ROTORWAY INTERNATIONAL

RI-162F
HELICOPTER POWERPLANT
OPERATION AND MAINTENANCE

3/98

WARNING

The construction and operation of “Home-Built Aircraft” of this type is demanding and could inflict serious injury and possible death. No such operation, construction or undertaking should be initiated unless thorough and complete knowledge, preparation and instruction are available and utilized. The seller (and its agents, servants, employees, contractors, successors, and assigns) makes no warranties express or implied regarding the clarity or correctness of the plans, ease of construction or operation nor the safety of this aircraft or any part thereof. Furthermore, buyer (and his heirs, administrators and assigns) releases and holds said seller (and its agents, servants, employees, contractors, successors, and assigns) harmless from any and all liability, damages, and causes of action which may be incurred by buyer or any third party as a result of the purchase, use, construction and/or operation of said aircraft (or any part thereof) or plans for same. Buyer assumes all risk and responsibility relative to the construction and/or operation of said aircraft. Seller admits no liability by publication of this warning.

INTRODUCTION

The RI-162F powerplant from RotorWay International has been completely assembled and dynamometer tested by factory technicians. Precise parts tolerances, assembly techniques and performance parameters are required of every engine leaving the factory. The oil pressure and ignition timing was adjusted to specification and fuel flow verified to be in the proper range at various power levels. The engine has been run long enough for the initial seating of the piston rings to occur. While the extended initial run-in period on your engine is very important, this critical period of “break in” was conducted in a tightly controlled and monitored condition in a dynamometer. As a result, every engine leaving the factory meets a tight parameter of torque and horsepower requirements.

After the engine has successfully completed its dynamometer run, a variety of additional adjustments and checks are performed prior to crating and shipment. This includes a valve lash adjustment and a re-torque of all bolts to specification. All open passages are plugged to help prevent moisture and dirt contamination.

It is very important to store the engine in a clean and dry environment prior to installation in the helicopter.

From this point on, the responsibility for longevity and reliability of the engine is yours. Before you remove the lid from your engine crate, it is important to read and familiarize yourself with this entire manual. We have attempted to address even the most basic procedures involving the proper maintenance and operation of the power plant. It is essential that proper and timely maintenance be performed. If you have any questions or if there is anything you are not sure about, please give our customer service department a call.

We advise you to attend our training program prior to starting the engine. The hands on instruction regarding the proper care and operation of the engine is extremely valuable to even the best mechanic.

A recommended maintenance schedule for the powerplant is included in this manual. You should purchase a log book formatted for powerplant maintenance. An accurate record of the work preformed on the engine is a valuable tool in evaluating future maintenance requirements.

The factory provides a complete rebuilding service for the powerplant. In the event you elect to preform the “TBO” procedures on the powerplant yourself, we have provided the necessary specifications in this manual. All of the parts necessary for a rebuild are depicted in this manual and are available from the factory.

Your engine will only perform well if you treat it properly. You must understand its needs and attend to them by monitoring and maintaining it. By combining the information in this manual with the knowledge gained in our factory training program you will be able to maintain peak performance from your powerplant.

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SECTION 1: General Service Information

SECTION 2: Individual System Procedures

Section 1: General Service Information

A. RI-162F ENGINE SPECIFICATIONS

Rated Horsepower @ 4250 RPM	150
Torque @ 4250 RPM	185 ft.lb.
Max Torque @ 3950 RPM	191 ft.lb.
Operational RPM (Calibrate with rotor RPM)	4250
Idle RPM	1750 - 2000
Bore, inches	4.00
Stroke, inches	3.228
Displacement, cubic inches	162
Compression Ratio	9.4:1
Flywheel Rotation (viewed from above)	Clockwise
Firing Order	1 - 2 - 3 - 4
Ignition Systems (Dual-Independent)	Electronic
Ignition Timing	Variable 14°-38° BTDC
Spark Plug Gap	.040" - .044"
Ignition Sensor/Timing Wheel Gap	.028" - .030"
Valve Lash Clearance	.004" - .006"
Engine Dry Weight (including main drive pulley, flywheel, water manifolds, dual ignition systems, and starter)	187 lbs.

NOTE: Measurements and adjustments must be made when the engine is cool and stable in temperature. See valve adjustment section.

B. TORQUE REQUIREMENTS

Main Drive Pulley Bolts [1]	28 ft. lbs.
Main Drive Flange Nut [1]	200 ft. lbs.
Cam Gear Bolts [2]	18 ft. lbs.
Rod Cap Nuts or Rod Bolts [3]	42 ft. lbs.
Main Stud Nuts	40 ft. lbs.
Cylinder Head Bolts (Final Torque Value)	22 ft. lbs.
Intake Manifold Bolts	12 ft. lbs.
Exhaust Manifold Bolts	120 in. lbs.
Polyloc Set Screws (Rocker Arms)	120 in. lbs.
Ignition Sensor Set Screw	15 in. lbs.
Ignition Sensor Jam Nuts	96 in. lbs.
Oil Pressure Adjustment Plug [1]	40 ft. lbs.
Oil Pressure Adjustment Jam Nut	108 in. lbs.
Case Bolts	15 ft. lbs.
Starter Bolts	18 ft. lbs.
Starter Mount Bolts	15 ft. lbs.
Lower Cover Bolts	15 ft. lbs.
Oil Pump Cover Bolts	15 ft. lbs.
Throttle Shaft Bearing Retention Bolt [1]	15 in. lbs.
Valve Cover Bolts	see tightening instructions on page 44

[1] Install with service removable Loctite #242
[2] Install with Loctite #271
[3] All rod bolts should be thoroughly oiled before installing (rods using nuts are not oiled).

B. TORQUE REQUIREMENTS (CONT'D.)

Ignition Module Mounting Bolts	75 in. lbs.
Throttle Position Sensor Bolts	25 in. lbs.
Plenum Cable Bracket Bolts	96 in. lbs.
Fuel Rail Retention Bolts	96 in. lbs.
Rocker Arm Studs [1]	40 ft. lbs.
Spark Plugs [2]	10 ft. lbs.
Timing Wheel Bolts [1]	96 in. lbs.
Cam End Plate	96 in. lbs.
Water Pump Bolts	120 in. lbs.

C. OIL REQUIREMENTS AND SPECIFICATIONS

AMBIENT AIR TEMPERATURE	GRADE OF OIL (MULTI- VISCOSITY)
Above 40° F	20 - 50 SF
0° F to 60° F	10 - 40 SF
Below 0° F	10 - 40 SF

NOTE: Pre-warming of the engine and oil may be necessary when ambient air temperature is below 0° F.

Oil System Capacity, U. S. quarts	5
Minimum Run-up Oil Temp. (Above 2000 rpm)	140° F
Minimum Climb-out Oil Temperature	150° F
Normal Operating Oil Temperature	160 - 210° F
Caution Operating Oil Temperature	210 - 240° F
Maximum Oil Temperature	240° F
Oil Pressure Requirements:	
MINIMUM at IDLE	30 PSI
MINIMUM at 4250 RPM	45 PSI
MAXIMUM	80 PSI
Adjust warm (180-200 F) @ 4250 RPM	50 - 55 PSI

CAUTION: The powerplant can be damaged during the first start-up if adequate oil pressure is not attained within the prescribed time limits.

CAUTION: Do not overfill the oil sump. If too much oil is added, the sump must be drained and then re-filled to the proper level. If any oil is spilled, it must be cleaned up before flight.

[1] Install with Loctite #271

[2] Coat threads with a light film Anti-Seize prior to installation.

D. GREASE REQUIREMENTS AND SPECIFICATIONS FOR THE MAIN DRIVE PULLEY

GREASE SERVICE INTERVAL: 3 “shots” every 25 hours.

One shot of grease equals one full stroke from a standard 14 oz. cartridge, lever action grease gun. The approximate shot dimension is .25 inch diameter by 1.5 inches long.

CAUTION: Grease must be pumped in very slowly. Rapid introduction of grease may cause the bearing seals to blow out.

GREASE TYPE: Determine which type of grease is appropriate for the climate you will be operating in.

For flight operating conditions ABOVE 0° F, use Mystik JT-6 Multi-Purpose Hi-Temp Grease.
Mystik JT-6 is a product of Cato Oil and Grease Company. The nearest distributor can be found by calling (405) 270-6200.

If flight operating conditions are BELOW 0° F, use Ronex MP.
Ronex MP is an Exxon product.

NOTE: It is not recommended to use Ronex MP if ambient air temperatures above 80° F are regularly encountered.

The correct grease for use in the Main Drive Pulley is also the correct type for use in all other parts of the helicopter. Since use of the correct type of grease is essential to proper performance, it is advisable to dedicate a grease gun specifically for helicopter service.

Bearing Replacement at 500 Hours: Bearing replacement in the Main Drive Pulley is a service offered by the factory. Contact a customer service representative to schedule this service.

E. FUEL REQUIREMENTS AND CONSUMPTION

Minimum Octane Rating 92
Fuel Pressure, PSI [1] ..... 40 - 60
Fuel Consumption at Full Power (approximately) ..... 68 lbs./hr.

F. FADEC SYSTEM SPECIFICATIONS

Throttle Idle Speed Screw ..... 1-7/8 to 2 turns open
Primary Throttle Position Sensor Idle Setting (On Digital Display) 0%
Secondary Throttle Position Sensor Idle Setting (On Digital Display) 0%

G. COOLING SYSTEM SPECIFICATIONS AND LIMITS

Antifreeze Type ..... Propylene Glycol with Additive
Replacement Interval ..... 250 Hours or 2 Years
Cooling system Capacity (Approx.) ..... 9-10 qts.
Minimum Climb-out Water Temperature [2] ..... 160° F
Normal Operating Water Temperature ..... 165°-190° F
Caution Operating Water Temperature ..... 190°-215° F
Maximum Operating Water Temperature ..... 215° F

CAUTION: Because of the inline thermostat used in the cooling system, the engine RPM must NOT exceed an idle until the coolant temperature reaches a minimum of 160° F and the thermostat opens. If the engine is operated above an idle while the thermostat remains closed, EXTREMELY HIGH COOLANT PRESSURES WILL DEVELOP, which may result in damage to the cooling system and other components.

The powerplant can also be damaged during the first start-up by improper bleeding of the cooling system, resulting in a rapid increase of engine and water temperature.

[1] Varies depending upon manifold pressure.

[2] The thermostat cycles open and closed at approximately 160° F. In extremely cold operating conditions, it is recommended that the radiator be partially blocked off to achieve a stabilized coolant temperature of 165° to 190° F at full operating RPM. Contact customer service for further details.

H. COMPONENT SPECIFICATIONS AND WEAR LIMITS

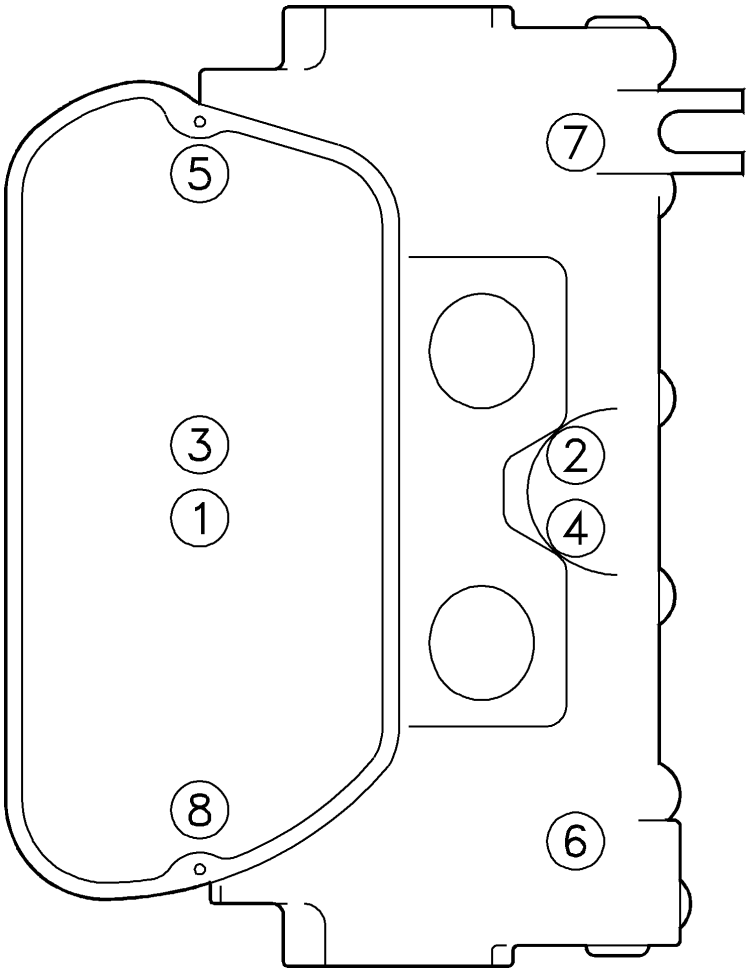
CYLINDERS		
Bore Size	STD	4.0005" ± .0005"
	MAX	4.0035"
Max. Taper		.0010"
Max. Egg		.0007"
Bore to Bore Distance		4.410" ± .002"
CRANKSHAFT		
Mains	STD	2.1645" ± .0003"
	MIN	2.1637"
Rods	STD	2.0860" / 2.0865"
	MIN	2.0855"
End Play	STD	.004" / .006"
	MAX	.014"
CASE		
Main Bore		2.5590" / 2.5600"
Cam Bore		1.0830" ± .0003"
PISTON		
Top Ring Gap		.028" / .030"
2nd Ring Gap		.015" / .020"
CAMSHAFT		
Journal	MIN	.9830"
Lobe Height	MIN	.326"
Timing (in crank degrees)		4° Retard ± 1°
End Play	STD	.002" / .006"
	MAX	.025"
RODS		
Small End	STD	.9275" / .9278"
	MAX	.9281"
Big End		2.2430" ±.0005"
VALVE SEAT		
Exhaust Width	STD	.080" / .090"
Intake Width	STD	.060" / .070"
Approx. Grind Angles (degrees)		15°, 44-1/2°, 60°
VALVE GUIDES		
Exhaust ID Clearance	STD	.0007" / .0010"
	MAX	.0020"
	MAX TAPER	.0008"
Intake ID Clearance	STD	.0003" / .0005"
	MAX	.0015"
	MAX TAPER	.0008"
VALVE SPRINGS (@ 1.125" Compressed Height)		155 / 180 lbs.
VALVE LIFT @ Valve	STD	.467" ± .005"
	MIN	.440"

I. CYLINDER HEAD TORQUE SEQUENCE

Installation Torque Procedures: Pre-check thread quality and installed bolt depths by applying a film of Anti-Seize to the bolts and installing them in the corresponding waterjacket holes. Install the cylinder heads and lightly snug all bolts. Repeatedly torque all bolts, following the proper sequence (shown below), to 10 ft. lbs. until none move at this torque. Repeat this process at 14, 18 and 22 ft. lbs.

Re-Torque Procedure: Following the proper sequence, one at a time, loosen each bolt 1 turn and re-torque to 22 ft. lbs.

NOTE: The engine must be cold when torquing cylinder head bolts.



Section 2: Individual System Procedures

A. INTRODUCTION

Every basic system required for powerplant operation is covered individually within this manual. The following topics are addressed only in this section:

1. Correct Installation
2. Preparation For Start-Up
3. Initial Start-Up Procedures
4. Maintenance Procedures
5. Diagnostic Procedures

Read each section entirely, including the diagnostic procedures, as this will help provide an overview and insight leading to successful and long lasting powerplant operation.

B. FUEL SYSTEM

1. INTRODUCTION

The RotorWay Exec 162F is currently the only piston powered helicopter utilizing a fully redundant, electronic fuel injection system. Electronic fuel injection has been the norm in the automotive industry for the last decade. Unfortunately these automotive systems are not suitable for aviation use because they do not provide the required redundancy. General Aviation has not been in a position to make the change to electronics because of the extremely high costs involved in developing and certifying this type of system.

The introduction of the RotorWay FADEC (Fully Automated Digital Electronic Control) System is the result of over four years of development and testing. It is a totally unique and customized system designed especially for use in the Exec 162F helicopter. It delivers fuel with extremely accurate air/fuel ratios. It automatically adjusts for changes in altitude, engine condition and outside temperature. Information regarding the system's condition is clearly presented to the pilot via warning lights and a digital display screen.

The FADEC System incorporates two separate and complete Engine Control Systems. Should the "Primary System" become unable to properly control the engine, FADEC will automatically switch to the "Secondary" or backup system.

The primary system uses a sophisticated Engine Control Unit (ECU) to assimilate information from a number of primary and secondary sensors. It then delivers the proper fuel mixture based on these values.

Primary sensors monitor two important engine conditions, RPM and Load. These values are essential elements in computing and delivering an accurate air/fuel ratio. FADEC "backs up" both primary sensors through specific ECU programming. Although only one RPM value is needed by the ECU, duplicate values are constantly monitored from each of the independent ignition systems. For load value, the ECU uses information from a throttle position sensor. Should this sensor fail, the primary ECU will use the readings from the secondary ECU's throttle position sensor. If the secondary throttle position sensor fails, the primary ECU will automatically switch to a sensor monitoring manifold pressure to calculate the load factor.

This additional redundance also applies to the barometric and air temperature sensors that both primary and secondary systems have.

Secondary sensors are not essential for engine operation while operating on the primary system. The ECU for the secondary system is capable of adjusting for altitude and temperatures the same as the primary ECU. Should both primary and secondary sensors fail, the ECUs are programmed to revert to preset default values.

The loss or intermittent failure of any sensor will be brought to the pilot's attention via a yellow warning light on the instrument panel. At the same time, a digital display screen informs the pilot of the specific problem. This same screen can be used to monitor a wide range of engine functions by selecting the appropriate item.

In the unlikely event that both the throttle position sensor and the manifold pressure sensor fail or if there is a Main ECU loss or malfunction, FADEC will automatically transfer control of the engine to the secondary system. A red warning light will illuminate on the instrument panel to inform the pilot of the deactivation of primary system. This "back up" is an independent system with its own ECU, throttle position sensor and plenum mounted injectors.

WARNING: Although the helicopter can start, hover and fly on the secondary system, it will not deliver as accurate an air/fuel ratio as the primary system and in certain operating conditions the throttle response is sluggish. While the pilot has the ability to manually activate the secondary engine control system by turning off the primary switch on the overhead panel, this system is not intended to be used as a regular means of engine control. The pilot should carefully land at the nearest safe site if the secondary system activates.

While the inner workings of the FADEC System are sophisticated and rather complex, the skills and tools needed to service the system are not. If you carefully follow all of the procedures contained in this section of the manual, you should have no difficulty understanding and maintaining the FADEC system. It is important to note that 99% of all problems with electronic engine control systems are wiring related. These problems include damaged wiring and faulty or loose connectors. Pay special attention to these components during construction and maintenance of the helicopter.

It is important for you to understand the FADEC system and the following procedures. This knowledge is essential for you to properly construct, maintain and fly the helicopter. If you have questions about the FADEC system or if you are unclear about any of the procedures, please call our customer service department.

2. FUEL REQUIREMENTS

The RI 162F powerplant is designed to burn premium unleaded or leaded automotive gasoline which has a minimum octane rating of 92. Use only gasoline from a known major brand station which has fuel specially formulated for fuel injection, such as Mobil, Texaco, Arco, etc. 100 low lead aviation gasoline may also be used.

NOTE: Regular maintenance includes rebuilding the cylinder heads at 500 hours if unleaded fuel is used. This is reduced to 250 hours if using 100 low lead or leaded automotive gasoline.

Do not attempt to use old gasoline because it may not deliver the required performance. In addition to possible moisture contamination, gasoline volatility is adjusted by the suppliers seasonally and geographically to reduce the chance of problems.

3. PREPARATION

WARNING: This fuel system is designed to operate at pressures up to 60 PSI. A fuel leak in this system could cause a fire or even an explosion. If you do not completely understand any of the following procedures please call customer service for additional assistance.

CAUTION: DO NOT connect the battery, put gasoline in the fuel tanks or turn on the fuel pumps until advised to do so during these procedures.

A. Review the plans to ensure that the proper routing and attachment of all fuel system components is correct. This includes fuel hoses, wiring and all individual components such as filters, pressure regulator, shut-off valve, etc.

B. Inspect all of the installed fuel hoses and make certain that you have complied with the following general rules:

1. Make sure that there is adequate clearance between the hose ends and anything they might be able to contact. While the hose is flexible, the hose ends are not.

2. Do not allow a hose to contact a sharp corner, nut, bolt, rivet stem or anything else that might cause damage.

3. Do not allow a hose to rub against anything, even if the surface on which it rubs is flat. The stainless steel braid is a very efficient low speed file and will abrade through anything that it moves against. In order to prevent chafing and to keep your hoses where you want them, support the hoses with wire ties or cushion loop clamps.

4. Do not force the hoses to bend too tight. Do not kink the hose, either by bending too tight, by misalignment between the hose end and fitting on short assemblies, or by getting the whole assembly into a helix on long assemblies.

5. Check tightness of all fuel hoses. Do not over-tighten the hose ends onto the adapter fittings. The seal is achieved by the design of the mating surfaces, not by muscle. If it leaks, it has probably been assembled incorrectly. Damage to the cone and seat can be caused by various mistakes on assembly, the most common of which are dirt and over-tightening.

C. Prepare for the inspection of FADEC System components by carefully adhering to the following procedures.

1. At the starter, disconnect the wire between the starter and the starter relay. Insure that this wire can not short against anything when the battery is eventually connected. This is done to protect against an inadvertent start of the powerplant and to allow a later testing of the starter relay.

2. Inspect the routing, security and condition of the FADEC wiring harness. It must be well supported and not allowed to chafe against <u>any</u> other component. Wires should not be pulled tight or radically bent. Connector plugs should be secured and not allowed to vibrate excessively. All plugs should be checked for proper connection (locking tabs engaged).

NOTE: Before installing a connector, inspect for any debris or damage inside the plug and make sure that the pins are straight. Confirm that the weather-tight seals are in place on plugs that are equipped with them. You should never have to force a plug together. This would be an indication of a broken plug, misaligned seal or a damaged pin.

CAUTION: Installation of the 36 pin plugs onto the ECUs with the white “pin alignment” piece removed will damage the pins of the connector plug. This could result in an erratic and dangerous malfunction of the ECU.

3. Connect the battery. First make sure that all of the overhead switches are off. It is also a good practice to verify that there is not a short in the system before connecting the battery for the first time. This can be accomplished by using an ohm meter between the positive and negative battery cables.

NOTE: During the following initial testing, if any of the switches fail to function properly, use the appropriate wiring harness schematic to troubleshoot the problem. Using a volt meter, check for power at the switch and at the line termination point to determine if the problem is the wiring or a part. If a switch is incorrectly wired, (it performs the wrong function), trace the wire through the harness to determine if a pin has been incorrectly positioned in a plug.

WARNING: Do NOT attempt to disassemble any FADEC connector plug without first contacting Customer Service. Special tools and procedures must be used on these parts to prevent damage and possible component failure. Handling of circuit boards can cause damage from static discharge.

D. Test the fuel pumps for proper operation by turning the switches on and off, one at a time. You should be able to hear a pump when it is operating. Run the pumps for as short a time as possible since running a pump dry can cause damage. By feeling the body of a pump you can tell if it is running or not. Each switch should operate one and only one pump.

E. Test the fuel pump inertia switches. This is accomplished by unbolting an inertia switch, holding it upright in one hand and striking it sharply with the other hand. Turn on the corresponding fuel pump switch. The fuel pump should remain OFF. (This can be verified by checking the fuel pressure gauge.) Reset the inertia switch by pushing downwards on the top of the switch. This should cause the fuel pump to turn on. Turn off the fuel pump switch and re-bolt the inertia switch to the bracket. Test the other inertia switch in the same manner.

F. Test the ignition switches. Begin by disconnecting plugs numbered A and C on the FADEC wiring harness. These plugs attach to the 6 pin receptacles of the ignition modules. Turn the switches on and off, one at a time, and verify voltage to pin A. The switches should remain off after testing. Do not reconnect plugs A and C at this time.

G. ARM the FADEC System. Refer to the EXEC 162F Flight Manual and follow the detailed procedures. Turn each FADEC switch on and off, one at a time, to insure that each provides an independent source of power. The green and red light on the instrument panel should indicate which system is operating. If any problems are encountered, refer to the diagnostic section under ARM FADEC.

H. Check the FADEC BACKUP System. Refer to the EXEC 162F Flight Manual and follow the detailed procedures. The green light on the instrument panel should be on and the red light off.

Turn all switches off. If any problems are encountered, refer to the diagnostic section under SECONDARY SYSTEM OPERATION.

NOTE: In order to perform the following procedures it will be necessary to remove all wires connected to the Ignition Modules and carefully lay down the seat back panel. Make sure that wires are not pulled tight and the panel is supported.

I. Re-arm the FADEC System. Read Section 7 of the EXEC 162F Flight Manual. The digital display monitor should be illuminated. If the digital display does not function properly, refer to the diagnostic section under digital display. When scanning "VALUES" on the monitor, the upper readout should be 0 (RPM). Verify that the lower readouts represent an accurate value for each condition.

1. The values for EMAN PRES and BARO PRES will be identical. In this application their values are derived from the same sensor.
2. The THR POS value should vary from 0 to 100 as the throttle position is changed.
3. Since the engine is not running and is developing a vacuum, the MAN PRES value should be close to the BARO PRES value. (These values are derived from two different sensors which can vary up to .5 kPa in accuracy.)
4. As the throttle position is changed, the PULSE WIDTH should vary from 10.0 to .5 at 70° F. (These values will change depending on air temperature and density.) The value for SPK ADV should vary from 14.0 to 12.0.
5. DUTY CYC, FUEL USED and MAX RPM should all be 0.
6. The AIR and WTR TEMPs should be accurate.
7. The SEC position will show values for throttle position, baro, and air temperature for the secondary system. This can be accomplished by selecting the SEC position and depressing the reset button.

If any of the values are incorrect, refer to the diagnostic section under SENSORS.

J. Test Diagnostics. Move the Digital Display to DIAG. The upper and lower readouts should be 0. If an error code is displayed at this time, refer to the diagnostics section under Error Codes.

1. Carefully disconnect the water temperature sensor plug. The yellow light on the instrument panel should activate. Number 5 should appear in the lower readout. Pressing the reset button should NOT clear the error. Carefully reconnect the plug. The error should remain illuminated indicating the system's ability to detect a "momentary" error. Pressing the reset button should clear the error message.

WARNING: If an error is recognized by FADEC during operation of the helicopter, **DO NOT** attempt to clear the error message by using the reset button! This is to be done, **AFTER LANDING**, to determine the nature of the problem. The **ONLY** exception to this rule is the normal "Diagnostic reset" which is performed during the starting procedure!

NOTE: From here on:

Manifold Pressure = MAP
Throttle Position Sensor = TPS
Barometric Pressure = BARO

2. Follow the same procedure, as in "1" above, to test the Primary TPS, Air Temperature and BARO sensors.

NOTE: FADEC will switch control to the "Backup System" if both the primary TPS and the MAP sensor fail. A momentary error condition, on either sensor, will **lock** the error as it relates to this switching function. This means that FADEC will switch to the Backup System the instant the other "load" sensor fails, even if the momentary error has been repaired and cleared. Only a re-start of the ECU will clear this lock.

3. Re-start the Main ECU by turning off both FADEC switches and then re-arming the system. Carefully unplug the MAP sensor. The yellow light on the instrument panel should activate. Number 2 should appear in the lower readout of the digital display. Carefully unplug the primary TPS. The primary green and yellow light should go out. The primary red light should illuminate. The secondary system should activate. Turn off both FADEC switches. Carefully re-connect the TPS and MAP sensor plugs. Re-arm the FADEC system. The red and yellow light should be off and the green lights on. Turn off both FADEC switches.

K. Test the operation of the starter relay. DO NOT engage the starter at this time. Connect a volt meter between the frame ground and the previously disconnected relay wire. Turn on the instrument switch and the key. Engage the starter button. The meter should read "12 volts". Turn off the key and verify lock out of the starter circuit. Turn off all switches. Reconnect the starter relay wire to the starter. DO NOT crank the engine at this time. If a problem is encountered use the wiring schematic and a volt meter to resolve it.

L. Test the fuel system for leakage. Read the Preface in Section 20 of the Construction Manual. Carefully observe the following procedures:

CAUTION: DO NOT perform the following test until the helicopter is ready for the first start up. Have a fire extinguisher by the helicopter and wear eye protection. If you have a leak, the pressure of this system can cause fuel to be sprayed surprisingly far and fast.

1. Put a total of three to four gallons of fuel in the fuel tanks. This is adequate for testing and for the initial start of the helicopter. Turn on the fuel valve. Turn on the instruments. Turn on one fuel pump and check for leaks. Immediately turn off the fuel pump and fuel valve if a leak is detected. Repair the leak.

WARNING: If a leak is found, pressure will remain in the system AFTER the pumps and valve have been turned off. SLOWLY disconnect the hose at the spot of the leak and be prepared for fuel to spray from the connection.

2. Turn on the second pump. Carefully re-check for leaks. One good way to check for small leaks is to run a clean finger around all of the connections on the fuel system. Even a small drop can be found using this procedure. (Smelling the drop should verify if it is fuel or simply oil used during the installation process.) We stress the importance of this inspection because A FUEL LEAK ON THIS SYSTEM CAN BE EXTREMELY DANGEROUS! Even the smallest leak can develop into a large one in a system operating at high pressure.

NOTE: Fuel is constantly being pumped in a circle when the pumps are running. (Gasoline is being returned to the fuel tank continuously.) The sounds which the fuel pumps make will change as the air is removed from the system. If you turn off the fuel valve when the pumps are running you will hear the sound change. This sound change is the result of the restriction on the inlet of the pumps. DO NOT OPERATE THE PUMPS WITH THE FUEL VALVE OFF.

3. The fuel pressure gauge should be reading approximately 55 PSI. Production differences between gauges, pressure senders and pressure regulators can cause a variance in the indicated pressure of up to 5 PSI. There should be a 1 to 3 PSI difference in pressure between operation with one and two pumps. The pressure regulator is designed to maintain a steady differential pressure between the fuel rails and the intake manifold. You should notice a decrease in the indicated fuel pressure when the motor is started and develops a vacuum in the intake manifold.

4. After the initial leak testing is complete, turn off all switches and turn off the fuel valve. CONTINUE TO REGULARLY INSPECT THE FUEL SYSTEM FOR LEAKAGE. This is especially important during the first few hours of operation and during each pre-flight inspection!

M. Carefully connect the ignition modules. Install the seat back panel and check the security of the wiring. Arm the FADEC System to test for proper re-connection of the components. Turn off all switches and verify that the fuel valve is off.

N. Before starting the helicopter for the first time, perform all procedures relating to "Preparation" in the Cooling, Oil and Ignition Sections of this Manual.

O. During the "First Hour Service" in Section III, you will be instructed to perform an additional inspection on the FADEC System. This inspection can only be accomplished when the engine is running.

4. COMPONENT SERVICE

CONTENTS:

A. INJECTORS: Primary and secondary injectors have different internal resistances and flow different amounts of fuel. Maintenance is not normally required on these components. If a problem should develop which requires injector replacement, the service procedures are the same for both types of injectors.

Injector	Part Number	Mfg. Number	Resistance
Primary	A24-5350	0280150 803	4-1/2 OHMS
Secondary	A24-5360	0280150 756	14 OHMS

TESTING: Carefully remove the connector plug from the injector. Use an ohm meter to measure the resistance between the two terminals of the injector. Compare this value against the injector's specified resistance. We recommend replacing an injector if the resistance reading is incorrect and you suspect that it is not properly delivering fuel. Comprehensive testing and cleaning of injectors can only be accomplished using special equipment. The flow rate and the spray pattern must be measured and analyzed to determine if the injector is performing according to all specifications.

REMOVAL: Carefully bleed off the fuel pressure and drain the fuel from the fuel rail assembly. Disconnect both fuel lines from the fuel rail and remove the retention bolts. Support the injectors to keep them from falling out of the fuel rail. Withdraw the parts collectively by moving them from side to side while pulling the injectors out of the intake manifold (or plenum). Carefully remove the injectors from the fuel rail with the same wiggling motion.

REPLACEMENT: Clean the fuel rail and inspect its injector bores. These bores must have a good finish and be free of scratches. If an injector is being reused, the O-rings must be replaced. Before installing the injectors, apply a light film of engine oil to the O-rings and to the bores into which the injectors will be inserted. Install both injectors in the fuel rail by pushing them into the bores while wiggling them from side to side. Install this assembly into the appropriate plenum or intake manifold bores using the same wiggling motion. Install and lightly snug the retention bolts. The fuel rail bolt holes are large enough to allow adjustment of the final mounting position. The alignment of the injectors must not be binding. Injectors must have clearance to easily move up and down in the bores. Once this alignment is correct, torque the bolts and safety wire them.

B. AIR AND WATER TEMPERATURE SENSORS: These sensors require no maintenance. Testing is accomplished by using an ohm meter to measure the resistance across the two terminals. Resistance at room temperature is approximately 2500 ohms. The value will vary with temperature. A failure of these components will normally result in an "open line" or a zero ohm condition.

C. BAROMETRIC AND MANIFOLD PRESSURE SENSORS: These sensors require no maintenance and are interchangeable. They both have a range of 2 BARS. The use of different pressure sensors will cause incorrect calculations by the ECU. The resistance should be "open line" across all terminals except A and C. This resistance should be approximately 1350 ohms. Testing of these components is most easily accomplished by switching the wiring harness connector plugs between the two pressure sensors. If the fault follows the sensor, the sensor is defective.

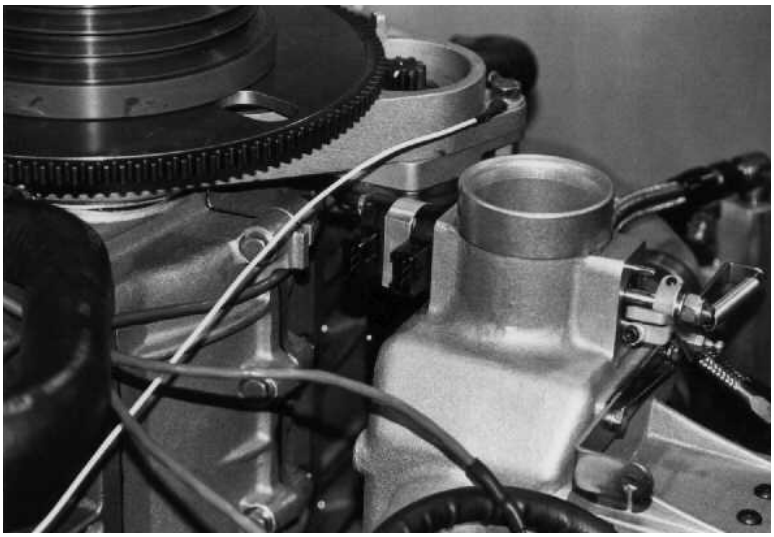
D. PRIMARY AND SECONDARY THROTTLE POSITION SENSORS: These sensors require no maintenance. Testing of these components is most easily accomplished by switching the wiring harness connector plugs between the two sensors. If the fault follows the sensor, the sensor is defective.

CAUTION: DO NOT loosen the retention bolts of the throttle position sensors unless replacement of a sensor is necessary. The relative position of each sensor to the throttle shaft is carefully adjusted to provide the proper signals to the primary and secondary systems. Incorrect "referencing" will adversely affect engine performance.

The measured resistance values between the three terminals of a throttle position sensor will vary between individual sensors. Comparing the values measured on a questionable sensor with the "trend" suggested by the following table may help you verify a fault in the sensor. (The number 1 sensor terminal is the top one.)

MEASURE TERMINAL NUMBERS	APPROXIMATE CLOSED THROTTLE RESISTANCE	APPROXIMATE FULL OPEN THROTTLE RESISTANCE
1-2	1K OHMS	4K OHMS
1-3	4K OHMS	4K OHMS
2-3	4K OHMS	1K OHMS

REMOVAL: Refer to the Plenum Assembly parts drawing and note the relative arrangement of parts numbered 1 through 6. Carefully remove the connector plugs and remove these parts from the plenum. You will notice that the sensors have an internal spring which causes them to rotate counter to the throttle shaft. You will also notice that silicone has been applied to the surfaces between parts 4 and 5. Clean off all traces of this silicone prior to replacing these parts.



REPLACEMENT: While it is not essential that the plenum assembly be removed from the engine compartment, removal will simplify the sensor adjustment process and make safety wiring of the sensor retention bolts easier.

NOTE: Replacement of throttle position sensors is a service offered by the factory. Please call Customer Service to schedule this work.

Check the fit of each sensor on the throttle shaft. They MUST slide easily on the shaft. De-burring of the sensor slot may be necessary. Be careful not to damage the sensors by allowing dirt to contaminate the internal rotating components. Final assembly of the throttle position sensors requires a bead of silicone to be applied to the area around the protruding ring of the TPS Spacer. The silicone will form a seal between the secondary throttle position sensor and the TPS spacer. This is done to prevent moisture contamination of the sensor. Since it is important to insure that the inside of the sensor assembly does not become contaminated, silicone must be applied only to the area outside of the protruding ring of the TPS Spacer.

NOTE: The replacement process is an important and tedious procedure. We suggest that you practice the sensor installation process before applying silicone to the parts for the final assembly.

Install all of the components on the throttle shaft. Lightly snug the retention bolts after positioning the sensors in the center range of their travel. (The bolts must be loose enough to allow adjustment of both sensors.) Install the primary and secondary connector plugs onto the proper throttle position sensors.

Insure that the throttle is at idle and that the throttle return spring is attached. Adjust the position of each throttle position sensor to meet all of the following conditions:

1. With the primary system engaged, the digital display monitor indicates a throttle position of 0.0%.

2. When a .002" feeler gauge is placed between the throttle stop roll pin and the throttle stop arm, (partially opening the throttle), the indicated throttle position is 0.5% to 1.0%.

3. After disconnecting the throttle return spring, the throttle shaft moves freely with no evidence of binding. It should easily return to the idle stop using only the self contained springs of the throttle position sensors.

4. Repeat the above steps for secondary TPS by switching connectors between TPS sensors, or by reading secondary values on display.

Torque the sensor retention bolts to 25 in. lbs. This additional tightening of the bolts may cause the sensor adjustment to change. Verify that ALL of the preceding conditions are still satisfied. Re-adjust the sensor positions if necessary. Once proper sensor adjustment has been verified, safety wire the retention bolts.

If the plenum was removed to facilitate replacement, re-install the plenum and carefully leak check the fuel system before starting the powerplant.

E. THROTTLE SHAFT ASSEMBLY: Maintenance is not normally required on this component. The replacement of this component is a service offered by the Factory. Please contact Customer Service to schedule this service.

REMOVAL AND REPLACEMENT: The plenum must be removed from the engine. All components must be removed from the throttle shaft. The throttle shaft bearings are Loctited into the plenum and onto the throttle shaft. The plenum must be warmed to 250° F before attempting to remove the shaft and bearings. The secondary injectors and the air temperature sensor must be removed from the plenum before heating. Do not exceed 275° F or you will damage the heat treatment of the aluminum. During the replacement process these bearings must be loctited. The Loctite must be allowed to "set" with the butterfly installed and with the shaft placed in the fully closed position. The shaft must then rotate with no binding or drag. All other components are then replaced. Be careful to accurately adjust the "full open" and "idle" positions of the throttle. Carefully follow the procedure for throttle position sensor replacement. Failure to adjust these settings accurately will cause serious damage to the engine. Install the plenum and leak test the fuel connections prior to starting the engine.

F. AIR FILTER: The air filter must remain clean in order to maintain proper engine performance. A common cause of power loss is a clogged or dirty air filter. A restrictive air filter will cause the engine to operate in an overly rich condition which could cause engine damage! If the air filter appears dirty or if it has been contaminated with grease, cleaning and re-oiling is required. If any damage is evident or if it can not be properly cleaned, replace the air filter. Certain local conditions may warrant an inspection and cleaning on a more regular basis than the 25 hour interval recommended in this manual.

CAUTION: Use ONLY "K&N" brand air filter oil and cleaning agent.

CLEANING: Lightly brush and tap off any surface dirt. (Heavy brushing will damage the gauze.) Pour the K&N cleaning agent into a "paint-tray" type pan. Roll the filter in the solution to dissolve and detach the grease and dirt. Keep the level of the cleaning solution in the pan low enough so that the inside of the filter does not become contaminated. Rinse the filter with cold water from the INSIDE outward. Shake the filter to remove as much water as possible and then allow it to air dry. Do NOT attempt to accelerate the drying process by using compressed air to blow through the filter. This WILL damage the air filter!

OILING: Holding the spray can approximately 3" away from the filter, make one pass along each pleat. Allow twenty minutes for the oil to spread and dry. Do not oil the filter twice. If the oil is properly applied, the filter's gauze should appear red, have no white spots and be "dripless".

G. FUEL PUMPS: Maintenance is not normally required to be performed on this component. One fuel pump will always produce 2 to 4 PSI less pressure than both pumps will produce when operating simultaneously. Check both fuel filters for contamination before assuming that the fuel pump, or pumps, are responsible for low fuel pressure. If a pump fails to operate, check the fuse and check for power and "ground" at the pump. If it is necessary to replace a fuel pump, turn off all of the switches and disconnect the wiring before removing the fuel hoses. After replacing a fuel pump, carefully leak check the fuel system before starting the engine.

H. FUEL FILTER: The fuel filter should be replaced prior to the recommended interval if your fuel quality is questionable or if lower than normal fuel pressure is encountered. The inlet and outlet fittings on the fuel filter are reusable. The two crush washers must be replaced during each filter change. After changing the fuel filter, always leak check the fuel system before starting the engine.

I. FUEL SHUT-OFF VALVE/FILTER ASSEMBLY: Refer to the parts drawing in Section 5 for the detailed breakdown of this component. It will be necessary to carefully drain the fuel tanks to service the entire assembly. However, with the shut-off valve in the off position, the filter can be serviced without draining the tank.

SERVICE FILTER: Have a fire extinguisher nearby. Position an appropriate container under the helicopter and fabricate a tray to direct any spilled fuel into the container. Hold fitting #15 with a wrench and disconnect the fuel hose. Be prepared for fuel to come out of the assembly at this time. Hold fitting #16 with a wrench and remove fitting #14. The fitting should loosen with a minimum amount of force, but be careful not to damage the assembly. Remove items numbered 10, 11 and 12. Carefully clean the filter and the inside diameter of the housing. If there is a large amount of debris trapped in the filter, this would be an indication that more frequent service is required. Inspect and replace both O-rings as necessary. Place a film of oil on the O-rings and a generous amount of oil on the threads of fitting #14 and in the tapered section of the housing bore. Carefully replace all components. Do not over tighten Fitting #14. The seal is made by the O-ring and NOT by how tight the fitting is secured. Over tightening can result in damage to the assembly. Re-connect the hose to fitting #15 and carefully leak check the system prior to starting the engine.

SERVICE SHUT-OFF VALVE: Service is not required unless a fuel leak develops around the O-rings. All fuel must be drained from the fuel tanks in order to service this component. Remove the lower snap ring from the shut-off rotor and carefully remove the valve assembly. Prior to replacement of the assembly, apply a film of oil to the O-rings and to the bore of the housing. It is very important to align the shut-off arm with the shut-off rotor so that when placed in the OFF position, the bore of the rotor is perpendicular to the main bore of the housing. This is necessary to maintain a proper seal in the OFF position. Carefully leak check the system prior to starting the engine.

J. ENGINE CONTROL UNIT: This component is **NOT** serviceable by anyone other than RotorWay International. **DO NOT** attempt to disassemble the ECU. **DO NOT** perform any resistance or voltage checks on the ECU. Call the Factory if you find or suspect that there is a problem with this component.

WARNING: Handling of circuit boards may cause damage from static discharge.

K. SECONDARY ENGINE CONTROL UNIT: Like the main ECU, this component is **NOT** serviceable by anyone other than RotorWay International. **DO NOT** attempt to disassemble or perform any resistance or voltage checks on this component. Call the Factory if you find or suspect that there is a problem.

WARNING: Handling of circuit boards may cause damage from static discharge.

L. FUEL PUMP INERTIA SWITCHES: This component should not require any maintenance. When these switches were initially installed they should have been tested to verify proper function. If a switch is found to be defective it **must** be replaced with an identical type switch which is available from RotorWay International.

TESTING: Leave the wiring plug connected and remove the switch from the mount. Insure that the switch is “set” by pushing downward on the top of the switch. Turn on the corresponding fuel pump and hold the switch upright in one hand. Strike the switch sharply with your other hand. The switch should operate and stop the fuel pump. Reset the switch and repeat the test. Re-mount the switch on the bracket and turn on the corresponding fuel pump. With a rubber mallet, hit the bracket to which the switch is mounted. The switch should NOT stop the fuel pump during this test. If a switch fails either of these tests it should be replaced.

5. DIAGNOSTICS

CONTENTS:

A. INTRODUCTION: If a problem occurs with the FADEC System, it is important to proceed in a manner which will positively identify the problem. Read the diagnostic section that deals with the specific problem which you have encountered. If the yellow warning light is activated, you will be given an indication of the nature of the problem by viewing the digital display monitor's "A and B" codes. If you feel that there is a problem with the FADEC System that is not identified in any of the above diagnostic sections, you should inspect the following:

A. The air filter for contamination.
B. The spark plugs for fouling.
C. The spark plug wires for damage.
D. The fuel injectors for malfunction.
E. The fuel for contamination.

WARNING: Contact Customer Service if you have **any** questions about the FADEC System. **Do not** continue to operate the engine if a problem is indicated **or** suspected. Even if the engine appears to operate properly, system failure or engine damage could be imminent.

B. "A" CODES: The yellow warning light will activate when a fault is recognized by the FADEC System. The nature of the fault is displayed on the Monitor when it is set to Diagnostics. It is normal to experience certain "A" code faults when starting the engine and when performing Ignition checks. An "A" code fault at any other time is **NOT** normal and represents a problem which must be corrected. An intermittent fault, which can be caused by damaged wiring or damaged connector plugs, can be cleared by pressing the reset button. This "clearing" procedure does **NOT** mean that the fault is corrected. Do **NOT** operate the helicopter until the problem has been located and repaired!

1. **CRANK SENSOR:** This code indicates that there is a problem with one or more of the ignition systems. The problem could be a defective ignition sensor or it could be faulty wiring.

2. **ENGINE RPM EXCEEDED:** If the engine exceeds 5000 RPM, this code will be activated. The Max RPM value should be viewed before turning off the FADEC System. Exceeding 5000 RPM can cause damage to the engine! Contact Customer Service to discuss what steps should be taken to inspect the engine for damage. Do **NOT** continue to operate the engine until this inspection is made!

   This code can also be activated by certain types of ignition faults. When an ignition is turned off and on (which is done during an ignition test), the ECU may become "confused" by the reappearance of the ignition signal. As the ECU attempts to re-synchronize the two signals, it may become momentarily confused and believe that the engine is operating above 5000 RPM. This will cause the ECU to activate the "RPM Exceeded" fault code. The ECU will also display an incorrect value in the MAX RPM readout. This is why you are instructed to reset the MAX RPM value during the starting procedure. It is important to note that defective wiring and defective connector plugs can also cause an ignition signal to be interrupted. Even a momentary interruption of an ignition signal can cause this code to be displayed.

4. INJ. DUTY EXCEEDED: This code should never be displayed unless the ECU is "fooled into believing" that the engine is operating at an extremely high RPM. This possibility is explained in #2 above.

5. IGNITION ERROR: This is the code which will appear if one of the ignition systems becomes inoperable. This will only happen if the engine is **above** 3000 RPM. (If an ignition is turned off when the engine is at an idle, this code will **not** appear.) This code can also be activated by the same types of ignition faults which are described in #2 above.

6. LOW BATTERY: This code will appear when the battery voltage drops below 10 volts. This can happen when cranking the engine. It can also happen in flight as a result of an inoperable alternator. At 9 volts the primary system will turn off and the secondary system will operate the engine.

7. CPU ERROR: If a situation should develop which causes the ECU to activate this code, the FADEC System will automatically activate the secondary system and deactivate the ECU controlled primary system. This process is so fast that you will not be able to see this code appear before the Display goes blank!

C. "B" CODES: Unlike some "A" code faults, **no** "B" code faults should occur during the normal operation of the helicopter. The yellow warning light will activate when a fault is recognized by the FADEC System. The nature of the fault is displayed on the Monitor when it is set to Diagnostics. An intermittent fault, which can be caused by damaged wiring, damaged connector plugs or intermittently faulty sensors can be cleared by pressing the reset button. This "clearing" procedure does **NOT** mean that the fault is corrected. Do **NOT** operate the helicopter until the problem has been located and repaired!

1. SELF CHECK PERFORMED: If a situation should develop which causes the ECU to activate this code, the FADEC System will automatically activate the secondary system and deactivate the ECU controlled primary system. This process is so fast that you will not be able to see this code appear before the Display goes blank!

2. MANIFOLD PRESSURE
3. THROTTLE POSITION
4. AIR TEMPERATURE
5. WATER TEMPERATURE
7. BAROMETRIC PRESSURE
These codes will appear when there is an intermittent or a continuous problem with either the appropriate sensor or its related wiring/connector plug. Refer to the correct component service section to test the sensor. If a problem is not detected, direct your attention to the "Wiring and Connector/Plug Faults" diagnostic section and inspect these components for damage.

6. VOLTAGE ERROR: This code indicates a problem in the alternator or in the voltage regulator which causes the voltage to go out of range.

D. VALUES: When the digital display monitor is set to read VALUES, The upper readout (A) will indicate engine RPM. The lower readout (B) will show a value for the selected condition. Check to insure that all readouts represent an accurate value for each condition. Refer to page 16 (I. Re-Arm the FADEC System) for detailed instructions.

There is also a selection on the display for secondary sensors. When at the "SEC" selection on the display, values of throttle position, baro pressure and air temperature can be observed. If any of these sensors fail, the "B" code will be indicated. If the throttle position fails, the ECU will shut down and the red light will illuminate.

E. FADEC POWER SUPPLY: The FADEC System uses relays to automatically switch two sources of power between the primary ECU controlled system and the secondary system.

If a problem is encountered, refer to the Wiring Guides and to the suggested test sequence in order to locate and correct the problem.

SUGGESTED TEST SEQUENCE:

1. Test for 12 Volts
   Switch Power In @ Plug #10 - A and B
   Primary ECU Power In @ Plug PP2 - 17 and 18
   Secondary ECU Power In @ Plug SP2 - 17 and 18
   Green Light + Out @ Plug #12 - E
2. Test for Ground @ Plug PP2 - 5 and 6
   @ Plug SP2 - 5 and 6

FADEC 1 and 2 SWITCHES: If the FADEC # 1 switch is turned on first the display should operate normally. If the # 2 switch is activated first the display will not work.

SUGGESTED TEST SEQUENCE:

1. Verify power and ground to primary ECU as above.
2. Swap primary ECU with secondary ECU.

F. SECONDARY SYSTEM OPERATION: The secondary system should activate in all of the following conditions:

1. If FADEC 2 switch is turned on first.
2. If the primary ECU has a power loss or fails.
3. Simultaneous loss or malfunction of the TPS and MAP sensors.
4. Internal ECU voltage fluctuations. This is checked by a "watch dog" circuit which is built into the ECU.

NOTE: If the secondary system activates properly but doesn't operate properly, check the following:

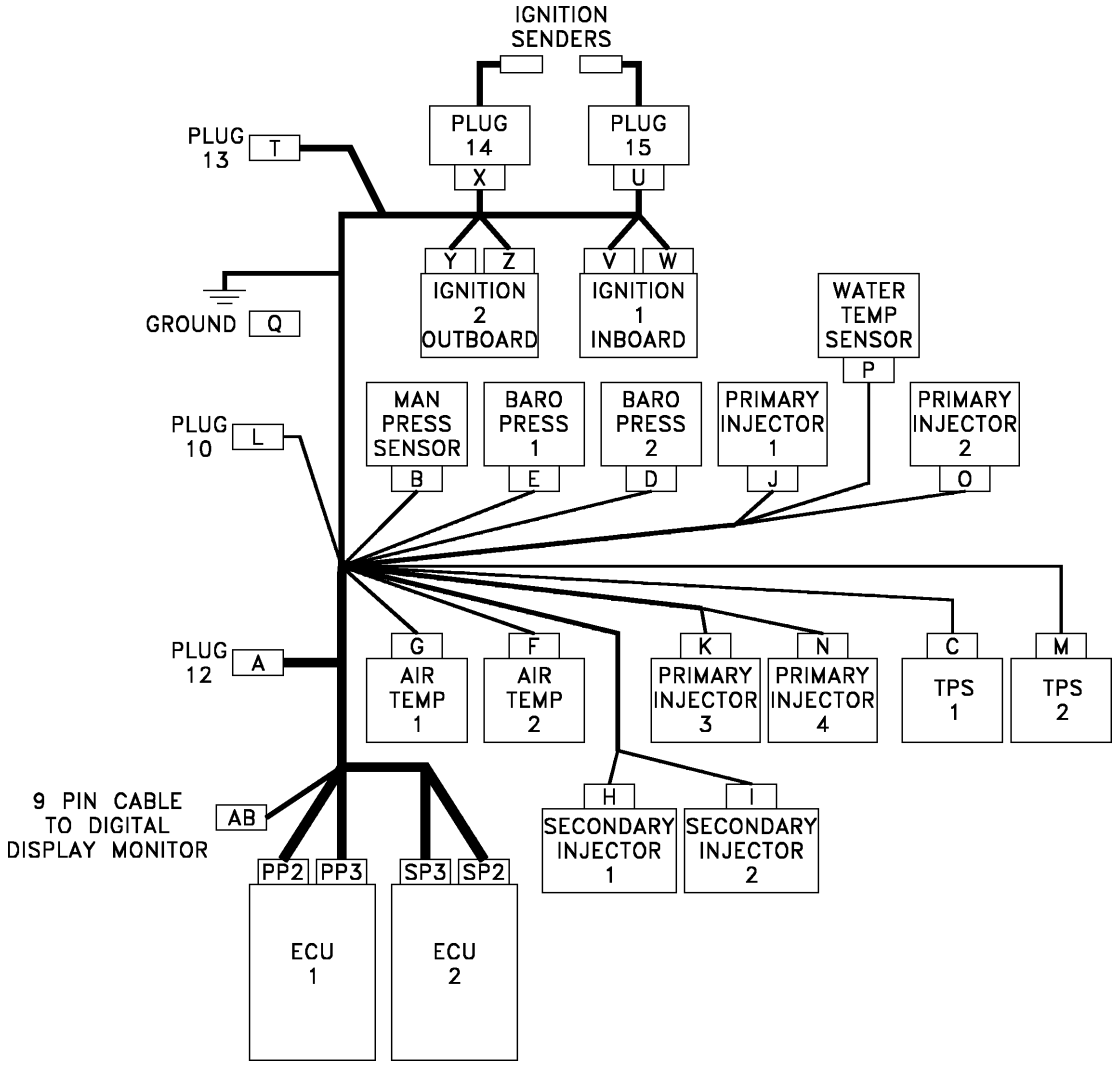
1. Voltage @ Plug H - Pin 2
   Voltage @ Plug I - Pin 2
2. Secondary TPS for function.

NOTE: Voltage readings at the secondary injectors will require ignition system be switched on and engine turning. This test should be accomplished with both secondary injectors disconnected and engaging starter for short intervals.

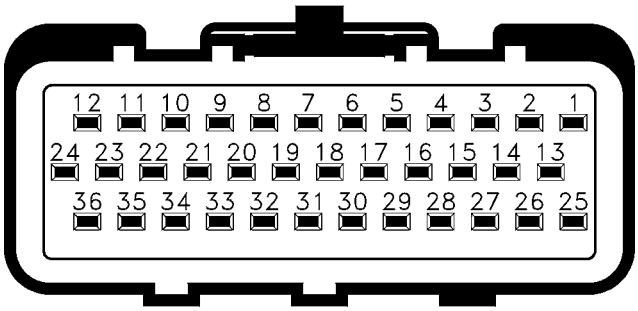
G. WIRING AND CONNECTOR/PLUG FAULTS: These types of faults can be the most difficult problems to locate. They can be caused by a damaged terminal, a loose wire or a broken wire. If the sensor involved with the problem checks good, and the fault is intermittent, you should individually wiggle each connector/plug in the harness that transmits the signal from the sensor. This may enable you to pinpoint the specific location of the problem. Use an ohm meter to find the exact spot of the fault. If plugs were improperly handled, pin damage may have occurred. Disassemble the connector and carefully examine the pins in question. If the main FADEC wiring harness becomes damaged you should call RotorWay Customer Service to discuss the repair. We do not recommend that you attempt pin replacement in these harnesses because special tools and techniques are required to properly complete the assembly.

H. FUEL PRESSURE IRREGULARITIES: The fuel pressure gauge should read approximately 55 PSI. Production differences between gauges, pressure senders and pressure regulators can cause a variance in the indicated pressure of up to 5 PSI. There should be a 1 to 3 PSI difference in pressure between operation with one and two pumps. You should record what the "normal" indicated fuel pressure is in your helicopter with both fuel pumps on before you start the engine. This value may be slightly lower with warm fuel than with cold fuel. If the fuel pressure becomes significantly lower than "normal", it is an indication that the fuel inlet or outlet filters have become plugged or it is an indication that the fuel pressure regulator is damaged. The important thing is to look for an "indicated" fuel pressure value which is out of the "normal" range. This is true for **all** operating pressure ranges. The pressure regulator is designed to maintain a steady "differential" pressure between the fuel rails and the intake manifold. You should notice a decrease in the indicated fuel pressure when the engine is started and develops a vacuum in the intake manifold. The pressure should decrease by approximately 1/2 PSI for each 1 inch decrease in manifold pressure. If the fuel pressure does not decrease as the manifold pressure decreases, there is a problem with the fuel pressure regulator or with the hose which connects it to the plenum.

I. FADEC WIRING HARNESS



ECU PIN LAYOUT - PLUGS PP2, PP3, SP2, SP3



J. FADEC HARNESS WIRING GUIDE

FROM				TO		
PLUG	PIN	DESCRIPTION	WIRE COLOR	PLUG	PIN	SPLICE WITH
PLUG A (PLUG 12)						
A	A	SWT PWR 1	RED/ORN	PP2	20	
A	B	AUX 0	BRN/YEL	PP2	8	
A	C	SWT PWR 2	RED/ORN/ORN	SP2	19	A-G
A	D	FPR CTRL 2	BRN/WHT/WHT	SP2	7	PP3-18
A	E	SWT PWR 1	RED/BLK/WHT	PP2	19	A-F
A	F	SWT PWR 1	RED/BLK/WHT	PP2	19	SP3-17
A	G	SWT PWT 2	RED/ORN/ORN	SP2	19	PP3-17
A	H	FPR CTRL 1	BRN/WHT	PP2	7	SP3-18
PLUG B MANIFOLD PRESSURE SENSOR						
B	A	ANALOG GROUND	BLK/ORN	PP2	36	
B	B	MAP	LT BLU/ORN	PP2	35	
B	C	VOLTAGE REFERENCE	ORN/BLK	PP2	34	
PLUG C THROTTLE POSITION 1						
C	1	ANALOG GROUND	BLK/LT GRN	PP2	33	E-A
C	2	THROTTLE POS 1	LT BLU/BLK	PP2	32	
C	3	VOLTAGE REFERENCE	ORN	PP2	31	E-C
PLUG D BARO PRESSURE 2						
D	A	ANALOG GROUND	BLK/WHT	SP2	30	F-B
D	B	BP2	LT BLU/RED/RED	SP2	26	
D	C	VOLTAGE REFERENCE	ORN/LT BLU	SP2	31	M-3
PLUG E BARO PRESSURE 1						
E	A	ANALOG GROUND	BLK/LT GRN	PP2	33	C-1
E	B	BP1	LT BLU/RED	PP2	26	
E	C	VOLTAGE REFERENCE	ORN	PP2	31	C-3
PLUG F AIR TEMP 2						
F	A	AIR TEMP 2	LT BLU/PNK/PNK	SP2	27	
F	B	ANALOG GROUND	BLK/WHT	SP2	30	D-A
PLUG G AIR TEMP 1						
G	A	AIR TEMP 1	LT BLU/PINK	PP2	27	
G	B	ANALOG GROUND	BLK/LT BLU	PP2	30	P-A
PLUG H SECONDARY INJECTOR 1						
H	1	INJECTOR S1 –	BRN/LT BLU/LT BLU	SP2	1	
H	2	INJECTOR S1 +	RED/PNK/PNK	SP2	14	
PLUG I SECONDARY INJECTOR 2						
I	1	INJECTOR S2 –	BRN/LT GRN/LT GRN	SP2	2	
I	2	INJECTOR S2 +	RED/WHT/WHT	SP2	13	
PLUG J PRIMARY INJECTOR 1						
J	1	INJECTOR #1 –	BRN/LT BLU	PP2	4	
J	2	INJECTOR #1 +	RED/PNK	PP2	16	
PLUG K PRIMARY INJECTOR 3						
K	1	INJECTOR #3 –	BRN/ORN	PP2	3	
K	2	INJECTOR #3 +	RED/YEL	PP2	15	

FADEC HARNESS WIRING GUIDE (CONT'D.)

FROM PLUG	PIN	DESCRIPTION	WIRE COLOR	TO PLUG	PIN	SPLICE WITH
PLUG L (PLUG 10) POWER						
L	A	V POWER 1	RED/BLK	PP2	17	PP2-18
L	B	V POWER 2	RED/BLK/BLK	SP2	17	SP2-18
PLUG M THROTTLE POSITION 2						
M	1	ANALOG GROUND	BLK/PNK	SP2	33	
M	2	THROTTLE POS 2	LT BLU/BLK/BLK	SP2	32	
M	3	VOLTAGE REFERENCE	ORN/LT BLU	SP2	31	D-C
PLUG N PRIMARY INJECTOR 4						
N	1	INJECTOR #4 –	BRN/PINK	PP2	1	
N	2	INJECTOR #4 +	RED/LT BLU	PP2	14	
PLUG O PRIMARY INJECTOR 2						
O	1	INJECTOR #2 –	BRN/LT GRN	PP2	2	
O	2	INJECTOR #2 +	RED/WHT	PP2	14	
PLUG P WATER TEMP SENSOR						
P	A	ANALOG GROUND	BLK/LT BLU	PP2	30	G-B
P	B	COOLANT TEMP	LT BLU	PP2	29	
PLUG Q (GROUND)						
Q	LUG	POWER GROUND	BLK	PP2	5	
Q	LUG	POWER GROUND	BLK	PP2	6	
Q	LUG	POWER GROUND	BLK	SP2	5	
Q	LUG	POWER GROUND	BLK	SP2	6	
Q	LUG	POWER GROUND	BLK	Y	E	
Q	LUG	POWER GROUND	BLK	V	E	
PLUG T (PLUG 13)						
T	A	IGN 1 SPWR	RED/LT GRN	W	A	
T	B	IGN 2 SPWR	RED/LT GRN/LT GRN	Z	A	
T	C	TACH #1	GRY/RED	W	E	
T	D	TACH #2	GRY/WHT	Z	E	
PLUG U IGNITION SENDER 1 (PLUG 15)						
U	A	CRANK PICKUP #1 +	WHT	V	A	
U	B	CRANK PICKUP #1 –	BLK	V	B	
U	C	SHIELD		V	C	
PLUG V IGNITION 1						
V	A	CRANK PICKUP #1 +	WHT	U	A	
V	B	CRANK PICKUP #1 –	BLK	U	B	
V	C	SHIELD		U	C	
V	D	IGN TRIG REF #1	BLK/ORN/ORN	PP2	24	SP2-24
V	E	POWER GROUND	BLK	Q	LUG	

FADEC HARNESS WIRING GUIDE (CONT'D.)

FROM PLUG	PIN	DESCRIPTION	WIRE COLOR	TO PLUG	PIN	SPLICE WITH
PLUG W IGNITION 1						
W	A	IGN 1 SPWR	RED/LT GRN	T	A	
W	B	CAVITY PLUG				
W	C	SPARK OUT 1	GRY	Z	C	PP2-12
W	D	TRIGGER #1	GRY/LT BLU	PP2	10	SP2-10
W	E	TACHOMETER #1	GRY/RED	T	C	
W	F	CTRL #1	GRY/BLK	Z	F	PP2-9
PLUG X IGNITION SENSOR 2 (PLUG 14)						
X	A	CRANK PICKUP #2 +	WHT	Y	A	
X	B	CRANK PICKUP #2 –	BLK	Y	B	
X	C	SHIELD		Y	C	
PLUG Y IGNITION 2						
Y	A	CRANK PICKUP #2 +	WHT	X	A	
Y	B	CRANK PICKUP #2 –	BLK	X	B	
Y	C	SHIELD		X	C	
Y	D	IGN TRIG REF #2	BLK/LT BLU/LT BLU	PP2	22	SP2-22
Y	E	POWER GROUND	BLK	Q	LUG	
PLUG Z IGNITION 2						
Z	A	IGN 2 SPWR	RED/LT GRN/LT GRN	T	B	
Z	B	CAVITY PLUG				
Z	C	SPARK OUT 1	GRY	W	C	PP2-12
Z	D	TRIGGER #2	GRY/ORN	PP2	23	SP2-23
Z	E	TACHOMETER #2	GRY/WHT	T	D	
Z	F	CTRL #1	GRY/BLK	W	F	PP2-9
PLUG AB 9-PIN CABLE TO DIGITAL DISPLAY MONITOR						
AB	1	DATA TRM +5V	RED	PP3	25	
AB	2	DATA TRM SSIO TXD	WHT	PP3	1	
AB	3	DATA TRM SSIO REG LATCH	GRN	PP3	13	
AB	4	DATA TRM SSIO CLOCK	ORN	PP3	26	
AB	5	DATA TRM SHIELD	ORN	PP3	6	
AB	6	DATA TRM DIGITAL GND	BLK	PP3	16	SP3-16
AB	7	DATA TRM RXD	BLU	PP3	14	
AB	8	NOT USED				
AB	9	NOT USED				
PLUG PRIMARY ECU P2						
PP2	1	INJ #1 –	BRN/LT BLU	J	1	
PP2	2	INJ #2 –	BRN/LT GRN	O	1	
PP2	3	INJ #3 –	BRN/ORN	K	1	
PP2	4	INJ #4 –	BRN/PNK	N	1	
PP2	5	PWR GND	BLK	Q	LUG	
PP2	6	PWR GND	BLK	Q	LUG	
PP2	7	FPWR CTRL 1	BRN/WHT	A	H	SP3-18
PP2	8	AUX 0	BRN/YEL	A	B	
PP2	9	CTRL #1	GRY/BLK	W	F	Z-F
PP2	10	TRG #1	GRY/LT BLU	W	D	SP2-10
PP2	11	CAVITY PLUG				
PP2	12	SPARK OUT	GRY	W	C	Z-C

FADEC HARNESS WIRING GUIDE (CONT'D.)

FROM				TO		
PLUG	PIN	DESCRIPTION	WIRE COLOR	PLUG	PIN	SPLICE WITH
PP2	13	INJ #1 +	RED/PNK	J	2	
PP2	14	INJ #2 +	RED/WHT	O	2	
PP2	15	INJ #3 +	RED/YEL	K	2	
PP2	16	INJ #4 +	RED/LT BLU	N	2	
PP2	17	V PWR 1	RED/BLK	L	A	
PP2	18	V PWR 1	RED/BLK	L	A	
PP2	19	SWT PWR 1	RED/BLK/WHT	A	E	A-F, SP3-17
PP2	20	SWT PWR 1	RED/ORN	A	A	
PP2	21	CAVITY PLUG				
PP2	22	IGN TRIG REF #2	BLK/LT BLU/LT BLU	Y	D	SP2-22
PP2	23	TRIG #2	GRY/ORN	Z	D	SP2-23
PP2	24	IGN TRIG REF #1	BLK/ORN/ORN	V	D	SP2-24
PP2	25	CAVITY PLUG				
PP2	26	BP1	LT BLU/RED	E	B	
PP2	27	AIR CHANGE TEMP	LT BLU/PNK	G	A	
PP2	28	CAVITY PLUG				
PP2	29	ENG COOLANT TEMP	LT BLU	P	B	
PP2	30	AGND	BLK/LT BLU	P	A	G-B
PP2	31	VREF	ORN	C	3	
PP2	32	T POS 1	LT BLU/BLK	C	2	E-C
PP2	33	AGND	BLK/LT GRN	C	1	E-A
PP2	34	V REF	ORN/BLK	B	C	
PP2	35	MAP	LT BLU/ORN	B	B	
PP2	36	AGND	BLK/ORN	B	A	
PLUG PRIMARY ECU P3						
PP3	1		WHT	AB	2	
PP3	2	CAVITY PLUG				
PP3	3	CAVITY PLUG				
PP3	4	CAVITY PLUG				
PP3	5	STATUS 2	VIO/LT BLU	SP3	8	
PP3	6			AB	5	
PP3	7	CAVITY PLUG				
PP3	8	STATUS 1	VIO	SP3	5	
PP3	9	CAVITY PLUG				
PP3	10	CAVITY PLUG				
PP3	11	CAVITY PLUG				
PP3	12	CAVITY PLUG				
PP3	13		GRN	AB	3	
PP3	14		BLU	AB	7	
PP3	15		WHT	SP3	28	
PP3	16	DIGITAL GROUND	BLK	AB	6	SP3-16+3C SHLD
PP3	17		RED/ORN/ORN	A	G	SP2-19, A-C
PP3	18		BRN/WHT/WHT	A	D	SP2-7
PP3	19	CAVITY PLUG				
PP3	20	CAVITY PLUG				
PP3	21	CAVITY PLUG				
PP3	22	CAVITY PLUG				
PP3	23	CAVITY PLUG				
PP3	24	CAVITY PLUG				
PP3	25		RED	AB	1	

FADEC HARNESS WIRING GUIDE (CONT'D.)

FROM				TO		
PLUG	PIN	DESCRIPTION	WIRE COLOR	PLUG	PIN	SPLICE WITH
PP3	26		ORN	AB	4	
PP3	27	CAVITY PLUG				
PP3	28	RED		SP3	15	
PP3	29	CAVITY PLUG				
PP3	30	CAVITY PLUG				
PP3	31	CAVITY PLUG				
PP3	32	CAVITY PLUG				
PP3	33	CAVITY PLUG				
PP3	34	CAVITY PLUG				
PP3	35	CAVITY PLUG				
PP3	36	CAVITY PLUG				
PLUG SECONDARY ECU P2						
SP2	1	IGN S1 –	BRN/LT BLU/LT BLU	H	1	
SP2	2	IGN S2 –	BRN/LT GRN/LT GRN	I	1	
SP2	3	CAVITY PLUG				
SP2	4	CAVITY PLUG				
SP2	5	PWR GND		Q	LUG	
SP2	6	PWR GND		Q	LUG	
SP2	7	FPR CTRL 2	BRN/WHT/WHT	A	D	PP3-18
SP2	8	CAVITY PLUG				
SP2	9	CAVITY PLUG				
SP2	10	TRIG #1	GRY/LT BLU	W	D	PP2-10
SP2	11	CAVITY PLUG				
SP2	12	CAVITY PLUG				
SP2	13	INJ S2 +	RED/WHT/WHT	I	2	
SP2	14	INJ S1 +	RED/PNK/PNK	H	2	
SP2	15	CAVITY PLUG				
SP2	16	CAVITY PLUG				
SP2	17	V PWR 2	RED/BLK/BLK	L	B	
SP2	18	V PWR 2	RED/BLK/BLK	L	B	
SP2	19	SWT PWR 2	RED/ORN/ORN	A	C	A-G, PP3-17
SP2	20	CAVITY PLUG				
SP2	21	CAVITY PLUG				
SP2	22	IGN TRIG REF #2	BLK/LT BLU/LT BLU	Y	D	PP2-22
SP2	23	TRIG #2	GRY/ORN	Z	D	PP2-23
SP2	24	IGN TRIG REF #1	BLK/ORN/ORN	V	D	PP2-24
SP2	25	CAVITY PLUG				
SP2	26	BP2	LT BLU/RED/RED	D	B	
SP2	27	ENG COOLANT TEMP 2	LT BLU/PNK/PNK	F	A	
SP2	28	CAVITY PLUG				
SP2	29	CAVITY PLUG				
SP2	30	AGND	BLK/WHT	D	A	F-B
SP2	31	V REF	ORN/LT BLU	M	3	
SP2	32	T POS 2	LT BLU/BLK/BLK	M	2	
SP2	33	AGND	BLK/PNK	M	1	
SP2	34	CAVITY PLUG				
SP2	35	CAVITY PLUG				
SP2	36	CAVITY PLUG				

FADEC HARNESS WIRING GUIDE (CONT'D.)

FROM				TO		
PLUG	PIN	DESCRIPTION	WIRE COLOR	PLUG	PIN	SPLICE WITH
PLUG SECONDARY ECU P3						
SP3	1		BLK	SP3	14	
SP3	2	CAVITY PLUG				
SP3	3	CAVITY PLUG				
SP3	4	CAVITY PLUG				
SP3	5	STATUS 1	VIO	PP3	8	
SP3	6			AB	5	
SP3	7	CAVITY PLUG				
SP3	8	STATUS 2	VIO/LT BLU	PP3	5	
SP3	9	CAVITY PLUG				
SP3	10	CAVITY PLUG				
SP3	11	CAVITY PLUG				
SP3	12	CAVITY PLUG				
SP3	13	CAVITY PLUG				
SP3	14		BLK	SP3	1	
SP3	15		RED	PP3	28	
SP3	16	DIGITAL GND	BLK	AB	6	PP3-16+3C SHLD
SP3	17	SWT PWR 1	RED/BLK/WHT	A	F	PP2-19, A-E
SP3	18	FPR CTRL 1	BRN/WHT	A	H	PP2-7
SP3	19	CAVITY PLUG				
SP3	20	CAVITY PLUG				
SP3	21	CAVITY PLUG				
SP3	22	CAVITY PLUG				
SP3	23	CAVITY PLUG				
SP3	24	CAVITY PLUG				
SP3	25	CAVITY PLUG				
SP3	26	CAVITY PLUG				
SP3	27	CAVITY PLUG				
SP3	28		WHT	PP3	15	
SP3	29	CAVITY PLUG				
SP3	30	CAVITY PLUG				
SP3	31	CAVITY PLUG				
SP3	32	CAVITY PLUG				
SP3	33	CAVITY PLUG				
SP3	34	CAVITY PLUG				
SP3	35	CAVITY PLUG				
SP3	36	CAVITY PLUG				

C. COOLING SYSTEM

1. COOLANT REQUIREMENTS

Propylene Glycol is the recommended choice for coolant/anti-freeze. Propylene Glycol offers improved cavitation corrosion protection, lower toxicity, and better overall performance than Ethylene Glycol.

We strongly recommend that you DO NOT use Ethylene Glycol coolant/anti-freeze.

It is also necessary to include a compatible supplemental coolant additive (a rust inhibitor/water pump lubricant). WIX #24056 and NALCOOL #3000 are two of the quality additives available. The best source for locating other brands is diesel parts stores because cylinder corrosion is common in diesel engines. Follow directions for the correct concentration of additive as more is not better.

We have tested a Propylene Glycol anti-freeze solution called COMPLEAT, which contains the proper concentrations of propylene glycol and corrosion inhibitor additive. The best type is their "PREMIXED" version, which already has the proper amount of distilled water added. This product is distributed by FLEETGARD Inc., a Cummins (diesel) company.

CAUTION: NEVER USE WATER ONLY IN THE COOLING SYSTEM. Never mix tap water or well water with the antifreeze concentrate. Use ONLY DISTILLED WATER to mix with the antifreeze solution.

We recommend that you have the coolant/anti-freeze solution tested once every year. This is a fairly common procedure and can be done by many auto parts stores or auto repair shops.

Normally, the coolant should be left in the system until the recommended change out time of the hoses (refer to the Maintenance Manual). At that time replace the hoses, hose clamps, coolant, and thermostat.

2. PREPARATION

Review the Prints and Manuals to ensure that all cooling system components are attached and routed correctly. Verify that all hoses are secure and that hose clamps are installed past the bead or flare on the end of the adjoining tube or fitting. All hoses must be protected from the exhaust manifold heat source. The tie down and routing of all hoses must be done in such a way as to prevent chafing damage.

3. REMOVING AIR FROM THE SYSTEM

Water pump priming and air removal is one aspect of the initial engine start-up which requires two people. One person (the pilot) must start the engine and monitor all instruments. Another person is needed to bleed air from the system and to check the cooling system for leaks. This person will also be in an excellent position to watch several other systems for potential problems.

CAUTION: Water temperature must be monitored constantly during the entire initial start-up procedure. It is an inherent characteristic of the cooling system to repeatedly lose the prime at the water pump during this period, causing the water temperature to increase very rapidly.

Complete the following before start-up:

A. Prepare the propylene glycol coolant solution according to the directions given by the manufacturer.

B. Open all three air bleed valves slightly. The valves are located on the rear corner of the radiator, the water pump, and the elbow on top of the waterjacket (remove safety wire). All are on the passenger side of the helicopter.

NOTE: Install a length of clear plastic hose on the air bleed valves and use a catch container under all bleed areas to recover as much coolant mixture as possible.

C. Slowly pour the coolant mixture into the surge tank until it flows continuously from the three air bleed valves. Once a steady stream of coolant without air bubbles is emitted, close the valves. Leave the surge tank cap off at this time. (The surge tank must be continuously filled during this process).

D. Check for any sign of leakage.

E. Turn on the instruments and verify that the needle on the water temperature gauge (as well as on the oil temperature gauge) moves from a low temperature setting to a "pegged low" position.

F. Ensure that enough additional coolant solution has been prepared so that the surge tank can be kept full after the engine is started.

G. All other systems must be prepared before starting the engine.

Carefully follow the procedures below during the initial start-up to prevent overheating and engine damage:

A. Start the engine.

CAUTION: On cold engine start-ups, before the thermostat is open, virtually all of the coolant is being forced through the oil sump/heat exchanger. Because of this, it is **VERY IMPORTANT** not to exceed an idle until the coolant temperature reaches 160° F and the thermostat opens. Oil temperature must also be in the green range on the gauge. **IF THE THERMOSTAT IS CLOSED AND THE ENGINE EXCEEDS 2400 RPM, THE PRESSURE IN THE COOLING SYSTEM COULD MORE THAN DOUBLE AND CAUSE CONSIDERABLE DAMAGE.**

B. Keep the surge tank 1/2 to 3/4 full AT ALL TIMES.

C. At the first sign of rapid water temperature increase, open the air bleed valve on the water pump and bleed the system until no air bubbles appear in the coolant. This corrective action should quickly lower and stabilize water temperature.

CAUTION: Do not allow the water temperature to exceed 185° F during the initial start-up period. If a rapid and continuous increase in water temperature occurs, and can not be stopped by "bleeding" at the water pump, the engine must be stopped before the water temperature reaches 185° F. Allow the engine to cool, then bleed out the air at the three air bleed valve locations.

Proper priming of the water pump is evident by a warming of the hoses to the water pump as well as a slow increase in water temperature.

D. The thermostat will begin to cycle open and closed when the water temperature reaches approximately 160° F. This is evident by a rapid decrease in water temperature followed by an increase back to approximately 160° F. When this cycling starts, additional air will flow through the system, most of which can be bled out through the radiator valve.

E. Make sure that the surge tank is 1/2 to 3/4 full and install the pressure cap.

F. After approximately seven minutes of running, the oil temperature should reach 140° F. Stop the engine and let it cool. Remove the cap from the surge tank.

CAUTION: The system MUST be allowed to cool before removing the cap. Removal of the pressure cap when the cooling system is hot can result in severe burns.

G. Open the air bleed valves on the water pump and radiator, and allow coolant to bleed for 10-15 seconds while keeping the surge tank full. Close the valves, fill the surge tank 1/2 to 3/4 full, and replace the cap.

A warm engine restart will display an initial temperature increase followed by a rapid decrease if correct priming is accomplished.

Re-bleed the system after each of the first few runs to ensure the complete removal of air. Continue to monitor the water temperature especially close during the first few hours of operation when problems are most likely to occur.

When the engine is cold, adjust the amount of coolant in the surge tank to half full. You may notice that when the engine is warm, the level in the tank decreases as the engine is run-up from an idle to full RPM. The level in the reservoir may increase when a hot engine is stopped. The level should then decrease as the engine cools and coolant is drawn back into the system.

NOTE: When all of the air has been removed from the system, the air bleed valve on the waterjacket elbow should be safety wired against the direction of rotation.

D. OIL SYSTEM

1. PREPARATION AND PRIMING

Prior to the first engine start-up, the oil pump MUST BE PRIMED. The RI-162F power plant uses a G-Rotor pump rather than a gear type unit. The G-Rotor has several design advantages over the gear type. It does have the disadvantage of needing a prime before first operation. The oil fittings have been angled up at the inlet and outlet side of the oil pump. This is done intentionally in order to keep enough oil at the pump to maintain a prime after shutdown of the engine. The pump should not have to be re-primed again even after a prolonged interval of no engine operation.

CAREFULLY follow the sequence outlined below before the initial starting of the engine.

A. Before installing the oil sump/heat exchanger or any oil hoses, they must all be thoroughly cleaned. Carefully flush them with solvent, completely drain and blow them dry.

NOTE: After cleaning the sump, lubricate the inside of the filler neck with oil to prevent the cap from galling the aluminum filler neck tube.

B. Before connecting any oil hoses to the engine, fill the oil pump inlet and outlet fittings with oil. These fittings are numbers 2 and 3 in the Oil System Parts List. These fittings will have to be refilled repeatedly until all of the trapped air has been bled out and they remain completely full.

C. Install all oil hoses. The fittings on the ends of the hoses are aluminum and can be permanently damaged if over tightened. Secure all hoses away from hot exhaust pipes. Secure hoses in such a way as to avoid any contact with ANY other component of the aircraft.

D. Before screwing on the oil filter, coat the rubber gasket with a light film of oil. Fill the oil filter with oil. It holds approximately 1/2 quart. Add the oil slowly, allowing it to soak in. Screw the filter onto the mount by hand. Tighten it firmly by hand only. Approximately 2/3 of a turn after initial contact is correct. Do NOT use a wrench to tighten the filter to the mount as this will make it next to impossible to remove for replacement.

E. Pour the remaining 1/2 quart of oil into the oil sump/heat exchanger. Scribe two lines on the dipstick which is attached to the breather cap. These lines should represent levels below the top of the filler neck of 8 3/4" and 9 1/4". The oil level must be maintained between these lines at all times. You will be instructed to “top off” the oil level after stopping the engine the first time.

NOTE: If the oil level in the sump is too low, ineffective oil cooling will result. If the oil level is too high, oil will blow out of the filler pipe.

F. The oil system is now ready for the first engine start-up. All other systems must be prepared before starting the engine. When the engine is started for the first time do NOT operate above a low idle until oil pressure is obtained.

CAUTION: If proper oil pressure is NOT obtained after 5 seconds of running, STOP the engine and re-prime the pump as explained in step C above. Adjust the oil pressure if necessary (see Oil Pressure Adjustment section below).

G. When correct oil pressure is observed, continue to run the engine until an oil temperature of 140° F is obtained and then STOP the engine.

WARNING: After the initial start-up and during the first run of the helicopter, carefully monitor the entire oil system for leaks. Oil can catch on **fire**, especially if it leaks onto the exhaust system.

H. After the engine is stopped, allow time for the oil to completely drain back into the oil sump/heat exchanger. Add oil to bring the level between the marks on the dipstick.

NOTE: At this time the re-bleeding of the cooling system should be done.

CAUTION: Check the oil level in the sump during each pre-flight inspection of the helicopter. Add oil if necessary to bring the oil level up to the scribe mark on the dipstick. Always check the oil pressure on each start-up and throughout each flight. Continually monitor the ENTIRE oil system for any leakage and regularly check all hoses for ANY sign of damage.

2. OIL PRESSURE ADJUSTMENT

A. Oil pressure adjustments must be made when the engine is at operating temperature. (See specification section for exact operating parameters.) The only time oil pressure would need to be adjusted when the engine is cold would be if the oil pressure did not meet the minimum or maximum specifications on initial start-up. Oil pressure MUST fall within the stated parameters at idle and at full RPM.

The oil pressure was set at the factory during the dynamometer testing of the engine. A slight adjustment may have to be made in order to "tune" the pressure regulator to your ship's particular oil system. This adjustment should be minor and should not have to be made during the initial warm up of your engine. However, do not take this for granted. Carefully monitor your oil pressure at all times.

B. To adjust the oil pressure, first look at the exploded view of the oil pump cover and the pressure regulator components, found in the Lower Cover Assembly drawing in Section V of this manual. Take the time to become familiar with the component parts. It is recommended that you make any adjustment to the oil pressure only when the engine is stopped. As you will notice, the adjustment requires that your hands come in close proximity to the hot exhaust system. This, in conjunction with the generally close quarters, warrants special care from a safety point of view.

C. Proceed as follows to make an adjustment of the oil pressure: Loosen the jam nut on the socket head cap screw. (Be careful not to move the cap screw when loosening the nut.) Turning the cap screw clockwise will increase the oil pressure and turning counter clockwise will lower the pressure. It is suggested that you turn the cap screw in increments of 1/4 turn at a time until the desired pressure is achieved. Each time an adjustment is made, re-torque the jam nut to 108 in. lbs. After any adjustment, completely clean off any trace of oil and check for any leaks. If an oil leak is found around the socket head cap screw where it enters the regulator plug, the O-ring must be replaced. To do this, remove the cap screw while carefully counting the exact number of turns as it comes out. Be prepared for a small stream of oil to come out of the regulator plug. When you reinstall the screw, turn it in exactly the same number of turns. By doing this you should be close to the previous setting. During any adjustment, pay close attention to the oil pressure. MAKE SURE you are not running the engine with incorrect oil pressure.

E. IGNITION SYSTEM

1. INTRODUCTION

The dual ignition system utilized on the RI-162F engine is extremely reliable and easy to maintain. It should provide many hours of trouble free performance. Many types of ignition systems were analyzed and evaluated before deciding to use this system.

The system consists of two complete and separate ignition units. Each unit fires one set of spark plugs. Unlike other ignition systems, they do not use a rotor and cap; they fire the spark plugs directly from the coils. The spark control is completely electronic. An advance curve is programmed into each ignition module and timing advance occurs automatically in response to RPM. This feature allows the ignition units to operate as “stand alone” systems. This is how they operate when the secondary fuel system is activated by FADEC in response to a major failure in the primary ECU controlled system. An additional feature allows the primary ECU (when activated) to override the programmed advance curve of the ignition modules. The ECU then controls ignition timing based on the specific performance requirements of the powerplant.

With this type of ignition system, a spark occurs every time a piston approaches its top position. A spark occurs on the compression stroke and at the end of the exhaust stroke. This “extra” spark on the exhaust stroke has no effect on the running engine since there is no mixture present to ignite. (An excess of fuel in the intake manifolds or cylinders can cause a pop or backfire on start-up.)

Each ignition system contains five components: ignition module, sensor, timing wheel, spark plugs, and spark plug wires. The only shared component between the two systems is the timing wheel which is mounted on the drive flange of the crankshaft. Each sensor transmits a signal to its own ignition module every time a tooth segment passes that sensor. The ignition module then identifies the relative position of the crankshaft and delivers a spark to the plugs based on the timing required for that RPM.

The entire function of spark advance from starting to full RPM operation is controlled and requires no adjustment. The maintenance is very simple on this system. Spark plugs and spark plug wires are replaced at proper intervals. A sensor or ignition module is replaced if either is found to be defective in pre or post flight checks. This should be the most trouble free and effective ignition system you could wish for in any aircraft.

NOTE: There are certain operational parameters that must not be violated. These will be covered in detail in this section of the manual. You must carefully read this material prior to installation of the units. Failure to do so could result in permanent damage to the ignition modules.

2. PREPARATION

WARNING: NEVER ELECTRIC WELD with either the ignition modules or the ECUs connected in ANY way to the electrical system of the ship. This means that the positive, negative, ground strap, and sensor connections must be disconnected before any welding is preformed!

DO NOT PROVIDE CURRENT to the ignition units until all of the following procedures have been done and double checked.

The following installation and operating procedures MUST be followed before the initial start-up of the engine. Failure to understand and follow these procedures will result in damage to the ignition systems.

A. Use the installation drawing to verify that the FADEC wiring harness has been correctly installed on the ignition modules. The “end” connectors on the harness should plug into the inboard module.

B. The separate grounding strap MUST be installed to the mounting plate. This effectively grounds the body of each unit. This is required in addition to the wiring harness ground connection of each unit.

C. Connect the sensors to the ignition modules: Use the ignition installation drawing to ensure that the correct sensor attaches to the proper module. The sensor wires need to be carefully secured to prevent damage. They also MUST be routed so that they do not come into close proximity with ANY other wires. The signal transmitted by these wires is very weak and interference from other wires close by could cause false signals to be sent to the ignition modules. Pay close attention to the routing of these wires in relation to the spark plug wires as they are proven the most likely source of interference. The FADEC wiring harness which is connected to the ignition modules must not be allowed to contact the spark plug wires.

D. Install the spark plugs: Be sure to gap, torque and install the end caps according to specifications. (Always inspect the spark plug threads for damage and apply a light film of anti-seize before installation.)

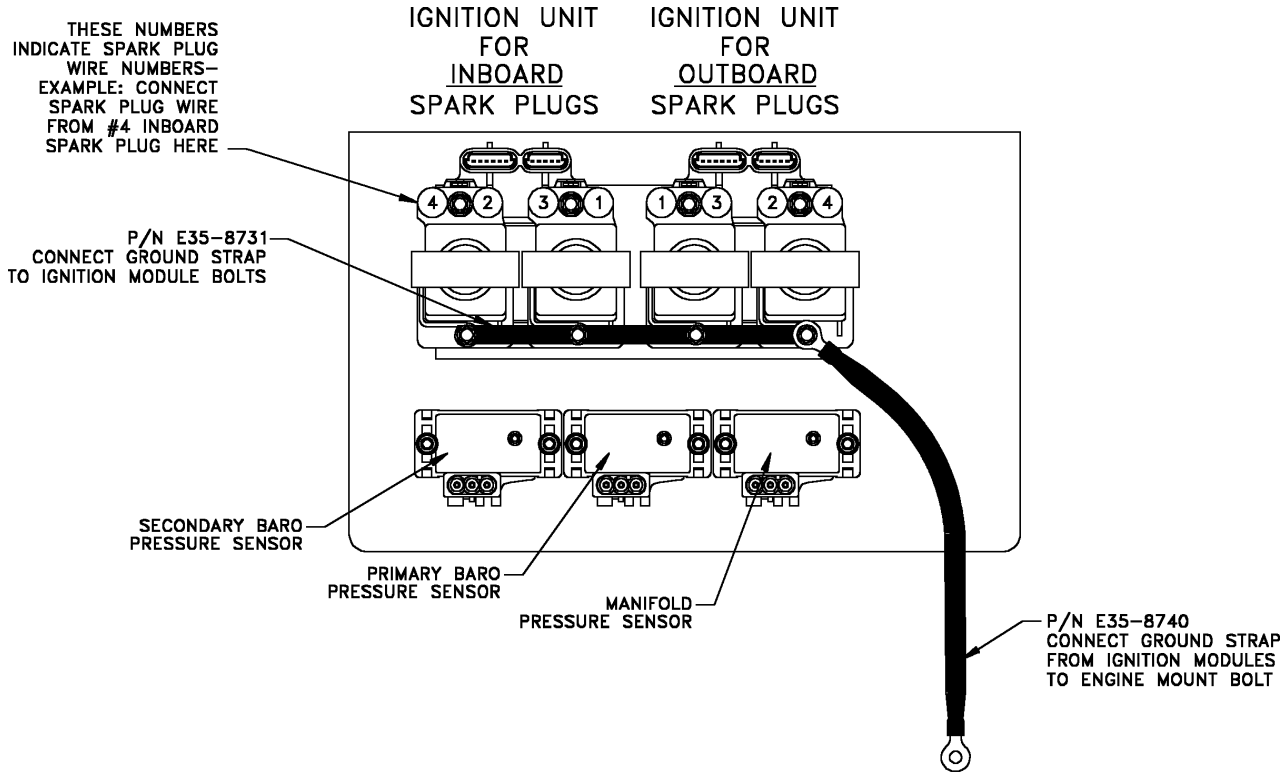
E. Install the spark plug wires: Use the ignition installation drawing as a guide to the proper connection of these wires. Be sure to double check the connections you have made. (Incorrect spark plug wire hookup is surprisingly easy to do.) Before attaching each wire, look inside the boot and verify that the metal end is in the proper position. When the wire is installed on either a coil tower or a spark plug it should snap into place and feel solidly attached. Wire separators have been provided to properly route the wires. Route the wires in such a way that all of the following conditions are met:

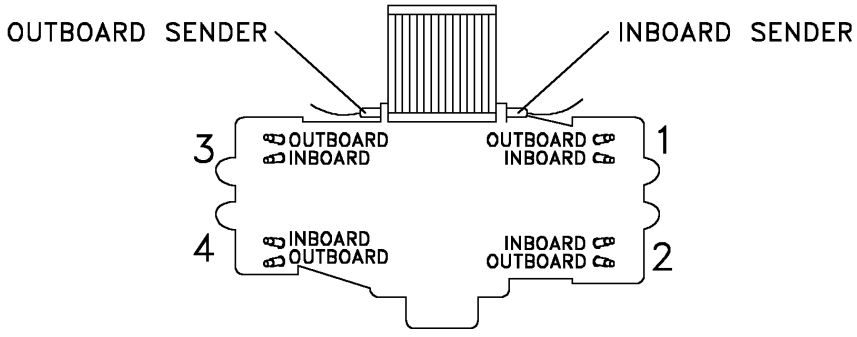
1. No two wires can come in direct contact with each other.
2. Wiring must be very well supported and not allowed to chafe or vibrate excessively.
3. No wire can be pulled tight. Some torque movement of the engine will occur and the wires must have enough slack to move with the engine.

WARNING: NEVER CRANK, START, OR RUN THE ENGINE WITH ANY OF THE SPARK PLUG WIRES DISCONNECTED FROM EITHER THE IGNITION MODULES OR THE PLUGS!

3. INSTALLATION DRAWING

CAUTION: USE **ONLY** GROUNDING STRAPS AND WIRES SUPPLIED BY ROTORWAY AND SPECIFIED BELOW BY PART NUMBER. **SUBSTITUTIONS ARE NOT PERMITTED.**





4. COMPONENT SERVICE

CONTENTS:

A. IGNITION SENSORS: The inboard and outboard ignition sensors are identical except for wire length and plug "gender".

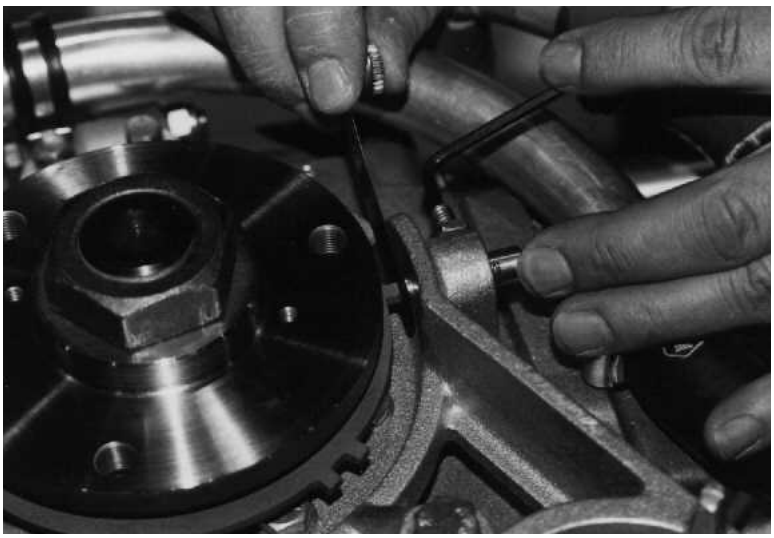
A24-5410 Inboard Ignition Sensor
Female Connector - 28" Lead
A24-5411 Outboard Ignition Sensor
Male Connector - 16" Lead

TESTING: Disconnect the sensor at the plug connector by lifting the lock tab and pulling the connector apart. Pull on the connector body only, **not** on the wires themselves. Terminal A should have the red wire and terminal B should have the black wire on both plugs. The resistance between terminals A and B, of the sensor, should be 650 to 700 ohms. Wiggle the sensor wire, while taking the resistance reading, to check for an intermittent "short".

REMOVAL: Disconnect the sensor at the plug connector by lifting the lock tab and pulling the connector apart. Pull on the connector body only. Do not pull on the wires themselves! Loosen the jam nut on the set screw which locks the sensor in place. Back off the set screw. Cut off the tie down straps for the sensor wire and remove the sensor. If it does not come out easily, carefully grab it with a pair of pliers and rotate it back and forth while attempting to pull it out. If the sensor is to be used again, be careful not to damage it. Do not squeeze it too hard or damage from crushing may occur. Carefully support the wire when removing the sensor or wires may break internally.

INSTALLATION: Deburr the sensor hole in the starter mount if necessary. The sensor must be able to slide in and out of the hole easily. Care should be taken to avoid elongating or enlarging the hole. Use compressed air to THOROUGHLY blow clean the area inside the starter mount which encloses the ignition timing wheel. (Chips could wedge between the wheel and sensor causing damage to the sensor.)

Rotate the engine (using a flywheel wrench) until a tooth of the timing wheel is exactly centered on the sensor hole. A small mirror and flashlight will be needed to verify the proper positioning of the tooth. Apply a LIGHT film of anti-seize to the outside diameter of the sensor. The end of the sensor which is toward the timing wheel MUST remain clean and free of lubricant. Excess anti-seize will only contaminate the sensor and act as a trap for dirt and chips.



Carefully insert the replacement sensor in the hole. Place a .028" feeler gauge between the sensor end and the timing wheel tooth. Firmly hold the sensor against the feeler gauge and torque the set screw to 15 in. lbs. DO NOT OVER TORQUE THE SET SCREW OR THE SENSOR CAN BE DAMAGED! While holding the set screw to keep it from turning, tighten the jam nut to 96 in. lbs. The feeler gauge should be able to be moved back and forth between the sensor and the tooth with a light drag. If the feeler gauge does not move easily, DO NOT force it. Loosen the jam nut and back off the set screw. Repeat the procedure until a proper gap is obtained. Verify a gap of .025" to .030" on two other teeth which are located 120 degrees on either side of the tooth used to set the gap. Do not leave the feeler gauge in place while rotating the flywheel as slight variations in gap could damage the sensor. (Be careful if you rotate the flywheel clockwise as this will cause the blades to turn.)

Using wire ties, secure the sensor wire in such a way as to keep it from vibrating or being damaged by the heat from the exhaust. Reconnect the sensor wire plug and make sure that the locking tab engages. (Route the wire according to the installation instructions.)

B. IGNITION MODULES: Inboard and outboard ignition Modules are identical and interchangeable components. Testing is covered in the following Diagnostic Section.

REPLACEMENT: It is important that the mounting holes in both the seat back panel and in the module backing plate are large enough for the mounting bolts to be tightened without any binding. The ignition modules must sit flat against the backing plate and not bind or twist during the bolt tightening process. Dielectric grease must be used, during assembly, between the ignition modules, backing plate and the seat back panel. The mounting bolts must be gradually tightened until snug. They must then be torqued to 75 in. lbs. The ground wires must be properly installed in order to provide an adequate “ground source” for the ignition modules.

C. SPARK PLUG WIRES: Spark plug wires should be replaced only with ones supplied by the factory. The use of incorrect spark plug wires can cause permanent DAMAGE to the ignition modules! The spark plug wire supplied by the factory is spherically wound and has a resistance which is less than 700 ohms per foot. It is a special grade of wire and has passed the testing required for its use. DO NOT use any wire because you believe it to be similar to the factory supplied type! A damaged spark plug wire will test as a “short” or have a high resistance value.

D. SPARK PLUGS: Use only direct replacement plugs. Do not change heat range and do not change to a non-resistor type plug. Damage to the ignition modules and to the engine can result from the use of incorrect spark plugs. Every 50 hours inspect and re-gap all spark plugs. Replace a plug at the first sign of damage or fouling. Mandatory replacement is 100 hours.

NOTE: Change spark plugs only when the engine is cold!

Inspect each plug carefully before installation. Pay close attention to any possible damage of the threads. Always screw a spark plug in by hand only and then torque it. If a plug has to be turned in with a socket, damage to the threads in the cylinder head will probably occur. Always pre-coat the threads of the spark plugs with a LIGHT film of anti-seize before installation. Secure the end cap onto the plug using Loctite #271.

5. DIAGNOSTICS

NOTE: The ignition modules cannot compute the proper spark timing sequence if the engine is cranking too slowly. Because of this, the ENGINE WILL NOT START! The modules can also be damaged by continuous operation at a low or a high voltage. For these reasons, ensure that the battery has a good charge before attempting to start the engine and verify that the alternator is working properly after start-up by monitoring the voltmeter.

Pre- and post-flight ignition checks are done by alternately turning off and on each system individually. The RPM may drop slightly but should not stop the engine or cause it to misfire dramatically.

WARNING: DO NOT perform the ignition checks above an idle, as a faulty system could stop the engine or possibly cause severe backfiring.

These diagnostic procedures are very simple and straight forward. They must be followed in sequence. Failure to do so can result in much wasted time and the possible purchase of unneeded and expensive parts! All of these procedures assume that the ignition system is installed properly. If you have a problem on the initial start-up, recheck your installation before following the diagnostic procedures.

Below are listed a series of possible problems which may be encountered. If you have a problem with the ignition system, find the heading which fits the problem and follow the accompanying procedure until a problem is found AND CORRECTED. If after correcting a problem the ignition system still does not preform properly, then and only then go on to the next procedure.

A. ENGINE WILL NOT START but signs of combustion are evident, (such as backfire or sputter):

1. If the battery is properly charged and the cranking speed is good, the engine is probably flooded. Turn off all FADEC switches and turn on both ignitions. Hold the throttle wide open (100% indicated) and crank the engine until no sign of combustion is evident. (No fuel is delivered to the engine below 1000 RPM at a wide open throttle setting.) If necessary, remove the spark plugs and check for signs of fouling. A common cause of backfire or sputter on start-up is fuel fouling of the spark plugs.

2. Check for power at <u>both</u> ignition modules using a voltmeter.

3. Try starting the engine on the inboard system only. Repeat on the outboard system only. If the engine starts and runs on either system and starts to miss or if it quits when the other system is turned on, see “Engine Runs On One System Only”.

4. If the engine will not start on either system, check the sensor gap on both the outboard and the inboard systems.

5. Install a timing light on #1 outboard spark plug wire. With <u>only</u> the outboard system turned on, crank the engine to check for spark. Do the same to outboard wires #2, #3 and #4. If a spark is present on all 4 plugs and none of the plugs were fouled, then there is probably not enough fuel present for start-up.

NOTE: Crank the engine <u>only</u> long enough to verify spark. DO NOT crank the engine for a prolonged period as this could damage the starter and the engine.

Pre-check the timing light for proper operation. If its operation is questionable, an alternate method may be used to verify spark at the plug: Remove the spark plug wire from the cylinder in question. Remove the spark plug and reattach the spark plug wire to it. Install an extra spark plug in the vacant hole. Attach a grounded strap to the base of the removed spark plug. Hold this grounded plug against a grounded surface which is not near any fuel source! Care must be taken to avoid shock AND to prevent the system from being run with a plug wire disconnected. For this reason, do not eliminate the grounding strap from this procedure.

6. If no spark is evident at ANY cylinder and if the voltage AND cranking speed are good, either a sensor or an ignition module is probably bad. In this case, skip 7-9 and proceed to 10. If any of the plugs show signs of spark proceed to 7.

7. If only one, two, or three of the spark plugs do not show signs of spark, then replace the questionable spark plugs and retest. (Defective spark plugs can cause this type of problem.)

8. If only one, two, or three of the spark plugs still show no evidence of a spark, remove the questionable spark plug wires from the defective cylinders. Check for continuity with an ohm meter. If a defective wire is found, retest that cylinder after replacing the wire.

9. If this is also not the problem, then either the sensor or the ignition module is defective.

10. Repeat procedures (1 through 9) on the inboard set of spark plugs.

11. A situation where both systems were defective would be very unlikely since a sensor or an ignition module would have to be defective on each system. Call customer service before proceeding further!

B. ENGINE WILL NOT START and no signs of spark are evident such as backfire or sputter:

1. Check for power at both modules using a voltmeter.

2. If the battery is properly charged and the cranking speed is good, the engine may be severely flooded. Turn off all FADEC switches and turn on both ignitions. Hold the throttle wide open (100% indicated) and crank the engine until no sign of combustion is evident. (No fuel is delivered to the engine below 1000 RPM at a wide open throttle setting.) If necessary, remove the spark plugs and check for signs of fouling.

   Insufficient fuel can also keep the engine from firing, so check for an apparent total lack of fuel!

3. Check sensor gap on both inboard and outboard units.

4. Install a timing light on #1 outboard wire. With only the outboard system on, crank the engine to check for spark. Repeat as necessary on the remaining wires to determine if a spark is being produced. (Do not crank engine for a prolonged period as this could damage the starter and the engine.)

   If a good spark is present on all plugs and the plugs were not fouled, there is probably not enough fuel present for start-up.

5. If no spark is evident at ANY spark plug and if the voltage AND cranking speeds are good, either a sensor or an ignition module is probably bad. In this case, skip 6-8 and proceed to 9. If any of the plugs show signs of spark, proceed to 6.

6. If only one, two, or three of the spark plugs do not show signs of spark, then replace the questionable spark plugs and retest. (Defective spark plugs can cause this type of problem.)

7. If only one, two, or three of the spark plugs still show no evidence of a spark, remove the questionable spark plug wires from the defective cylinders. Check for continuity with an ohm meter. If a defective wire is found, retest that cylinder after replacing the wire.

8. If this is also not the problem, then either the sensor or the ignition module is defective.

9. Repeat this process on the inboard set of spark plugs.

10. A situation where both systems were defective would be very unlikely since a sensor or an ignition module would have to be defective on each systems. Call customer service before proceeding further!

C. ENGINE RUNS ON ONE SYSTEM ONLY.

1. Identify whether the inboard or outboard system is defective. Check for power to the defective system using a voltmeter.

2. Install a timing light on a wire of the operable system to verify proper operation of the light. (Run the engine at an idle only.) Check to determine if any of the spark plugs of the defective unit are firing. Do this by checking each of them with the timing light at idle. IF NONE of the spark plugs show any sign of spark, proceed to 3. If some of the cylinders are firing, check the spark plugs in the defective cylinders for signs of fouling and check the corresponding spark plug wires for damage.

3. Test the ignition sensor using an ohm meter and check the sensor gap on the defective system. These checks should be a good indication of the sensor's condition. To verify whether the ignition sensor or the ignition module is defective, proceed to 4.

4. Warm up the engine and verify good restart ability. Stop the engine and "reverse" the spark plug wire positions on each module. (On each module switch the #1 wire with the #2 wire and the #3 wire with the #4 wire.) Switch both connector plugs between the modules. (Referring to the FADEC Wiring Harness, switch Plugs A and B with Plugs C and D.) Re-start the engine. If the problem stays with the same ignition switch, the **ignition sensor** or the wiring for that circuit is defective. If the problem "changes" to the other ignition switch, the problem is the **ignition module**, the corresponding spark plugs or the corresponding spark plug wires.

6. IGNITION TIMING

The ignition timing will vary depending on whether the engine is operating on the primary system or on the secondary system. When operating on the secondary system, the ignition modules completely control the timing of the spark. In this mode, at "operating RPM", the timing should be 28 to 30 degrees before TDC. The actual timing will vary depending on the exact RPM. Timing should be verified, with a timing light, at operating RPM, (approximately 4250 RPM). It should only be checked when the engine is operating with a "light load". When operating on the ECU controlled primary system, the ignition timing is modified by the ECU and should match the value given on the digital display monitor.

F. VALVE TRAIN

1. VALVE COVER REMOVAL AND INSTALLATION

A. Prior to valve cover removal, prepare for a small amount of oil to drain from the rocker box.

B. Remove the two bolts securing each cover and remove the cover.

C. Inspect the rubber O-rings on all four bolts and replace them if they are deformed.

D. Inspect the valve cover gaskets and replace them if necessary. When replacing a gasket, apply enough silicone to the seating area of the valve cover to fill void areas where the gasket does not match. Install the gasket, then invert the valve cover onto a flat surface. Allow the silicone to dry before reinstalling the valve cover on the engine.

E. Center the valve cover both vertically and horizontally over the cylinder head rocker box. (If reusing the same gasket, you should be able to feel when the cover slips into the previously formed depression.) Insert the bolts and tighten to the point where the large washer under the head of the bolt just contacts the valve cover. Tighten the bolts no more than an additional 1/2 to 3/4 turn. Visually check to insure that only the gasket is contacting the cylinder head. Repeat the process on the other cover.

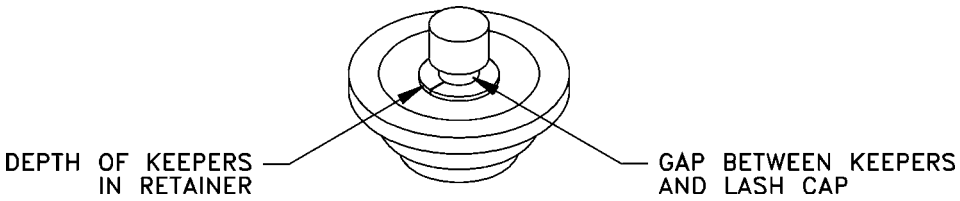
CAUTION: The gaskets can be damaged if the valve covers are not positioned properly or if the bolts are over-tightened. Check for oil leaks after engine start-up.

2. VALVE TRAIN INSPECTION

A. The following 3 inspections should be done every 25 hours. They should be performed prior to each valve lash measurement. While these parts normally do not wear and require no maintenance, it is important to monitor their condition in order to prevent a failure.

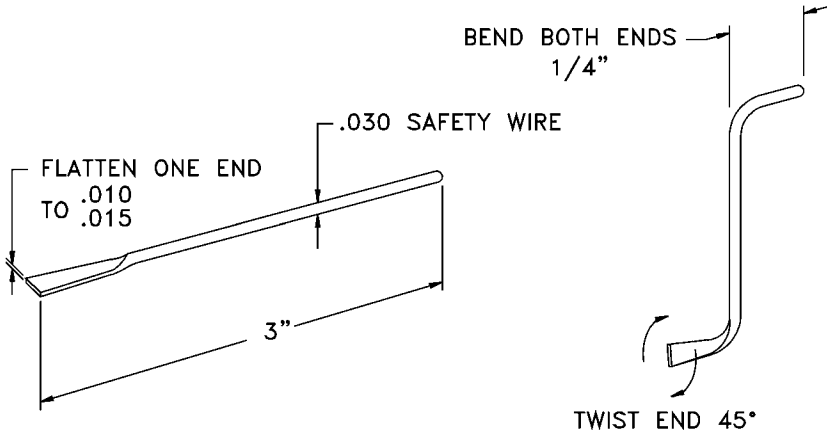
WARNING: If you have any questions regarding these procedures, DO NOT continue to operate the engine! Call Customer Service for additional instructions.

1. Spring Retainer: Note the relative depth of the keeper set in each spring retainer. You may notice a slight variance on different valves, but no keeper set should be sunk deeply into a retainer. The important thing to look for is any change in the relative position of each keeper set. If you determine that a keeper set seems to be sinking deeper into its retainer, DO NOT continue to operate the engine. Call customer service for further instructions.



2. Valve Stem and Spring Keeper: If you look closely at the top of each valve assembly you will notice a gap between the lash cap and the spring keepers. If excessive wear occurs between the valve and the keepers, this gap will decrease and eventually the lash cap will contact the keepers. Continued wear beyond this point can cause engine failure. This gap is normally between .020" and .030". While it is not necessary to measure this gap exactly, it is important to note any radical change. Use the following drawing to make a wire gauge which will be used to monitor this gap on each valve. The .010"/.015" end should easily fit into the gap. The .030" end should fit snugly if it will go into the gap at all. DO NOT continue to operate the engine if a keeper contacts a lash cap. Call customer service for further instructions if ANY wear of these components is apparent.

   Fabricate this gauge from a piece of .030" safety wire. Use a hammer to flatten one end of the wire to a thickness of .010" to .015".



3. Valve Guide: If excessive wear occurs between a valve and valve guide, the guide will develop an “hour glass” shape on its inside diameter. This can cause excessive oil consumption and if the wear becomes extreme it will cause engine failure by damaging the valve itself. To inspect for wear: Rotate the engine to the proper position for valve adjustment of the individual valve/valve guide to be inspected. Prior to measuring and adjusting the valve lash, grasp the valve spring retainer with your fingers and move it up and down. During this process look between the coils of the valve spring and watch the part of the valve stem which protrudes from the guide. Wear would be evident by excessive movement and by a visible gap between the valve stem and guide. You will need to use a fair amount of pressure to get any movement, but under all conditions never use a tool to pry on the assembly.

Since this is a difficult area to view, it might be helpful to use a small inspection light. Next try to move it from side to side while looking for valve stem movement. Abnormal wear will usually cause more movement in one direction than in the other. This is a subjective measurement since the valve spring is trying to keep the valve from moving and varying degrees of pressure will cause different amounts of deflection. However, you should be able to notice a difference between a normal assembly and one which has excessive valve guide wear. If you determine that a valve may have more "play" than normal proceed as follows: Remove the rocker arm, (see Valve Train - Lash Cap, Rocker and Pushrod Inspection). Carefully install an external valve spring compressor on the suspect assembly and compress the spring just enough to allow unrestricted movement of the valve. Without the interference of valve spring pressure you should be able to verify if the guide has excessive wear.

B. Lash Cap, Rocker and Pushrod: Perform if lash is found to be in excess of .008". Rotate the engine to the proper position for valve adjustment of the individual valve to be inspected. (See Valve Adjustment). Loosen the set screw and rocker nut. Remove the rocker nut with set screw. Set it and all additional parts on a clean surface for inspection and replacement in the engine. Carefully remove the rocker and the ball. Remove the pushrod taking note of which end goes against the rocker and which end goes into the pushrod tube. Inspect the lash cap for wear. The top surface which comes in contact with the rocker should not be "dished out". It should also be relatively snug on the valve and certainly should not rock at all on the valve. Replace as necessary. Visually inspect the rocker and the pushrod for any signs of excessive wear. Roll the pushrod on a flat surface to ensure that it is not bent. Replace any part as necessary. Replace the parts exactly as removed.

   CARE MUST BE TAKEN that the pushrod is properly seated in both the rocker and in the lifter, (at the bottom of the pushrod tube). A common error is to have the pushrod improperly located in the rocker arm. Adjust the lash as per instructions in the lash adjustment section. After the adjustment has been made, slowly rotate the engine through two complete revolutions and repeat the valve adjustment as necessary. Continue this process until lash remains unchanged after two complete revolutions. If any parts were replaced, a valve adjustment should be performed hourly until the lash stabilizes.

NOTE: When replacing a lash cap, it is important to seat it on the valve completely. Tapping the lash cap onto the valve with a **plastic** tipped hammer may be necessary. It is important that the piston is **not** near the top of its stroke when tapping on the lash cap. Observing the gap between the lash cap and the keeper will ensure that the lash cap is seated properly.

NOTE: When replacing lash caps it is important to realize that an intake lash cap is different from an exhaust lash cap. The cavity on an exhaust lash cap is .120"/.125" deep. This depth on an intake lash cap is .145"/.150". Incorrectly installing an intake lash cap on an exhaust valve would result in the lash cap hitting the valve keepers.

C. Camshaft Lift Inspection: This should be done if excessive valve adjustment is repeatedly performed on a valve AND on the valve directly opposite it, suggesting wear or breakdown of a cam lobe. Remove the valve cover from one side of the engine and mount a 1" dial travel indicator exactly parallel with the valve and contacting the "flat" of the valve spring retainer. (This is generally done with a magnetic base type indicator mounted on a fabricated steel plate attached locally to the rocker box.)

   Zero the indicator when the engine is in the position to adjust that particular valve. Rotate the engine through two complete revolutions and note the maximum lift generated at the valve. Compare your findings with the specifications in the "Component Specifications And Wear Limits" section of this manual. If you find that a reading appears to be out of tolerance, take a reading on the valve directly opposite the suspect valve to verify that the problem is with the cam lobe and not something else. This is not an inspection that is regularly performed. It should only need to be done at 500 hour intervals unless a problem warrants the inspection.

3. VALVE LASH ADJUSTMENT

CAUTION: Valve adjustments can ONLY be made after the engine has cooled down and its internal temperature has stabilized at 50° to 90° F. The aluminum case, waterjackets, and cylinder heads will expand with temperature more than the steel pushrods, causing a major difference between "hot" and "cold" valve lash. Adjustments made to a warm engine can result in valves not closing when the engine is cool; conversely, if the engine is too cold when making the adjustments, the lash settings will be too big at operating temperatures.

A. MAKE SURE that the ignition switches are OFF

B. Remove both valve covers. (See "Valve Cover Removal")

C. Rotate the engine in a counter clockwise direction (looking down from the top) until the oval holes in the flywheel are centered over the seam of the engine case. At this point, two of the valves are FULLY open. This happens every 180 crankshaft degrees at approximately 90 degrees before and after top dead center.

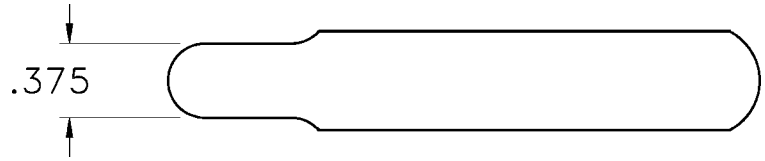
NOTE: The only proper way to rotate the engine is with a specially made tool which grips the flywheel ring gear. Two sources to obtain this tool are Snap On Tools and Mac Tools. DO NOT attempt to rotate the engine by engaging the starter or by rotating the main rotor blades by hand. This can cause damage to the rotor system and displace lead/lag adjustments. If making a valve lash adjustment with the main rotor blades attached, be aware that any movement of the engine in a clockwise direction will cause the blades to rotate.

D. The rocker directly opposite from the valve, which is fully open, is now ready for adjustment. Example: If the #1 exhaust valve is fully open, the #3 exhaust valve is ready for adjustment at the rocker.

CAUTION: You may notice that there are crankshaft positions in which the valve lash will be slightly increased. Do not re-adjust the lash at these locations. The lash must be properly set in the crankshaft position which places the valve opposite the one to be adjusted at a full open position.

E. Use the feeler gauge set which has been modified per the following drawing. Measure the clearance as follows: Insert the blade between the rocker and the lash cap. While moving the rocker up and down, center the rocker on the valve. The proper size is determined when the feeler gauge has a light drag when moved back and forth. (The feeler gauge must be a snug fit and should not easily slide in and out between the valve and rocker.)

NARROW THE REQUIRED FEELER GAUGE AS SHOWN. LEAVE A SMOOTH ROUND EDGE.

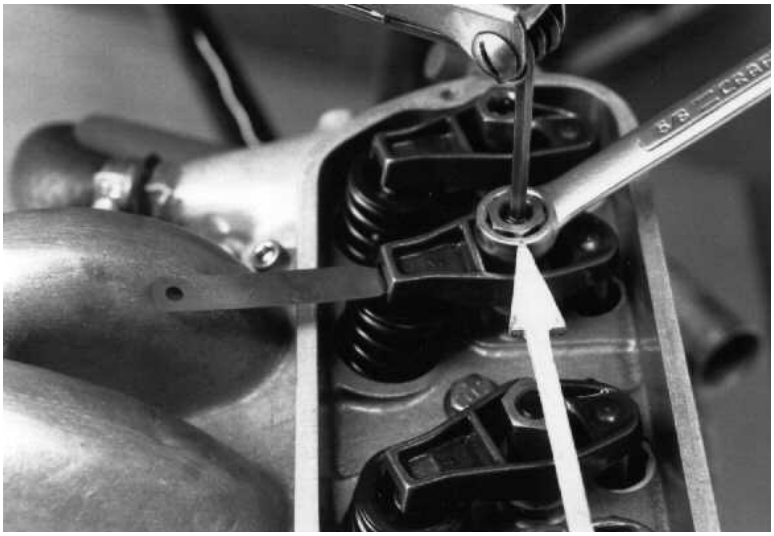


NOTE: IT IS IMPORTANT to measure the lash before any adjustment is made. In addition to making the correct adjustment you are also monitoring the valve train for excessive wear of parts. A clear and simple indication of wear in the valve train is the continued development of excessive lash on any one valve. For this reason, it is recommended that you keep records of all valve lash adjustments.

Any time a lash measurement is made and several of the valves have a lash of more than .008", this is a clear indication that you need to make more regular adjustments. Any lash found in excess of .008" warrants an inspection of the corresponding lash cap.

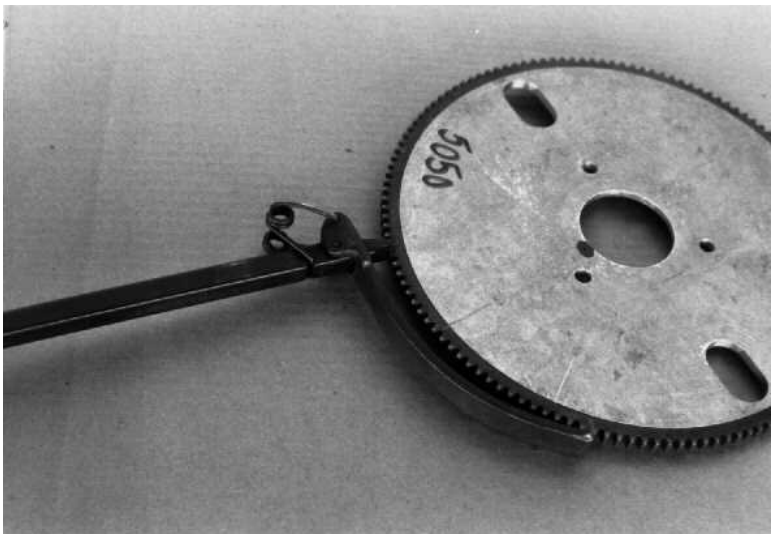
WARNING: Because of the design of the camshaft in the RI 162F engine, it is essential that proper lash be maintained. Excessive lash will cause damage to the lash caps, pushrods, camshaft, and the timing gear.

F. If adjustment is required, loosen the set screw and rocker nut. With the .004" feeler gauge in place, tighten the rocker nut by hand until the feeler gauge is snug when you move the rocker up and down. Hold the nut in place and tighten the set screw to 120 in. lbs. Check the adjustment. The .004" feeler gauge should easily slide between the rocker and the lash cap. When moving the rocker up and down, if the .006" feeler gauge can be inserted, it must have a light drag when moved back and forth between the rocker and lash cap. It should not move in and out loosely. (The reason that you should first turn the rocker nut down snug by hand is that the tightening of the set screw causes the nut to back off slightly and loosen up your adjustment. A little practice will give you the right feel for the process.)

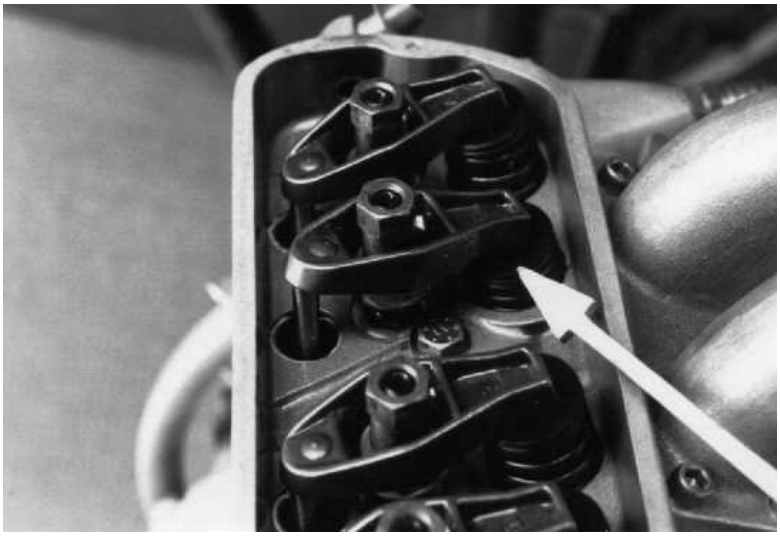


G. Rotate the engine until another set of valves are fully open. Measure and adjust the lash on the opposite valve in the same manner. Continue the process until ALL of the valves are measured and adjusted. Then rotate the engine and re-check all eight valve lash settings.

FLYWHEEL ROTATION TOOL



FULLY OPEN VALVE



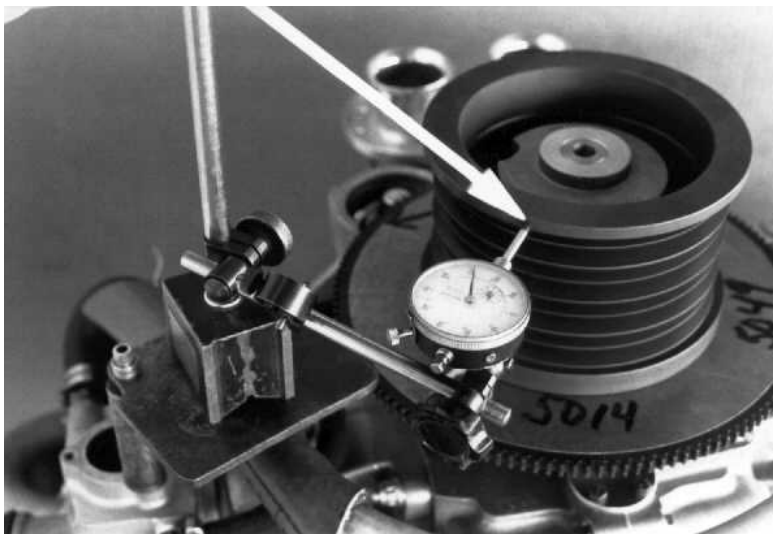
G. MAIN DRIVE PULLEY

1. REMOVAL

The drive pulley, flywheel and drive flange are indexed with punch marks. Note the mark on the base of the pulley and on the flywheel next to it. These should be lined up upon reassembly. After the pulley is removed, you will see another punch mark on the flywheel next to a mark on the drive flange. These must also be lined up on reassembly. In order to keep the engine from rotating while the bolts retaining the pulley are removed, hold the flywheel with the special flywheel rotating tool. Loosen and remove the three bolts, pulley and the flywheel. There may be a shim between the pulley and the flywheel. If there is, outline its location for reassembly.

2. INSTALLATION

Clean all surfaces of the parts to be reassembled. Place the flywheel on the drive flange aligning the index marks. Insert all three bolts with washers in the pulley prior to positioning it onto the flywheel. Align the index marks and carefully lower the pulley onto the flywheel. Lightly snug, then torque each of the bolts to 28 ft. lbs. Remove one spark plug from each cylinder. Prior to removal, clean the area around each plug to avoid dirt contamination of internal engine parts. Using a dial indicator, check the run out of the main drive pulley when rotating the engine. This can be done by attaching a fabricated steel plate to the engine and mounting the indicator on a magnetic base. (See photo below.)



The indicator should contact the pulley on the outside surface approximately .150" from the top of the pulley. The total indicated run out reading must be .004" or less. If it is not, the pulley can be moved to a different position on the flywheel. If it still runs out too much, a shim will have to be added between the pulley and the flywheel in order to correct the problem. Once the pulley meets the run out requirement, remove and replace the bolts one at a time using Service Removable Loctite #242. Removing, applying Loctite, replacing, and re-torquing the bolts one at a time should not change the run out, but recheck the reading to be sure.

3. BEARING REPLACEMENT

This is a service offered by the factory. Refer to the parts list and exploded view drawing of the Main Drive Pulley when performing this maintenance.

Remove the snap ring from the shaft. Deburr the shaft. Heat the assembly to 275° F. DO NOT exceed 300° F at any time during this procedure! Carefully support the pulley and press out the shaft-drive cup assembly. Remove the snap ring which retains the bearings in the pulley. Carefully deburr the snap ring groove area of the pulley. Reheat the pulley to 275° F. Carefully support the pulley and press out the bearings and spacer. Allow all parts to air cool.

Remove the grease fitting and thoroughly clean the pulley including the bearing bore and the drilled passageways. All traces of Loctite must be removed and the bearing bore must be carefully deburred. Use acetone to final clean the bearing bore. Replace the grease fitting. Similarly clean the drive cup assembly and the bearing spacer. Place the drive cup assembly in a freezer and allow enough time for it to stabilize in temperature before proceeding. Place the pulley in an oven and heat to 275 degrees F.

Wipe all surface lubrication from the replacement bearings. Using an air grinder with an abrasive disk, carefully grind a notch in the narrower of the two bearings, part number A24-1602. (Use the old bearing as a guide.) Use acetone to clean the I.D. and O.D. of both bearings. Remove one seal from each bearing by carefully prying them out with a small screwdriver. On the notched bearing, remove the seal from the side with the notch. Put a light film of #609 Loctite on the O.D. of both bearings.

Remove the pulley from the oven and install the bearings and the bearing spacer. It is important that the notch in the bearing lines up with the drilled passageway upon assembly. The seal remaining in each bearing must face out! If the pulley was properly prepared, the bearings should drop in. However, make sure to carefully align the bearings when assembling and use an arbor press to seat and align the bearings in the pulley bore. The bearings must be pressed by contact on the outer race and not on just the inner race. Install the snap ring in the pulley. Remove the cup assembly from the freezer. Wipe off any moisture contamination on the shaft using acetone. Put a light film of #609 loctite on the portion of the shaft which will contact the top bearing. Similarly place a light film on the I.D. of the bottom bearing. Immediately install the cup assembly. It should drop in. If the press is required, only light pressure is allowed or damage to the bearings could occur. Wipe off any excess Loctite from the bottom of the shaft and install the snap ring. Allow the assembly to cool and check the bearings for freedom of movement by rotating the drive cup in the pulley. If the bearings feel tight or rough, lightly tap the shaft of the drive cup with an aluminum or brass hammer. This will usually free up the bearings. Slowly pump 7 shots of grease into the pulley while rotating the drive cup.

NOTE: RI 162F engines shipped after the introduction of ACIS (Altitude Compensation Induction System) have an additional groove on the main drive pulley for the belt that drives the supercharger. This type of pulley requires the use of the main drive pulley grease tool, part number E38-6700. To use the tool, find the threaded hole in the supercharger belt groove. Remove the set screw which plugs the hole. Screw the threaded end of the tool into the hole and apply the grease. When done, remove the tool and reinstall the set screw, making sure the screw is tight. Wipe away excess grease.

Section 3: Start-Up and Engine Run In Procedures

A. INTRODUCTION

It is important that you read this entire manual as vital procedures are contained throughout. Each section contains relevant information essential to properly start and operate the powerplant. It is mandatory that you read Section II (Individual System Procedures) prior to starting the power plant for the first time. Failure to follow all of these procedures may damage the engine. Monitor the RI-162F engine very closely especially during the first 5 hours of operation.

WARNING: The engine can be started without the main rotor blades installed, however:
A. The pitch control rods of the rotor system must be removed from the rotating swash plate.
B. All remaining components of the drive system must be connected.
C. The engine must not be operated above 2000 RPM.
D. The engine must not be run at idle for extended periods of time.

WARNING: When the starter is engaged, all drive train components will turn, including the main rotor blades if they are installed.

WARNING: It is **VERY IMPORTANT** to not exceed an idle until the coolant temperature reaches 160° F and the thermostat opens. Oil temperature must also be in the green range on the gauge. **IF THE THERMOSTAT IS CLOSED AND THE ENGINE EXCEEDS 2400 RPM, THE PRESSURE IN THE COOLING SYSTEM COULD MORE THAN DOUBLE AND CAUSE CONSIDERABLE DAMAGE.**

DO NOT idle the engine for long, extended periods of time. Once the coolant and oil temperatures reach the green range on the gauges, the RPM and LOAD should be varied for most effective “run in”. The engine should NEVER be idled for longer than is necessary. On shut down, idle the engine only long enough to cool down and stabilize the engine components. A water temperature drop of 5-10° F after set down from a hover is adequate for component stabilization.

Follow the maintenance requirements closely. Frequent inspections will expose the need for adjustments before problems and damage occur. Individual experiences may also direct you toward ADDITIONAL inspections and adjustments beyond the increments outlined in this manual.

WARNING: DO NOT operate the RI-162F powerplant in a rough running condition under load. (High frequency vibration or roughness in the engine is readily felt through the pedals in the ship).

The initial start-up procedure on the engine will require at least two people. Each person should have definite responsibilities. A comprehensive review of all procedures and related duties ahead of time will eliminate most of the confusion during the exciting first few minutes of engine operation. Proper preplanning and complete comprehension of all material contained in this manual are essential ingredients to a successful operation of the powerplant.

B. FIRST START OUTLINE SUMMARY

1. Prepare the Fuel System, Cooling System, Oil System and Ignition System for first start-up by complying with the information contained in Section II.

2. Wear safety glasses and have a fire extinguisher nearby. Be careful of all rotating parts, especially the main rotor blades, the tail rotor blades, and belt assemblies.

3. It is advisable to perform these procedures away from other people because of the distractions and danger a crowd presents.

4. Pay special attention to:

   A. Leaks, which present a fire hazard
   B. Oil pressure
   C. Water temperature
   D. Rotating parts

5. We advise you to attend our training program prior to starting the engine. The hands-on instruction regarding the proper care and operation of the engine is extremely valuable to even the best mechanic.

C. MAINTENANCE REQUIREMENTS

FIRST HOUR SERVICE

1. **MEASURE AND ADJUST VALVE LASH AND INSPECT VALVE TRAIN:** If any adjustment is necessary at one hour, valve adjustment should be repeated hourly until the lash stabilizes. (Initial "break in" of the valve train may require several hourly adjustments. It is extremely important to make these inspections and adjustments.)

2. **RE-TORQUE BOLTS:** Re-torque the bolts on the exhaust manifold flanges, intake manifolds, and waterjacket elbows.

3. **INSPECT COOLING SYSTEM:** Check entire system, including engine, for any sign of leakage. Make sure all hose clamps are installed past the bead or flare on the end of the adjoining tube or fitting and re-tighten them. Check the hoses, making sure there is no interference with vibrating or rotating parts or any sign of heat damage. Re-bleed the cooling system at the water pump, radiator, and engine.

4. **INSPECT OIL SYSTEM:** Check entire system for any sign of leakage. Check the security of all oil line connections. Also check the lines for proper clearance from other parts and heat sources.

5. **INSPECT FUEL SYSTEM:** Check the security of all fuel hoses and check for any signs of leakage on the entire system.

6. **INSPECT IGNITION SYSTEM:** Check all wiring, including spark plug wires, for proper mounting and condition. Replace any wire that shows any sign of damage.

7. **INSPECT THROTTLE CONTROL:** Check return spring and linkage for proper adjustment and freedom of movement.

8. **INSPECT EXHAUST SYSTEM:** Check the entire exhaust system for cracks and leaks. A proper fit of each exhaust manifold to its mating port is important. This can be verified while idling the engine and positioning your finger approximately 1/2" away from the exhaust ports. Test all the way around the circumference of each port for any escaping gases. If no turbulence is felt within the proximity, you can be assured that the system will be sufficiently leak free at full RPM.

   Check the security and condition of all exhaust related shielding.

NOTE: After first run-up, retighten exhaust bolts.

WARNING: All four gaskets should be replaced at the first hint of flange leakage. Any type of exhaust system leak may allow carbon monoxide fumes to enter the cabin area. Exposure to these fumes can be fatal and any indication of leakage must be corrected before operation is continued.

9. **INSPECT FADEC WIRING:** While idling the engine, carefully wiggle all FADEC system connector plugs and wires. Pay special attention to the ECU plugs and wiring bundle. If any problem is encountered, refer to the diagnostic section for the FADEC system.

FIRST FIVE HOUR SERVICE

1. **TORQUE CYLINDER HEAD BOLTS:** The engine must be cold when torquing these bolts. (See "Cylinder Head Torque Sequence" in Section I.) Remove rockers as necessary to access all head bolts. Valve lash adjustment must be done after replacing the rockers. It is advisable to perform this procedure in conjunction with the required valve lash adjustment sequence.

2. **INSPECT AND CLEAN THE FUEL PRE-FILTER:** See Fuel System components section.

3. **REPEAT ALL FIRST HOUR ITEMS**

FIRST TEN HOUR SERVICE

1. **CHANGE OIL AND FILTER**

2. **REPEAT ALL FIRST HOUR ITEMS**

FIRST 25 HOUR SERVICE

1. **TORQUE CYLINDER HEAD BOLTS:** The engine must be cold when torquing these bolts. (See "Cylinder Head Torque Sequence" in Section I.) Remove rockers as necessary to access all head bolts. Valve lash adjustment must be done after replacing the rockers. It is advisable to perform this procedure in conjunction with the required valve lash adjustment sequence.

2. **PERFORM ALL "REGULAR" 25 HOUR SERVICE ITEMS**

Section 4: Inspection and Maintenance Schedule

A. INTRODUCTION

The following schedule is presented as a guide to the regular maintenance required on the engine. It should be followed exactly, as all of the procedures are essential to achieving a long lasting and reliable powerplant. In no way does this mean this is all of the maintenance YOUR engine may require! By closely monitoring all systems and analyzing any problems you encounter, you may find that you need to increase the amount of the attention you give to an individual system or component. Obviously if any problem is encountered either at a regular maintenance interval or during post or pre flight inspections, immediate action must be taken and you will need to closely monitor the situation until you are certain that the problem is completely resolved.

Each service should be performed at every increment in the life of the powerplant.

The procedures necessary to complete each maintenance item are covered in the Individual System Procedures section of the manual.

WARNING: After any rework of the cylinder heads or waterjackets, the inspection and maintenance schedule for a new engine should be followed.

B. 25 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 25 hours.

1. **SERVICE AIR FILTER:** Clean as necessary and inspect for damage.

2. **GREASE MAIN DRIVE PULLEY:** Refer to the specification section for procedure and for correct type and quantity of grease.

3. **TORQUE CYLINDER HEAD BOLTS:** The engine must be cold when torquing these bolts. (See “Cylinder Head Torque Sequence” in Section I.) Remove rockers as necessary to access all head bolts. Valve lash adjustment must be done after replacing the rockers. It is advisable to perform this procedure in conjunction with the required valve lash adjustment sequence.

4. **MEASURE AND ADJUST VALVE LASH AND INSPECT VALVE TRAIN:** Also, if any initial measurement is in excess of .008", inspect the lash cap for wear and repeat valve adjustment at one hour intervals until the lash stabilizes. If repeated excess lash is encountered, all related valve train components should be inspected.

5. **INSPECT COOLING SYSTEM:** Check entire system, including engine, for any sign of leakage. Check the security of all hoses, and make sure all hose clamps are installed past the bead or flare on the end of the adjoining tube or fitting. Re-tighten all hose clamps. Check the hoses, making sure there is no interference with vibrating or rotating parts or any sign of heat damage.

6. **INSPECT OIL SYSTEM:** Check entire system for any sign of leakage. Check the security of all oil line connections. Also, check the lines for proper clearance from heat sources and other parts.

7. **INSPECT FUEL SYSTEM:** Check the security of all fuel hoses and check for any signs of leakage on the entire system.

8. **INSPECT EXHAUST SYSTEM:** Check entire exhaust system for cracks and leaks. Proper fit of each exhaust manifold to its mating port is important. Proper fit can be verified while idling the engine and positioning your finger approximately 1/2" away from the exhaust ports. Test all the way around the circumference of each port for any escaping gases. If no turbulence is felt within the proximity, the system will be sufficiently leak free at full RPM.

   Also check the security and condition of all exhaust related shielding.

9. **INSPECT IGNITION SYSTEM:** Check all wiring, including spark plug wires, for proper mounting and condition. Replace any wire that shows any sign of damage.

10. **RE-TORQUE BOLTS:** Re-torque the bolts on the exhaust manifold flanges, intake manifolds, and waterjacket elbows.

11. **INSPECT THROTTLE CONTROL:** Check return spring and linkage for proper adjustment and freedom of movement. Check cable ends and cable for wear.

12. **CHANGE OIL AND FILTER:** Change oil and filter every six months even if 25 hours of operation has not yet occurred.

C. 50 HOUR SERVICE

NOTE: The following maintenance item is to be performed **EVERY** 50 hours.

1. **SPARK PLUGS:** Re-gap all spark plugs to specification. Check all spark plugs for proper burning. The central ceramic insulator should be a light tan in color, the outside barrel should be light charcoal to dark brown in color. (Prolonged idling of the engine will cause a black soot to form on the spark plugs which will shield visibility of the above determination of colors.) The electrode should have sharp square edges. Replace a spark plug if any sign of wear or damage is evident. Clean and apply a light film of anti-seize to the threads before re-installing the spark plugs.

2. **PERFORM ALL REGULAR 25 HOUR SERVICE ITEMS**

D. 100 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 100 hours.

1. **REPLACE SPARK PLUGS**

2. **TEST CYLINDER LEAKAGE:** Using a cylinder leak down tester, measure the percentage of leakage of each cylinder. If reading is above 15%, determine the source of leakage and repair. With tester hooked up, listen for air leakage at:

   Tail pipe (leaking exhaust valve)
   Plenum intake (leaking intake valve)
   Oil sump breather (leaking by piston rings)

3. **REPLACE FUEL FILTER**

4. **PERFORM ALL REGULAR 25 AND 50 HOUR SERVICE ITEMS**

E. 250 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 250 hours.

1. **REPLACE AIR FILTER**

2. **REPLACE ALL WATER HOSES:** Replace all water hoses, hose clamps, thermostat and coolant. Replace every five years even if 250 hours of operation has not yet occurred.

3. **REPLACE CAM GEAR**

4. **REBUILD CYLINDER HEADS (IF USING 100 LOW LEAD OR LEADED AUTOMOTIVE GASOLINE):** Specifications have been given to perform this service and all of the necessary parts are available from the factory. This is a critical and complex task and should not be attempted by anyone who is not familiar with all aspects of aluminum cylinder head rebuilding. This service is offered by the factory.

5. **PERFORM ALL REGULAR 25 AND 50 HOUR SERVICE ITEMS**

F. 500 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 500 hours.

1. **REBUILD CYLINDER HEADS (IF USING UNLEADED GASOLINE):** Specifications have been given to perform this service and all of the necessary parts are available from the factory. This is a critical and complex task and should not be attempted by anyone who is not familiar with all aspects of aluminum cylinder head rebuilding. This service is offered by the factory.
   NOTE: If using 100 low lead aviation gasoline or leaded automotive gasoline, cylinder heads must be rebuilt every 250 hours.

2. **INSPECT CAMSHAFT LIFT AND END PLAY**

3. **REPLACE MAIN DRIVE PULLEY BEARINGS:** This service is offered by the factory.

4. **PERFORM ALL REGULAR 25, 50, 100 AND 250 HOUR SERVICE ITEMS**

G. 1000 HOUR SERVICE

NOTE: The following maintenance items are to be performed **EVERY** 1000 hours.

1. **REPLACE SPARK PLUG WIRES**

2. **REPLACE ALL FUEL HOSES:** Replace every three years even if 1000 hours of operation has not yet occurred.

3. **REPLACE FUEL INJECTORS**

4. **COMPLETE ENGINE OVERHAUL:** This is a critical and complex task. It is recommended that this service be performed only by the factory and not by anyone else even if they are familiar with all aspects of internal engine overhaul. However, specifications have been given to perform this service and all the necessary parts are available from the factory.

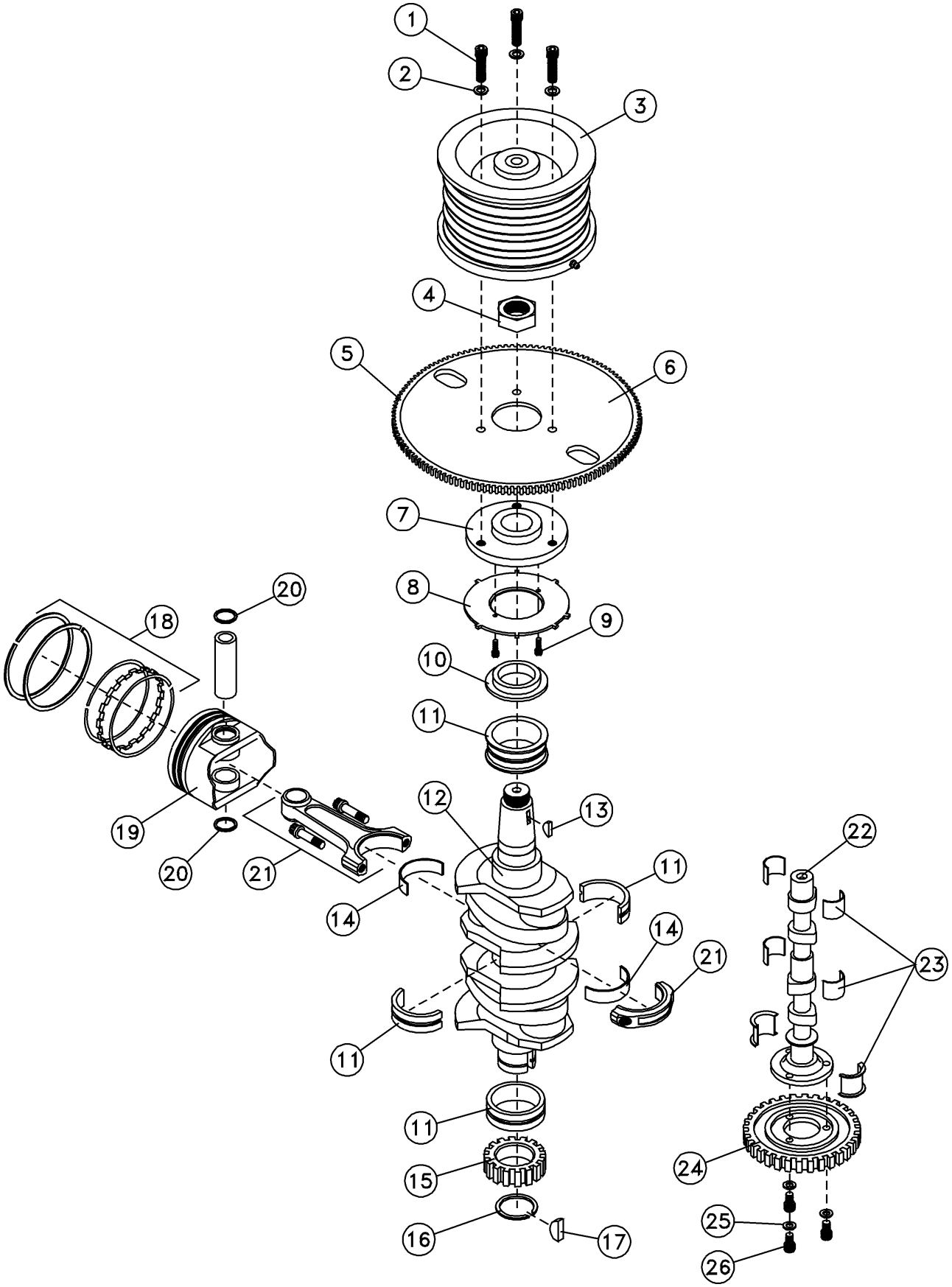
5. **PERFORM ALL REGULAR 25, 50, 100, 250 AND 500 HOUR SERVICE ITEMS**

Section 5: Drawings and Parts Lists

A. ROTATING PARTS ASSEMBLY

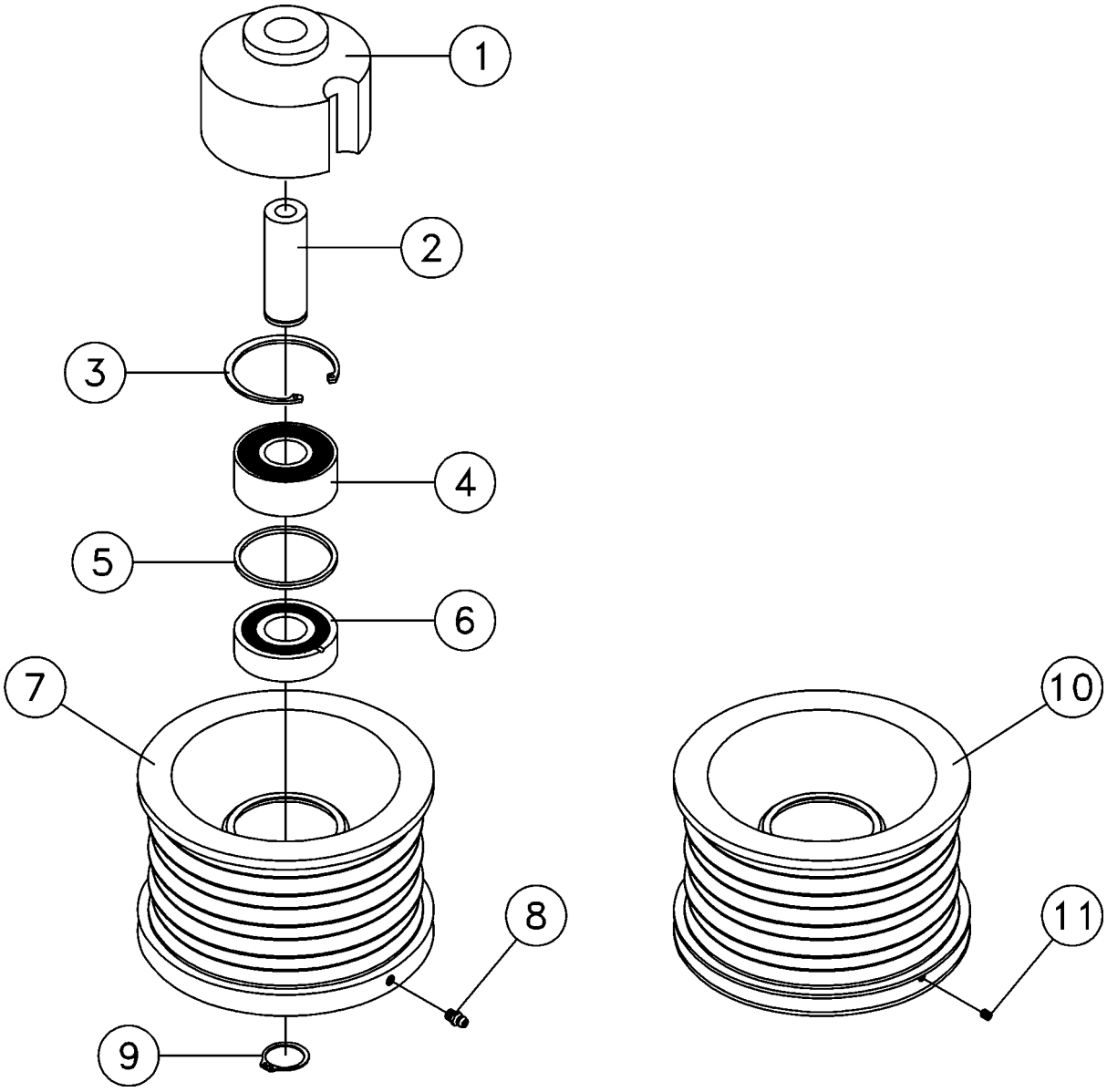
REF. #	PART #	DESCRIPTION	QTY.
1	E00-2611	Bolt 3/8-24 X 1-1/4 SHCS	3
2	E00-4600	AN960-616 3/8 Regular Washer	3
3	A24-1600	Main Drive Pulley Assy	1
	A24-1601	Main Drive Pulley Assy (With Supercharger Belt Groove)	1
4	A24-1012	Crank Nut	1
5	A24-1902	Ring Gear	1
6	A24-1901	Flywheel	1
	A24-1900	Flywheel Assy	1
7	A24-1201	Main Drive Flange	1
8	A24-1211	Timing Wheel	1
9	E00-2310	Bolt 10-32 X 1/2 SHCS	2
10	A24-1009	Thrust Flange	1
11	A24-1013	Main Bearing Set	1
12	A24-1001	Crankshaft	1
	A24-1300	Crankshaft and Flange Assy	1
13	A24-1008	Key-Drive Flange	1
14	A24-1005	Rod Bearing Set	1
	A24-1510	Timing Gear Set, Straight Teeth, Steel	1
15	A24-1520	Crank Gear, Straight Teeth, Steel	1
16	A24-1011	Snap Ring-Crank Gear	1
17	A24-1007	Key-Crank Gear	1
18	A24-1704	162F Piston Ring Set	4
	A24-6020	162F Piston Ring Set, ACIS	4
19	A24-1750	162F Piston (with Pin and Snap Rings)	4
	A24-1702	162F Piston, ACIS	4
20	A24-1740	Spiral Retaining Ring-Piston	8
21	A24-1810	Connecting Rod Assy	4
	A24-1820	Connecting Rod Assy, ACIS	4
22	A24-1501	Camshaft	1
23	A24-1014	Cam Bearing Set	1
24	A24-1530	Cam Gear, Straight Teeth, Steel	1
25	E00-4501	AN960-516 5/16 Regular Washer	3
26	E00-2526	Bolt 5/16-24 X 1/2 SHCS	3

ROTATING PARTS ASSEMBLY



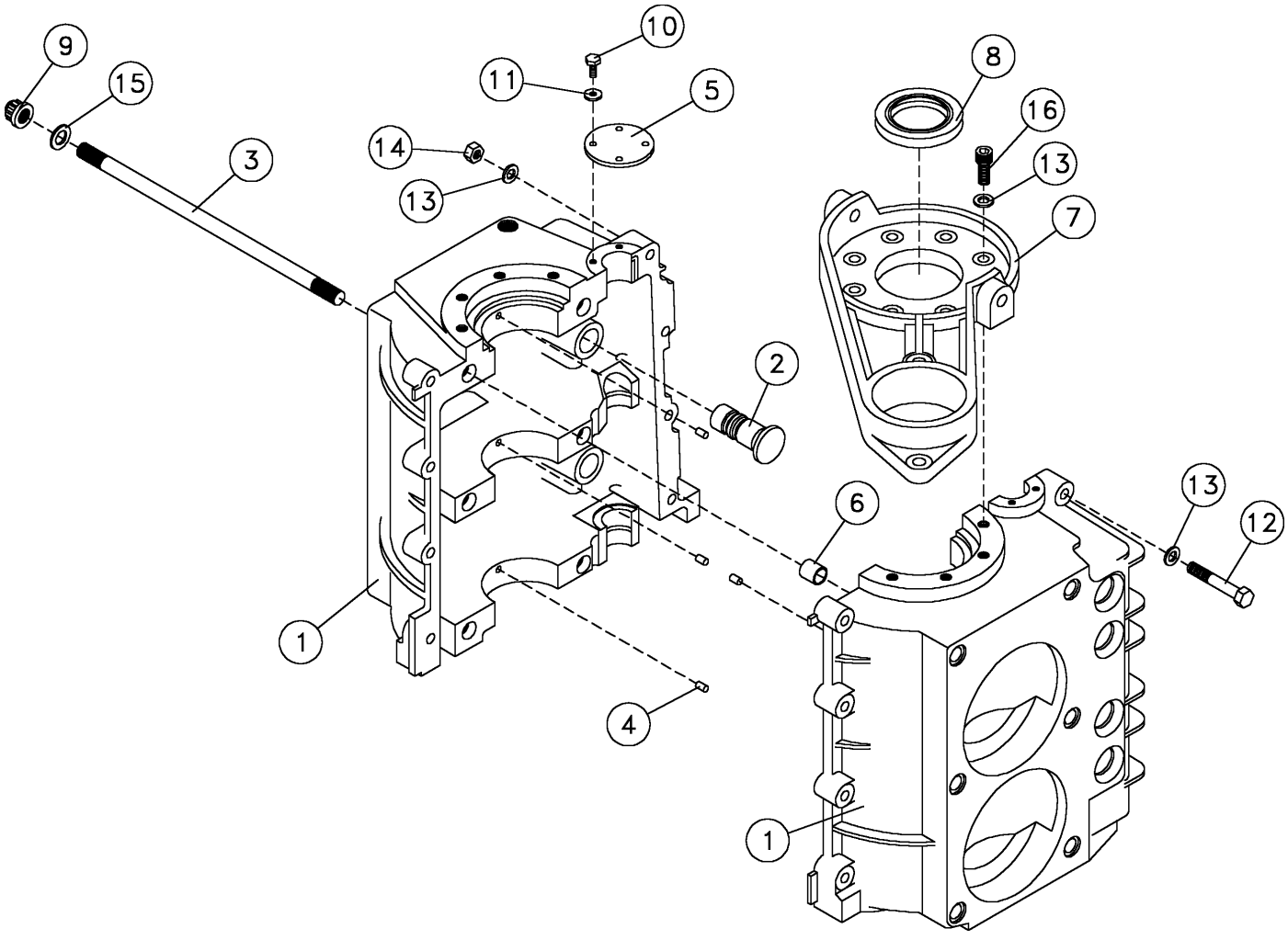
B. MAIN DRIVE PULLEY ASSEMBLY

REF. #	PART #	DESCRIPTION	QTY.
1	A24-1601	Upper Drive Cup	1
2	A24-1603	Stub Shaft	1
3	A24-1605	Snap Ring, Large	1
4	A24-1630	Bearing	1
5	A24-1622	Bearing Spacer	1
6	A24-1602	Bearing	1
7	A24-1610	Main Drive Pulley	1
8	E00-1619	Grease Fitting	1
9	A24-1604	Snap Ring, Small	1
10	A24-1611	Main Drive Pulley, ACIS (With Groove for Supercharger Belt)	1
11	E00-9312	10-32 x 1/4 Set Screw	1



C. CRANKCASE ASSEMBLY

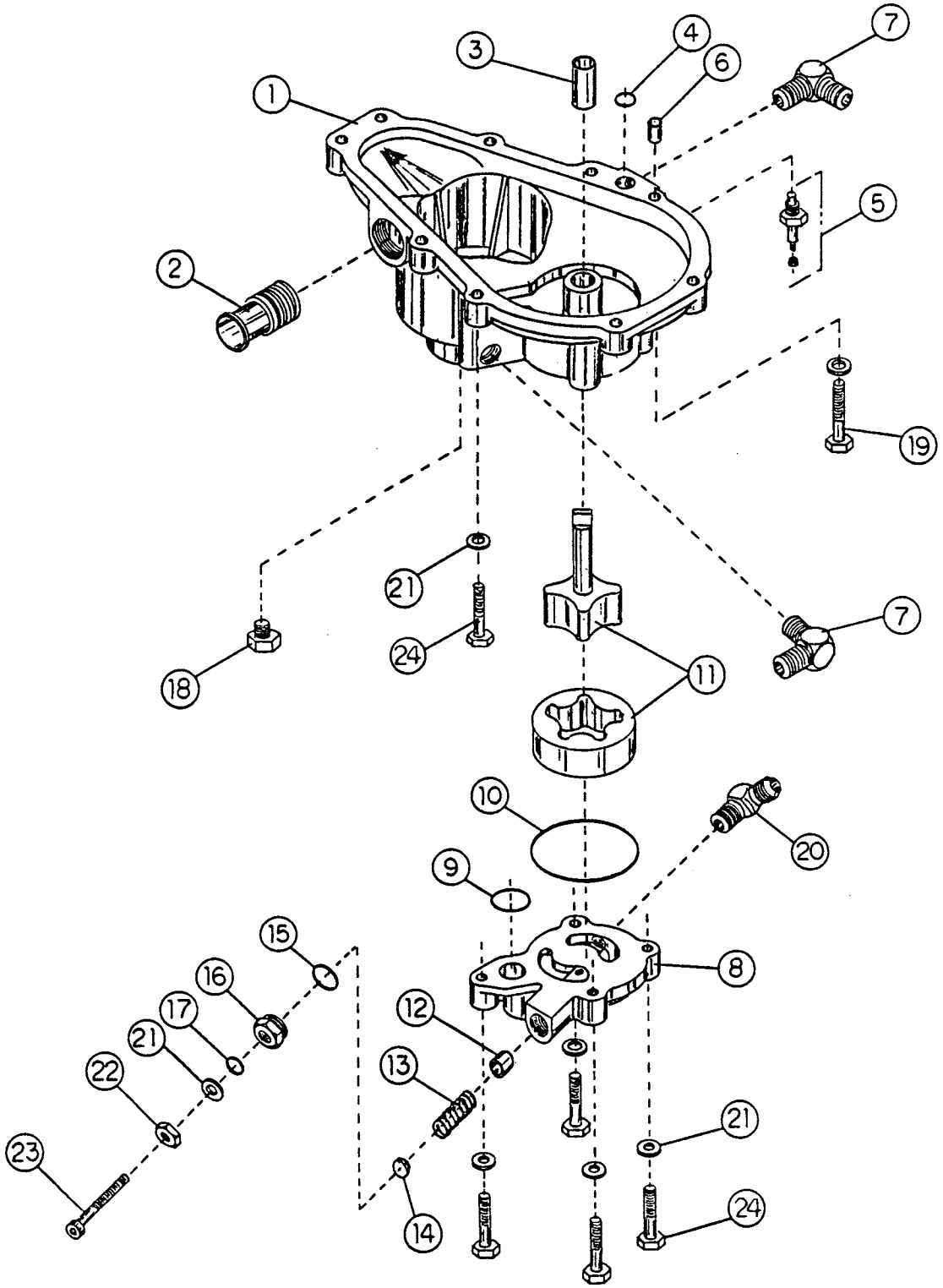
REF. #	PART #	DESCRIPTION	QTY.
1	A24-2001	Crankcase	1
2	A24-2003	Lifters	8
3	A24-2004	Main Stud	6
4	A24-2006	Bearing Pin	4
5	A24-2013	Cam End Plate	1
6	A24-2014	Crankcase Dowel	6
7	A24-2101	Starter Mount	1
8	A24-2103	Oil Seal-Crankshaft	1
9	E00-3901	Nut SPS 42 FLW-720	12
10	E00-2300	Bolt 3/16 X 1/2	4
11	E00-4301	AN960-10 3/16 Regular Washer	4
12	E00-2518	Bolt 5/16 X 2-1/8	8
13	E00-4501	AN960-516 5/16 Regular Washer	24
14	E00-3500	AN365-524A 5/16-24 Fiberlock Nut	8
15	E00-4702	AN960-716 7/16 Regular Washer	12
16	E00-2504	Bolt 5/16-18 X 3/4 SHCS	8



D. LOWER COVER ASSEMBLY

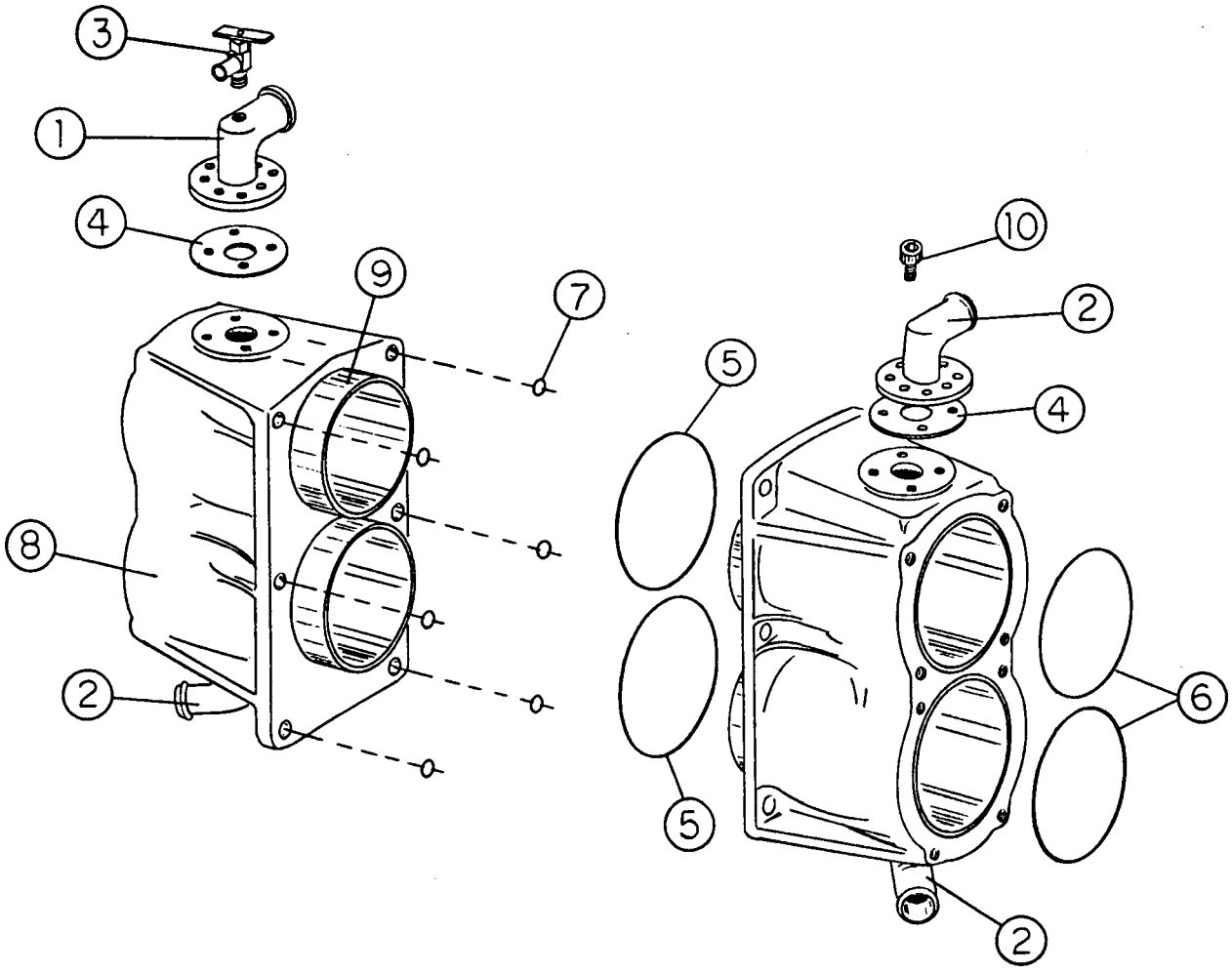
REF. #	PART #	DESCRIPTION	QTY.
1	A24-2007	Lower Cover	1
2	A24-2010	Oil Exit Fitting	1
3	A24-2015	Bushing-Lower Cover	1
4	A24-2016	O-Ring (Main Galley)	1
5	A24-2201	Oil Temp Sender	1
6	A24-2202	Lower Cover Dowel	2
7	A24-2230	90° Oil Hose Fitting	2
	A24-2231	-8 Tee, 3/8 NPT on Side (ACIS)	1
	E38-6460	-8 to -6 Adapter (ACIS)	1
8	A24-2401	Oil Pump Cover	1
9	A24-2402	Oil Pump Cover O-Ring (Small)	1
10	A24-2403	Oil Pump Cover O-Ring (Large)	1
11	A24-2410	Oil Pump Assy	1
12	A24-2450	Piston	1
13	A24-2451	Spring	1
14	A24-2452	Spring Backing Plate	1
15	A24-2453	Gasket (Regulator)	1
16	A24-2454	Oil Pressure Adjustment Plug	1
17	A24-2455	O-Ring (Regulator)	1
18	A24-2220	Oil Drain Plug (1/4 Pipe)	1
19	E00-2529	Bolt 5/16-18 X 2	2
20	A24-2240	45° Oil Hose Fitting	1
21	E00-4501	AN960-516 5/16 Regular Washer	14
22	E00-3501	AN316-5R 5/16 Jam Nut	1
23	E00-2530	Bolt 5/16-24 X 2 SHCS	1
24	E00-2527	Bolt 5/16-18 X 1-1/2	1

LOWER COVER ASSEMBLY



E. WATER JACKET ASSEMBLY

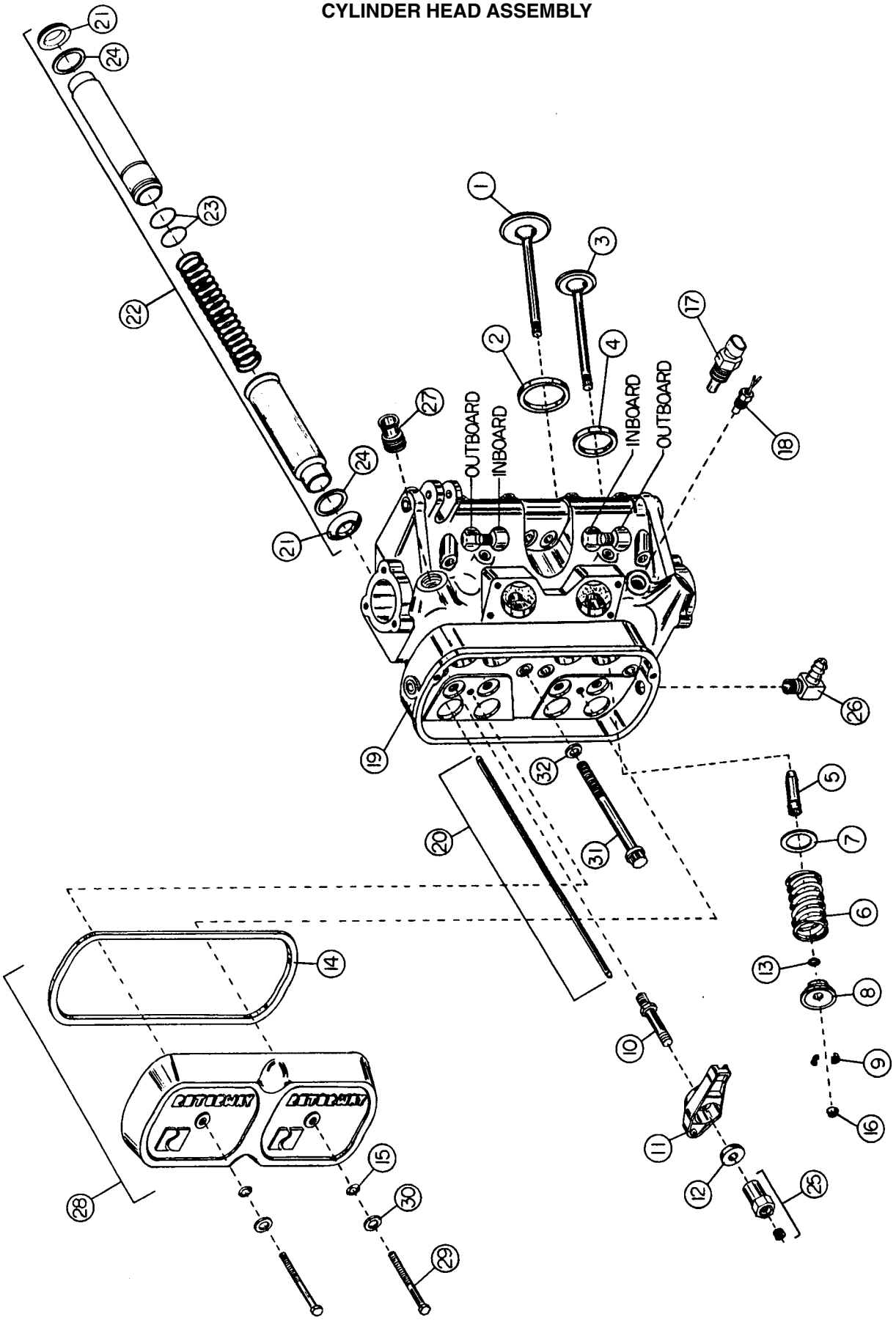
REF. #	PART #	DESCRIPTION	QTY.
1	A24-3040	Waterjacket Elbow, Tapped	1
2	A24-3030	Waterjacket Elbow	3
3	A24-5460	90° Bleed Valve	1
4	A24-3005	Waterjacket Elbow Gasket	4
5	A24-3006	O-Ring (Cylinder Base)	4
6	A24-3007	Compression Seal O-Ring (S.S.)	4
7	A24-3009	O-Ring (Main Stud)	12
	A24-3010	Waterjacket/Sleeve Assy	2
8	A24-3011	Waterjacket	2
9	A24-3012	Cylinder Sleeve	4
10	E00-2443	Bolt 1/4-20 X 5/8 SHCS	16
	A24-3300	Outlet Water Manifold (Large Radius)	1
	A24-3301	Inlet Water Manifold (Small Radius)	1
	A24-3360	Hose, Elbow to Manifold (Upper)	2
	A24-3370	Hose, Manifold to Cylinder Head	2
	A24-3380	Hose, Cylinder Head to Elbow (Lower)	2
	A24-3120	Fire sleeve	8
	E00-9520	Lined Clamp for 1" Hose	12
	E00-9115	1" Cushion Loop Clamp	3



F. CYLINDER HEAD ASSEMBLY

REF. #	PART #	DESCRIPTION	QTY.
1	A24-4002	Intake Valve	4
2	A24-4003	Intake Valve Seat	4
	A24-4004	Intake Valve Guide	4
3	A24-4055	Exhaust Valve	4
4	A24-4056	Exhaust Valve Seat	4
5	A24-4057	Exhaust Valve Guide	4
6	A24-4008	Valve Spring	8
7	A24-4009	Spring Shim	8
8	A24-4010	Spring Retainer	8
9	A24-4011	Spring Keeper (2 per valve)	16
10	A24-4012	Rocker Arm Stud	8
11	A24-4013	Rocker Arm	8
12	A24-4014	Pivot Ball	8
13	A24-4015	O-Ring (Valve Stem)	8
14	A24-4017	Gasket (Valve Cover)	2
15	A24-4018	O-Ring (Valve Cover)	4
	A24-4040	Lash Cap (Intake)	4
16	A24-4050	Lash cap (Exhaust)	4
17	A24-5430	FADEC Water Temp Sensor (Install near Cyl. #2)	1
18	A24-2201	Water Temp. Sender (Install near Cyl. #4)	1
19	A24-4090	Cylinder Head (With Seats and Guides)	2
	A24-4095	Cylinder Head (With Valves)	2
	A24-4100	Cylinder Head Complete Assy	2
20	A24-4110	Pushrod	8
21	A24-4204	Pushrod Tube Seals	16
22	A24-4260	Pushrod Tube Assy	8
23	A24-4270	Pushrod Tube O-Ring	16
24	A24-4280	Pushrod Tube Seal Ring	16
25	A24-4300	Polyloc Assy	8
26	A24-4075	90° Oil Drain Fitting	2
27	A24-4071	Water Hose Fitting	4
28	A24-4030	Valve Cover (with Gasket)	2
29	E00-2430	Bolt 1/4-20 X 2-3/4	4
30	E00-4402	MS15795-10 1/4 Large Washer	4
	A24-4036	Bolt 3/8 X 2 12 Point	4
	A24-4037	Bolt 3/8 X 3-1/8 12 Point	4
31	A24-4038	Bolt 3/8 X 4-5/8 12 Point	8
32	E00-4600	AN960-616 3/8 Regular Washer	20

CYLINDER HEAD ASSEMBLY

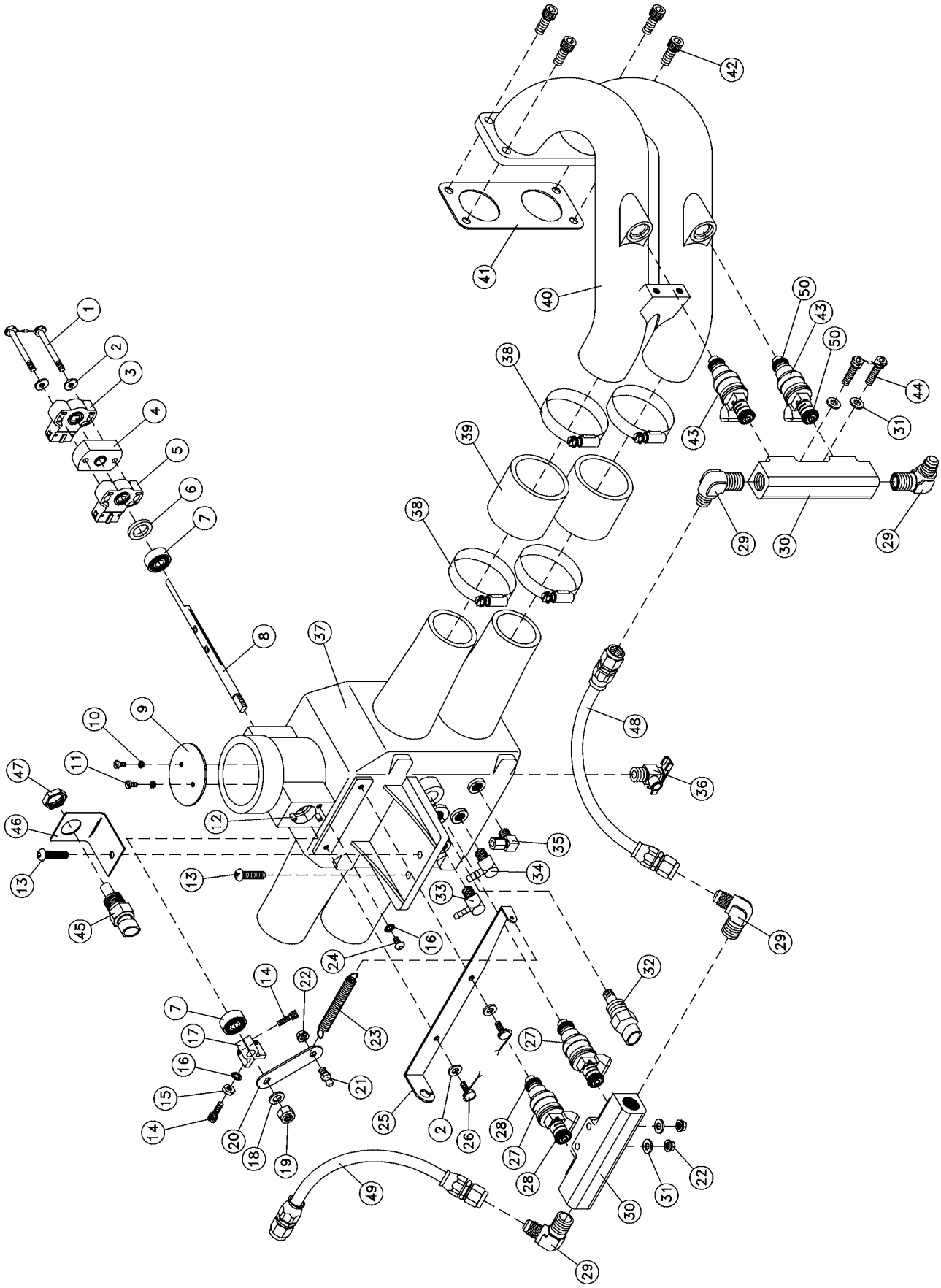


G. PLENUM AND MANIFOLD ASSEMBLY

REF. #	PART #	DESCRIPTION	QTY.
1	E00-2324	Bolt 3/16 X 1-7/8 Drilled Head	2
2	E00-4301	AN960-10 3/16 Regular Washer	4
3	A24-5160	Throttle Position Sensor (Primary)	1
4	A24-5190	TPS Spacer	1
5	A24-5170	Throttle Position Sensor (Secondary)	1
6	A24-5180	TPS Bushing	1
7	A24-5130	Throttle Shaft Bearing	2
8	A24-5120	Throttle Shaft	1
9	A24-5220	Butterfly	1
10	E00-4102	#6 Lock Washer	2
11	E00-2100	6-40 X 5/16 Screw	2
12	E00-5103	5/32 X 3/4 Roll Pin	2
13	E00-2445	Bolt 1/4-28 X 1-1/8 Button Head SHCS	2
	A24-5280	Throttle Stop Arm Assy	1
14	E00-2325	Bolt 10-32 X 5/8 SHCS	2
15	E00-3102	10-32 Jam Nut	1
16	E00-4304	#10 Lock Washer Internal Tooth	2
17	A24-5250	Throttle Stop Arm	1
18	E00-4501	AN960-516 5/16 Regular Washer	1
19	E00-3500	AN365-524A 5/16-24 Fiberlock Nut	1
	A24-7692	Throttle Arm Assy	1
20	A24-7690	Throttle Arm	1
21	A24-7691	Ball Stud	1
22	E00-3411	1/4-28 Small Hex Locknut	3
23	A24-5340	Throttle Return Spring	1
24	E00-2326	Bolt 10-32 X 3/8 Button Head SHCS	1
25	A24-5330	Plenum Cable Bracket	1
26	E00-2327	Bolt 3/16 X 3/8 Drilled Head	2
27	A24-5360	Fuel Injector (Secondary)	2
28	A24-5370	Fuel Injector O-Ring (Secondary)	8
29	A24-5300	-6 to 3/8 NPT 90° Fitting	6
30	A24-5380	Fuel Rail	3
31	E00-4401	AN960-416 1/4 Regular Washer	6
32	A24-5420	Air Temp. Sensor	1
33	A24-5450	3/16 Hose X 1/8 NPT 90° Fitting (to Fuel Pressure Regulator)	1
34	A24-5440	1/4 Hose X 1/8 NPT 90° Fitting (to Manifold Pressure Sensor)	1
35	E28-7240	1/8 NPT X 1/8 Compression Fitting (to Manifold Pressure Gauge)	1
36	A24-5460	90° Bleed Valve	1
37	A24-5010	Plenum	1
	A24-5011	Plenum (ACIS)	1
38	E00-9550	Lined Clamp for 1-3/4" Hose	8
39	A24-5390	Hose, Runner to Plenum	4
40	A24-5020	Intake Manifold Runner	2
41	A24-7002	Intake Manifold Gasket	2
42	E00-2533	Bolt 5/16-18 X 7/8 SHCS	8
43	A24-5350	Fuel Injector (Primary)	4
44	E00-2446	Bolt 1/4-20 X 7/8 SHCS Drilled Head	4
45	A24-5430	Secondary Air Temp Sensor	1
46	A24-5400	Bracket, Secondary Air Temp Sensor	1
47	A24-5490	Nut, Secondary Air Temp Sensor	1
48	A24-5470	Fuel Hose Assy. (Pilot [1])	1
49	A24-5480	Fuel Hose Assy. (Pass.[1])	1
50	A24-5371	Fuel Injector O-ring (Primary)	4

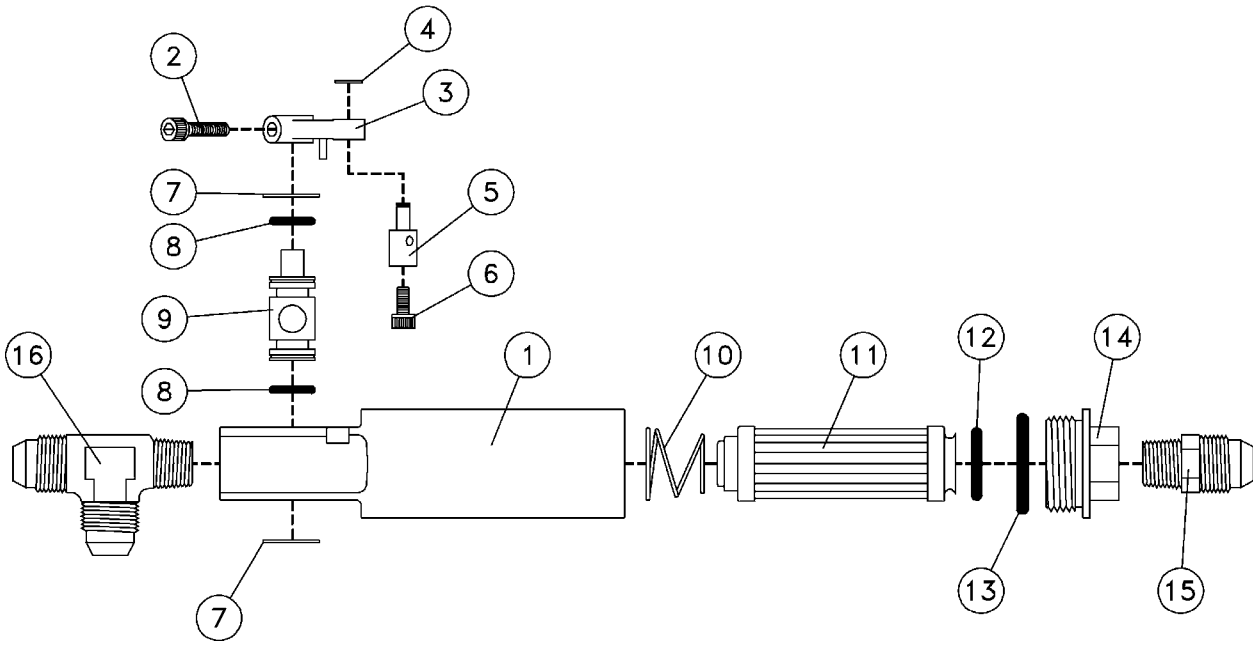
[1] Hoses are swapped for ACIS.

PLENUM AND MANIFOLD ASSEMBLY



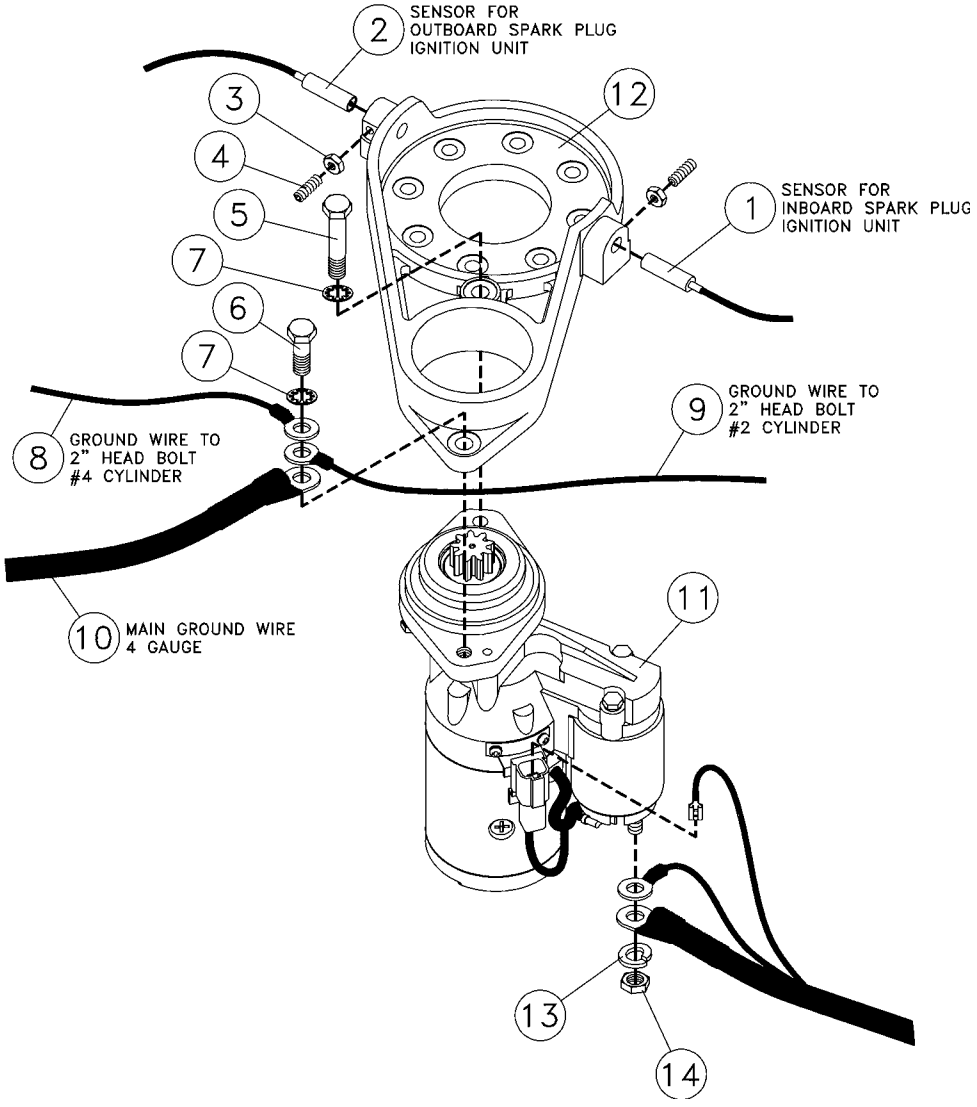
H. FUEL SHUT-OFF VALVE/FILTER ASSEMBLY

REF. #	PART #	DESCRIPTION	QTY.
	E25-4660	Fuel Shut-off Valve/Filter Assy	1
1	E25-4680	Fuel Valve/Filter Housing	1
2	E00-2325	Bolt 10-32 X 5/8 SHCS	1
3	E25-4810	Fuel Shut-off Arm	1
4	E25-4790	Clip	1
5	E25-4800	Cable Attachment Barrel	1
6	E00-2328	Bolt 10-32 X 3/8 SHCS	1
7	E25-4840	Snap Ring, Rotor	2
8	E25-4830	O-Ring, Rotor	2
9	E25-4820	Fuel Shut-off Rotor	1
10	E25-4870	Filter Spring	1
11	E25-4860	Stainless Steel Filter Element	1
12	E25-4880	Filter O-Ring	1
13	E25-4695	End Plug O-Ring	1
14	E25-4690	Fuel Valve End Plug	1
15	E25-4240	Adapter, 3/8 NPT X -8 Straight	1
16	E25-4300	Tee, -8 X 3/8 On Run	1



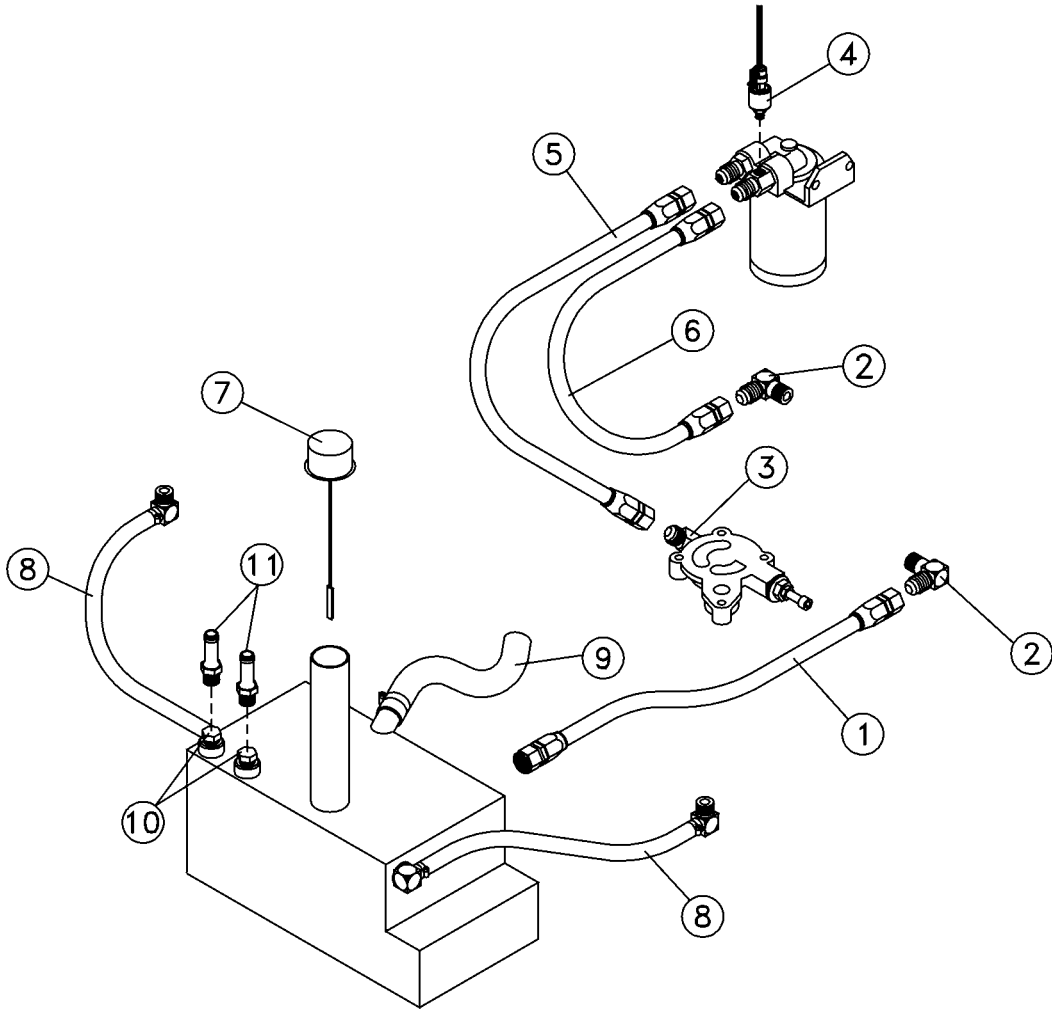
I. ELECTRICAL SYSTEM

REF. #	PART #	DESCRIPTION	QTY.
1	A24-5410	Inboard Ignition Sensor	1
2	A24-5411	Outboard Ignition Sensor	1
3	E00-3403	MS35691-405 1/4-20 Jam Nut	2
4	E00-9303	1/4-20 X 3/4 Set Screw	2
5	E00-2609	Bolt 3/8 X 2	1
6	E00-2602	Bolt 3/8 X 1-1/8	1
7	E00-4603	3/8 Internal Tooth Lock Washer	2
8	A24-8120	Ground Wire Assy. (#4 Cylinder)	1
9	A24-8110	Ground Wire Assy. (#2 Cylinder)	1
10	E35-8402	Ground Wire Assy. 4 Gauge	1
11	A24-8101	Starter (Lightweight)	1
12	A24-2101	Starter Mount	1
13	E00-4504	5/16 Lock Washer	1
14	E00-3900	8mm X 1.25 mm Nut	1



J. OIL SYSTEM

REF. #	PART #	DESCRIPTION	QTY.
1	E28-6112	Oil Hose, Sump to Oil Pump	1
2	A24-2230	90° Fitting	2
3	A24-2240	45° Fitting (Pump Outlet)	1
4	E36-3120	Oil Pressure Sender	1
5	E28-6142	Oil Hose, Oil Pump to Filter	1
6	E28-6122	Oil Hose, Filter to Engine	1
7	E28-1201	Oil Breather Cap With Dipstick	1
8	E28-1192	Valve Cover Drain Hose	2
9	E28-1230	Main Oil Drain Hose	1
10	E28-1180	3/8 NPT Brass Plug	2
11	E38-6660	1/2” X 3/8 NPT Hose Barb (ACIS)	2



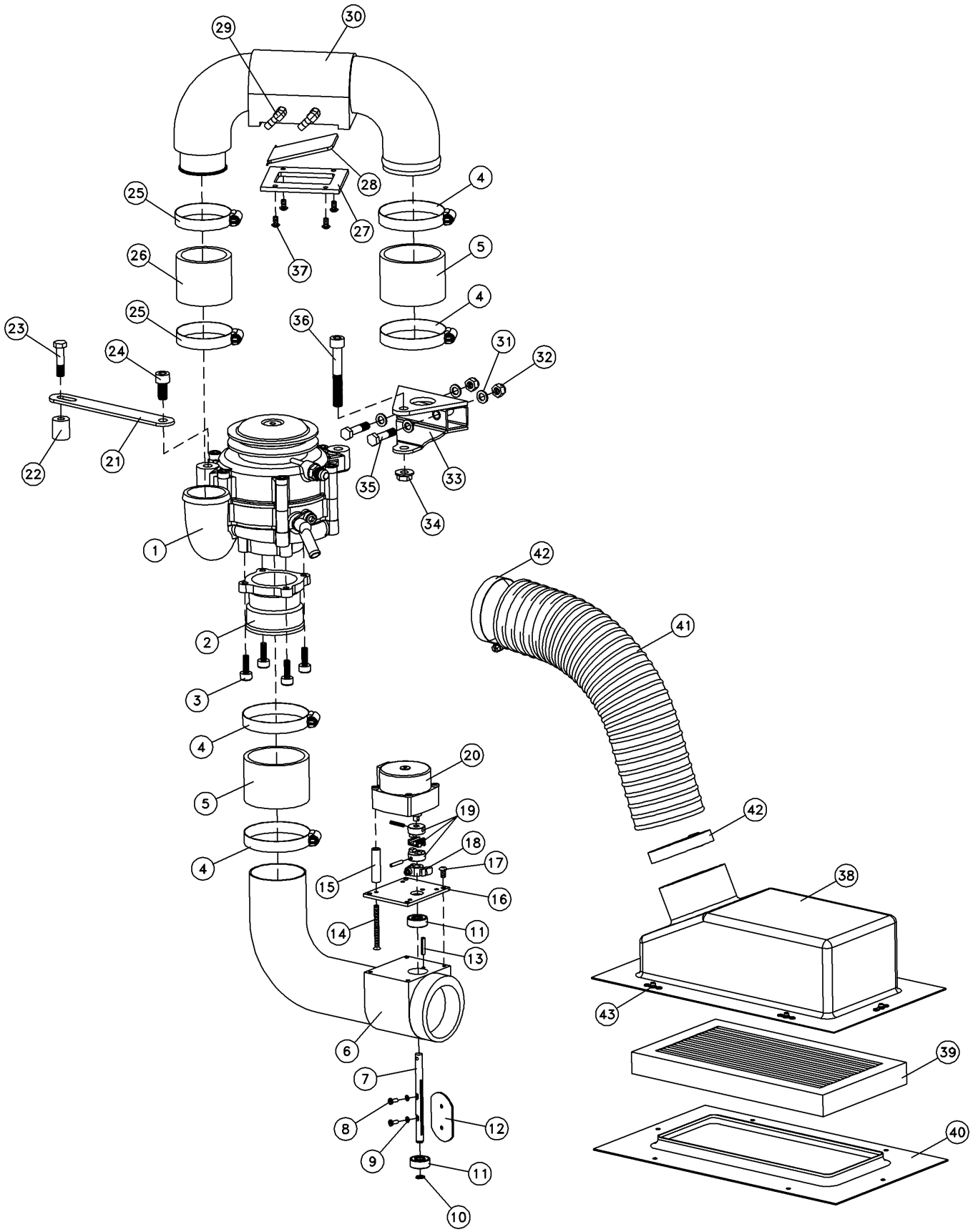
K. GASKETS AND O-RINGS

PART #	DESCRIPTION	QTY. PER ENGINE
A24-1101	Complete set	1
A24-2016	Main Galley O-Ring	1
A24-2103	Oil Seal-Crankshaft	1
A24-2402	Oil Pump Cover O-Ring (Small)	1
A24-2403	Oil Pump Cover O-Ring (Large)	1
A24-2453	Oil Pump Regulator Gasket	1
A24-2455	Oil Pump Regulator O-Ring	1
A24-3005	Waterjacket Elbow Gasket	4
A24-3006	Cylinder Base O-Ring	4
A24-3007	Compression Seal S.S. O-Ring	4
A24-3009	Main Stud O-Ring	12
A24-4015	Valve Stem O-Ring	8
A24-4017	Valve Cover Gasket	2
A24-4018	Valve Cover O-Ring	4
A24-4204	Pushrod Tube Seal	16
A24-4270	Pushrod Tube O-Ring	16
A24-5370	Fuel Injector O-Ring	12
A24-7002	Intake Manifold Gasket	2
A24-9710	Exhaust Manifold Gasket	4

L. ALTITUDE COMPENSATION INDUCTION SYSTEM

REF. #	PART #	DESCRIPTION	QTY.
1	E38-3000	Supercharger Assy	1
2	E38-3040	Lower Adapter	1
3	E00-2901	Bolt 6mm X 20 mm SHCS	4
4	E00-9540	#40 Lined Hose Clamp	4
5	E38-6030	Hose, 2-1/2" I.D. X 2"	2
6	E38-5000	Stepper Assy	1
7	E38-5050	Stepper Butterfly Shaft	1
8	E00-2100	6-40 X 5/16 Screw	2
9	E00-4102	#6 Lock Washer	2
10	E38-5140	Snap Ring	1
11	E38-5080	Sealed Bearing	2
12	E38-5060	Stepper Butterfly	1
13	E00-5103	5/32 X 3/4 Roll Pin	1
14	E00-1206	8-32 X 2" Csk Screw, All Thd	4
15	E38-5101	Stepper Bushing	4
16	E38-5090	Stepper Motor Mounting Plate	1
17	E00-2326	10-32 X 3/8 Button Hd Cap Screw	4
18	E38-5112	Throttle Stop Arm	1
	E00-2325	Bolt 10-32 X 5/8 SHCS	1
19	E38-5071	Flex Coupling (3 pieces)	1
	E00-5101	1/8 X 3/4 Roll Pin	2
	E38-5000	Stepper Motor Assembly	1
20	E38-5010	Stepper Motor	1
	E38-5120	Stepper Motor Controller	1
	E00-1100	6-32 X 1/2 Phil. Hd. Screw	2
	E00-3100	6-32 Fiberlock Nut	2
	E00-1100	#6 Washer	4
21	E38-6200	Adjustment Strap	1
22	E38-6210	Spacer, Adjustment Strap	1
23	E00-2534	Bolt 5/16-18 X 1-5/8 SS	1
24	E00-2902	Bolt 10mm X 20 mm SHCS SS	1
25	E00-9532	#32 lined Hose Clamp	2
26	E38-6040	Hose, 2" I.D. X 2"	1
27	E38-4030	Flapper Cover	1
28	E38-4020	Flapper	1
	E38-4040	Flapper Pin	2
29	E38-4080	1/4 Hose X 1/8 NPT 90° Fitting	2
	E38-4091	1/4” X 42” Blue Hose (1 makes 2)	1
	E00-9170	Plastic Hose Clamp -004	4
30	E38-4000	Flapper Assy	1
31	E00-4501	AN960-516 (5/16 Reg. Washer)	4
32	E00-3500	AN365-524A (5/16 Fiberlock Nut)	2
33	E38-6300	Mounting Bracket Weldment	1
34	E00-3903	10mm Locknut, Stainless Steel	1
35	E00-2514	Bolt AN5-15A (5/16-24 X 1-3/4)	2
36	E00-2903	Bolt 10mm X 70mm SHCS SS	1
37	E00-2332	10-32 X 1/2 Button Hd Cap Screw	4
38	E38-6000	Air Filter Housing	1
39	E38-6010	ACIS Air Filter	1
40	E38-6050	Air Filter Retainer	1
41	E38-6020	3" Flex Hose, 2 ft.	1
42	E00-9544	#44 Lined Hose Clamp	2
43	E00-7000	NAS680A-08 (8-32 Nut Plate)	6
	E00-1201	MS35206-246 (8-32 X 5/8 Screw)	6
	E00-6200	AAC-32 (3/32 X 1/8 Pop Rivet)	12
	E38-6440	Supercharger Belt	1
	E38-6430	1/2” Oil Drain Hose, 25”	2
	E00-9006	#6 Hose Clamp	4
	E38-6600	ACIS Oil Cooler	1
	E38-6610	Hose Assy, Engine to Oil Cooler	1
	E38-6620	Hose Assy,Cooler to Supercharger	1
	E38-6630	Plastic Tie, Oil Cooler Mount	4
	E38-6640	Foam Pad, Oil Cooler Mount	4
	E38-6650	Locking Tab, Oil Cooler Mount	4
	A24-2231	Oil “T”-8 X3/8 NPT on Side	1
	E38-6460	-8 to -6 Adapter	1

ALTITUDE COMPENSATION INDUCTION SYSTEM



Section 6: Hourly Service Chart

DESCRIPTION	25	50	100	250	500	1000
1. SERVICE AIR FILTER	X					
2. GREASE MAIN DRIVE PULLEY	X					
3. TORQUE CYLINDER HEAD BOLTS	X					
4. INSPECT AND ADJUST VALVES	X					
5. INSPECT COOLING SYSTEM	X					
6. INSPECT OIL SYSTEM	X					
7. INSPECT FUEL SYSTEM	X					
8. INSPECT EXHAUST SYSTEM	X					
9. INSPECT IGNITION SYSTEM	X					
10. RE-TORQUE BOLTS	X					
11. INSPECT THROTTLE CONTROL	X					
12. CHANGE OIL AND FILTER (or every 6 mo.)	X					
13. INSPECT SPARK PLUGS		X				
14. REPLACE SPARK PLUGS			X			
15. TEST CYLINDER LEAKAGE			X			
16. REPLACE FUEL FILTER			X			
17. REPLACE AIR FILTER				X		
18. REPLACE WATER HOSES AND COOLANT (or every 5 yr.)				X		
19. REPLACE CAM GEAR [2]				X		
20. REBUILD CYLINDER HEADS (LEADED FUEL) [1]				X		
21. REBUILD CYLINDER HEADS (UNLEADED FUEL) [1]					X	
22. INSPECT CAMSHAFT LIFT AND END PLAY					X	
23. REPLACE MAIN DRIVE PULLEY BEARINGS					X	
24. REPLACE SPARK PLUG WIRES (or every 3 yr.)						X
25. REPLACE FUEL HOSES (or every 3 yr.)						X
26. REPLACE FUEL INJECTORS						X
27. COMPLETE ENGINE OVERHAUL						X

[1] Rebuild the cylinder heads every 500 hours if unleaded fuel is used. This is reduced to 250 hours if using 100 low lead or leaded automotive gasoline.

[2] Cam timing gear sets made of steel, supplied June 1999 and later, may be used for up to 400 hours.