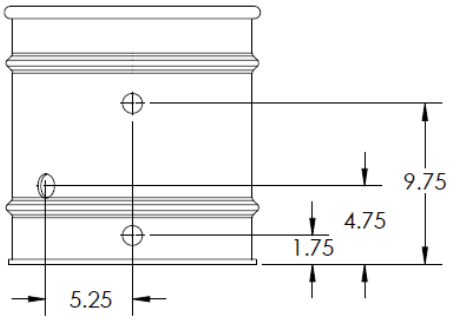
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1

Materials List (From McMaster-Carr):
1) 4392T65 (1 ea)
2) 4452K212 (2 ea)
3) 4452K213 (1 ea)







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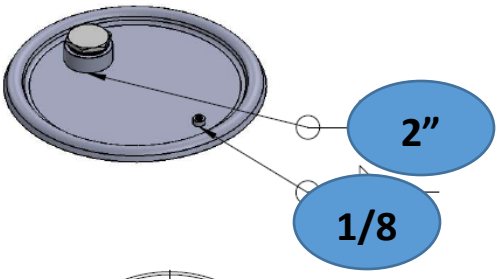
			CHECKED		
			ENG APPR.		
			MFG APPR.		
			Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

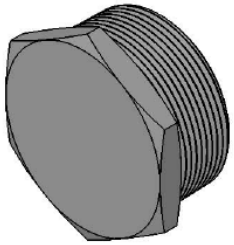
PROPRIETARY AND CONFIDENTIAL
SOLIDWORKS Drawing Provided by Intertek Automotive Research

TITLE: IVB Blowby Heater Barrel

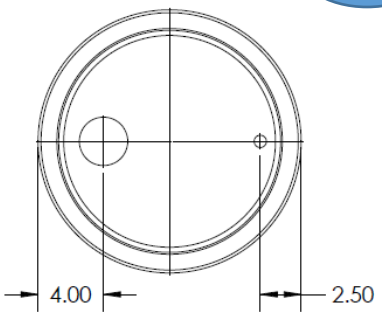
SIZE	DWG. NO.	REV
A		
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

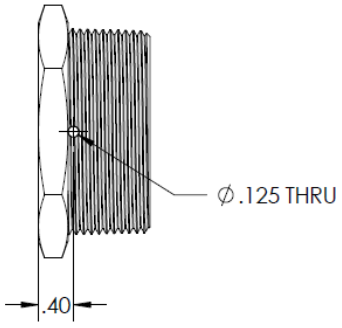
5 4 3 2 1





Materials List (From McMaster-Carr):
1) 4452K138 (1 ea)
2) 4452K149 (1 ea)
3) 4452K217 (1 ea)





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			MFG APPR.		
			Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

PROPRIETARY AND CONFIDENTIAL
SOLIDWORKS Drawing Provided by Intertek Automotive Research

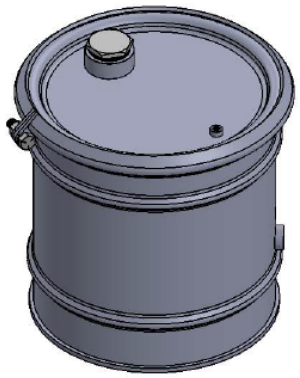
TITLE: IVB Blowby Heater Tank Lid

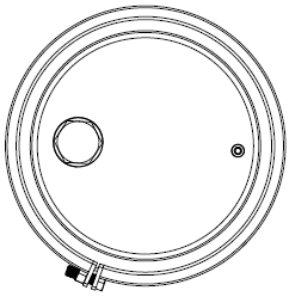
SIZE	DWG. NO.	REV
A		
SCALE: 1:8	WEIGHT:	SHEET 1 OF 1

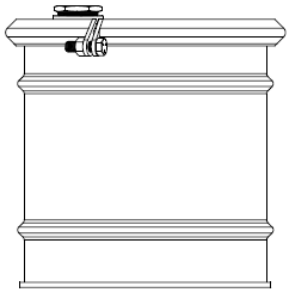
5 4 3 2 1

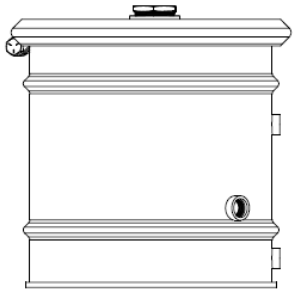
Materials List (From McMaster-Carr):

1) 4392T65 (1 ea)
2) 4452K138 (1 ea)
3) 4452K149 (1 ea)
4) 4452K212 (2 ea)
5) 4452K213 (1 ea)
6) 4452K217 (1 ea)









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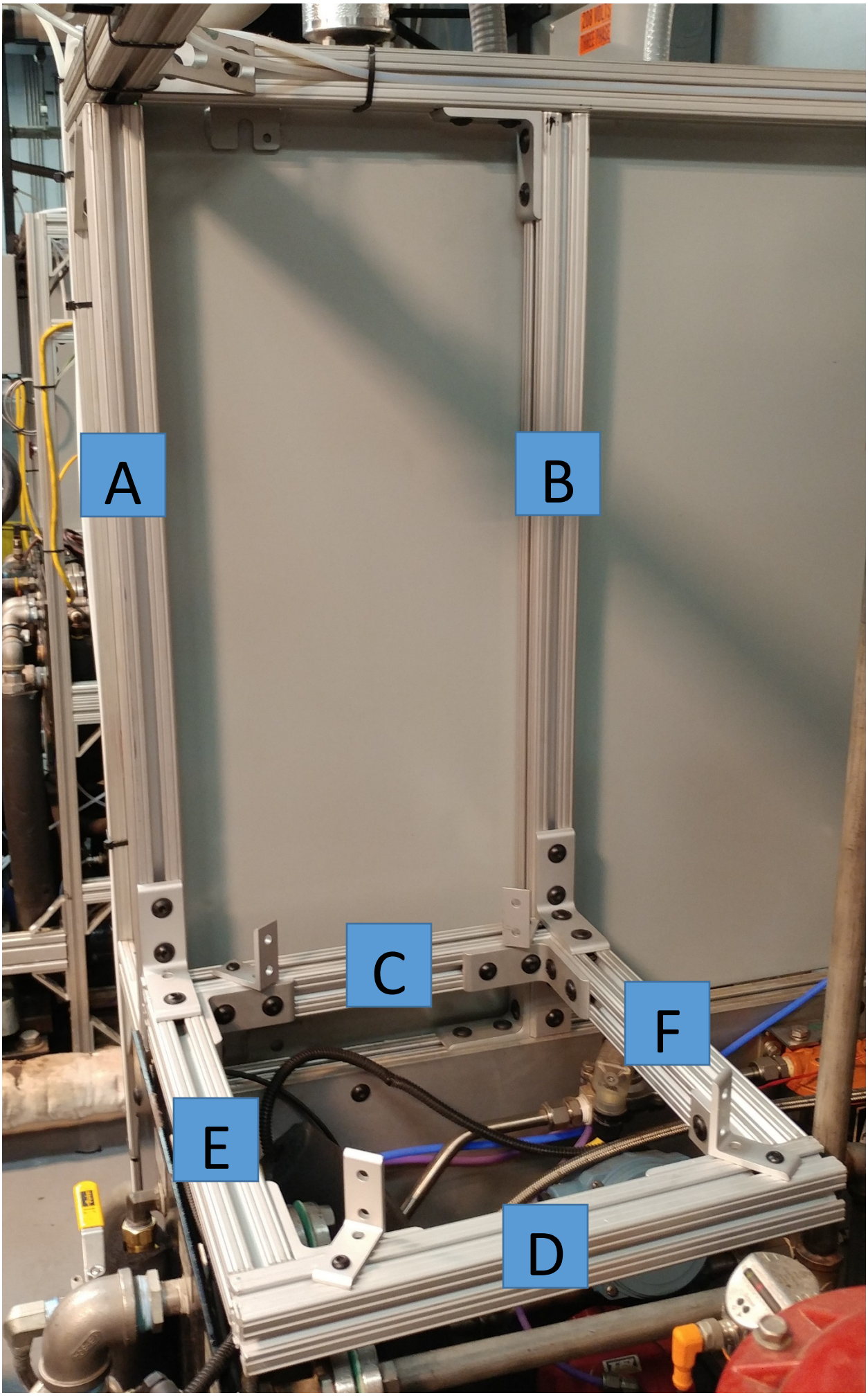
			ENG APPR.		
			MFG APPR.		
			Q.A.		
			COMMENTS:		
		MATERIAL			
NEXT ASSY	USED ON				
APPLICATION		DO NOT SCALE DRAWING			

TITLE: IVB Blowby Heater Tank Assembly

SIZE	DWG. NO.	REV
A		
SCALE: 1:12	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1


A
B
C
F
E
D

A. - 1 ½ in 80/20 x 27 5/8” (cut to fit your stand)
B. - 1 ½ in 80/20 x 29 5/8” (cut to fit your stand)
C. - 1 ½ in 80/20 x 14 ½”
D. - 1 ½ in 80/20 x 14 ½”
E. - 1 ½ in 80/20 x 12 ½”
F. - 1 ½ in 80/20 x 12 ½”

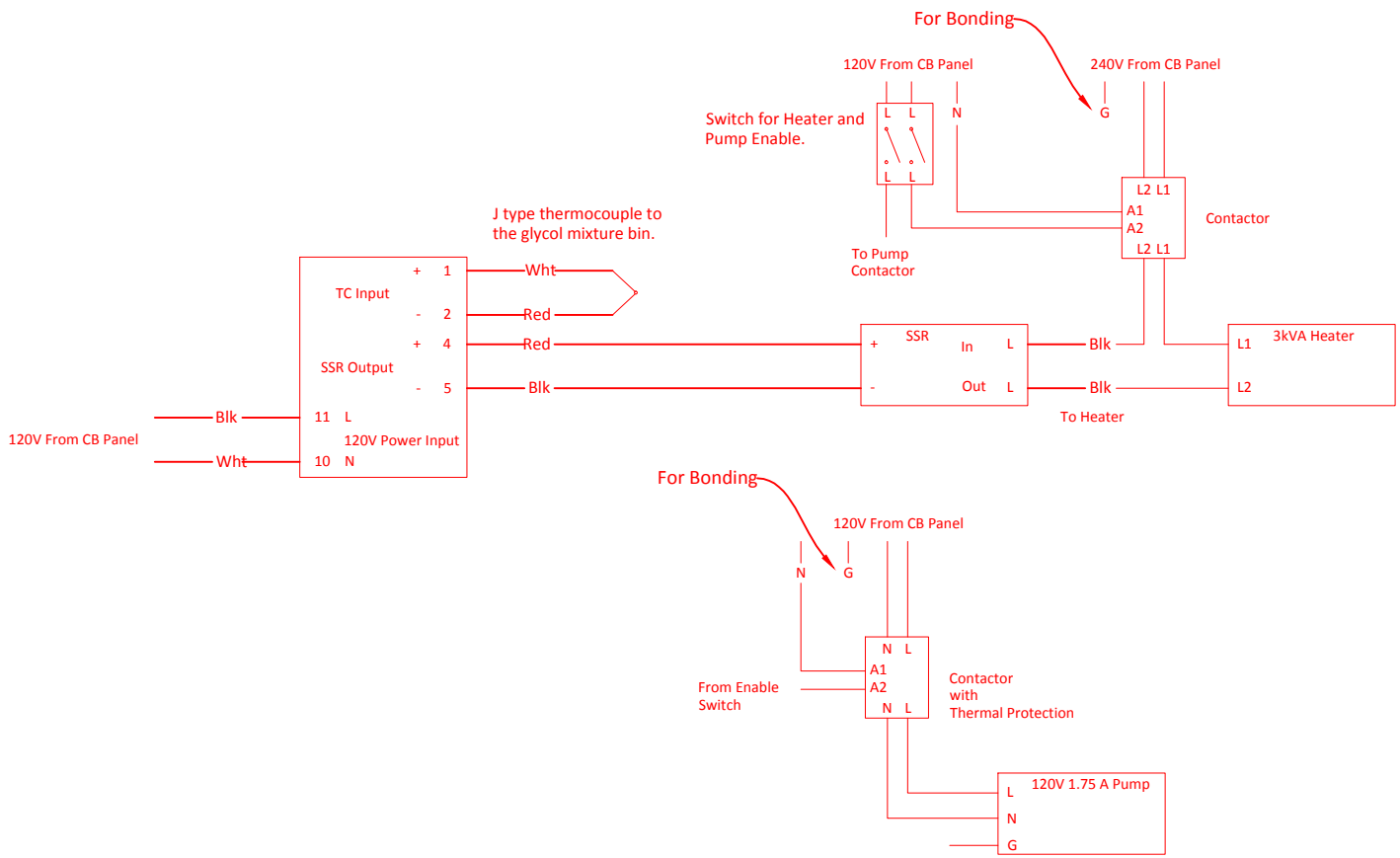
11ea. - 80/20 bracket’ McMaster # 47065T241

4ea. - 80/20 bracket, McMaster # 47065T239

Aluminum T – slotted frame solid, McMaster #47065T103

Blow by Heater Add

Note:
Enclosure mounted
by Power Cab.



Intertek Automotive Research	
Title: Stand 165 Toyota	
Other Applicable Drawings	Printed Circuit Boards
Designed By: M. Govoni	Lab
Scale	Date: 10/11/2016
Drawing No.: XXX	