

## 6. Apparatus (General Description)

6.1 The test engine is a Ford, spark ignition, four stroke, 4-cylinder gasoline turbocharged direct injection (GTDI) engine with a displacement of 2.0 L. Features of this engine include variable camshaft timing, dual overhead camshafts driven by a timing chain, four valves per cylinder and electronic direct fuel injection. It is based on the Ford Motor Co. 2012 Explorer engine with a displacement of 2.0 L.

6.2 Configure the test stand to accept a Ford 2.0L GTDI engine. All special equipment necessary for conducting this test is listed herein.

6.3 Use the appropriate air conditioning apparatus to control the temperature, pressure, and humidity of the intake air.

6.4 Use an appropriate fuel supply system (Fig. 1).

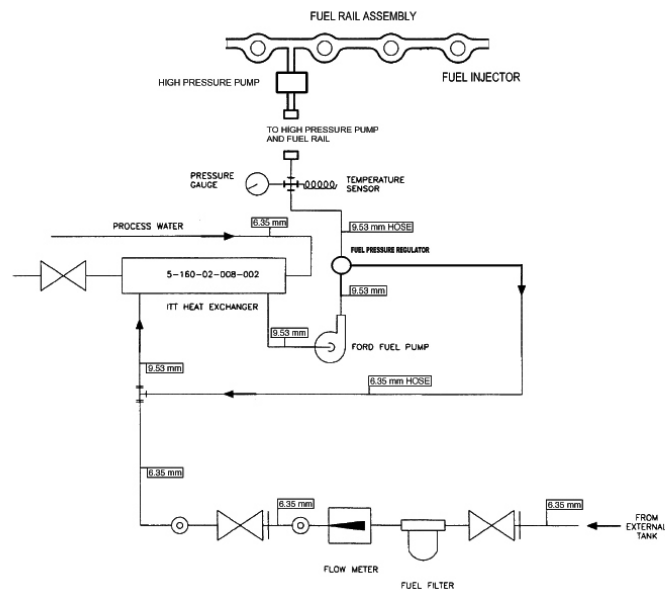


Figure 1

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

## 7. Apparatus (The Test Engine)

7.1 Sequence?? Test Engine—The test engine part are available from the Ford Motor Co. (A1.1, use parts list .xl). A detailed listing of all parts is given in Annex (A1, use parts list .xl).

7.1.1 Engine parts other than valve train and drive parts can be replaced during the test, provided the reason for replacement was not oil related.

7.2 Required New Engine Parts—Use new parts listed in test parts list (see A1.4) and the gaskets list (A1.5) for each test. New valve train drive parts and piston rings must be used for each test. Do not modify or alter test parts without the approval of Sequence ?? Surveillance Panel.

7.3 Reusable Engine Parts—The parts listed in the reusable engine parts list (A1.2), test stand set up kit (A1.6), and fastener kit (A1.3) can be reused (all of these can be used in numerous engine assemblies as long as they remain serviceable). Crankshaft and bearings, connecting rods and bearings, pistons, camshafts, timing chain covers, cylinder blocks, cylinder head assemblies, turbocharger, PCV valve and fuel injectors may be used for a maximum of 6 tests as long as they remain serviceable. These parts should be kept together as a set for all 6 tests. Damaged threads in the block can be corrected with commercially available thread inserts.

7.4 Specially Fabricated Engine Parts—The following subsections detail the specially fabricated engine parts required in this test method:

7.4.1 Intake Air System (see Fig. A2.12) Intake air system shall use the stock 2012 Explorer air cleaner assembly (A1.6).

7.4.5 Oil Pan and pick up tube—Use a modified oil pan with dipstick, fill port and pick up tube listed in A1.7 and shown in Fig. A2.1. These can be obtained from the supplier listed in A9.2.

7.4.7 Driveline—Use the flywheel, clutch, pressure plate, bellhousing, clutch spacer listed in Annex (A1.7) from the supplier listed in A9.2

7.5 Special Engine Measurement and Assembly Equipment—Items routinely used in laboratory and workshop are not included. Use any special tools or equipment shown in the 2012 Explorer service manual for assembly. A list of these tools is shown in Annex A1.8. Complete any assembly instructions not detailed in Section 7 according to the instructions in the 2012 Explorer Service Manual.

7.5.1 Piston Ring Positioner—Use the piston ring positioner to locate the piston rings from the cylinder block deck surface by 38 mm. This allows the compression rings to be positioned in a consistent location in the cylinder bore for the ring gap measurement. Fabricate the positioner according to the details shown in Fig. A2.17.

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

7.5.4 Engine Service Tools—A complete list of special tools for the test engine is shown in Annex A1.8. The tools are available from a Ford dealership. These are designed to aid in performing several service items, in addition to the following specific service items that require special tools to perform the functions indicated (if not self-explanatory).

7.5.7 Engine Parts Cleaning—Clean the cylinder block, cylinder heads, pistons, oil pan and front cover using Tierra Tech model MOT500NS ultrasonic parts cleaner or similar apparatus. See X2.1.18. Rinse parts with parts cleaning soap, NAT-50 or PDN-50 (Annex X2.1.23) before putting into ultrasonic cleaner.

After all the measurements, the engine is ready for cleaning. Put all of the following components into ultrasonic parts cleaner for 30 minutes:

- Cylinder block with main bearings. Oil jets are removed.
- Bare pistons without wristpins (The piston compression and oil rings are removed from each piston prior to going into the ultrasonic cleaner, they will get replaced with a new set)
- Bare cylinder head (No valvetrain components)
- OHT oil pan
- Front cover

The ultrasonic parts cleaner solution is also provided by Tierra Tech, Ultrasonic solution 7 and B (X2.1.19). The cleaning procedure is described below:

Add solution once ultrasonic machine reaches a minimum of 140°F. DO NOT add the degreasers until the ultrasonic machine has reached a temperature of 140°F.

- 5 ½ gallons of ultrasonic solution 7
- ½ gallon of ultrasonic solution B
- Change the soap and water solution at least after every 25 hrs. of use.

\*Note: The solution shown above is based upon the MOT-500NS model (158 gallon capacity). Quantities will be different for a different size unit.

After 30 minutes, the parts are removed and immediately sprayed with hot water, then solvent and left to air dry.

The remaining components are spray cleaned with Stoddard solvent then blown out with pressurized air and left to air dry:

- Camshafts and all valve train.
- Intake manifold/ Throttle body (not being separated)
- Fuel pump housing with piston.
- Vacuum pump and oil screen.
- Intake and outlet of the turbocharger are lightly wiped down with solvent. The oil screen is also cleaned. (We don't clean the inside of the turbocharger)
- The carbon build up on the injectors is wiped of
- Oil Pump
- VCT solenoids are sprayed with solvent.
- Valve Cover
- Turbo charger oil lines
- Oil separator (PCV housing on the cylinder block)
- Oil pick up tube
- Oil squirters/jets
- Crankshaft
- Rods and pins

- All valvetrain
- The test batch camshaft sprockets and crankshaft gear.
- The test batch timing chain is cleaned as described in the Timing Chain Cleaning Procedure.

7.5.8 Cylinder Deglazing—Use a flexible cylinder hone Flex Hone Model: GB33432 and Pneumatic Honing Drill, Westward 1/2 Reversible Air Drill, Model: 5ZL26G to deglaze the cylinder walls. See X2.1.20 and X2.1.21

## 6 Miscellaneous Engine Components-Preparation:

7.6.1 Engine Build-Up and Measurement Area-Environment—The ambient atmosphere of the engine buildup and measurement areas shall be reasonably free of contaminants. A relatively constant temperature (within  $\pm 3$  °C) is necessary to ensure acceptable repeatability in the measurement of parts dimensions. To prevent moisture forming on cold engine parts that are brought into the buildup or measurement areas, maintain the relative humidity at a nominal maximum of 50 %.

### 7.6.2 Throttle Body:

7.6.2.1 Clean the butterfly and bore of the throttle body with carburetor cleaner (Chemtool B12) (X2.1.34) and air-dry before each test. Do not disassemble the throttle body as this will cause excessive wear on the components. The idle air screw can be removed for the cleaning process. Fully close the idle air screw during test operation.

7.6.2.2 There is no specific life for the throttle body. However, the clearance between the bore and the butterfly will eventually increase and render the body unserviceable. When the clearance becomes too great to allow control of speed, torque, and air-fuel ratio, discard the throttle body.

7.6.8 Water Pump Drive System—Use only the pulleys and belt provided in the Sequence ?? test stand set-up parts list (see Annex A1.6), crankshaft pulley, water pump and pulley, tensioner, and six groove belt shown in Figure 6.

7.6.11 Oil Separators—Clean with degreasing solvent (7.7.1) and allow to air-dry.

7.7 Solvents and Cleaners Required—No substitutions for 7.7.1 – 7.7.5 are allowed. (Warning—Use adequate safety provisions with all solvents and cleaners. See Annex X1.)

7.7.1 Solvent—Use only mineral spirits (ie Stoddard Solvent) 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). (Warning—Combustible. Health hazard.) Obtain a Certificate of Analysis for each batch of solvent from the supplier.

7.7.2 Organic Solvent, Penmul L460. (Warning—Combustible. Health hazard.). Annex X2.1.22

7.7.4 Ultrasonic Cleaner, Tierra Tech ultrasonic solution 7 and B available from supplier shown in Annex X1.4.

7.7.5 Parts Cleaning Soap, NAT-50 or PDN-50 have been found to be acceptable. (Warning—Health hazard.) Annex X2.1.23

7.8 Assembling the Test Engine-Preparations—Use the longblock obtained from the supplier in A9.1. If this is the first test on a new engine, disassemble the longblock in accordance with the 2012 Explorer workshop manual. Required new parts and reusable parts are listed in Annex A1

7.8.1 Parts Selection—Instructions concerning the use of new or used parts are detailed in 7.1.1, 7.2, and 7.3.

7.8.2 Sealing Compounds—Use a silicon-based sealer as needed on the contact surfaces between the rear seal housing and oil pan and the front cover and cylinder block, cylinder head and oil pan. Use Motorcraft Gasket Maker between (TA-16) or equivalent between the (Jason couldn't find where you're putting this)

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

NOTE 1—Non-silicon liquid or tape thread sealers can be used on bolts and plugs.

7.8.3 Gaskets and Seals—Install new gaskets and seals during engine assembly.

7.8.4 Block Preparations—Inspect block, including oil galleries for debris and rust. Remove any debris or rust that is found. Remove oil gallery plugs. Removal of coolant jacket plugs is left to the discretion of the laboratory.

7.8.4.1 **Deglazing Procedure:** Deglazing is performed after ultrasonic cleaning under the following conditions to achieve a 9ra to 13ra and 30+5 degree crosshatch:

1. Mount the engine block in an engine stand or suitable fixture so it is secure and will not move during deglazing operation.
2. Rinse cylinder bores with Stoddard solvent.
3. Deglaze cylinder bores using drill and hone shown in Figure 3 and Figure 4.
4. Run the drill at 500 rpm horizontal drill speed for 25 to 35 vertical strokes over elapsed time of 20 to 25 seconds. There should be a steady supply of lubricant supplied during each stroke.
5. 50/50 ratio, Stoddard Solvent (mineral spirits) and EF411, is the hone lubricant used.
6. Clean cylinders after honing deglazing with warm/hot water or hot water and Tide detergent using a brush, then oil cylinders with EF411.
7. Replace ball hone after deglazing 24 engine blocks

8. Measure surface finish and crosshatch.



**Figure 3: Pneumatic Honing Drill**

Pneumatic Honing Drill

Brand: Westward

1/2 Reversible Air Drill

Model: 5ZL26G

RPM: 500

Max Psi: 90



**Figure 4: Cylinder Hone**

Flexible Cylinder Hone

Brand: Flex Hone

Model: GB33432

Bore Dia.: 3-3/4"

Abrasive Material: Silicon Carbide Grit 320

- **Crosshatch Procedure:**

Materials:

1. Hatchview Software (<http://digitalmetrology.myshopify.com/products/hatchview>) (X2.1.24)
2. USB microscope. (X2.1.25)
3. Computer System Requirements: Windows XP, Vista or Windows 7 (32 or 64 bit), an available USB 2.0 port is required for live “video” viewing.

Preparation:

1. Cylinder should be clean of any oil or residue from honing to maintain consistency of measurements.
2. Adjust focus of camera while face of the camera is placed against the cylinder wall.
3. Set camera resolution to 640x480 and 30 fps.
4. Use the identification feature available in the program to title the image with cylinder number and test number.

Measurement:

1. The measurement is taken at the rear most longitudinal position of each cylinder.
2. The measurement is taken at 1.5 in. down from the top of the cylinder deck. A ruler is used to measure.
3. The measurement is to range for 25° to 35° with a target of 30°

#### 7.8.4.3 Crankshaft preparation

- (1) Clean the crankshaft according to section 7.5.7
- (2) Spray the crankshaft with degreasing solvent.

(3) Measure the main journals and connecting rods journals (horizontal diameter, vertical diameter) bearing inside diameter and clearance and verify that they meet the service limits.

(5) The crankshaft is polished with 400 grit 3M utility cloth while it is still lightly coated in Stoddard solvent. A final finish is given using 600 grit crocus cloth. The crankshaft is cleaned with Stoddard solvent for the final time.

7.8.4.4 Piston and rod assembly: Clean the pistons according to section 7.5.7. Measure piston, piston pin and pin rod hole diameters to insure they meet service limits. Install the pistons on the connecting rods per the procedure in the 2012 Explorer workshop manual.

#### 7.8.5 Piston Rings:

##### 7.8.5.1 Ring Gap Adjustment:

The piston rings are cleaned and wiped with EF411 to get the factory coating off. The 1st ring is gapped to .070" and the second ring is gapped to .075". These gaps have been shown to produce acceptable blowby levels with the surface finish and crosshatch pattern achieved in 7.8.4.1. but may need to be adjusted to achieve a 24 hour minimum blowby level of 70 L/min and an average blowby of 65-75 L/min. The ring placement is 1.5" (38mm) from the deck using ring positioner shown in Figure A2.17.

##### 7.8.5.2 Piston Ring Cutting Procedure:

(1) Cut the top and second compression ring gaps to the required gap using the Sanford Piston Ring Grinder. (X2.1.26) ring cutting burr (X2.1.27) rotated at a rated speed of 3450 r/min. Remove equal amounts from both sides of the gap. Make final cuts on the down stroke only. The ring is cut with a maximum increment of 0.125 mm until the desired ring gap is achieved.

(2) After the rings are cut remove the ring from the cutting tool, debur using a Sunnen soft stone (X2.1.28) and wipe with a dry towel.

##### 7.8.5.3 Installation:

(1) Install the oil control rings and the compression rings on the pistons with the gaps located over the piston pin. Position the gaps at approximately 180° intervals, with the top compression ring gap toward the rear. Install the rings using a ring spreader tool, keeping the rings' surfaces parallel to the ring groove in the piston.

(2) If any rings require replacement, then measure and record the new ring gap(s) and ring side clearance(s). Calculate ring side clearance by determining the difference between the ring groove width and the associated ring width.



7.8.6 Cylinder Bore Measurements—Measure the cylinder bores with the bearing caps in place. Clean the bores with a dry rag. The bores shall be clean and dry when they are measured. Use a bore gage micrometer to determine the diameter of cylinders at the top, middle and bottom using the bore ladder shown in figure A2.18.

7.9 Assembling the Test Engine-Installations—Assemble the engine according to the instructions in the 2012 Explorer service manual unless specified herein.

7.9.1 Cylinder block— The heater hose tube is removed from the block as shown in Figure 5 and plugged with a 5/8" freeze plug coated in RTV.



**Figure 5: Cylinder Block Heater Hose Tube**

7.9.2 Piston Installation—Install piston and rod assemblies in proper cylinders, taking care to ensure rings are not damaged during installation. Wipe the cylinders with EF-411. Install the pistons and connecting rods with the notches facing the rear. Install the rod bearing caps and torque according to the procedure in the 2012 Explorer workshop manual.

7.9.3 Oil System Components—All oil system components in the engine are production configuration with the exception of the oil pan and the oil pickup tube, shown in figure A2.1.

7.9.4 Cylinder Head Installation—Cylinder heads are obtained from the supplier in A9.1. Heads may be used for up to 6 tests, as long as they remain serviceable.

(1) Disassemble heads and inspect for any debris or other deleterious materials and remove as necessary.

(2) Clean the cylinder head in the Ultrasonic cleaner as described in section 7.5.7

(3) Determine valve guide clearance at the top and middle of the heads on the transverse side of the guide. Reject any heads that exceed the service limits shown in the 2012 Explorer work shop manual.

(4) Measure and record intake and exhaust valve springs, spring free length, and spring load at a compressed height of 28.7 mm. Verify the compressed spring load is  $460 \pm 21$  N. Reject any springs not meeting this criteria.

(5) Assemble the cylinder heads in accordance with the service manual. The valves are lapped before installation and new intake and exhaust valve seals are installed.

(6) Set the valve lash per the procedure in the workshop manual and record the valve lash.

7.9.5 Chain and Camshaft Installation Procedure: Measure the test chain according to the Timing Chain Measurement Procedure prior to installing it in the engine. Install camshaft and timing chain according to the procedure in the 2012 Explorer work shop manual. If using the Ford camshaft alignment tool (Ford P/N 303-1565) (X2.1.29) be sure not to let it bind in slots at the rear of the camshafts. It should be loose after the timing chain installation is complete. Be sure camshaft positioning tool is flat before installing. Use a spanner on the harmonic balancer or a flywheel lock to hold the crankshaft. Alternate method, the crankshaft positioning crankshaft TDC timing peg (Ford P/N 303-507) (X2.1.30) can be used to hold the crankshaft in place while performing this installation. Install the timing chain with the lettering on the black link facing forward. This will insure the chain is installed in the same orientation if/when it is removed and reinstalled during the test. Coat the timing chain with test oil every time it is installed in the engine. Install the chain tensioner and guides according to the 2012 Explorer workshop manual. After tensioner is installed and the pin is pulled from the tensioner to release the tensioner arm, do not move or apply any force to the tensioner arm.

7.9.6 Balance Shaft Housing— Do not install the balance shaft housing; it cannot be used with the test oil pan. The balancer is removed and the oil passage is plugged with a CFM Balance Shaft Delete Kit (Part number 1-0180) (X2.1.31).

7.9.7 Oil Pan and Baffle—Install oil pan baffle to the oil pan as shown in Fig. A2.1. Install the oil pan according to the procedure in the 2012 Explorer service manual.

7.9.8 Water Pump, Water Pump Drive—Install the water pump and pulley, the crankshaft pulley, and tensioner according to the 2012 Explorer service manual. These are the only components needed to drive the water pump. All other production front end accessory drive components do not need to be installed. The engine cannot be used to drive any external engine accessory other than the water pump. Pull back tensioner and install water pump drive belt as shown in Fig. 6. Ensure that there is a minimum contact angle of  $20^\circ$  between the drive belt and the water pump pulley.

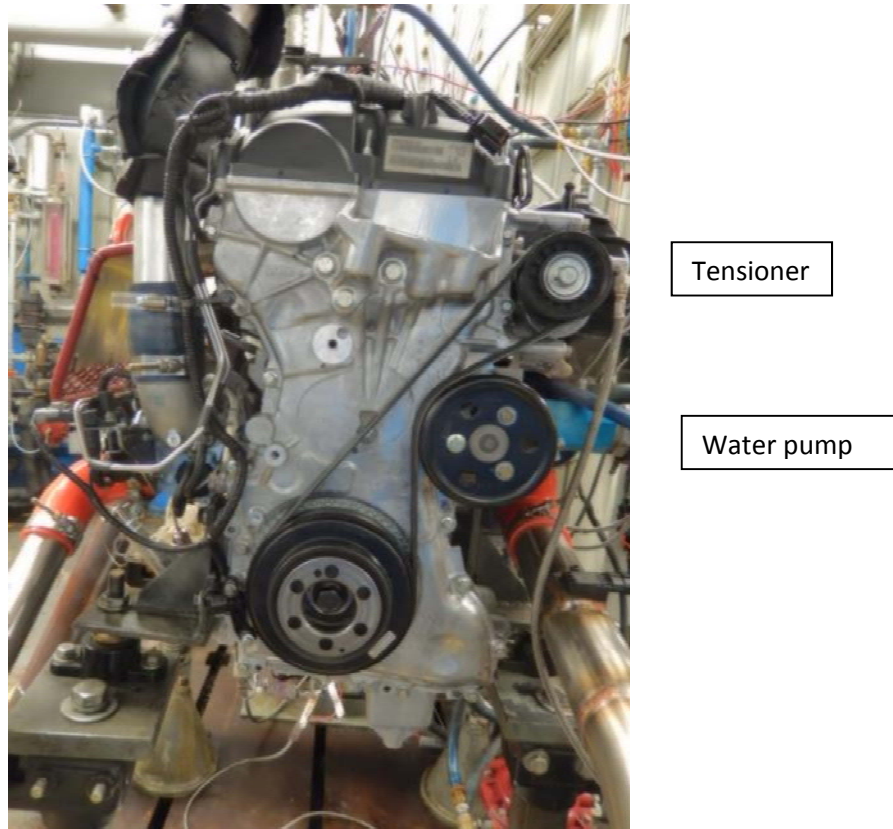


FIG. 6 Water Pump Drive Arrangement

7.9.9 Engine cooling system – Use coolant inlet and outlet from the supplier shown in A9.2. Plumb the external coolant system as shown in figures A2.2 and A2.3.

7.9.10 Cylinder block oil separator - Install a dummy PCV valve (PCV valve with the internal components removed) in oil separator on the side of the engine block. A functional PCV is located at the stand in the external crankcase ventilation system.

7.10 Pre-break in and End of Test Timing Chain Cleaning Procedure:

1. Place a brand new timing chain into an ultrasonic bath with Stoddard solvent for 20 minutes.
2. Remove the chain from the ultrasonic cleaner and dip into room temperature Stoddard solvent to cool chain. Dip the chain in heptane or solvent 142 to prevent rust before measuring.
3. Let the chain dry and cool off for at least 2 hours in the metrology lab before starting the measurement procedure. This will allow the temperature of the chain to stabilize. Oil chain with EF-411 prior to pre-break in measurement. After measuring pre-break in

measurement wipe off EF-411 oil from chain and coat with test oil. No need to coat end of test chain with oil after cleaning.

**(Note: Do not clean the timing chain when it is removed for measuring after break in or if it is removed during the test for a repair)**

7.11 Timing Chain Measuring Procedure: The timing chain is measured three times during the test. When the chain is new before the initial installation into the engine, after the 8 hour engine break in and at the end of the test.

- Use the George-O-Matic chain measurement apparatus (A9.6) shown in Figure 7.
- Parts list show in A1.8



Figure 7: Chain Measurement Apparatus

1. Check calibration standard on measurement apparatus. If the indicator reading is less than  $\pm 0.0005$ " proceed to next step. If reading is larger, then investigate source of error.
2. Orient the sprockets of the measurement apparatus such that they are aligned with their alignment orientation marks.
3. Install chain on measurement apparatus with the "key" link in the standard (aligned) location.

4. Insure that the USB digital interface cable between the indicator and the computer is connected and that the first cell of the spreadsheet is selected into which the data will begin being entered.
5. Energize the drive motor on the chain measurement apparatus and run until a minimum of 30 chain lengths worth of reading have been captured (207 sprocket revolutions).
6. When complete, examine the averages for the three measurement ranges and verify the total range does not exceed  $\pm 0.0003''$ ; if it does, repeat the measurement by overwriting the data.
7. Chain elongation =  $2 * (\text{measurement} - \text{initial measurement}) / \text{nominal chain length}$ . The nominal chain length is 43.125''.

7.10 Engine Installation on the Test Stand—Functions that are to be performed in a specific manner or at a specific time in the assembly process are noted.

7.10.1 Mounting the Engine on the Test Stand—Mount the engine on the test stand so that the flywheel friction face is  $(0.0 \pm 0.5)^\circ$  from vertical. Four motor mounts are used (Quicksilver part# 6628-A) (X2.1.33) as shown in Figure A2.4 and Figure A2.5. Drawings of the mount brackets can be found in the Figure A2.6 and Figure A2.7. The engine must be at  $(0.0 \pm 0.5)^\circ$  roll angle.

7.10.1.1 Flywheel: The flywheel bolts get lightly coated with Loctite 565 to prevent any oil from seeping out of the holes. Torque the flywheel to 108-115 Nm. The flywheel is obtained from the supplier in A9.2

7.10.1.2 Clutch and pressure plate - The clutch, pressure plate and spacer are obtained from the supplier in A9.2. Put the flat side on the clutch toward the engine. The spacer goes between the flywheel and pressure plate. Torque the pressure plate bolts to 25-33 Nm. Each clutch gets replaced every 6 runs.

7.10.1.3 Driveline: The driveline is greased every test. Driveline specifications:

- A. Driveline Degree: 2 degrees
- B. 21.5" collapsed length from flange to flange
- C. 1410 series flanges
- D. 2.75" pilot
- E. 3.75" bolt circle
- F. 3.50" x .083" stub and slip

7.10.2 Exhaust System and Gas Sampling Fittings:

7.10.2.1 A typical exhaust system, and fittings for backpressure probe, O<sub>2</sub> sensors and thermocouple are illustrated in Figs. A2.8. Exhaust components should be constructed of either solid or bellows pipe/tubing. Other type flexible pipe is not acceptable.

7.10.2.2 The backpressure probe can be used until they become unserviceable. If the existing probes are not cracked, brittle, or deformed, clean the outer surface and clear all port holes. Check the probes for possible internal obstruction and reinstall the probes in the exhaust pipe. Stainless steel probes are generally serviceable for several tests; mild steel probes tend to become brittle after one test. Exhaust gas is noxious. (Warning—Any leaks in the connections to the sample probe will result in erroneous readings and incorrect air-fuel ratio adjustment.)

#### 7.10.4 Fuel Management System:

##### 7.10.4.1 Fuel Injectors:

(1) The fuel injectors can be used for 6 test.

(2) Inspect the O-rings to ensure they are in good condition and will not allow fuel leaks, replace if necessary. Install the fuel injectors into the fuel rail and into the cylinder head.

7.10.4.2 Powertrain Control Module: The engine uses a PCM provided by Ford Motor Company to run this test. The PCM contains a calibration developed for this test, use a PCM that contains calibration U5J0110D1VEPfn13\_78\_2.. The PCM module is available from the supplier listed in A9.2.

(1) The PCM power shall come from a battery ( $13.5 \pm 1.5$ ) V or a power supply that does not interrupt/interfere with proper PCM operation. Connect the PCM battery/power supply to the engine wire harness with an appropriate gage wire of the shortest practical length so as to maintain a dc voltage of (12 to 15) V and minimize PCM electrical noise problems. Ground the PCM ground wire to the engine. From the same ground point, run a minimum two gage wire back to the battery negative to prevent interruption/interference of the PCM operation. The power supply can also be used for the Lambda measuring devices.

7.10.5 Spark Plugs—Install new Motorcraft CYFS-12-Y2 spark plugs. Spark plugs come pregapped. Torque the spark plugs to 9 to 12 N·m. Do not use anti-seize compounds on spark plug threads.

7.10.6 Crankcase Ventilation System—The crankcase ventilation system is a closed system allowing blowby to be vented from the crankcase and drawn into the intake manifold. The metal parts of the crankcase ventilation system get flushed with carburetor cleaner (Chemtool B12) (X2.1.34) or any equivalent solvent after every test, then blown out with pressurized air and are left to air dry. All the hoses (ie tygon) get replaced every test. If using a smooth bore Teflon braided stainless steel hose, these can be reused after cleaning in an industrial degreaser (Penmul L460). A diagram of the crankcase ventilation system is shown in Figure A2.9 and A2.10.

7.10.6.1 System description: - Blowby flows through the oil drain back passages in cylinder block and head and through the front cover and out through the camshaft cover. The blowby heat exchanger and oil separator prevents loss of oil, fuel and water into PCV system. A typical heat exchanger cooling system is shown if Figure A2.11. The PCV valve flows approximately 120 L/min. Blowby flowrate is 65 to 75 L/min. When excessive plugging of the PCV valve occurs or there is excess blowby, it is vented to the

fresh air tube after the mass air flow sensor. A dummy PCV valve (PCV valve with the internal components removed) is placed in the stock PCV valve location in the block mounted oil separator is used for crankcase pressure measurement.

7.10.6.2 Blowby Heat Exchanger and Oil Separator: Use ITT Heater exchanger S-160-02-008-002 (X2.1.9) and Moroso oil separator, Part number 85487 (A9.4). Disassemble and soak both in Penmul L460 (X2.1.22) for 24hrs. Rinse with hot water, then rinse a final time with Stoddard solvent and let air dry.

7.10.7 Intake Air Components—Install the fresh air tube, air cleaner assembly, and new air filter. Modify the air cleaner assembly to accept fittings for inlet air temperature thermocouple and pressure tap as shown in Fig. A2.12. The excessive blowby tube is shown connected to the fresh air tube after.

7.10.7.1 Water to Air Turbocharger Intercooler - Use Type 5 or Type 52 intercooler (A9.5) from [www.frozenboost.com](http://www.frozenboost.com). The intercooler accumulates significant amounts of blowby condensate during each test. The air side of the intercooler must be spray cleaned with Stoddard solvent, rinsed with hot water and left to air dry. Use commercial Aqua Safe descaler to clean the water side.

7.10.7.2 Intercooler Tubing: Fabricate the intake air system with 916±150 mm long 51 mm ID stainless steel tubing from the turbocharger to the intercooler and 916±150 mm 64 mm ID stainless steel tubing from the intercooler to the throttle body. Locate the MAPT sensor 305±25 mm from the intake surface of the throttle body and the intake air charge temperature thermocouple 1 inch downstream from the MAPT sensor. The post turbo boost pressure measurement probe should be placed a minimum of 12 inches upstream from the MAPT sensor. The measurements can be seen in Figure A2.13 and typical installation is shown in figure A2.14.

7.10.8 External Hose Replacement—Inspect all external hoses used on the test stand and replace any hoses that have become unserviceable. Check for internal wall separations that could cause flow restrictions. Check all connections to ensure security.

7.10.9 Wiring Harness—There are two wiring harnesses used on the test stand, an dynamometer harness that connects to the stand power and PCM and an engine harness. Obtain the dynamometer wiring harness and engine wiring harness from the supplier listed in A9.2.

7.10.10 Electronic Throttle Controller: Throttle is controlled using simulated accelerator pedal position signals. The dyno wiring harness is supplied with an Accelerator Pedal Position jumper cable with un-terminated pigtail leads. The test laboratory must connect two voltage command signals, Acc Pos Sensor 1 and Acc Pos Sensor 2, to the Accelerator Pedal Position jumper cable. The voltage control ranges for each signal are shown in Table 1. The wiring schematic and pin-out description for this connection is shown in Figure 8.

Command Signal	Operating Range	Min Signal (Idle)	Max Signal (WOT)
Acc Pos Sensor 1	0-5.0 VDC	0.75 VDC (15%)	4.25 VDC (85%)

Acc Pos Sensor 2	0-2.5 VDC	0.375 VDC (15%)	2.125 VDC (85%)
Note: Acc Pos Sensor 2 should always equal 50% of Acc Pos Sensor 1			

Table 1: Accelerator Position Sensor Control Ranges

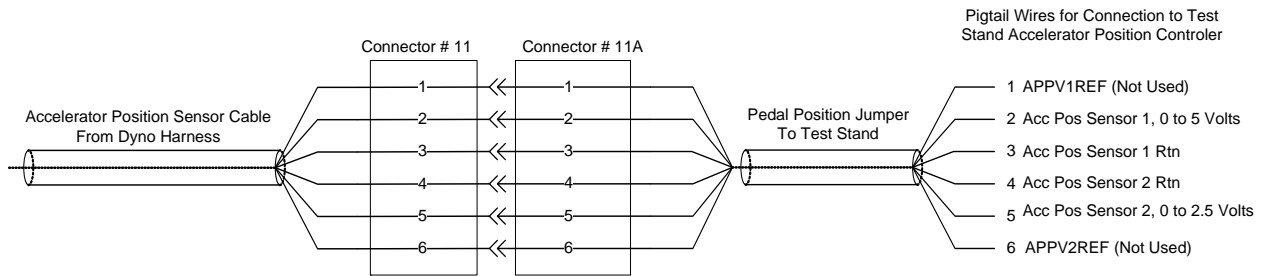
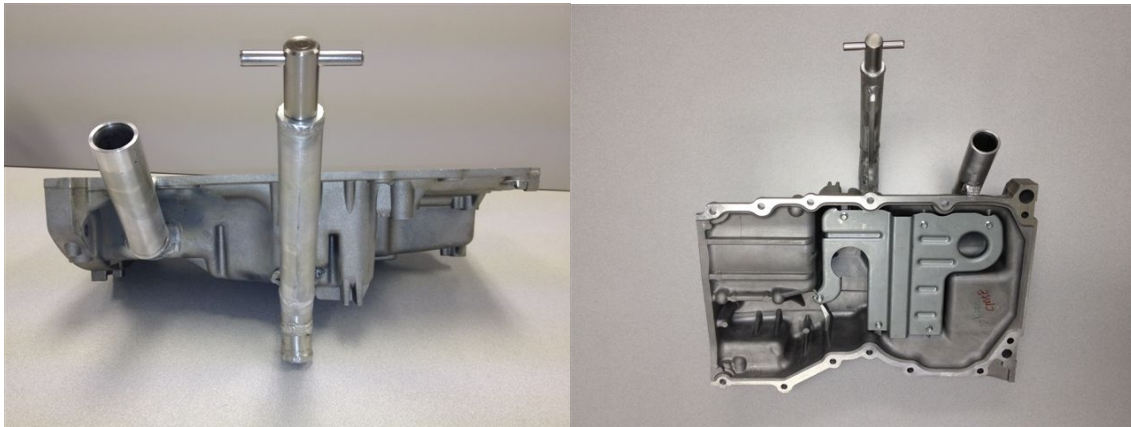


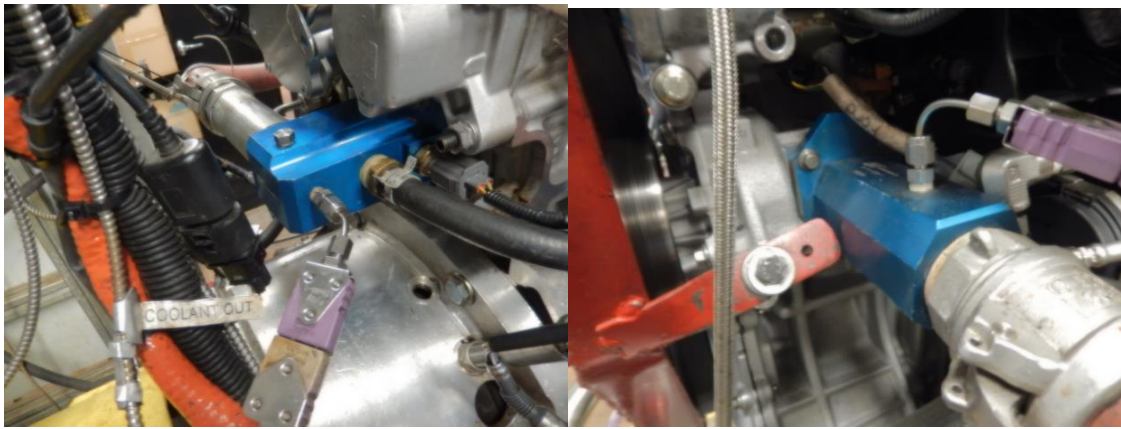
Figure 8: Accelerator Position Wiring Schematic





Oil pan

Figure A2.1

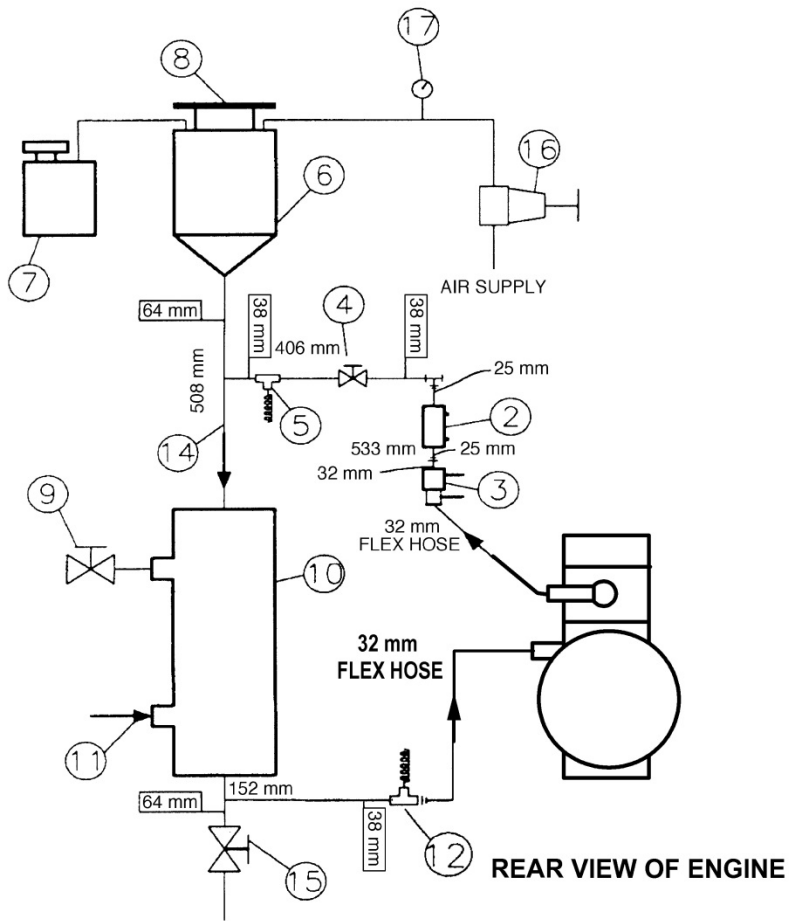


Coolant out

Coolant in

Coolant in and out connections and thermocouple locations

FIG. A2.2



NOTE 1—Observe temperature sensor locations in thermostat housing and at water pump inlet.

NOTE 2—Components of Engine Cooling System—

- (1) Thermostat housing with temperature sensor
- (2) Sight glass
- (3) Flowmeter
- (4) Flow control valve
- (5) Optional temperature control sensor
- (6) Fabricated coolant reservoir
- (7) Constant full expansion tank
- (8) Pressure radiator cap (MOTORCRAFT RS40 P/N D2YY-8100-A)
- (9) Process water control valve (regulated by temperature controller with three remote set points)
- (10) Heat exchanger (ITT Standard P/N 5-030-06-048-001 TYP.)
- (11) Process water supply (shell side)
- (12) Tee with temperature sensor for coolant inlet; located (300 to 400) mm upstream of pump inlet at the block face
- (13) Water pump inlet (Oil filter adapter)
- (14) Engine coolant (tube side)
- (15) Coolant system drain valve
- (16) Coolant pressure regulator
- (17) Coolant pressure gage
- (18) External coolant pump

FIG. 2.3 Typical Engine Cooling System Schematic (cont.)



Figure A2.4: Motor mounts, front

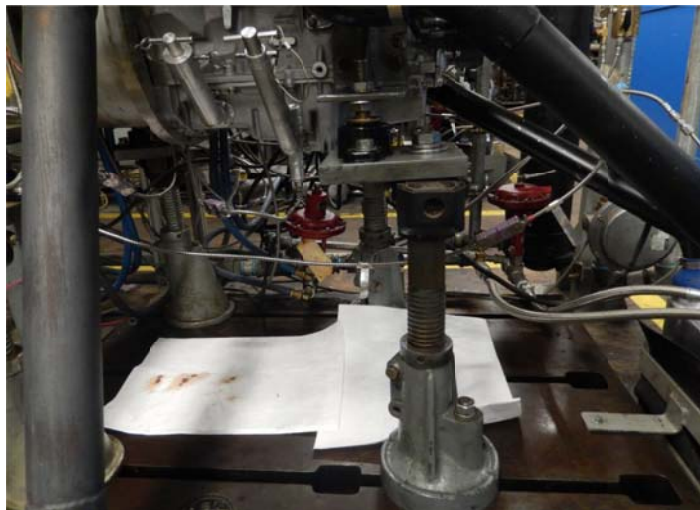


Figure A2.5: Motor mounts, rear

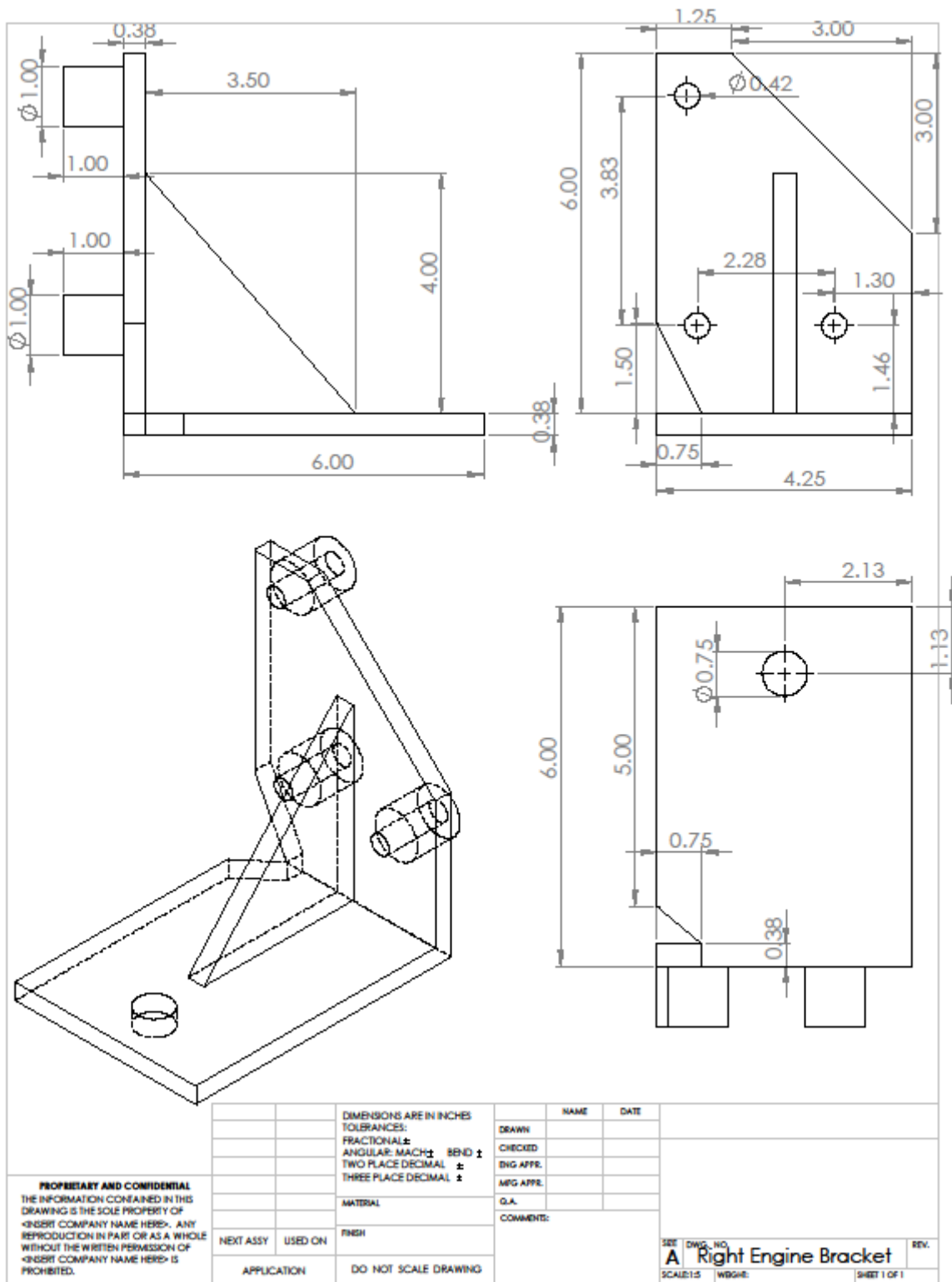


Figure A2.6

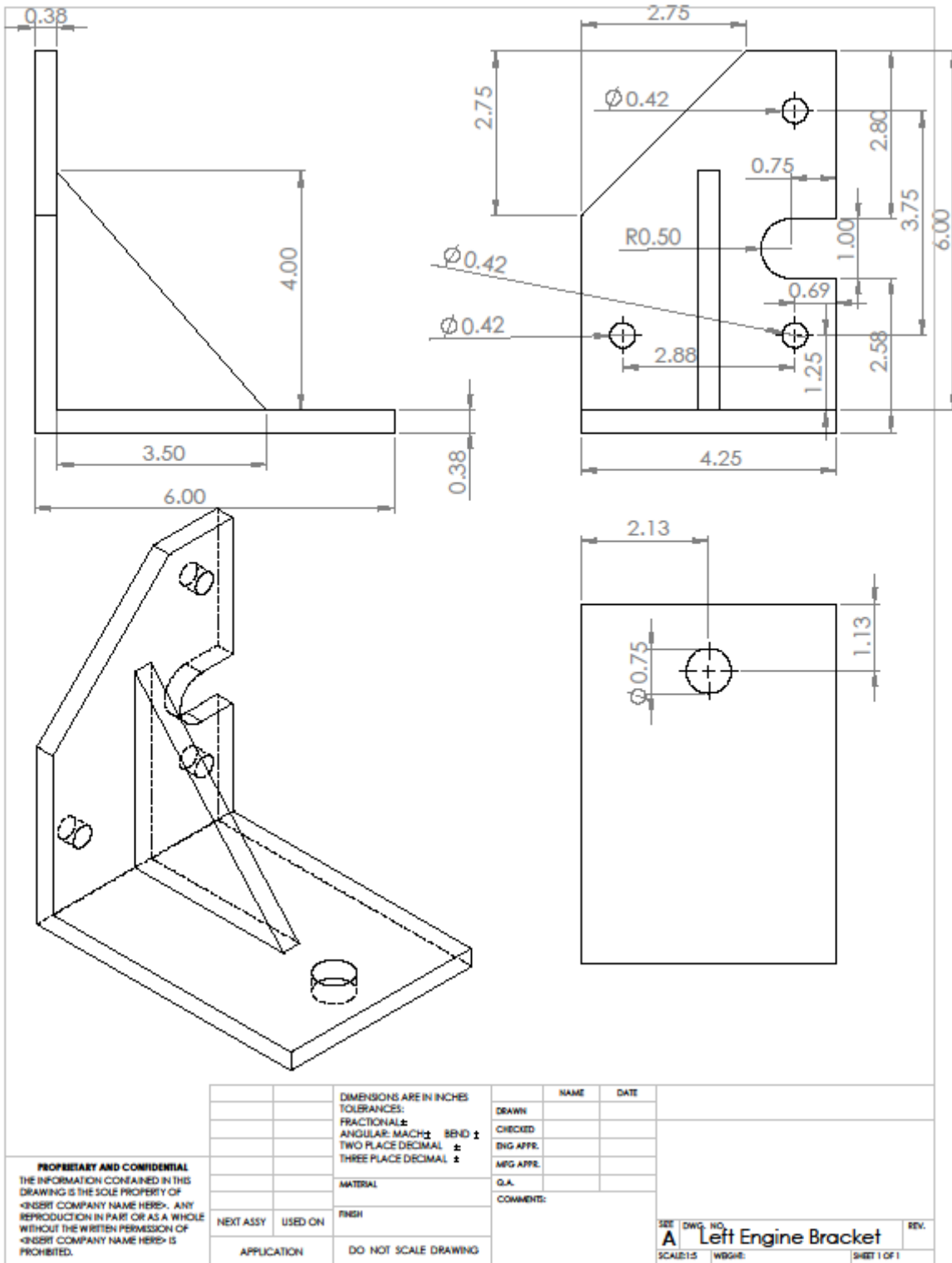


Figure A2.7

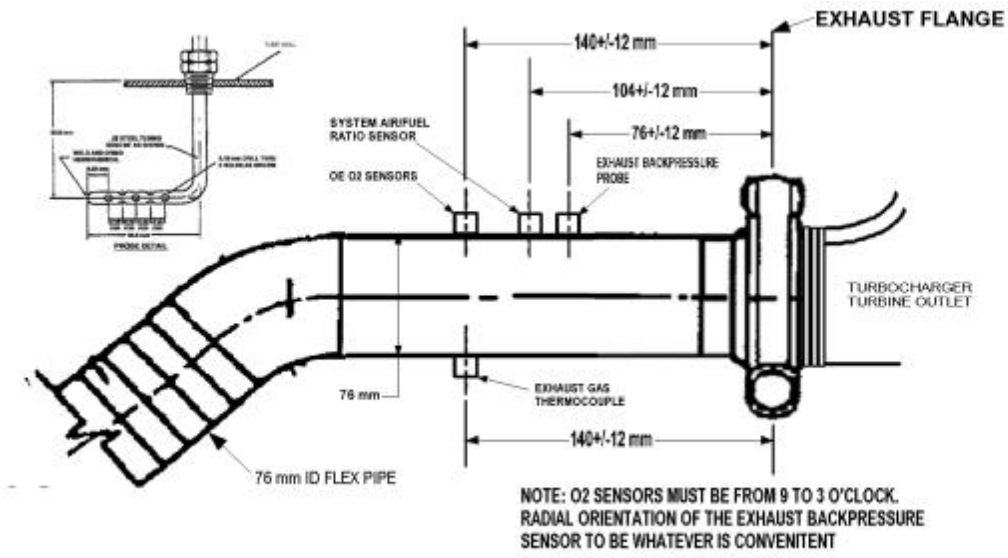


Figure A2.8: Exhaust Measurements and Instrumentation

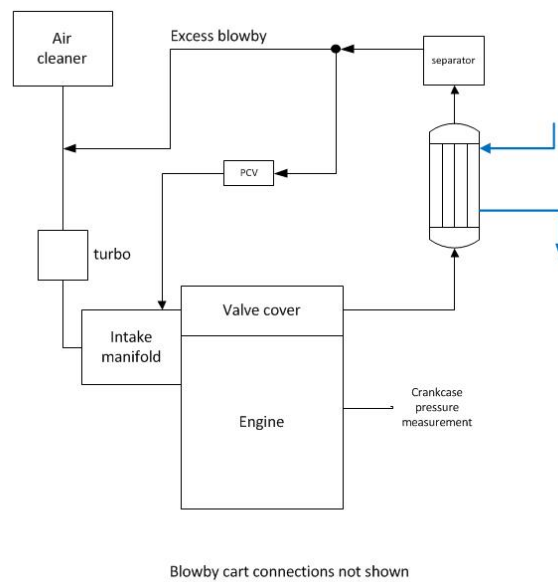


Figure A2.9: Crankcase Ventilation System

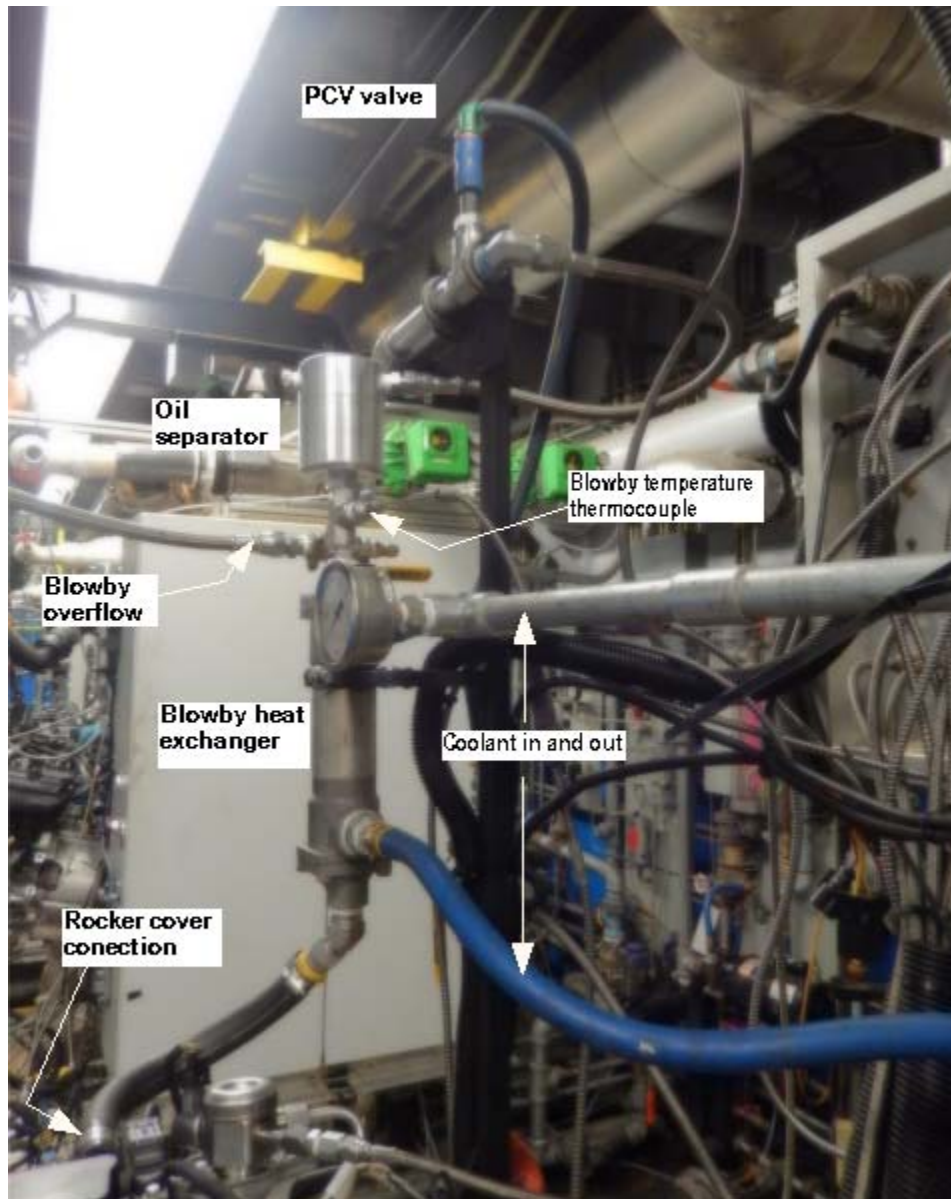
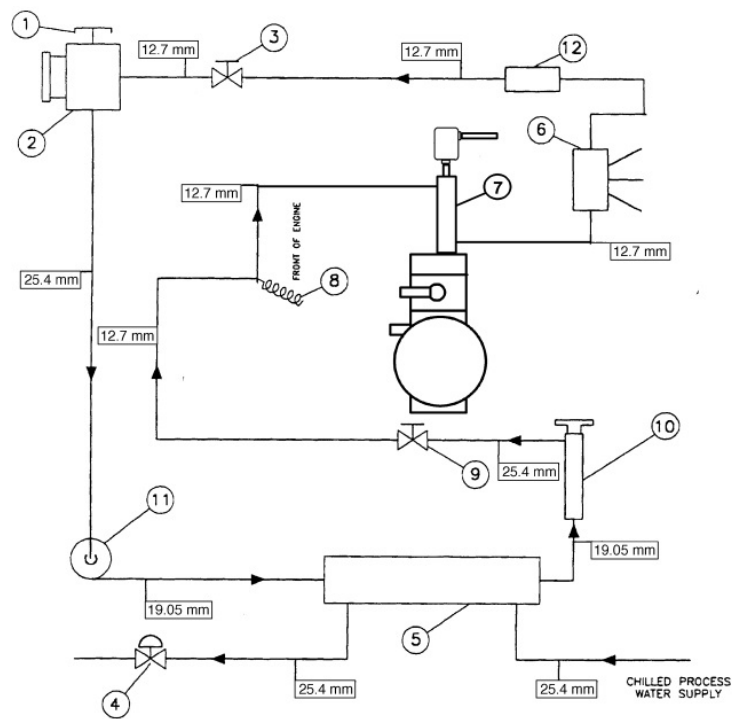


Figure A2.10: Crankcase Ventilation System



Legend

- (1) Vented reservoir cap
- (2) Coolant reservoir (fabricated)
- (3) Pressure control valve (optional)
- (4) Chilled process water control valve
- (5) System heat exchanger
- (6) F and P Co. flowrator tube, FF-1-35-G-10/448D053U06
- (7) CCV Heat Exchanger
- (8) Inlet temperature sensor
- (9) Flow control valve
- (10) External heat source
- (11) Electric coolant pump DAYTON 6K581A
- (12) ABB Kent-Taylor flow element, 1330LZ08000-8375A

FIG. 2.11 Typical CCV Heat Exchanger Heating and Cooling System



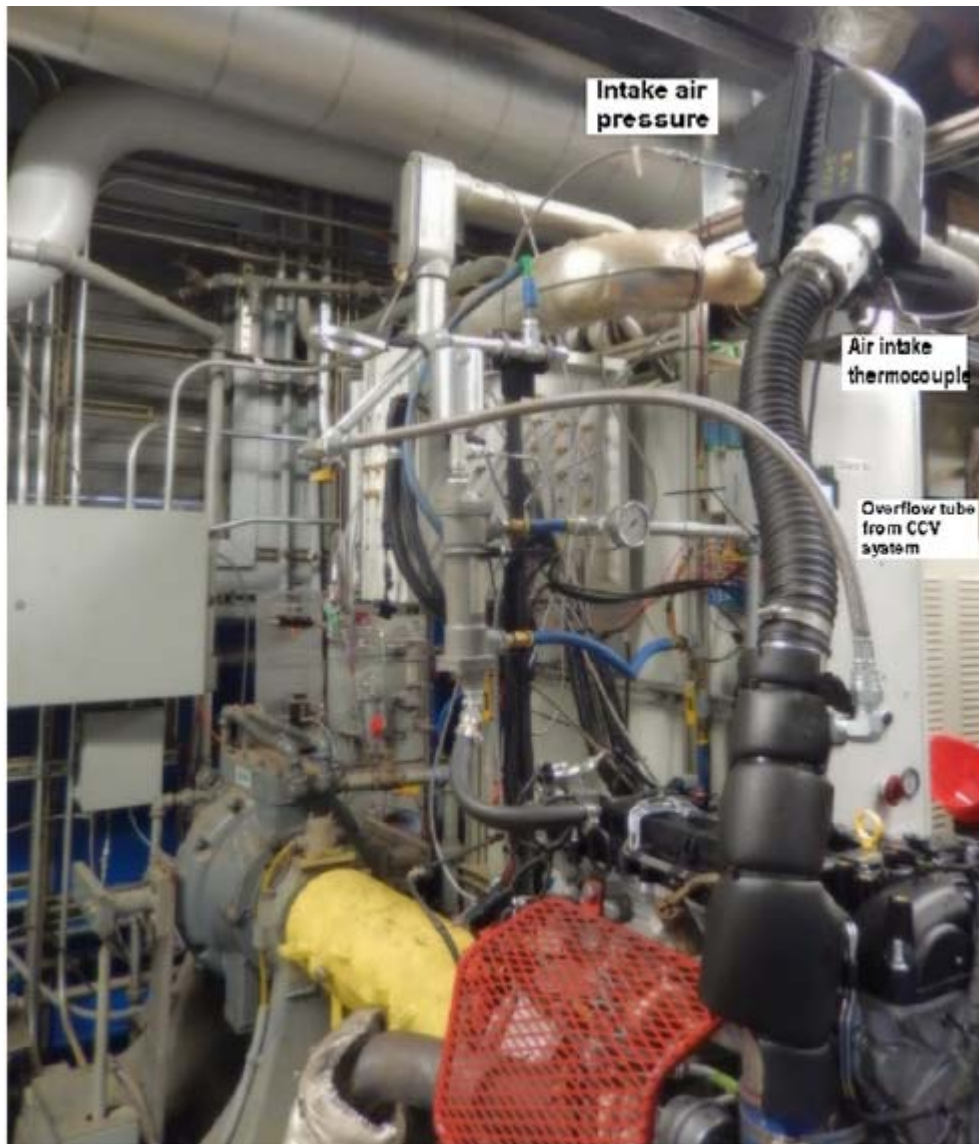


FIG. 2.12 Typical air intake system

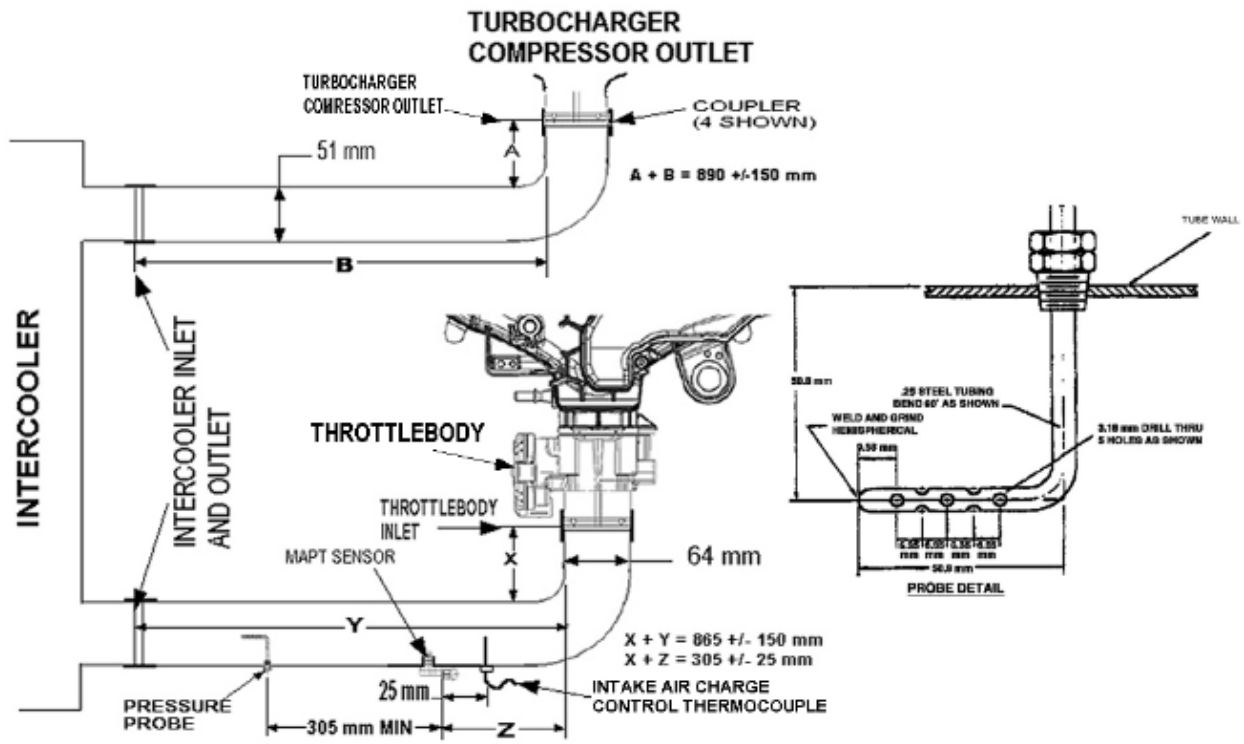


Figure A2.13: Intercooler Tubing Measurements and Instrumentation

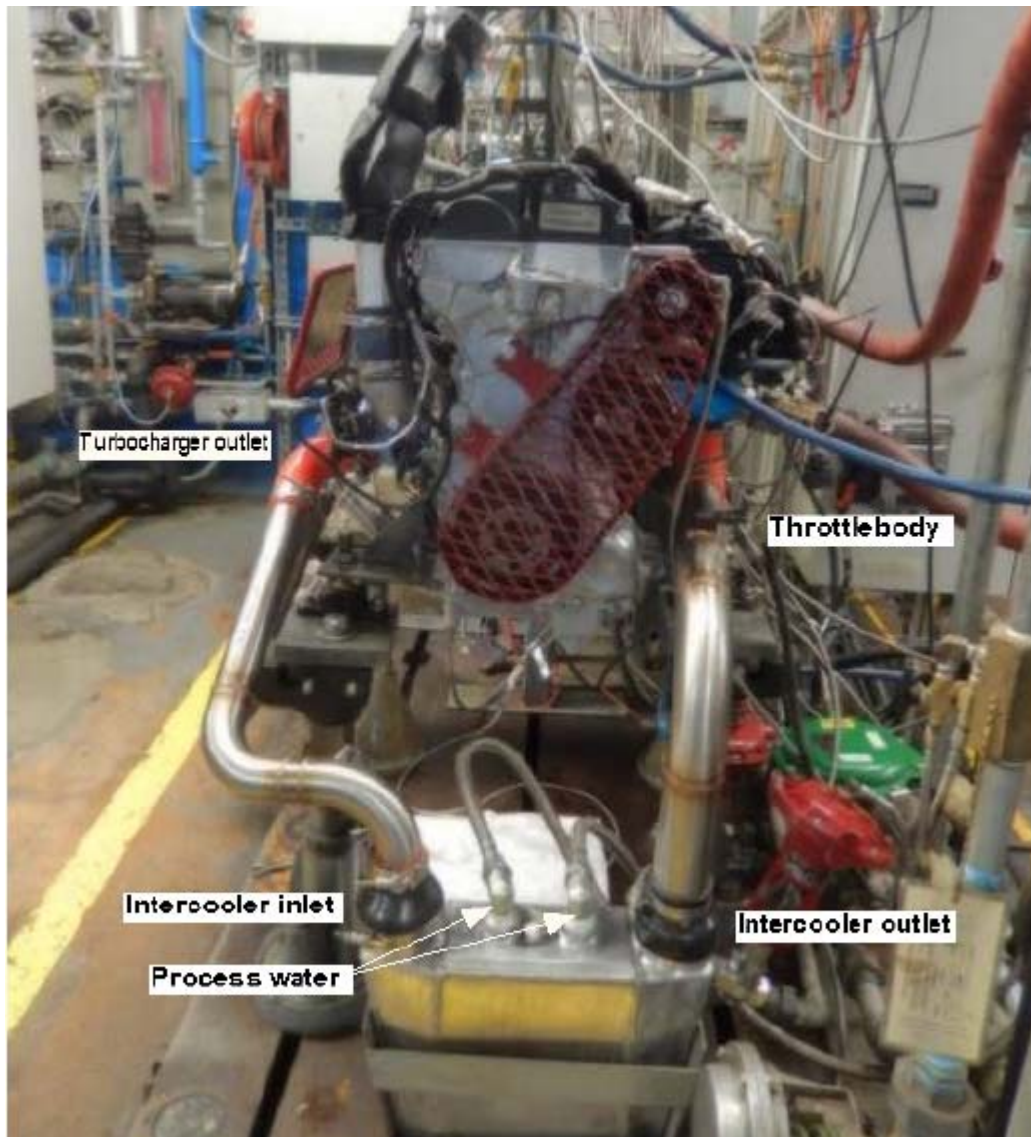


Figure A2.14 Typical intercooler installation



Figure A2.15 Oil cooler showing oil gallery pressure location

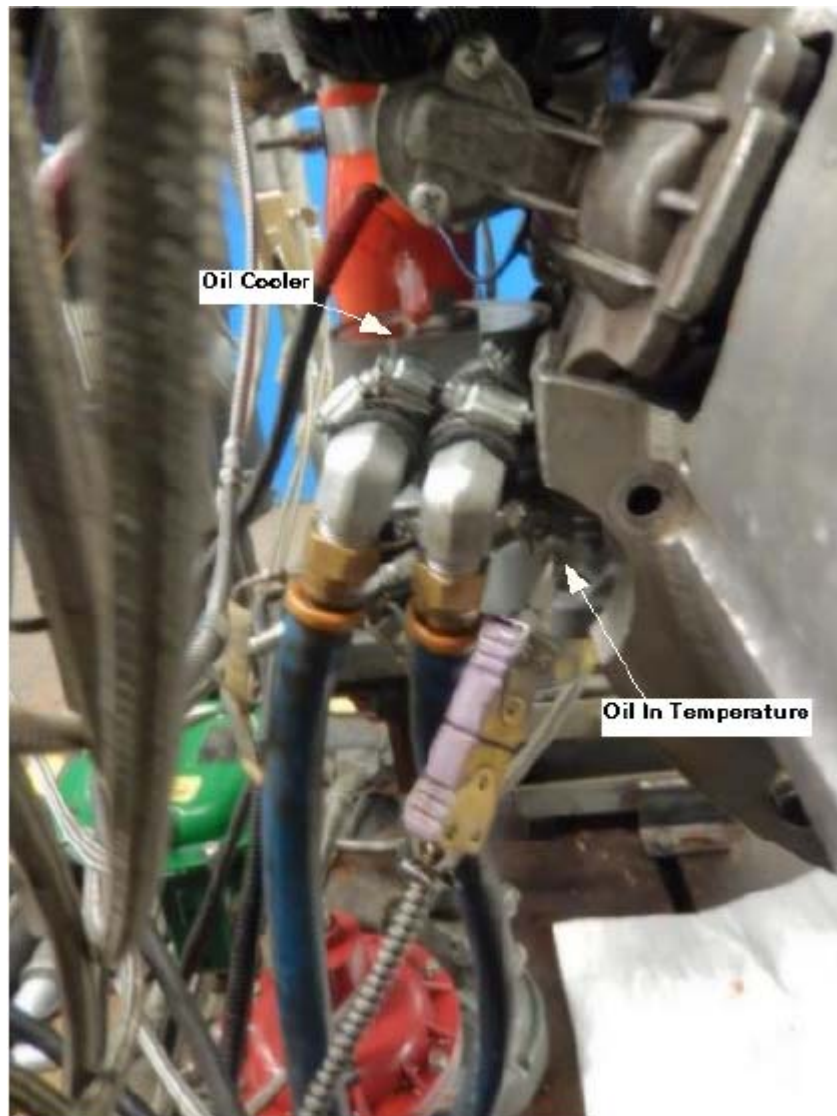


Figure A2.16 Oil cooler showing oil in temperature location

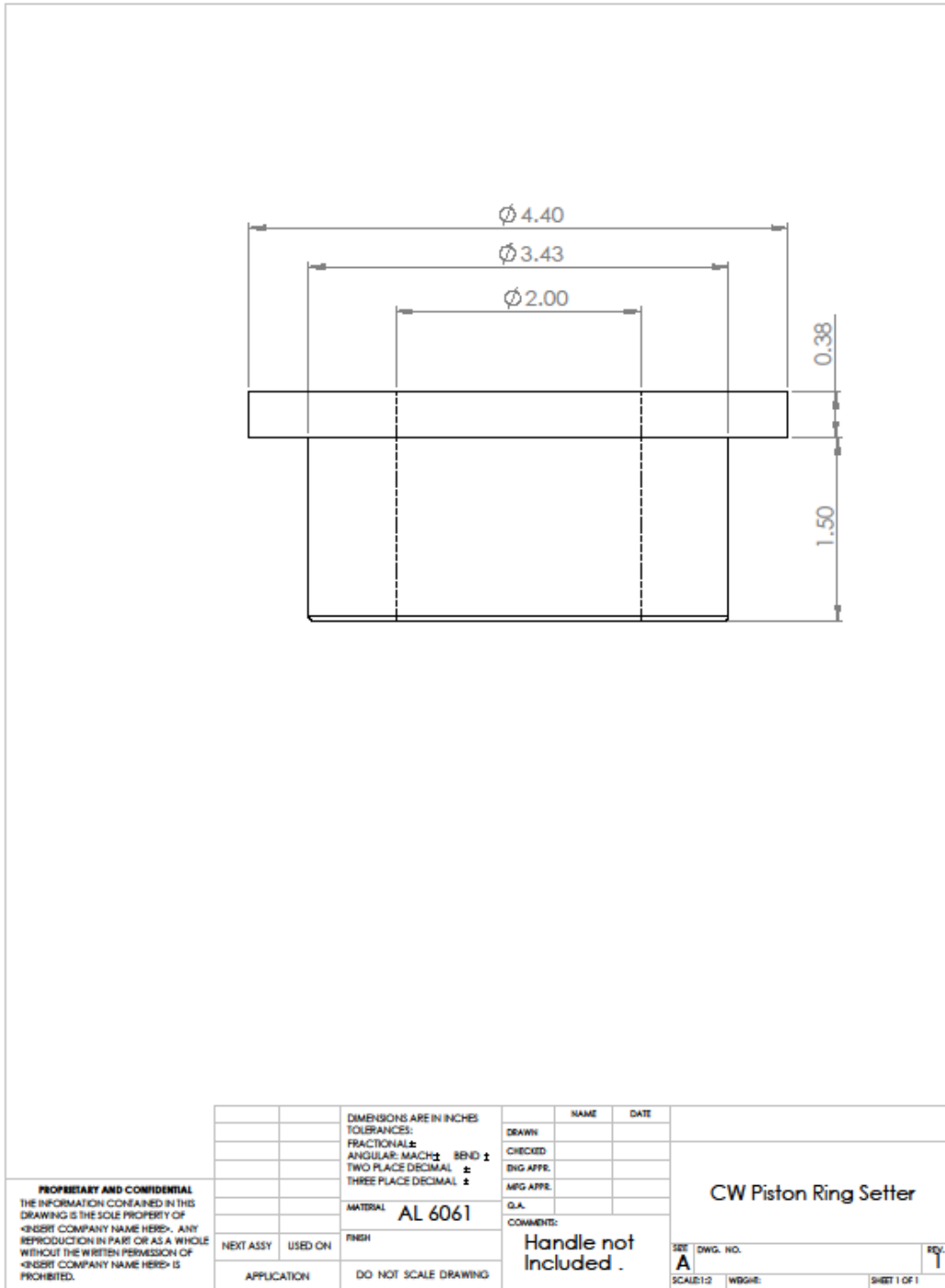
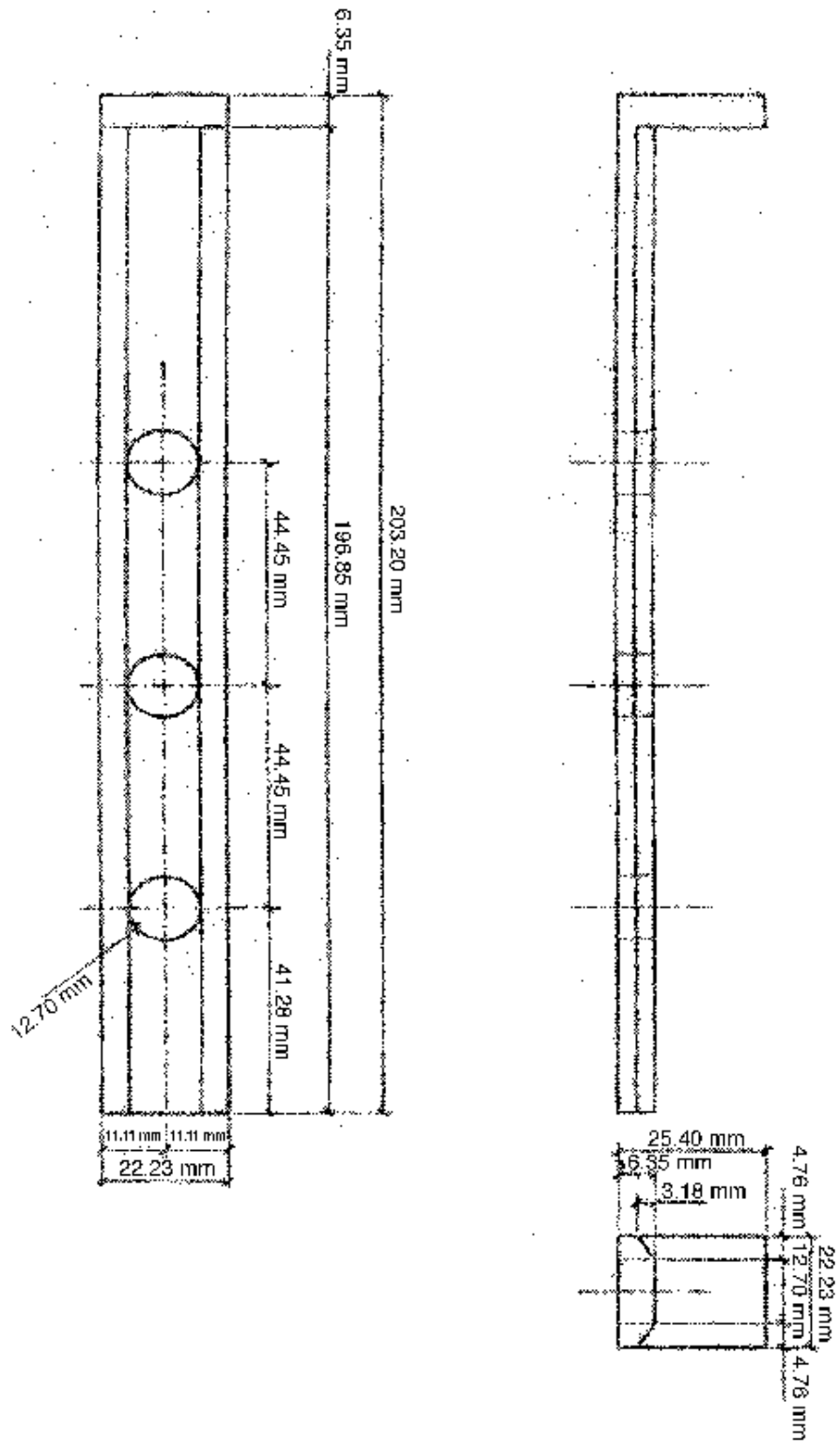


Figure A2.17



Bore Ladder

Figure A2.17

**CW Head Build Data Sheet**

**Head #:** \_\_\_\_\_

**Engine #:** \_\_\_\_\_

**Head Run #:** \_\_\_\_\_

**Tests#:** \_\_\_\_\_

**Date:** \_\_\_\_\_

	Valve Guide Diameter (mm)	Valve Stem Diameter (mm)	Clearance (mm)
1A Intake			
1B Intake			
2A Intake			
2B Intake			
3A Intake			
3B Intake			
4A Intake			
4B Intake			

	Valve Guide Diameter (mm)	Valve Stem Diameter (mm)	Clearance (mm)
1A Exhaust			
1B Exhaust			
2A Exhaust			
2B Exhaust			
3A Exhaust			
3B Exhaust			
4A Exhaust			
4B Exhaust			

	Spring Free Length (mm)	Spring Tension @28.7mm
1A Intake		
1B Intake		
2A Intake		
2B Intake		
3A Intake		
3B Intake		
4A Intake		
4B Intake		

	Spring Free Length (mm)	Spring Tension @28.7mm
1A Exhaust		
1B Exhaust		
2A Exhaust		
2B Exhaust		
3A Exhaust		
3B Exhaust		
4A Exhaust		
4B Exhaust		

Intake Valve Lash Measurement	
(mm)	
1F	
1R	
2F	
2R	
3F	
3R	
4F	
4R	

Exhaust Valve Lash Measurement	
(mm)	
1F	
1R	
2F	
2R	
3F	
3R	
4F	
4R	

**Head Flatness:** \_\_\_\_\_

**Mechanic Initials:** \_\_\_\_\_

Cylinder Head Build Data Sheet

Figure A2.18



**CW Cylinder Bore Measurement Record**

**Block #:** \_\_\_\_\_

**Test #** \_\_\_\_\_

**Block Run #:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Cylinder Bore Measurements**

Finish Target (RA): \_\_\_\_\_  
Bore Gauge Set: XXX mm

Out of Round (limit): 0.0XXmm  
Taper (limit): 0.0XX mm

Cylinder Number	Location	Longitudinal Diameter (mm)	Transverse Diameter (mm)	Surface Finish (µmm)
	Top			
1	Middle			
	Bottom			
	Top			
2	Middle			
	Bottom			
	Top			
3	Middle			
	Bottom			
	Top			
4	Middle			
	Bottom			

Cylinder Number	Top Ring Gap (mm)	Second Ring Gap (mm)
1		
2		
3		
4		

**REGAP/EOT**

Cylinder Number (mm)	Top Ring Gap (mm)	Second Ring Gap (mm)
1		
2		
3		
4		

Approved \_\_\_\_\_

**Block Flatness:** \_\_\_\_\_

**Mechanic Initials:** \_\_\_\_\_

Cylinder Bore Measurement Record

Figure A2.19

<b>CW Engine Measurement Record</b>
-------------------------------------

**Engine Number:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Test Number:** \_\_\_\_\_

**Technician:** \_\_\_\_\_

**Main Bearing Journals (mm)**

Journal Number	Horizontal Diameter	Vertical Diameter	Bearing Inside Diameter	Clearance
1				
2				
3				
4				
5				

**Rod Bearing Journals (mm)**

Journal Number	Horizontal Diameter	Vertical Diameter	Bearing Inside Diameter	Clearance
1				
2				
3				
4				

Crankshaft End Play (mm) \_\_\_\_\_

Engine Bearing Measurement Record

Figure A2.20

A9.1 Test Engine Parts—The required parts for use in the Chain wear test procedure are for the 2.0L GTDI engine which are supplied by the test sponsor (Ford Motor Company) through Ford Component Sales:

Ford Motor Co.  
290 Town Center Dr  
Dearborn, MI 48126

A9.2 Various Materials—

Oil pan and baffles,  
Oil screen,  
Flywheel  
Clutch, pressureplate, spacer, bellhousing  
Dynamometer and engine wire harnesses  
Are available from the following supplier:  
OH Technologies  
9300 Progress Pkwy.  
Mentor, OH 44060

A9.3 Various Materials—

Are available from the following supplier:  
Test Engineering, Inc.  
12758 Cimarron Path, Ste. 102  
San Antonio, TX 78249-3417

A9.4 Test engine Parts –

A9.4 Oil separator

Moroso Part number 85487  
Are available from the following supplier:  
American Muscle  
Summit Racing

A9.5 Type 5 or Type 52 intercooler from [www.frozenboost.com](http://www.frozenboost.com)

A9.6 Chain Measurement Apparatus can be obtained from George.

A9.8 Powertrain Control Module are available from the following supplier:

## Annex X

### X1. PISTON AND RING MEASUREMENTS RECORD FORMS

X1.1 The necessary engine measurement record forms are shown in Figs. X1.1-X1.3.

### X2. SOURCES OF MATERIALS AND INFORMATION

X2.1 The following sources are provided for convenience only. This does not represent an exclusive or complete listing of required materials or information sources.

X2.1.1 Test Engine Parts— Chain wear test parts can be purchased through Ford Component Sales and Ford or Lincoln dealers:

Ford Motor Co.  
290 Town Center Dr  
Dearborn, MI 48126

X2.1.2 ASTM Test Monitoring Center—All communications with the TMC should be directed as follows:

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

X2.1.3 Test Sponsor—All communications with the test sponsor (Ford Motor Co.) should be directed as follows:

Ford Motor Company  
Diagnostic Service Center II  
1800 Fairlane Drive,  
Room 410  
Allen Park, MI 48101

X2.1.4 Aeroquip Hose and Fittings—Aeroquip hose and fittings can be obtained from the following supplier:

Aeroquip Corp.  
1225 W. Main  
Van Wert, OH 45891

X2.1.5 Fuel Information and Availability—General information concerning EEE fuel, including availability, can be obtained from the following:

Haltermann Products  
1201 S. Sheldon Rd.  
P.O. Box 249  
Channelview, TX 79530-0429

X2.1.7 Intake-Air Humidity Instruments—The Alnor Dewpointer, EG & G, Foxboro, Hy-Cal, General Eastern and Protimeter dewpoint meters are suitable for measurement of the intake-air specific humidity.

X2.1.9 Heat Exchangers—ITT Standard Heat Exchangers can be obtained from the following supplier:

Kinetics Engineering Corp.  
2055 Silber Road, Suite 101  
Houston, TX 77055

X2.1.10 Fuel Flow Measurement—Mass fuel flowmeters are available from the following supplier:

Micro Motion Corp.  
7070 Winchester Circle  
Boulder, CO 80301

X2.1.12 Parts Washer and Chemicals—A dishwasher type parts cleaner and associated chemicals can be obtained from the following supplier:

Better Engineering Manufacturing  
8361 Town Court Center  
Baltimore, MD 21236-4964

X2.1.13 Crankcase and Intake—Air Pressure Gages—Gages are available from the following supplier:

Dwyer Instrument Co.  
Junction of Indiana State Highway 212 and U.S. Highway 12  
P.O. Box 373  
Michigan City, IN 46360

X2.1.14 Blowby Heat Exchanger Coolant—Nacool 2000 Engine Cooling System Treatment is available from the following supplier:

Nalco Chemical Co. Functional Chemicals Group  
One Nalco Ctr.  
Naperville, IL 60566-1024

X2.1.15 Lubricants—EF-411 is available from local distributors of ExxonMobil products.

X2.1.16 Tygon Hose—Tygon hose is available through local Cadillac Plastic Co. distributors or the following supplier:

The Norton Co.  
12 East Avenue  
Tallmadge, OH 44278

X2.1.17 Special Tools for the Test Engine—Special tools to facilitate assembly and disassembly of the engine are available from the following supplier:

Owatonna Tool Co.  
2013 4th St.  
NW Owatonna, MN 55060

X2.1.18; : Tierra Tech model MOT500NS ultrasonic parts cleaner or similar Tierra Tech ultrasonic parts cleaner can be obtained from Tierra Tech

X2.1.19: Tierra Tech Ultrasonic solution 7 and B cleaner can be obtained from Tierra Tech

X2.1.20: Flex Hone Model: GB33432 can be obtained from Granger

X2.1.21: Pneumatic Honing Drill, Westward 1/2 Reversible Air Drill, Model: 5ZL26G can be obtained from Granger

X2.1.22: Penmul L460 can be obtained from Penetone Corp., P.O. Box 22006, Los Angeles, CA 90022

X2.1.23: Parts Cleaning Soap, (NAT-50 or PDN-50) known to the committee at this time is Better Engineering Manufacturing, 8361 Town Court, Baltimore, MD 21236.

X2.1.24: Hatchview Software (<http://digitalmetrology.myshopify.com/products/hatchview>)

X2.1.25: USB microscope.

X2.1.26: The sole source of supply of the Sanford Piston Ring Grinder known to the committee at this time is Sanford Mfg. Co., 300 Cox St., P.O. Box 318, Roselle, NJ 07203.

X2.1.27: The sole source of supply of the 3/16 in. carbide ring cutting burr, No. 74010020 known to the committee at this time is M. A. Ford.

X2.1.28: The sole source of supply of Sunnen soft stone, No. JHU-820 known to the committee at this time is Sunnen, Inc., 7910 Manchester, St. Louis, MO 63143.

X2.1.29: Ford camshaft alignment tool (Ford P/N 303-1565) can be obtained from a Ford or Lincoln dealer

X2.1.30: Crankshaft TDC timing peg (Ford P/N 303-507)

X2.1.31: CFM Balance Shaft Delete Kit (Part number 1-0180).

X2.1.32 X2.1.33: Quicksilver part# 6628-A

X2.1.34: Chemtool B12