Operator's Manual

Lycoming

TO-360 *76* Series

Approved by FAA

2nd Edition Part No. 60297-26

LYCOMING

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570/323-6181

July 2007

TO-360 *76* Series Operator's Manual
Lycoming Part Number: 60297-26

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ATTENTION

OWNERS, OPERATORS AND MAINTENANCE PERSONNEL

This operator's manual contains a description of the engine, its specifications, and detailed information on how to operate and maintain it. Such maintenance procedures that may be required in conjunction with periodic inspections are also included. This manual is intended for use by owners, pilots and maintenance personnel responsible for care of Lycoming powered aircraft. Modifications and repair procedures are contained in Lycoming overhaul manuals; maintenance personnel should refer to these for such procedures.

SAFETY WARNING

Neglecting to follow the operating instructions and to carry out periodic maintenance procedures can result in poor engine performance and power loss. Also, if power and speed limitations specified in this manual are exceeded for any reason; damage to the engine and personal injury can happen. Consult your local FAA approved maintenance facility.

SERVICE BULLETINS, INSTRUCTIONS AND LETTERS

Although the information in this manual is up-to-date at time of publication, users are urged to keep abreast of later information through Lycoming Service Bulletins, Instructions and Service Letters which are available for all Lycoming distributors or from the factory by subscription. Consult the latest revision of Service Letter No. L114 for subscription information.

SPECIAL NOTE

The illustrations, pictures and drawings shown in this publication are typical of the subject matter they portray; in no instance are they to be interpreted as examples of any specific engine, equipment or part thereof.

IMPORTANT SAFETY NOTICE

Proper service and repair is essential to increase the safe, reliable operation of all aircraft engines. The service procedures recommended by Lycoming are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the task. These special tools must be used when and as recommended.

It is important to note that most Lycoming publications contain various Warnings and Cautions which must be carefully read in order to minimize the risk of personal injury or the use of improper service methods that may damage the engine or render it unsafe.

It is also important to understand that these Warnings and Cautions are not all inclusive. Lycoming could not possibly know, evaluate or advise the service trade of all conceivable ways in which service might be done or of the possible hazardous consequences that may be involved. Accordingly, anyone who uses a service procedure must first satisfy themselves thoroughly that neither their safety nor aircraft safety will be jeopardized by the service procedure they select.

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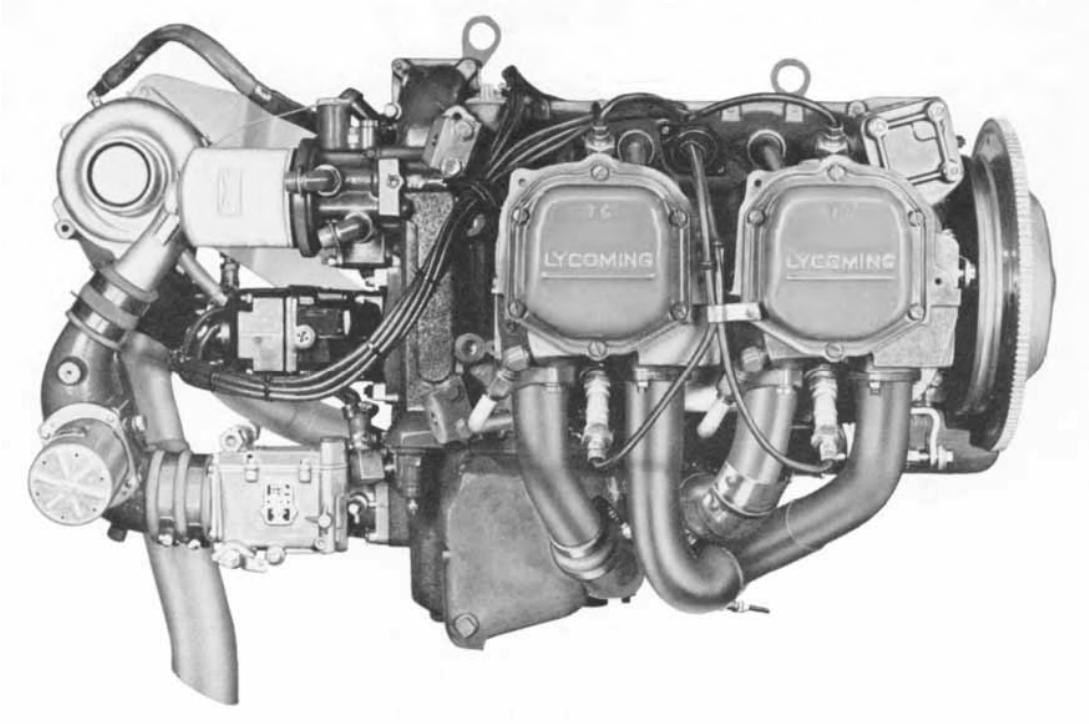
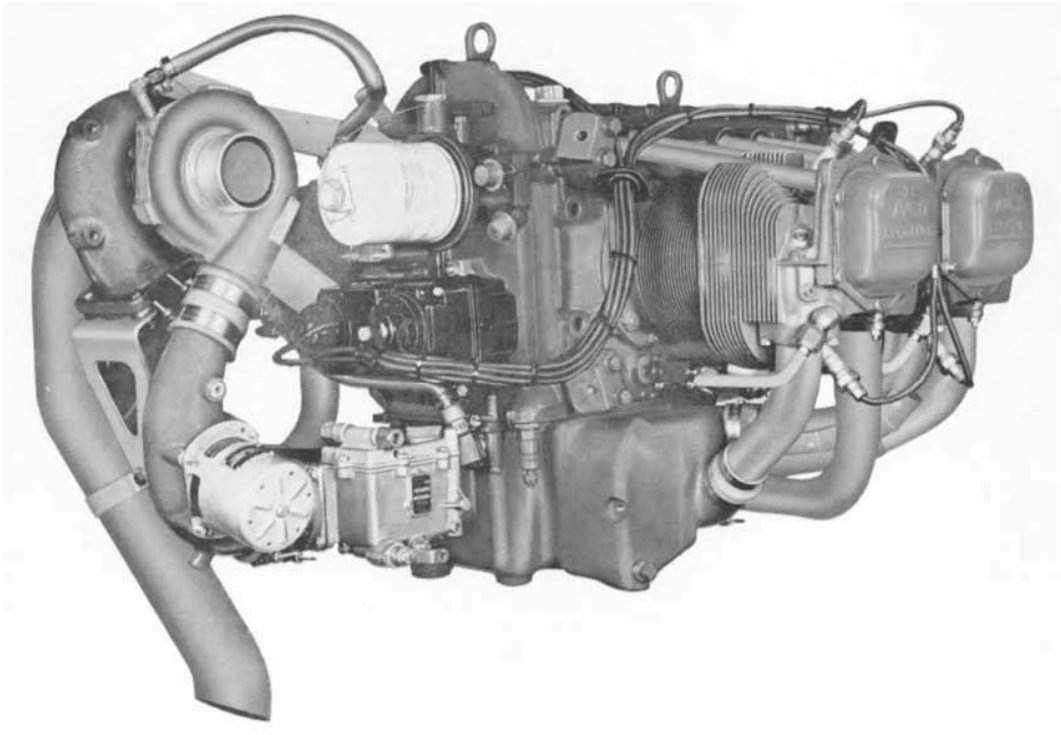


Right Side View



¾ Right Rear View

LYCOMING *76* SERIES OPERATOR'S MANUAL

SECTION 1
DESCRIPTION

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SECTION 1

DESCRIPTION

General – The Lycoming TO-360 "76" series is a four cylinder direct drive, horizontally opposed, wet sump, carbureted, turbocharged, air-cooled engine.

In referring to the location of the various components, the parts are described in their relationship to the engine as installed in the aircraft. Thus, the power take-off end is considered the front and the accessory drive end the rear. The sump section is considered the bottom and the opposite side where the shroud tubes are located is the top. References to the left (even) and right (odd) side is made with the observer facing the rear of the engine. The cylinders are numbered from the front to the rear. The 1 and 3 cylinders are on the right side, 2 and 4 cylinders are on the left. The crankshaft turns in a clockwise rotation when viewed from the rear of the engine. The direction of rotation for the accessory drives are determined with the observer facing the drive pad.

NOTE

The letter "L" in the model prefix denotes the reverse rotation of the basic model. Example: TO-360-E1A6D has clockwise rotation of the crankshaft. Therefore, LTO-360-E1A6D has a counterclockwise rotation of the crankshaft. Likewise the rotation of the accessory drives of the LTO-360 are opposite those of the basic model as listed in Section 2 of this manual.

The letter "D" used as the 4^{th} or 5^{th} character in the model suffix denotes that the particular model employs the dual magnetos housed in a single housing. Example: TO-360-E1A6D.

Cylinders – The cylinders are of conventional air-cooled construction with two major parts, head and barrel, screwed and shrunk together. The heads are made from an aluminum alloy casting with a fully machined combustion chamber. The rocker box is cast as an integral part of the cylinder head which forms the housing for both intake and exhaust valve rockers. The cylinder barrels, which are machined from chrome nickel molybdenum steel forgings, have deep integral machined cooling fins and the inside of the barrels are ground and honed to a specified finish.

Valve Operating Mechanism – A conventional type camshaft is located above and parallel to the crankshaft. The camshaft actuates the hydraulic lifter which operate the valves through push rods and valve rockers. The valve rockers are held in place by the use of the rocker arm fulcrum. The valve springs bear against hardened steel seats and are retained on the valve stems by means of split keys.

Crankcase – The crankcase assembly consists of two reinforced aluminum alloy castings with the accessory housing as an integral part, fastened together by means of studs, bolts and nuts. The mating surfaces of the two castings are joined without the use of gaskets and the main bearing bore is machined for use of precision type main bearing inserts.

Crankshaft – The crankshaft is made from a chrome nickel molybdenum steel forging. All bearing journal surfaces are nitride hardened. Freedom from torsional vibration is assured by a system of pendulum type dynamic counterweights.

Connecting Rods – The connecting rods are made in the form of "H" section from alloy steel forging. They use a replaceable bearing insert in the crankshaft ends and bronze bushing in the piston pin end. The bearing caps on the crankshaft ends are retained by two bolts and nuts through the rod and cap.

Pistons – The pistons are machined from an aluminum alloy. Piston pins are of the full floating type with a plug located on each end of the floating pin. The pistons employ half wedge rings along with an oil regulator ring. Consult the latest revision of Service Instruction No. 1037 for proper piston and ring combinations.

Oil Sump – The sump incorporates an oil drain plug, oil suction screen, mounting pad, the carburetor, the intake riser and the intake pipe connections.

Cooling System – The engine is designed to be air-cooled by air pressure actuated by the forward movement of the aircraft. Close fitting baffles are provided to build up a pressure and direct air through the cylinder fins. The air is then exhausted to the atmosphere through the gills or augmenter tube usually located at the rear in the cowling of the aircraft.

Induction System – The engine is equipped with a Marvel-Schebler type HA-6 horizontal carburetor, equipped with a manual mixture control and idle cut-off. Distribution of the fuel-air mixture is obtained through the center zone induction system, which is integral with the oil sump and is submerged in oil, insuring a more uniform vaporization of the fuel and aiding the cooling of oil in the sump. From the riser the fuel-air mixture is distributed to each cylinder by individual intake pipes.

Turbocharger System – A turbocharger is mounted as an integral part of the engine. The engine is provided with a manifold pressure relief valve, which limits the manifold pressure thus preventing the possibility of overboosting.

Lubrication System – The lubrication system is of the pressure wet sump type. The oil pump located on the exterior of the crankcase accessory section, draws oil through a drilled passage leading from the oil suction screen located in the sump. The oil from the pump then enters a drilled passage in the accessory section to the oil pressure screen housing where a flexible line carries the oil to the external oil cooler. In the event that cold oil or an obstruction should restrict the flow of oil to the cooler, an oil cooler bypass valve is provided. Pressure oil from the cooler returns to a second connection in the oil pressure screen housing from which point a drilled passage conducts the oil to the oil pressure relief valve, located at the bottom of the accessory section.

The oil pressure relief valve regulates the engine oil pressure by allowing the excessive oil to return to the sump, while the balance of the pressure oil is fed to the main oil gallery. The oil is distributed by means of a separate drilled passage to the main bearing of the crankshaft. Angular holes are drilled through the main bearing journals to the connecting rod journals. Oil from main oil gallery also flows to the camshaft and valve gear passages and is then conducted through branch passages to the hydraulic lifters and camshaft bearing. Oil enters the tappets through indexing holes and travels out through the hollow push rod tubes to the valve mechanism lubricating the valve rockers and valve stems. Residual oil from the bearing, accessory drives and rocker boxes is returned by gravity to the sump where after passing through the oil suction screen, it is again circulated through the engine. Pressure build up within the crankcase is held to a minimum by means of a breather located on the top rear of the crankcase.

Priming System – Provision for a primer system is provided for all engines employing a carburetor.

Ignition System – Dual ignition is provided by a Bendix type D4RN-2021 magneto. The magneto incorporates an integral feed thru capacitor and requires no external nose filter in the ground lead.

NOTE

The letter "D" used as the 4th or 5th character in the model suffix means that the basic model has the dual magneto housing in a single unit.

The letter "L" in the model prefix denotes the reverse rotation of the crankshaft to the basic model. Example: TO-360-E has a clockwise rotation of the crankshaft. Therefore, the LTO-360-E has a counterclockwise rotation. Likewise the rotation of the accessory drives of the LTO-360-E engine are opposite those of the basic model as listed in Section 2.

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SECTION 2
SPECIFICATIONS

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SECTION 2

SPECIFICATIONS

TO-360-E

FAA Type Certificate E26EA
Rated Horsepower RPM (Sea Level) ..... 180 @ 2575*
Rated Horsepower RPM (12,000 feet) ..... 180 @ 2575*
Performance Cruise Horsepower ..... 135 @ 2400 RPM
Economy Cruise Horsepower ..... 117 @ 2200 RPM
Bore, inches 5.125
Stroke, inches 4.375
Displacement, cubic inches 361
Compression ratio 8.00:1
Firing order 1-3-2-4
Spark occurs, degrees BTC ..... 20°
Valve rocker clearance (hydraulic tappets collapsed) ..... .028-.080
Propeller drive ratio 1:1
Propeller drive rotation (viewed from rear) ..... Clockwise

* - Rated maximum horsepower at 36.5 inches of mercury manifold pressure.

STANDARD DRY WEIGHT

TO-360-E1A6D ..... 346 lbs.

*Accessory Drive	Drive Ratio	**Direction of Rotation
Starter	16.550:1	Counterclockwise
Alternator	3.250:1	Clockwise
Magneto Drive	1.000:1	Clockwise
Tachometer Drive	0.500:1	Clockwise
Vacuum Pump Drive	1.313:1	Counterclockwise
Propeller Gov. Drive	1.000:1	Clockwise

* - When applicable.
** - Viewed facing the drive pad.

NOTE

Engine with letter "L" in prefix will have opposite rotation to the above.

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SECTION 3
OPERATING INSTRUCTIONS

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SECTION 3

OPERATING INSTRUCTIONS

1. GENERAL. Close adherence to these instructions will greatly contribute to long life, economy and satisfactory operation of the engine.

NOTE

YOUR ATTENTION IS DIRECTED TO THE WARRANTIES THAT APPEAR IN THE FRONT OF THIS MANUAL REGARDING ENGINE SPEED, THE USE OF SPECIFIED FUELS AND LUBRICANTS, REPAIRS AND ALTERATIONS. PERHAPS NO OTHER ASPECT OF ENGINE OPERATION AND MAINTENANCE CONTRIBUTES QUITE SO MUCH TO SATISFACTORY PERFORMANCE AND LONG LIFE AS THE CONSTANT USE OF THE CORRECT GRADES OF FUEL AND OIL, CORRECT ENGINE TIMING, AND FLYING THE AIRCRAFT AT ALL TIMES WITHIN THE SPEED AND POWER RANGE SPECIFIED FOR THE ENGINE. DO NOT FORGET THAT VIOLATION OF THE OPERATION AND MAINTENANCE SPECIFICATION FOR YOUR ENGINE WILL NOT ONLY VOID YOUR WARRANTY BUT WILL SHORTEN THE LIFE OF YOUR ENGINE AFTER ITS WARRANTY PERIOD HAS PASSED.

New engines have been carefully run-in by Lycoming and therefore no further break-in is necessary insofar as operation is concerned; however, new and newly overhauled engines should avoid low power below 65% of rated during the first 50 hours or until the oil consumption has stabilized. The engine should also be operated on straight mineral oil for a minimum of 50 hours or until the oil consumption has stabilized. After this period a change to an approved additive oil Spec. MIL-L-6082 or ashless dispersant oil Spec. MIL-L-22851 may be made if so desired.

NOTE

Cruising should be done at 65% to 75% power until a total of 50 hours has accumulated or oil consumption has stabilized. This is to ensure proper seating of the piston ring and is applicable to new engines and engines in service following cylinder replacement or top overhaul of one or more cylinders.

The minimum fuel octane rating is listed in the flight chart, paragraph 8 of this section. Under no circumstances should fuel of a lower octane rating or automotive fuel (regardless of octane rating) be used.

2. PRESTARTING ITEMS OF MAINTENANCE. Before starting the aircraft engine for the first flight of the day, there are several items of maintenance inspection that should be performed. These are described in Section 4 under Daily Pre-Flight Inspection. They must be observed before the engine is started.

3. STARTING PROCEDURES.

The following starting procedures are recommended; however, the starting characteristics of various installations will necessitate some variation from these procedures.

NOTE

Cranking period must be limited to ten (10) to twelve (12) seconds with five (5) minutes rest between cranking periods.

a. Carbureted Engines (Cold).

(1) Perform pre-flight inspection.

(2) Set propeller governor control in full RPM position.

(3) Turn fuel valves "On".

(4) Move mixture control to "Full Rich" position.

(5) Turn boost pump on (where applicable).

(6) Open throttle control approximately ¼ travel.

(7) Prime with 1 to 3 strokes of the manual priming pump or activate the electric primer for 1 to 2 seconds.

(8) Set magneto selector switch. (Consult airframe manufacturer's handbook for correct position.)

(9) Engage starter switch.

(10) When engine fires, move the magneto switch to "Both".

(11) Check the oil pressure gauge. If minimum oil pressure, as stated in paragraph 8 of this section, is not indicated within thirty seconds, stop engine and determine trouble.

NOTE

If engine fails to achieve a normal start, assume it to be flooded and use standard clearing procedure. Then repeat the above steps.

b. Carbureted Engines (Hot).

(1) Proceed as outlined for cold engines above, omitting the priming step.

4. COLD WEATHER STARTING. During extreme cold weather it may be necessary to preheat the engine oil before starting.

5. GROUND RUNNING AND WARM-UP. The engine covered in this manual is air pressure cooled and depends on the forward speed of the aircraft to maintain proper cooling. Particular care is necessary, therefore, when operating the engine on the ground. To prevent overheating, it is recommended that the following precautions be observed.

NOTE

Any ground running that requires full throttle operation must be limited to three minutes or less if the indicated cylinder head temperature should exceed the maximum (as stated in this manual).

a. Head the aircraft into the wind.

b. Leave mixture control in the "Full Rich" position.

c. Operate only with the propeller in minimum blade angle setting.

d. Warm-up at approximately 1000-1200 RPM. Avoid prolonged idling and do not exceed 2200 RPM on the ground.

e. Engine is warm enough for take-off when the throttle can be opened without the engine faltering.

6. GROUND CHECK.

a. Warm-up as directed above.

b. Check both oil pressure and oil temperature.

c. Leave mixture control in "Full Rich" position.

d. Move the propeller control through its complete range to check operation and return it to full low pitch position. Full feathering check (twin engine) on the ground is not recommended but the feathering action can be checked by running the engine between 1000-1500 RPM; then momentarily pulling the propeller control into the feathering position. Do not allow the engine RPM to drop more than 500 RPM.

e. A proper magneto check is important. Additional factors, other than the ignition system, affect magneto drop-off. They are load-power output, propeller pitch and mixture strength. The important thing is that the engine runs smoothly because the magneto drop-off is affected by the variables listed above. Make the magneto check in accordance with the following procedures.

(1) Controllable Pitch Propeller – With the propeller in minimum pitch angle, set the engine to produce 50 to 65% power as indicated by the manifold pressure gauge. Mixture should be in the full rich position. At these settings, the ignition system and spark plugs must work harder because of the greater pressure within the cylinders. Under these conditions ignition problems, if they exist, will occur. Magneto checks at low power setting will only indicate fuel-air distribution quality.

NOTE

Aircraft that are equipped with fixed pitch propeller or not equipped with a manifold pressure gauge may check magneto drop-off with engine operating at a maximum of 2000-2100 RPM.

(2) Switch from both magnetos to one and note drop-off, return to both until engine regains speed and switch to the other magneto and note drop-off. Then return switch to both. Drop-off should not exceed 175 RPM and should not exceed 50 RPM between the right and left magneto. A smooth drop-off past normal is usually a sign of a too lean or a too rich mixture.

f. Do not operate on a single magneto for too long a period. A few seconds is usually sufficient to check drop-off and will minimize the possibility of plug fouling.

7. OPERATION IN FLIGHT.

a. See airframe manufacturer's instructions for recommended power setting.

b. *Fuel Mixture Leaning Procedure* – Improper fuel/air mixture during flight is responsible for many engine problems, particularly during take-off and climb power setting. The procedures described in this manual provide proper fuel/air mixture when leaning Lycoming engines. They have proven to be both economical and practical by eliminating excessive fuel consumption and reducing damaged parts replacement. It is therefore recommended that operators of all Lycoming aircraft power plants utilize the instructions in this publication any time the fuel/air mixture is adjusted during flight.

Manual leaning may be monitored by exhaust gas temperature indication, fuel flow indication, and by observation of the engine speed and/or airspeed. However, whatever instruments are used in monitoring the mixture the following rules should be observed by the operator of Lycoming aircraft engines.

GENERAL RULES

Never exceed the maximum red line cylinder head temperature of 500°F (260°C).

For maximum service life, the cylinder head temperature should be maintained below 435°F (224°C) during high performance cruise operation and below 400°F (205°C) for economy cruise powers.

Maintain mixture control in "Full Rich" position for rated take-off, climb, and maximum cruise powers (above approximately 75%). However, during take-off from high elevation airport or during climb, roughness or loss of power may result from over-richness. In such a case adjust mixture control only enough to obtain smooth operation – not for economy. Observe instruments for temperature rise. Rough operation due to over rich fuel/air mixture is most likely to be encountered in carbureted engines at altitudes above 5,000 feet.

Operate the engine at maximum power mixture for performance cruise powers and at best economy cruise power; unless otherwise specified in the aircraft owner's manual.

Always return the mixture to full rich before increasing the power setting.

Operate the engine maximum power mixture for performance cruise powers and at best economy mixture for economy cruise power; unless otherwise specified in the aircraft owner's manual.

During let down flight operations it may be necessary to manually lean uncompensated carbureted engines to obtain smooth operation.

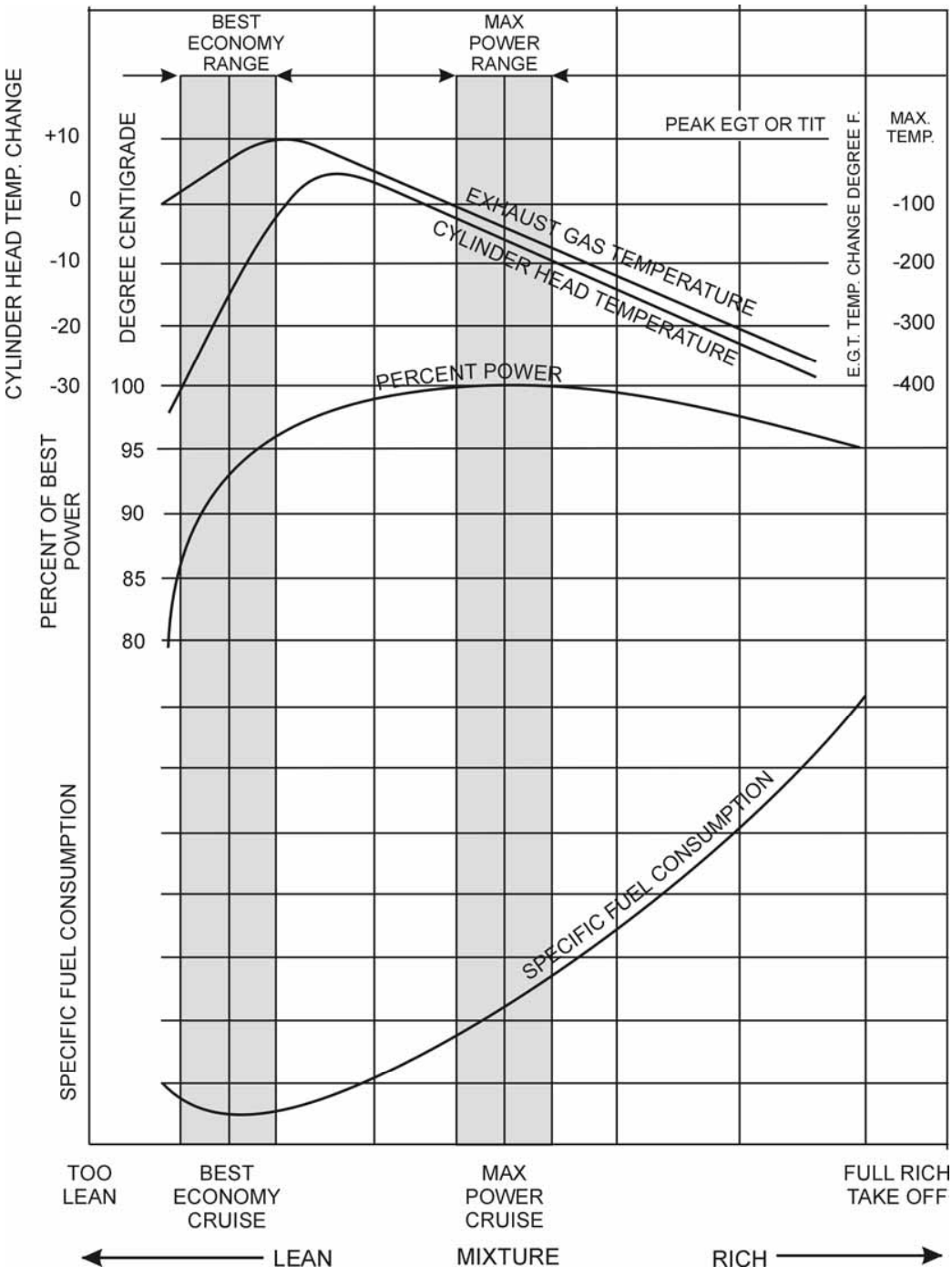

Figure 3-1. Representative Effect of Leaning on Cylinder Head Temperature, T.I.T. (Turbine Inlet Temperature), Engine Power and Special Fuel Consumption at Constant Engine RPM and Manifold Pressure

On turbocharged engines do not exceed 1650°F turbine inlet temperature (TIT).

1. LEANING TO TURBINE INLET TEMPERATURE OR EXHAUST GAS TEMPERATURE GAUGE.

a. Turbocharged Engines.

(1) Best Economy Cruise – Lean to peak turbine inlet temperature (TIT) or 1650°F, whichever occurs first.

(2) Maximum Power Cruise – The engines must always be operated on the rich side of peak TIT. Before leaning to obtain maximum power mixture it is necessary to establish a reference point. This is accomplished as follows:

(a) Establish a peak TIT for best economy operation at the highest economy cruise power without exceeding 1650°F.

(b) Deduct 125°F from this temperature and thus establish the temperature reference point for use when operating at maximum power mixture.

(c) Return mixture control to full rich and adjust the RPM and manifold pressure for desired performance cruise operation.

(d) Lean out mixture until TIT is the value established in step (b). This sets the mixture at best power.

NOTE

For maximum turbocharger life it is recommended that turbine inlet temperature be held to observed 1625°F or less.

2. LEANING TO FLOWMETER.

Lean to applicable fuel-flow tables or lean to indicator marked for correct fuel-flow for each power setting.

3. LEANING WITH MANUAL MIXTURE CONTROL. (Economy Cruise 75% power or less.) Without flowmeter or TIT gauge.

a. Slowly move mixture control from "Full Rich" position toward lean position.

b. Continue leaning until a slight loss of power is noted (loss of power may or may not be accompanied by roughness).

c. Enrich mixture control until engine runs smoothly and power is regained.

As shown in Figure 3-1, page 3-5, if engine speed and throttle setting are kept constant at normal cruise conditions, the affect of leaning on engine power and engine temperatures will be shown. Power drops rapidly when the engine is leaned beyond peak exhaust gas temperature; also, best power is attained on the right side of peak exhaust gas temperature.

NOTE

To obtain smooth engine operation during full throttle climbs above 12,000 feet, the fuel flow may be manually leaned to a maximum exhaust gas temperature of 1450°F.

8. ENGINE FLIGHT CHART.

FUEL AND OIL –

Model *Aviation Grade Fuel

TO-360-E .....100 or 100LL Commercial

* - Refer to the latest revision of Service Instruction No. 1070.

Fuel Pressure, psi –

Model	Maximum	Minimum
TO-360-E		
Inlet to Fuel Pump	35	-2
Inlet to Carburetor	35	13

Fuel Consumption (Gal. per Hour) –

TO-360-E
Normal Rated (2575 RPM, 180 HP).....18.2
75% Rated (2400 RPM, 135 HP).....11.5
65% Rated (2200 RPM, 117 HP).....8.9

Lubrication Oil –

	*Recommended Grade Oil	
Average Ambient Air	MIL-L-6082 Grades	MIL-L-22851 Ashless Dispersant Grades
All Temperature	--------	SAE 15W-50 or 20W-50
Above 80°F	SAE 65	SAE 60
Above 60°F	SAE 50	SAE 40 or SAE 50
30° to 90°F	SAE 40	SAE 40
0° to 70°F	SAE 30	SAE 30, 40, 20W-40
0° to 90°F	-------	SAE 20W-50
Below 10°F	SAE 20	SAE 3, 20W-30

* - Refer to the latest revision of Service Instruction No. 1014 for complete lubrication oil recommendations.

Lubrication Oil (Cont). –

Average Ambient Air	*Oil Inlet Temperature Desired	Maximum
Above 80°F	180°F (82°C)	245°F (118°C)
Above 60°F	180°F (82°C)	245°F (118°C)
30° to 90°F	180°F (82°C)	245°F (118°C)
0° to 70°F	170°F (77°C)	225°F (107°C)
Below 10°F	160°F (71°C)	210°F (99°C)

* - Engine oil temperature should not be below 140°F (60°C) during continuous operation.

Oil Sump Quantities –

TO-360-E
Maximum safe quantity in sump..... 6 qts. (U.S.)
Minimum safe quantity in sump ..... 2 qts. (U.S.)

Oil Pressure, psi –

	Max.	Min.*	Idling
Normal Operation	90	60	15
Starting and Warm-Up	115		

* - See Section 5, Page 5-6 for oil pressure relief valve adjustment.

Oil Consumption –

TO-360-E	Max. Oil Cons. Qts. Per Hour
Normal Rated (2575 RPM, 180 HP)	0.80
75% Rated (2400 RPM, 135 HP)	0.45
65% Rated (2200 RPM, 117 HP)	0.39

Cylinder Head Temperature –

Maximum permissible .....500°F (260°C)

NOTE

Cylinder head temperature taken at the Bayonet Location. For maximum service life of the engine, maintain cylinder head temperatures between 150°F (66°C) and 400°F (205°C) during continuous operation.

9. ENGINE SHUT-DOWN.

a. Set propeller at minimum blade angle (where applicable).

b. Idle until there is a decided drop in cylinder head temperature.

c. Move mixture control to the idle cut-off position.

d. When engine stops, turn ignition switch to the off position.

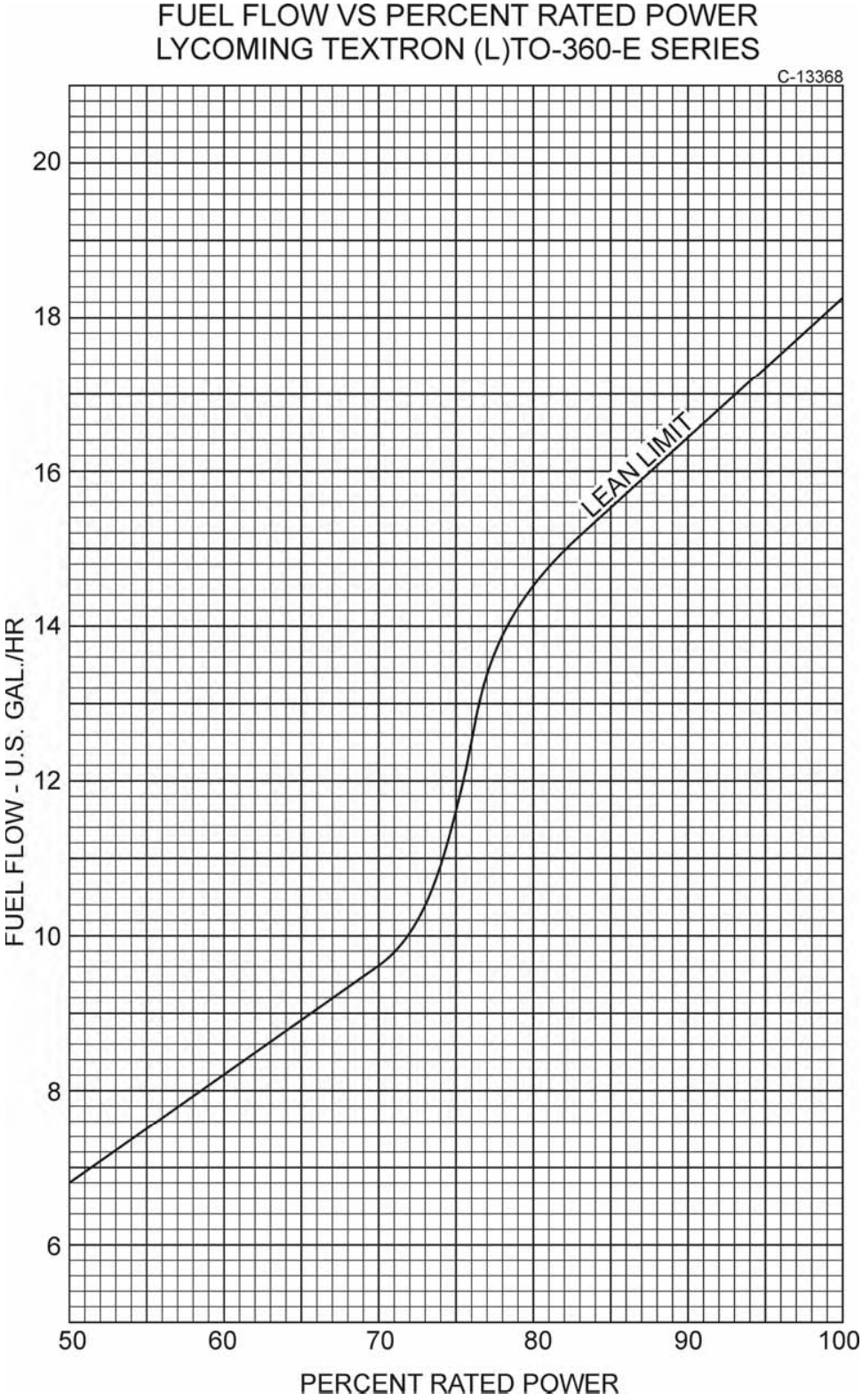

Figure 3-2. Fuel Flow vs Percent Rated Power –
TO-360-E Series

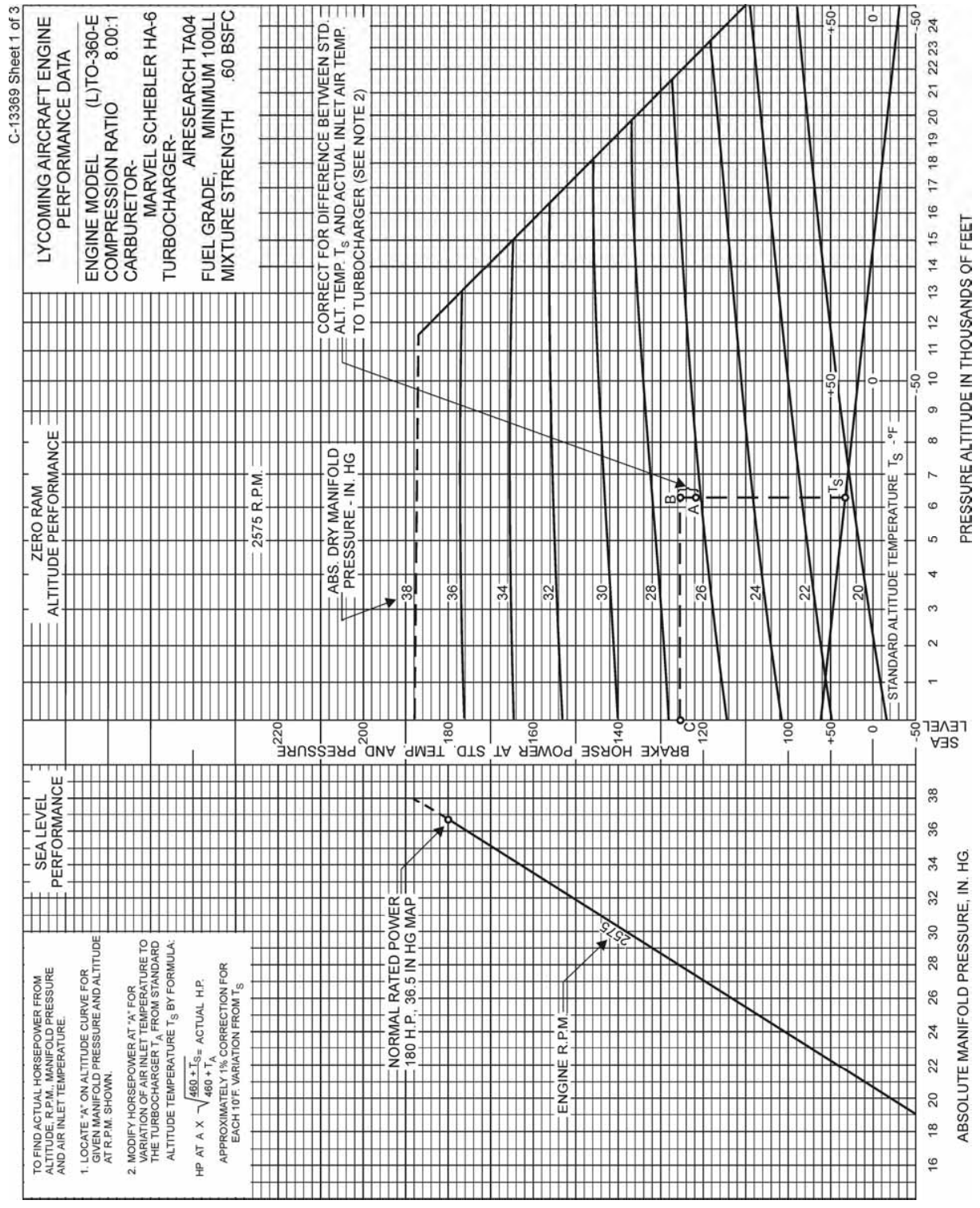

Figure 3-3. Sea Level and Altitude Performance –
TO-360-E Series – Sheet 1 of 3

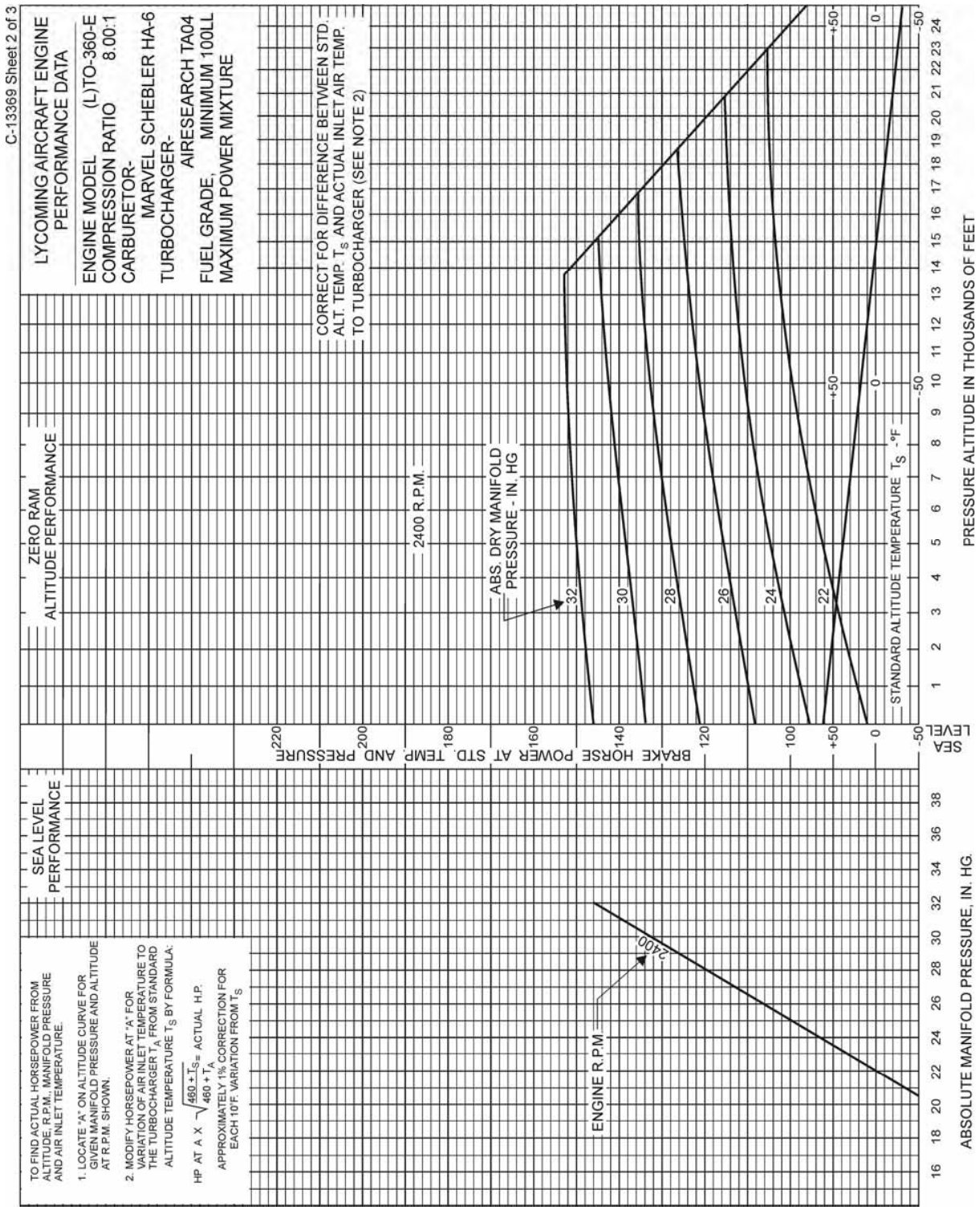

Figure 3-4. Sea Level and Altitude Performance –
TO-360-E Series – Sheet 2 of 3

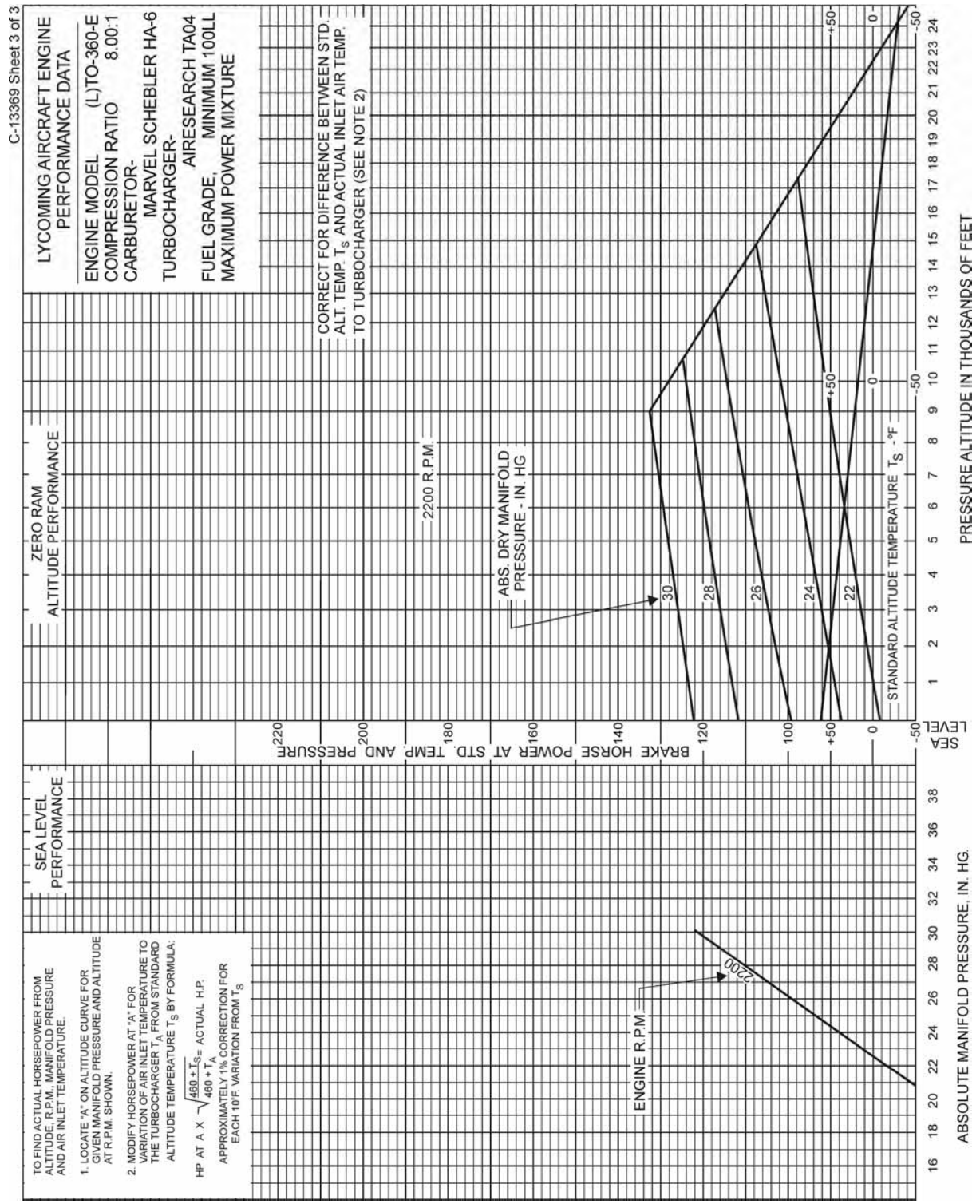

Figure 3-5. Sea Level and Altitude Performance –
TO-360-E Series – Sheet 3 of 3

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SECTION 4
PERIODIC INSPECTIONS

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SECTION 4

PERIODIC INSPECTIONS

NOTE

Perhaps no other factor is quite so important to safety and durability of the aircraft and its components as faithful and diligent attention to regular checks for minor troubles and prompt repair when they are found.

The operator should bear in mind that the items listed in the following pages of this section do not constitute a complete aircraft inspection, but are meant for the inspection of the engine only. Consult the aircraft manufacturer's handbook for additional airframe instructions.

Pre-Starting Inspection – The daily pre-flight inspection is a check of the aircraft prior to the first flight of the day. This inspection is to determine the general condition of the aircraft and engines.

The importance of proper pre-flight inspection cannot be over emphasized. Statistics prove several hundred accidents occur yearly directly responsible to poor pre-flight inspections.

Among the major causes of poor pre-flight inspection are the lack of concentration, reluctance to acknowledge the need for a check list, carelessness bred by familiarity and haste.

1. DAILY PRE-FLIGHT.

a. Be sure all switches are in the "off" position.

b. Be sure magneto ground wires are properly connected.

c. Check oil level.

d. See that fuel tanks are full.

e. Check fuel and oil line connections, note any minor indications for repair at the 50-hour inspection. Repair any leaks that may be observed before the aircraft is flown.

f. Open the fuel drain to remove any accumulation of water and sediment.

g. Make sure all shields and cowling are in place and secure. If any are missing or damaged, repair or replacement should be made before the aircraft is flown.

h. Check all controls for general condition, travel, and freedom of operation.

i. Inspect the induction system air filter and service in accordance with the aircraft manufacturer's recommendations.

2. 25-HOUR INSPECTION. After the first twenty-five hours operating time; new, rebuilt or newly overhauled engines should undergo a 50-hour inspection, including draining and renewing the lubricating oil.

3. 50-HOUR INSPECTION. In addition to the items listed for daily pre-flight inspection, the following maintenance check should be made after every 50 hours of operation.

a. Ignition System –

(1) If fouling of spark plugs has been apparent, rotate bottom plugs to top position and top plugs to the bottom.

(2) Examine spark plug ends of cable and ceramics for corrosion and deposits. This condition is evidence of either leaking spark plugs, improper cleaning of the spark plug walls, or connector ends. Where this condition is found, clean the cable ends, spark plug, and ceramics with a dry clean cloth or a clean cloth moistened with methyl-ethyl-ketone. All parts should be clean and dry before reassembly.

(3) Check ignition harness for security of mounting clamps and be sure connections are tight at spark plug and magneto terminals.

b. Fuel and Induction System – Check the primer lines for leaks and security of the clamps. Remove and clean the fuel inlet strainers. Check the mixture control and throttle linkage for travel, freedom of movement, security of the clamps and lubricate if necessary. Check the air intake ducts for leaks, security, filter damage; evidence of dust or other solid material in the ducts is indicative of inadequate filter care or damaged filter. Check vent lines for evidence of fuel or oil seepage. If present, fuel pump may require replacement.

c. Lubrication System –

(1) Remove the oil suction screen and check carefully for presence of metal particles that are indicative of internal engine damage. This step is not feasible unless the oil is being changed and should be omitted on installations employing an external full flow oil filter.

(2) Replace external full flow oil filter element. Examine the filter element for metal particles or carbon contamination. Drain and renew lubricating oil on installations not employing external full flow oil filter.

NOTE

Intervals between oil changes can be increased as much as 100% on engines equipped with full flow oil filters provided the element is replaced each 50 hours of operation. However, the use of high lead content fuel, the operation in dusty areas, cold climates and where short flight and long idle periods are encountered, more frequent oil changes may be necessary.

(3) Check oil lines for leaks, particularly at connections and for security at clamp locations. Also check for wear due to rubbing or vibration and for dents and cracks.

d. Exhaust System – Check attaching flanges at exhaust ports on cylinder head for evidence of leakage. If they are loose they must be removed and machined flat before they are reassembled and tightened. Examine the exhaust manifold for leakage and loose connections. Repair or replace as necessary.

e. Cooling System – Check cowling and baffles for damage and secure anchorage. Any damaged or missing part of the cooling system must be repaired or replaced before the aircraft resumes operation.

f. Cylinders – Check rocker box covers for evidence of oil leaks. If found replace gasket and tighten screws to specified torque (50 in.-lbs.).

Check cylinder for evidence of excessive heat which is indicated by burned paint on the cylinder. This condition is indicative of internal damage to the cylinder and, if found, its cause must be determined and corrected before the aircraft resumes operation.

Heavy discoloration and appearance of seepage at cylinder head and barrel attachment area is usually due to emission of the thread lubricant used during the assembly of the cylinder head and barrel at the factory, or by slight gas leakage which stops after the cylinder assembly has been in service for awhile. This condition is neither harmful nor detrimental to the engine performance and operation. If it can be proven that leakage exceeds these conditions, the cylinder should be replaced.

g. Turbocharger – All mounting brackets of the exhaust system should be checked along with hose clamps on induction system.

4. 100-HOUR INSPECTION. In addition to the items listed for daily pre-flight and 50-hour inspection, the following maintenance checks should be made after every 100 hours of operation.

a. Electrical System –

(1) Check all wiring connected to the engine or accessories. Any shielded cables that are damaged should be replaced. Replace clamps or loose wires and check terminals for security and cleanliness.

(2) Remove spark plugs; test, clean and regap. Replace if necessary.

b. *Magnetos* – Check breaker points for pitting and minimum gap. Check for excessive oil in the breaker compartment. If oil is found, wipe dry with a clean lint free cloth. The felt located at the breaker points should be lubricated in accordance with the magneto manufacturer's instructions. Timing procedure is described in Section 5, paragraph 1b, page 5-1 of this manual.

c. *Engine Accessories* – Engine mounted accessories such as pumps, temperature and pressure sensing units should be checked for secure mounting and tight connections.

d. *Cylinders* – Visually check cylinder for cracked or broken fins.

e. *Engine Mounts* – Check the engine mounting bolts and bushings for security and excessive wear. Replace any bushing or bolts that are excessively worn.

5. 400-HOUR INSPECTION. In addition to the items listed for daily pre-flight, 50-hour and 100-hour inspections, the following maintenance check should be made every 400 hours of engine operation.

Valve Inspection – Remove rocker box covers and check for freedom of valve rockers when the valves are in the closed position. Look for evidence of abnormal wear or broken parts in the area of the valve tips, valve keys, springs and spring seats. If any indications are found, the cylinder and all of its components should be removed (including the piston and connecting rod assembly) and inspect for further damage. Replace any parts that do not conform with the lists shown in the latest revision of Table of Limits, SSP-1776.

6. NON-SCHEDULED INSPECTIONS. Occasionally, service bulletins or service instructions are issued by Lycoming that require inspection procedures that are not listed in this manual. Such publications usually are limited to specified engine models and become obsolete after corrective modification has been accomplished. All such publications are available from Lycoming distributors, or from the factory by subscription. Consult the latest revision of Service Letter No. L114 for subscription information. Maintenance facilities should have an up-to-date file of these publications available at all times.

SECTION 5
MAINTENANCE PROCEDURES

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SECTION 5

MAINTENANCE PROCEDURES

The procedures described in this section are provided to guide and instruct personnel in performing such maintenance operations that may be required in conjunction with the periodic inspections listed in the preceding section. No attempt is made to include repair and replacement operations that will be found in the applicable Lycoming Overhaul Manual.

1. IGNITION AND ELECTRICAL SYSTEM.

a. Ignition Harness and Wire Replacement – In the event that an ignition harness or an individual lead is to be replaced, consult the wiring diagram to be sure that the harness is correctly installed. Mark the location of the clamps and clips to be certain the replacement is clamped at the correct locations.

b. Timing Magneto to Engine – Remove the top spark plug from No. 1 cylinder and place thumb over the spark plug hole. Rotate the crankshaft in direction of normal rotation until the compression stroke is reached. This is indicated by a positive pressure inside the cylinder tending to push the thumb from the spark plug hole. Continue rotating the crankshaft until the advance timing mark on the front face of the starter ring gear support is in alignment with the small hole located at the two o'clock position on the front face of the starter housing. (Ring gear may be marked at 20° and 25°. Consult specifications for correct timing mark for your installation.) At this point, the engine is ready for assembly of the magneto.

c. Dual Magneto –

(1) Place the engine in No. 1 firing position as directed in paragraph 1b.

(2) Install the magneto to engine gasket on the magneto flange.

WARNING

DO NOT ATTACH HARNESS SPARK PLUG LEAD ENDS TO THE SPARK PLUGS UNTIL ALL MAGNETO-TO-ENGINE TIMING PROCEDURES AND MAGNETO-TO-SWITCH CONNECTIONS ARE ENTIRELY COMPLETED.

(3) Remove engine to magneto drive gear train backlash by turning engine magneto drive in direction opposite to normal rotation and return to timing mark on the starter support in direction of normal rotation.

(4) Remove the timing window plug from the most convenient side of the magneto housing and the plug from the rotor viewing location of the center of the housing.

(5) Turn the rotating magnet drive shaft in the normal direction of magneto rotation until the painted tooth of the large distributor gear is centered in the timing hole.

(6) Observe that at this time the built in pointer just ahead of the rotor viewing window aligns with the "R" or "L" mark on the rotor depending on whether the magneto is of right or left hand rotation as specified on the magneto nameplate.

(7) Hold the magneto on its No. 1 firing position (tooth in window center and pointed over "R" or "L" mark on rotor) and install magneto to the engine and loosely clamp in position.

(8) Attach red lead from the timing light to left switch adapter lead, green lead to right switch adapter lead and the black lead of the timing light to the magneto housing.

(9) Turn the magneto in direction of rotor rotation until the red timing light comes on.

(10) Rotate the magneto in the opposite direction until the red light just goes off indicating that the left main breaker has opened. Then evenly tighten the magneto mounting clamps.

(11) Back engine up (counterclockwise rotation) approximately 10°, the red light should be on, then carefully "bump" crankshaft in direction of normal rotation, at the same time observing the timing light.

(12) At the No. 1 firing position of the engine, the red light should go off indicating the left main breaker opening. The right main breaker monitored by the green light must open within ± 2° engine degrees of the No. 1 firing position.

(13) Repeat steps (9) through (11) until the condition described in step (12) is obtained.

(14) Complete tightening of the magneto securing clamps by torqueing to 150 in.-lbs.

(15) Recheck timing once more as stated in step (12) and if satisfactory disconnect timing light. Remove adapter leads.

(16) Reinstall plugs in timing inspection holes. Torque plugs to 12-15 in.-lbs.

(17) Install the harness, as shown in Figure 5-1 to spark plugs and connect switch leads to proper terminal.

NOTE

Some timing lights operate in the reverse manner as described. The light comes on when the breaker points open. Check your timing light instructions.

d. Internal Timing – Dual Magneto – Check the magneto internal timing and breaker synchronization in the following manner.

(1) Main Breaker – Connect the timing light negative lead to any unpainted surface of the magneto. Connect one positive lead to the left main breaker terminal and the second positive lead to the right main breaker terminal.

(2) Back the engine up a few degrees and again bump forward toward number one cylinder firing position while observing the timing lights. Both lights should go out to indicate the opening of the main breakers, when the timing pointer is indicating within the width of the "L" or "R" mark. If breaker timing is incorrect loosen breaker screws and correct. Retorque breaker screws to 20-25 in.-lbs.

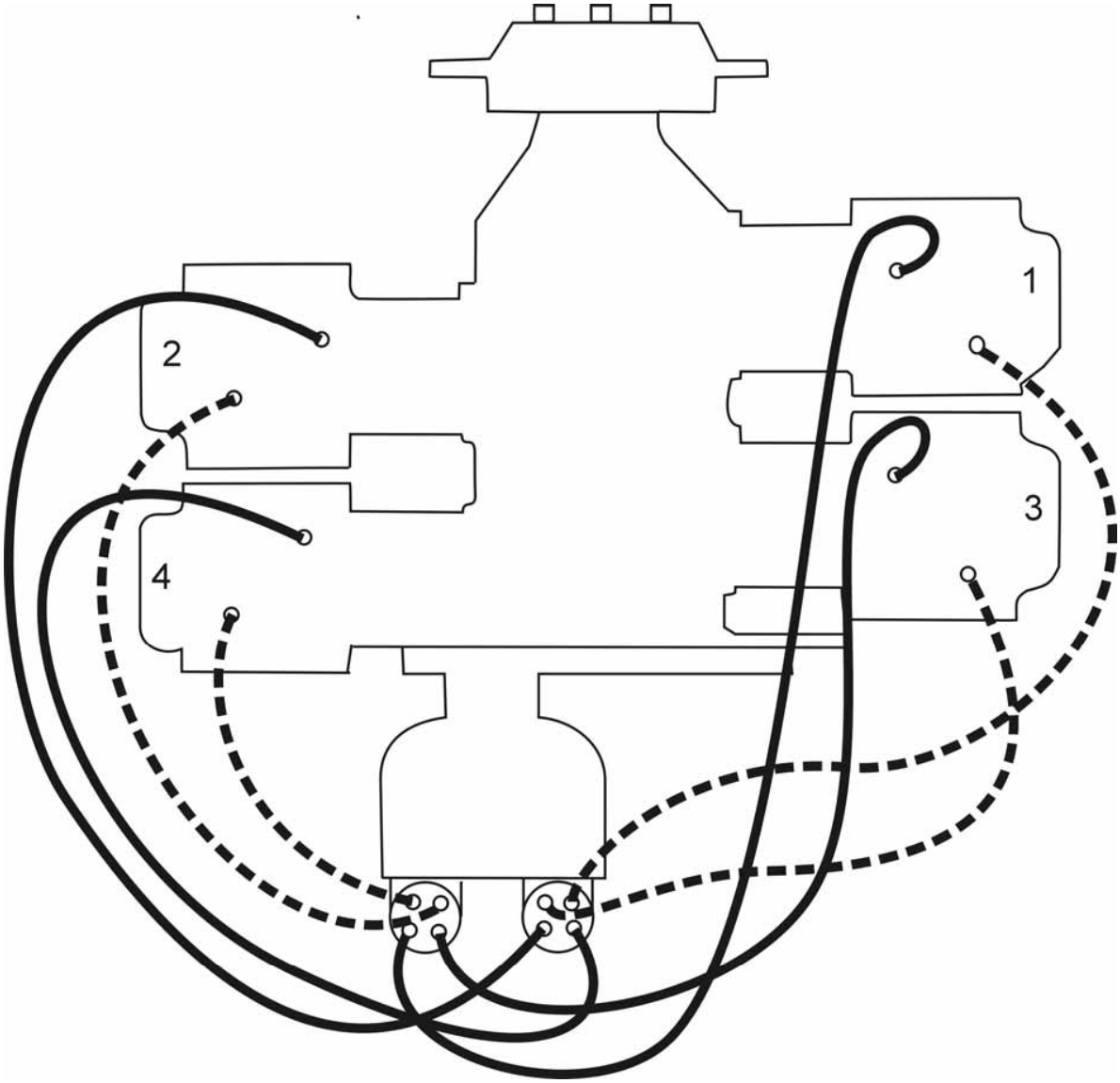

Figure 5-1. Ignition Wiring Diagram

(3) *Retard Breaker* – Remove timing light leads from the main breaker terminals. Attach one positive lead to the retard breaker terminal, and second positive to the tachometer breaker, is used.

(4) Back the engine up a few degrees and again bump forward toward number one cylinder firing position until pointer is aligned with 15° retard timing mark. See Figure 5-2. Retard breaker should just open at this position.

(5) If the retard timing is not correct, loosen cam securing screw and turn the retard breaker cam as required to make the retard breaker open per paragraph (4). Retorque cam screw to 16-20 in.-lbs.

(6) Observe the tachometer breaker is open by the cam lobe. No synchronization of this breaker is required.

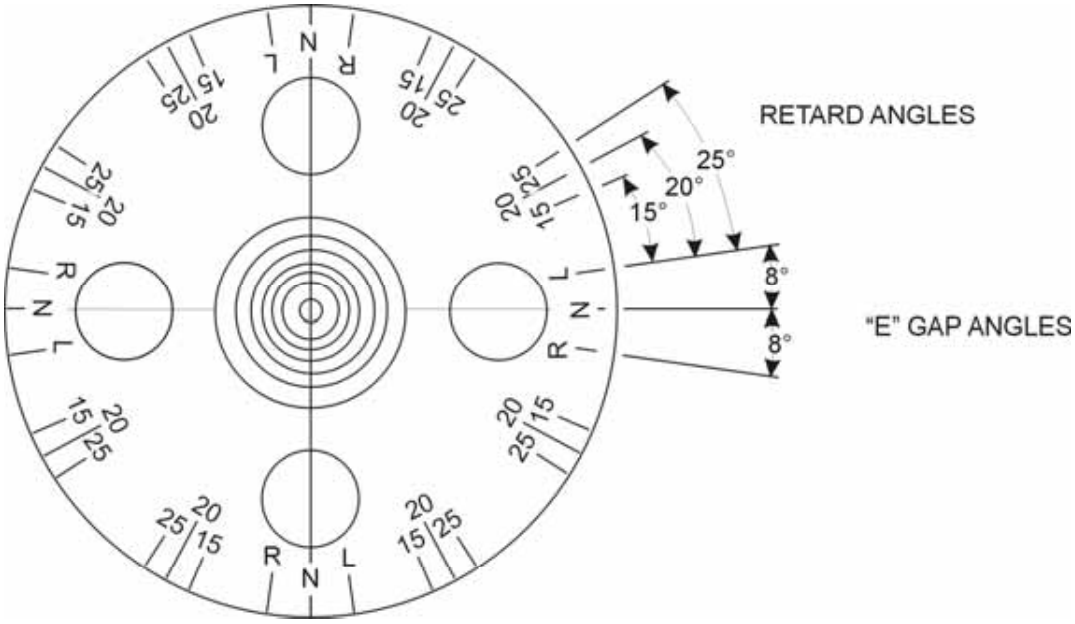

Figure 5-2. Timing Marks of Rotating Magneto

(7) Check action of impulse coupling (D-2000 series only). With the ignition switch off observe breaker cam end of rotor while manually cranking engine through a firing sequence. Rotor should alternately stop and then (with an audible snap) be rotated rapidly through a retard firing position.

e. Alternator Output – The alternator should be checked to determine that the specified voltage and current is being obtained.

2. FUEL SYSTEM.

a. Repair of Fuel Leaks – In the event a line or fitting in the fuel system is replaced, only a fuel soluble lubricant, such as clean engine oil or Loctite Hydraulic sealant may be used. Do not use any other form of thread compound.

b. Carburetor Fuel Inlet Screen Assembly – Remove the assembly and check the screen for distortion or openings in the strainer. Replace for either of these conditions. Clean screen assembly in solvent and dry with compressed air and reinstall. The fuel inlet screen assembly is tightened to 35-40 in.-lbs.

c. Fuel Grades and Limitations – The recommended aviation grade fuel for the subject engines is listed in Section 3, Item 8.

In the event that the specified fuel is not available at some locations it is permissible to use a higher octane fuel. Fuel of an octane lower than specified is not to be used. Under no circumstances should automotive fuel be used (regardless of the octane rating).

NOTE

It is recommended that personnel be familiar with the latest revision of Service Instruction No. 1070 regarding specified fuel for Lycoming engines.

d. Air Intake Ducts and Filters – Check all air intake ducts for dirt or restrictions. Inspect and service air filters as instructed in the aircraft manufacturer's handbook. Replace any filter or air duct that shows signs of deterioration or collapse.

e. Idle Speed and Mixture Adjustment –

(1) Start the engine and warm up in the usual manner until oil and cylinder head temperatures are normal.

(2) Check magneto as described in Section 3, paragraph 6e(1). If the "drop-off" is normal, proceed with the idle adjustment.

(3) Set throttle stop screw so that the engine idles at the idling RPM recommended by the aircraft manufacturer. If the RPM changes appreciably after making the idle adjustment during the succeeding steps, readjust the idle speed to the desired RPM.

(4) When the idling speed has been stabilized, move the cockpit mixture control lever with a smooth steady pull toward the "idle cut-off" position and observe the tachometer for any change during the leaning process. Caution must be exercised to return the mixture control to full rich position before the RPM can drop to a point where the engine cuts out. An increase of more than 50 RPM while leaning out indicates an excessively rich idle mixture. An immediate decrease in RPM (if not preceded by a momentary increase) indicates the idle mixture is too lean.

If the above indicates that the idle adjustment is too rich or too lean, turn the idle mixture adjustment in the direction required for correction, and check this new position by repeating the above procedure. Make additional adjustments as necessary until a check results in a momentary pick-up of approximately 50 RPM. Each time the adjustment is changed, the engine should be run up to 2000 RPM to clear the engine before proceeding with the RPM check. Make final adjustment of the idle speed adjustment to obtain the desired idling RPM with closed throttle. The above method aims at a setting that will obtain maximum RPM with minimum manifold pressure. In case the setting does not remain stable, check the throttle linkage; any looseness in the linkage, would cause erratic idling. In all cases, allowance should be made for the effect of weather conditions and field altitude upon idling adjustment.

3. LUBRICATION SYSTEM.

a. Oil Grades and Limitations – Service the engine in accordance with the recommended grade oil as specified in Section 3, item 8.

b. Oil Suction and Oil Pressure Screens – At each fifty hours inspection, remove, inspect for metal particles, clean and reinstall.

NOTE

On installations employing external oil filters, the inspection of the oil suction screen is impractical at this time, but should be observed when the lubricating oil is changed.

c. Oil Relief Valve (Non-Adjustable) – The function of the oil pressure relief valve is to maintain engine oil pressure within specified limits. The valve although not adjustable, may be controlled by the addition of a maximum of nine (9) P/N STD-425 washers under the cap to increase pressure or the removal of the washer will decrease the oil pressure. Particles of metal or other foreign matter lodged between the ball and seat will result in faulty readings. Inspect and clean the valve if excessive pressure fluctuations are noted.

d. Oil Relief Valve (Adjustable) – The adjustable oil relief valve enables the operator to maintain engine oil pressure within the specified limits. If the pressure under normal operating conditions should consistently exceed the maximum or minimum specified limits, adjust the valve as follows.

With the engine warmed up and running at approximately 2000 RPM, observe the reading on oil pressure gauge. If the pressure is above maximum or below minimum specified limits, stop engine and screw adjusting screw counterclockwise to decrease pressure and clockwise to increase the oil pressure. Depending on installation the adjusting screw may have the screw driver slot plus a pinned 3/8-24 castellated nut and may be turned with either a screw driver or a box end wrench.

4. CYLINDERS – Although the complete procedure for disassembly and reassembly of cylinder is given here, it is recommended that as a field operation, cylinder maintenance should be confined to replacement of the entire assembly. Valve replacement should be undertaken only as an emergency measure.

a. Removal of Cylinder Assembly –

(1) Remove the exhaust manifold.

(2) Remove rocker box drain tube, intake pipe and any clips that might interfere with the removal of the cylinder assembly.

(3) Disconnect ignition leads and remove spark plugs.

(4) Remove rocker box cover and rotate crankshaft until piston is approximately at top dead center of the compression stroke. The approximate position may be located by observing the top of piston through the spark plug hole and also observing that both valves are in the closed position.

(5) Remove the 5/16-24 self-locking nuts. Thus removing the valve rocker, valve fulcrum, shim and rotator from the exhaust valve.

NOTE

Do not lose shim when valve rocker fulcrum is removed from cylinder head.

(6) Remove push rods by grasping ball end and pulling rod out of shroud tube. Remove ¼-20 nut, lockplate and shroud tube spring and pull shroud tubes through holes in cylinder head.

NOTE

The hydraulic lifters, push rods, rocker arms and valves must be reassembled in the same location from which they were removed.

(7) Remove cylinder base nuts, then remove cylinder by pulling directly away from the crankcase. Be careful not to allow the piston and connecting rod to drop against the crankcase as the piston leaves the cylinder.

f. Removal of Valves and Valve Spring from Cylinder – Place the cylinder over a block of wood so as to hold the valves in a closed position. Compress the valve spring using the valve spring compressor (Service Tool No. ST-419). Remove the split keys from the end of the valve stem. The valve springs and valve spring seats may now be removed from cylinder head. Hold the valve stems so that the valves will not drop out and remove the cylinder from the holding block. The valves may be removed from the inside of the cylinder.

c. Removal of Piston from Connecting Rod – Remove piston pin plugs. Insert piston pin puller (Service Tool No. 64843) through piston pin, assemble puller nut; then proceed to remove piston pin. Do not allow the connecting rod to rest on cylinder pad of crankcase. Support with heavy rubber bands, discarded cylinder base oil ring seals or any other suitable method.

d. Removal, Disassembly, Cleaning, Inspection and Reassembly of Hydraulic Lifters –

(1) Remove hydraulic lifters from crankcase.

(2) Being careful not to scratch socket, insert a suitable tool into lifter socket and compress. This will force the trapped oil out of the vent hole and release the pressure on the spring clip.

(3) Remove and discard the spring clip.

CAUTION

UPON RELEASE, SPRING CLIP MAY SPRING UP WITH GREAT FORCE. BE CAREFUL!

(4) Remove push rod socket and plunger assembly from the lifter body. Clean all parts in solvent. Inspect the lifter body for the following imperfections.

Spalling – If the face of the hydraulic lifter shows small nicks or indentations near the center of the face, it is considered pitted or spalled. The pitting will constitute small irregular holes, not to be confused with Rockwell harness check marks which are round and even. The area covered by spalling will vary with the different lifters, but regardless of the degree, the lifter must be replaced.

Scoring – The lifter face is scored when small scratch like lines are found on the surface. These marks are usually found near the outer edge of the face and will appear to radiate from the center. Other scoring marks may be present and extend to the center of the lifter face. Any lifter with this condition in evidence must be replaced.

Face Wear – The operation of the lifter provides that the lifter rotates during the wiping operation of the cam. This will form a groove, or path. This path will extend all the way across the face and deeper penetrations will be noted at the center of the face. If the wear is excessive, it will be noticeable to the touch if the fingernail is rubbed across the face of the lifter. This condition requires replacement of the hydraulic lifter.

(5) Reassemble the plunger assembly and push rod socket into the hydraulic lifter body. Secure with a new spring clip.

NOTE

The hydraulic lifter must be perfectly dry in order to obtain the correct dry lifter clearance.

e. Assembly of Valves in Cylinder –

(1) Prelubricate the valve stems and interior of valve guides with Molytex "O" grease or equivalent and insert each valve stem in its respective guide. Hold valve stem tips to prevent falling from cylinder.

(2) Place cylinder with valves over a wood block so that the valves are held against the seats. Assemble the lower valve spring seats, auxiliary valve spring and outer valve spring over the valve stems and valve guides. Place the upper valve spring seat on top of the springs.

NOTE

When installing valve springs, place the dampener end of spring (close wound coils is marked with dye or lacquer) toward cylinder head.

(3) Using a valve spring compressor (Service Tool No. ST-419) compress the valve spring and place the split keys in the groove around the upper end of valve stems. Slowly release the pressure on the valve spring compressor and allow the upper spring seat to lock itself in place around the valve keys.

f. Assembly of Cylinder and Related Parts – Rotate the crankshaft so that the connecting rod of the cylinder being assembled is at the top center of the compression stroke and both lifters are on the base circle of the cam lobe. They can be checked by rocking the crankshaft over the center. The lifters should not move at this position.

(1) Install lifter assembly in its respective position in the crankcase.

(2) Assemble piston with rings so that the cylinder number stamped on the dome of piston is toward the front of engine. The piston pin should be a hand push fit. If difficulty is experienced in inserting the piston pin, it is probably caused by carbon or burrs in the piston pin hole. Inspect and correct any problem that hinders the installation of the piston pin. During assembly always use a generous amount of oil both in the piston hole and on the piston pin.

(3) Assemble one piston pin plug at each end of piston pin. Place new cylinder base "O" ring seal around cylinder barrel flange. Coat piston, rings and inside of cylinder barrel generously with oil.

(4) Using ring compressor (Service Tool No. 64712), assemble the cylinder over the piston so that the intake and exhaust ports are at the bottom of the engine. Push the cylinder all of the way on, catching the ring compressor as it is pushed off.

NOTE

Before installing cylinder hold-down nuts, lubricate crankcase thru-stud threads with any one of the following lubricants or combination of lubricants.

1. *90% SAE 50W engine oil and 10% STP.*
2. *Parker Thread Lube.*
3. *60% SAE 30 engine oil and 40% Parker Thread Lube.*

(5) Install cylinder base hold-down nuts and tighten as directed in the following steps.

NOTE

At any time a cylinder is replaced, it is necessary to retorque the thru-studs on the cylinder on the opposite side of the engine.

(a) Tighten ½ inch hold-down nuts to 300 in.-lbs. (25 ft.-lbs.) torque, using the sequence beginning with the top right nut and proceeding clockwise.

(b) Using the same sequence as stated in step (a), tighten hold-down nuts to 600 in.-lbs. (50 ft.-lbs.) torque.

(c) Tighten 3/8 inch hold-down nuts to 300 in.-lbs. (25 ft.-lbs.) torque. Tightening sequence is optional.

(d) As a final check, hold the torque wrench on each nut for five seconds at the proper torque. If the nut, under this condition, does not turn, it may be presumed to be tightened to the correct torque.

CAUTION

AFTER ALL CYLINDER BASE NUTS HAVE BEEN TIGHTENED, REMOVE ANY SMALL NICKS IN THE CYLINDER FINS BY FILING OR BURRING.

(6) Install a new shroud tube oil seal on the crankcase end of each shroud tube and fit a new annular ring in the groove provided in the rocker box end of the shroud tube. Install each shroud tube through rocker box and seat the end firmly in the crankcase. Place a spring, lockplate and nut over the stud provided in the rocker box and secure both shroud tubes in place. Bend tang of the lockplate to prevent the nut and spring from loosening.

(7) Assemble each push rod in its respective shroud tube and assemble each fulcrum and rocker arm on its respective stud. Install plain 5/16-24 nut to hold rocker arm in place. Before installing exhaust valve rocker arm, place rotator cap over end of exhaust valve stem.

(8) Be sure that the piston is at top center of the compression stroke and both valves are on the base circle of the camshaft. Check clearance between the valve stem tip and the valve rocker arm. In order to check this clearance, place the thumb of one hand on the valve rocker directly over the end of the push rod and press down so as to compress the hydraulic lifter spring. While holding the spring in the compressed position, measure the clearance between the valve stem tip and the rocker arm. The clearance should be between .028 and .080 inch. If the clearance does not come within these limits, add or subtract shim under the rocker fulcrum as required to correct the clearance. After clearance is set, remove plain 5/16-24 nut and install 5/16-24 self-locking nut on fulcrum stud. Torque self-locking nut to 150 in.-lbs.

(9) Install inter-cylinder baffles, rocker box covers, intake pipes, rocker box drain back tubes and exhaust manifold.

6. ALTERNATOR DRIVE BELT TENSION.

Check the tension of a new belt at the first 25 hours after installation. Consult the latest revision of Service Instruction No. 1129 for the correct method of checking the alternator belt.

7. EXHAUST BYPASS VALVE ADJUSTMENT.

The exhaust bypass bleed bolt must be adjusted so as to reach the critical altitude of 12,000 feet, full throttle and 36.5 inches Hg. manifold pressure.

Adjust the bypass bleed bolt so that there is ¼ inch between the bolt head and top of jam nut.

For each flat turn of the bypass bleed bolt head it will change the critical altitude two hundred (200) feet. See Figure 7-1 for the location of bypass bleed bolt and jam nut.

SECTION 6
TROUBLE SHOOTING

ENGINE

TURBOCHARGER

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SECTION 6

TROUBLE-SHOOTING

Experience has proven that the best method of trouble-shooting is to decide on the various causes of a given trouble and then to eliminate the causes one by one, beginning with the most probable. The following charts list some of the more common troubles which may be encountered in maintaining engines, their probable causes and remedies.

1. TROUBLE-SHOOTING – ENGINE.

TROUBLE	PROBABLE CAUSE	REMEDY
Failure of Engine to Start	Lack of fuel.	Check fuel system for leaks. Fill fuel tank. Clean dirty lines, strainers or fuel valves.
	Overpriming.	Leave ignition "off" and mixture control in "idle cut-off". Open to full throttle and "unload" engine by cranking for a few seconds. Turn ignition switch on and proceed to start engine in normal manner.
	Magneto improperly timed to engine.	Check magneto timing as described in Section 5.
	Defective spark plugs.	Clean, adjust or replace spark plugs.
	Defective ignition wires.	Check with electric tester and replace any defective wires.
	Defective battery.	Replace with fully charged battery.
	Improper operation of magneto breaker.	Clean points. Check internal timing of magneto.
	Lack of sufficient fuel flow.	Disconnect fuel line and check fuel flow.
	Water in carburetor.	Drain carburetor and fuel lines.
	Internal failure.	Check oil screens for metal particles. If found, complete overhaul of engine may be necessary.

TROUBLE	PROBABLE CAUSE	REMEDY
Failure of Engine to Idle Properly	Incorrect idle mixture.	Adjust mixture as described in Section 5.
	Leak in induction system.	Tighten all connections in the induction system. Replace any parts that are defective.
	Incorrect idle speed adjustment.	Adjust throttle stop to obtain proper idle. See Section 5.
	Uneven cylinder compression.	Check condition of piston rings and valve seats.
	Faulty ignition system.	Check entire ignition system.
	Insufficient fuel pressure.	Check fuel pump and drive.
Low Power and Uneven Running	Mixture too rich indicated by sluggish operation. Extreme case indicated by black smoke from exhaust.	Readjustment of the carburetor by authorized personnel is necessary.
	Mixture too lean indicated by overheating of cylinder head and backfiring.	Check fuel lines for dirt or other restrictions. Readjustment of the carburetor by authorized personnel is necessary.
	Leaks in induction system.	Tighten all connections. Replace defective parts.
	Defective spark plugs.	Clean, gap or replace spark plugs as necessary.
	Improper fuel.	Fill tank with fuel of recommended grade. See Section 3.
	Magneto breaker points not working properly.	Clean points. Check internal timing of magneto. See Section 5.
	Defective spark plug terminal connector.	Replace connectors on spark plug leads.
	Defective ignition wire.	Check wire with electric tester. Replace defected wire.

TROUBLE	PROBABLE CAUSE	REMEDY
Failure of Engine to Develop Full Power	Leak in induction system.	Tighten all connections and replace any defective parts.
	Throttle lever out of adjustment.	Adjust throttle lever for full travel.
	Improper fuel flow.	Check strainer, gauge and flow at the fuel inlet.
	Restriction in air scoop.	Examine air scoop, filter and remove restriction.
	Improper fuel.	Drain and refill tank with recommended octane fuel. See Section 3.
	Faulty ignition.	Tighten all connections. Check ignition timing.
Rough Engine	Cracked engine mount.	Replace or repair defective mount.
	Defective mounting bushing.	Install new bushing.
	Uneven compression.	Check compression.
Low Oil Pressure	Insufficient oil.	Fill to proper level with recommended oil. See Section 3.
	Air lock or dirt in relief valve.	Remove and clean oil pressure relief valve.
	Leak in oil pump suction line.	Check gasket between sump and crankcase.
	High oil temp.	See "High Oil Temperature" in Trouble column.
	Defective pressure gauge.	Replace gauge.
	Stoppage in oil pump intake passage.	Check oil passage and sump gasket for obstruction. Clean suction screen.
High Oil Temperature	Insufficient cooling air.	Check air inlet and outlet for deformation or obstruction.
	Insufficient oil supply.	Fill to proper level with recommended oil. See Section 3.

TROUBLE	PROBABLE CAUSE	REMEDY
High Oil Temperature (Cont.)	Low grade oil.	Replace with oil conforming to specifications.
	Clogged oil lines or screens.	Remove and clean oil screens or lines.
	Excessive blow-by.	Usually caused by worn or stuck piston rings.
	Failing or failed bearing.	Examine sump for metal particles. If found, overhaul of engine is indicated.
	Defective temperature gauge.	Replace gauge.
	Defective oil cooler lines.	Check inside of oil lines for obstruction. Flush out lines and oil cooler.
Excessive Oil Consumption	Low grade of oil.	Fill sump with oil conforming to specifications. See Section 3.
	Failing or failed bearing.	Check sump for metal particles.
	Worn piston rings.	Install new rings.
	Incorrect installation of piston rings.	Install new rings.
	Failure of rings to seat.	Use mineral base oil. Climb to cruise altitude at full power and operate at 65% to 75% cruise power setting until oil consumption stabilizes. See Section 3.

2. TROUBLE-SHOOTING – TURBOCHARGER.

TROUBLE	PROBABLE CAUSE	REMEDY
Excessive Noise or Vibration	Improper bearing lubrication.	Supply required oil pressure. Clean or replace oil line, clean oil screen. If trouble persists, overhaul turbocharger.
	Leak in engine intake or exhaust system.	Tighten loose connections or replace manifold exhaust gaskets as necessary.
	Dirty impeller blades.	Disassemble and clean turbocharger.

TROUBLE	PROBABLE CAUSE	REMEDY
Engine Will Not Deliver Rated Power	Clogged induction system.	Clean all ducting and filter.
	Foreign material lodged in compressor, impeller or turbine.	Disassemble and clean.
	Excessive dirt build-up in compressor.	Thoroughly clean compressor assembly. Service air cleaner and check for leakage.
	Leak in engine intake and exhaust.	Tighten loose connection or replace exhaust manifold gasket as necessary.
	Turbocharger impeller binding, frozen or fouling housing.	Check bearing. Replace turbocharger.
	Rotating assembly bearing seizure.	Overhaul turbocharger.

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SECTION 7
INSTALLATION AND STORAGE

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SECTION 7

INSTALLATION AND STORAGE

1. PREPARATION OF ENGINE FOR INSTALLATION. Before installing an engine that has been prepared for storage, remove all dehydrator plugs, bags of desiccant, and preservative oil from the engine. Preservative oil can best be removed by removing the bottom spark plugs and rotating the crankshaft three (3) or four (4) revolutions by hand. The preservative oil will then drain through the bottom spark plug holes. Draining will be facilitated if the engine is tilted from side to side during the above operation. Preservative oil which has accumulated in the sump can be drained by removing the oil sump drain plug. Engines that have been stored in a cold place should be removed to an environment of at least 70°F (21°C) for a period of 24 hours before preservative oil is drained from the cylinders. If it is not possible to move the engine, heat the cylinders with heat lamps before attempting to drain the preservative oil.

After the sump has been drained, the drain plug should be replaced and safety wired. Fill the sump with the proper lubricating oil as stated in the latest revision of Service Instruction No. 1014. The crankshaft should again be turned several revolutions to saturate the interior of the engine with clean oil. When installing the spark plugs, make sure that they are clean; if not, wash them in clean petroleum solvent. Of course, there will be a small amount of preservative oil remaining in the engine, but this can cause no harm. However, after twenty-five (25) hours of operation, the lubricating oil should be drained while the engine is hot. This will remove any residual preservative oil that may have been present.

CAUTION

DO NOT ROTATE THE CRANKSHAFT ON AN ENGINE CONTAINING PRESERVATIVE OIL BEFORE REMOVING THE SPARK PLUGS, BECAUSE IF THE CYLINDERS CONTAIN ANY APPRECIABLE AMOUNT OF THE MIXTURE, THE RESULTING ACTION, KNOWN AS HYDRAULICING, WILL CAUSE DAMAGE TO THE ENGINE. ALSO, ANY CONTACT OF THE PRESERVATIVE OIL WITH A PAINTED SURFACE SHOULD BE AVOIDED.

General – Should any of the dehydrator plugs containing crystals of silica-gel or similar material, be broken during their term of storage or upon their removal from the engine, and if any of the contents should fall into the engine, that portion of the engine must be disassembled and thoroughly cleaned before using the engine. The oil screens should be thoroughly cleaned in gasoline or some other hydrocarbon solvent. The fuel screen located in the fuel inlet of the carburetor should also be removed and cleaned in a hydrocarbon solvent. The operator should also note if any valves are sticking. If they are this condition can be eliminated by coating the valve stem generously with a mixture of gasoline and lubricating oil.

Inspection of Engine Mounting – If the aircraft is one from which an engine has been removed, make sure that the engine mounts are not bent or damaged by distortion or misalignment as this can produce abnormal stresses within the engine.

Attaching Engine to Mounts – See aircraft manufacturer's recommendations for the method of mounting the engine.

Oil and Fuel Line Connections – The oil and fuel line connections are called out on the installation drawing in this section.

2. PREPARATION OF CARBURETORS FOR INSTALLATION.

Carburetors that have been prepared for storage should undergo the following procedures before being placed in service.

Remove the fuel drain plug and drain preservative oil from float bowl. Remove the fuel inlet screen assembly and clean in a hydrocarbon solvent. Reinstall the fuel drain plug and fuel inlet screen assembly. Tighten screen assembly to 35-40 in.-lbs. torque.

CORROSION PREVENTION IN ENGINES INSTALLED IN INACTIVE AIRCRAFT

Corrosion can occur, especially in new or overhauled engines, on cylinder walls of the engine that will be inoperative for periods as brief as two (2) days. Therefore, the following preservation procedures is recommended for inactive engines and will be effective in minimizing the corrosion condition for a period of up to thirty (30) days.

NOTE

Ground running of the engine for brief periods of time is not a substitute for the following procedure; in fact, the practice of ground running will tend to aggravate rather then minimize this corrosion condition.

a. As soon as possible after the engine is stopped, move the aircraft into the hangar, or other shelter where the preservation process is to be performed.

b. Remove sufficient cowling to gain access to the spark plugs and remove both top and bottom from each cylinder.

c. Spray the interior of each cylinder with approximately two (2) ounces of corrosion preventive oil while cranking the engine about five (5) revolutions with the starter. The spray gun nozzle may be placed in either the top or bottom spark plug holes.

NOTE

Spraying should be accomplished using an airless spray gun (Spraying Systems Co., "Gunjet" Model 24A-8395 or equivalent). In the event an airless spray gun is not available, personnel should install a moisture trap in the air line of a conventional spray gun and be certain oil is hot at the nozzle before spraying cylinders.

d. With the crankshaft stationary, again spray each cylinder through the spark plug holes with approximately two (2) ounces of corrosion preventive oil. Assemble spark plugs and do not turn crankshaft after cylinders have been sprayed.

The corrosion preventive oil to be used in foregoing procedure should conform to specification MIL-L-6529, Type 1 heated to 200°F/220°F (93°C/104°C) spray nozzle temperature. It is not necessary to flush preservative oil from the cylinder prior to flying the aircraft. The small quantity of oil coating the cylinder will be expelled from the engine during the first few minutes of operation.

NOTE

Oils of the type mentioned are to be used in Lycoming aircraft engines for corrosion prevention only, and not for lubrication. See the latest revision of Lycoming Service Instruction No. 1014 for recommended lubricating oil.

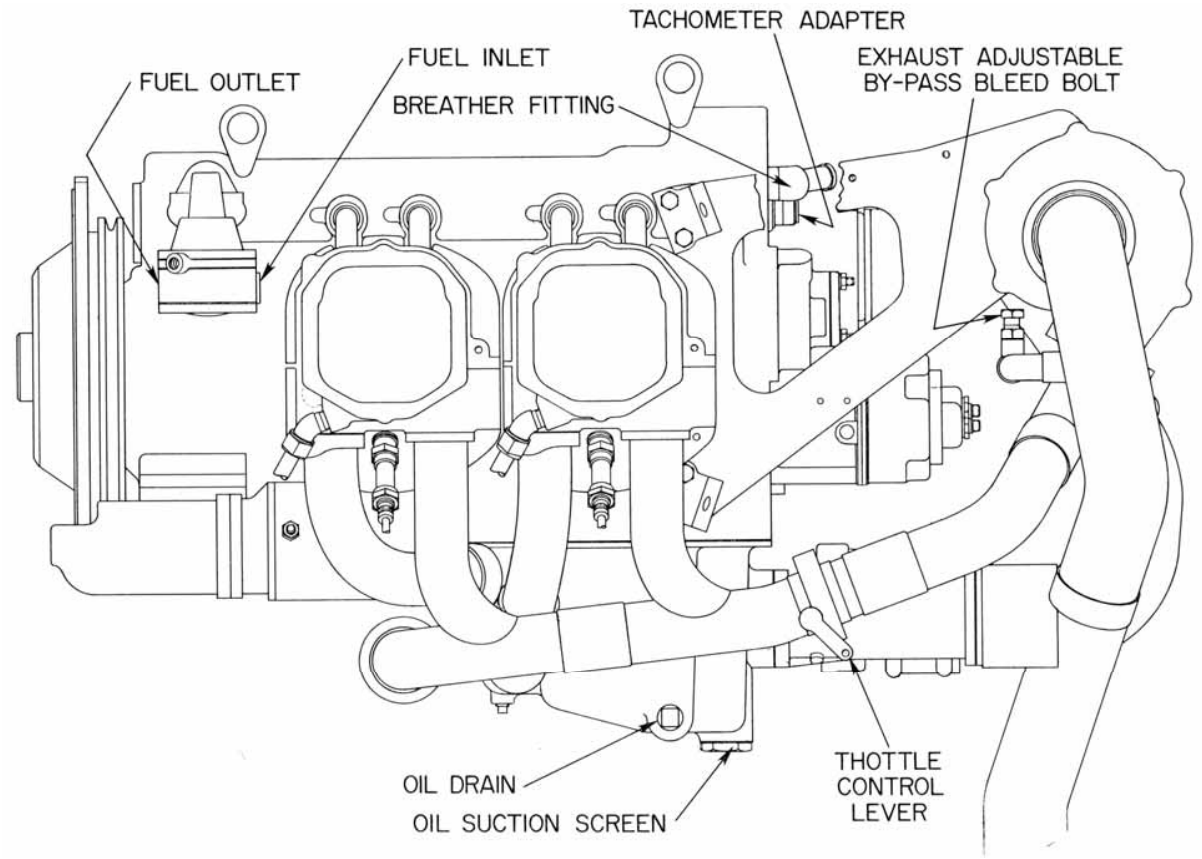

Figure 7-1. Installation Drawing –
Left Side View

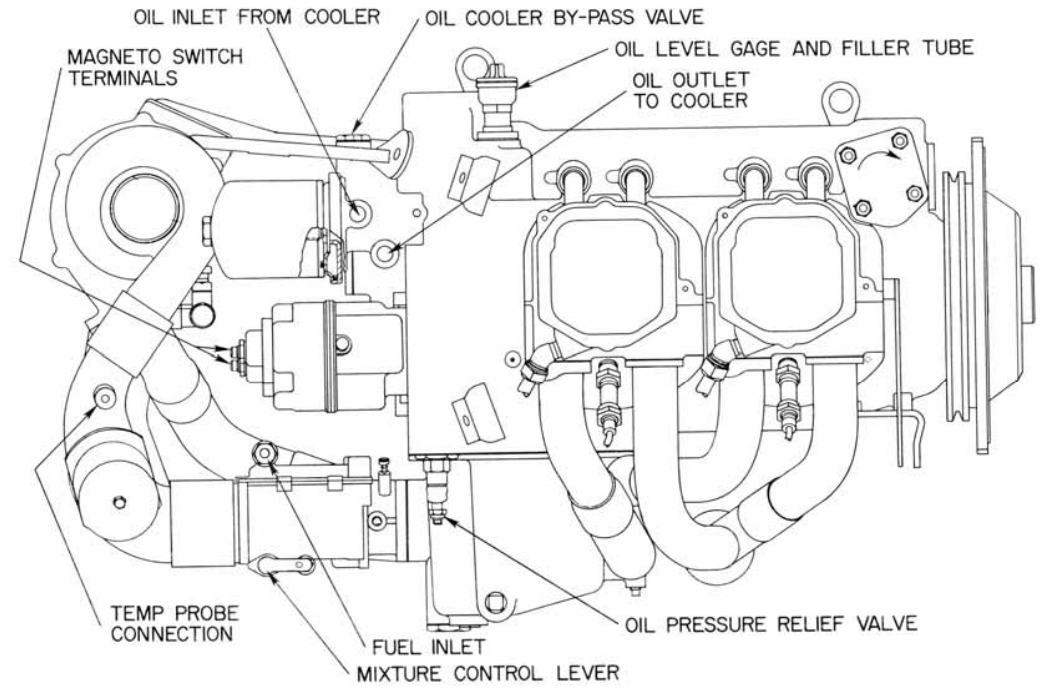

Figure 7-2. Installation Drawing –
Right Side View

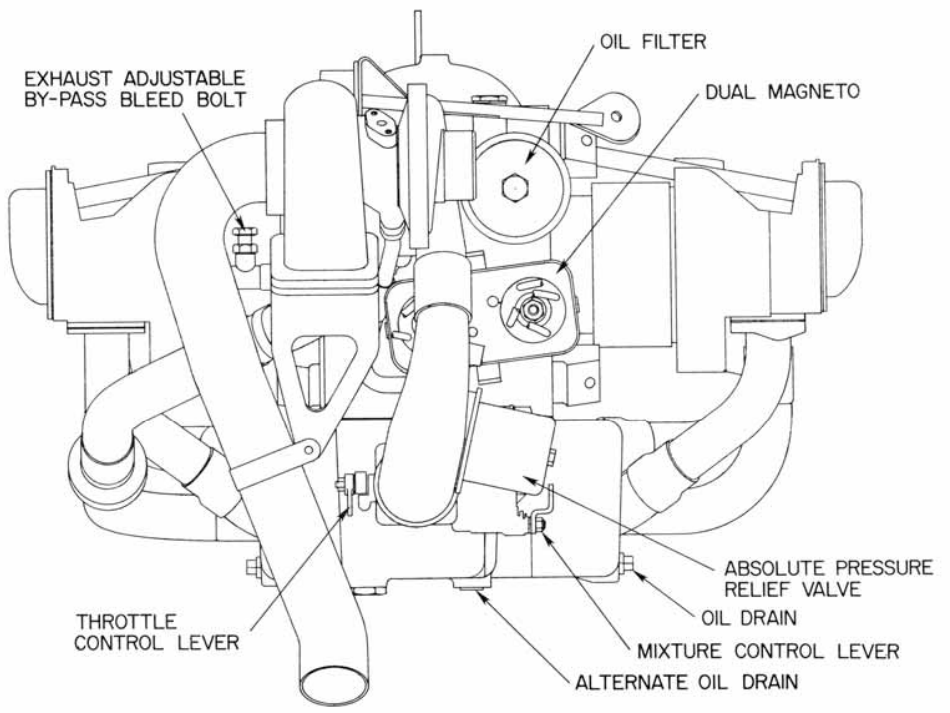

Figure 7-3. Installation Drawing –
Rear View

SECTION 8
TABLES

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SECTION 8

TABLES

FOR TIGHTENING TORQUE RECOMMENDATIONS AND INFORMATION CONCERNING TOLERANCES AND DIMENSIONS THAT MUST BE MAINTAINED IN LYCOMING AIRCRAFT ENGINES, CONSULT THE LATEST REVISION OF SPECIAL SERVICE PUBLICATION NO. SSP-1776.

CONSULT LATEST REVISION OF SERVICE INSTRUCTIONS NO. 1029 AND NO. 1150 FOR INFORMATION PERTINENT TO CORRECTLY INSTALLING CYLINDER ASSEMBLY.

FIXED WING ONLY

GROUND RUN AFTER TOP OVERHAUL
OR CYLINDER CHANGE WITH NEW RINGS

(DO NOT USE AFTER MAJOR OVERHAUL)

1. Avoid dusty location and loose stones.
2. Head aircraft into the wind.
3. All cowling should be in place, cowl flaps open.
4. Accomplish ground run in full flat pitch.
5. Never exceed 200°F. oil temperature.
6. If cylinder head temperatures reach 400°F., shut down and allow engine to cool before continuing.

Type Aircraft_____

Registration No._____

Aircraft No._____

Owner_____

Engine Model_____ S/N_____

Date_____

Run-Up By_____

GROUND RUN

			Temperature				Pressure				Temperature			Fuel Flow	
Time	RPM	MAP	L. oil	R. oil	L. cyl.	R. cyl.	L. oil	R. oil	L. fuel	R. fuel	L. carb.	R. carb.	Amb. Air	Left	Right
5 min	1000														
10 min	1200														
10 min	1300														
5 min	1500														
5 min	1600														
5 min	1700														
5 min	1800														

Mag. Check

Power Check

Idle Check

Adjustment Required

After Completion of Ground Run

1. Visually inspect engine(s)
2. Check oil levels

FLIGHT TEST AFTER TOP OVERHAUL OR CYLINDER CHANGE WITH NEW RINGS

1. Test fly aircraft one hour.
2. Use standard power for climb, and at least 75% power for cruise.
3. Make climb shallow and at good airspeed for cooling.
4. Record engine instrument readings during climb and cruise.

Tested by______________________________

FLIGHT TEST RECORD

			Temperature				Pressure				Temperature			Fuel Flow	
Time	RPM	MAP	L. oil	R. oil	L. cyl.	R. cyl.	L. oil	R. oil	L. fuel	R. fuel	L. carb	R. carb	Amb. Air	Left	Right
(Climb)															
Cruise															

Adjustment Required After Flight

After Test Flight.

1. Make careful visual inspection of engine(s).
2. Check oil level(s).
3. If oil consumption is excessive, (see operator's manual for limits), remove spark plugs and check cylinder barrels for scoring.

FULL THROTTLE HP AT ALTITUDE
(Normally Aspirated Engines)

Altitude Ft.	% S.L. H.P.	Altitude Ft.	% S.L. H.P.	Altitude Ft.	% S.L. H.P.
0	100	10,000	70.8	19,500	49.1
500	98.5	11,000	68.3	20,000	48.0
1,000	96.8	12,000	65.8	20,500	47.6
2,000	93.6	13,000	63.4	21,000	46.0
2,500	92.0	14,000	61.0	21,500	45.2
3,000	90.5	15,000	58.7	22,000	44.0
4,000	87.5	16,000	56.5	22,500	43.4
5,000	84.6	17,000	54.3	23,000	42.2
6,000	81.7	17,500	53.1	23,500	41.4
7,000	78.9	18,000	52.1	24,000	40.3
8,000	76.2	18,500	51.4	24,500	39.5
9,000	73.5	19,000	50.0	25,000	38.5

TABLE OF SPEED EQUIVALENTS

Sec./Mi.	M.P.H.	Sec./Mi.	M.P.H.	Sec./Mi.	M.P.H.
72.0	50	24.0	150	14.4	250
60.0	60	22.5	160	13.8	260
51.4	70	21.2	170	13.3	270
45.0	80	20.0	180	12.8	280
40.0	90	18.9	190	12.4	290
36.0	100	18.0	200	12.0	300
32.7	110	17.1	210	11.6	310
30.0	120	16.4	220	11.2	320
27.7	130	15.6	230	10.9	330
25.7	140	15.0	240	10.6	340

CENTIGRADE-FAHRENHEIT CONVERSION TABLE

Example: To convert 20°C to Fahrenheit, find 20 in the center column headed (F-C); then read 68.0°F in the column (F) to the right. To convert 20°F to Centigrade; find 20 in the center column and read –6.67°C in the (C) column to the left.

C	F-C	F	C	F-C	F
-56.7	-70	-94.0	104.44	220	428.0
-51.1	-60	-76.0	110.00	230	446.0
-45.6	-50	-58.0	115.56	240	464.0
-40.0	-40	-40.0	121.11	250	482.0
-34.0	-30	-22.0	126.67	260	500.0
-28.9	-20	-4.0	132.22	270	518.0
-23.3	-10	14.0	137.78	280	536.0
-17.8	0	32.0	143.33	290	554.0
-12.22	10	50.0	148.89	300	572.0
-6.67	20	68.0	154.44	310	590.0
1.11	30	86.0	160.00	320	608.0
4.44	40	104.0	165.56	330	626.0
10.00	50	122.0	171.11	340	644.0
15.56	60	140.0	176.67	350	662.0
21.11	70	158.0	182.22	360	680.0
26.67	80	176.0	187.78	370	698.0
32.22	90	194.0	193.33	380	716.0
37.78	100	212.0	198.89	390	734.0
43.33	110	230.0	204.44	400	752.0
48.89	120	248.0	210.00	410	770.0
54.44	130	266.0	215.56	420	788.0
50.00	140	284.0	221.11	430	806.0
65.56	150	302.0	226.67	440	824.0
71.00	160	320.0	232.22	450	842.0
76.67	170	338.0	237.78	460	860.0
82.22	180	356.0	243.33	470	878.0
87.78	190	374.0	248.89	480	896.0
93.33	200	392.0	254.44	490	914.0
98.89	210	410.0	260.00	500	932.0

INCH FRACTIONS CONVERSIONS
Decimals, Area of Circles and Millimeters

Inch Fraction	Decimal Equiv.	Area Sq. In.	MM Equiv.	Inch Fraction	Decimal Equiv.	Area Sq. In.	MM Equiv.
1/64	.0156	.0002	.397	1/2	.5	.1964	12.700
1/32	.0312	.0008	.794	17/32	.5312	.2217	13.494
3/64	.0469	.0017	1.191	35/64	.5469	.2349	13.891
1/16	.0625	.0031	1.587	9/16	.5625	.2485	14.288
3/32	.0937	.0069	2.381	19/32	.5937	.2769	15.081
7/64	.1094	.0094	2.778	39.64	.6094	.2916	15.478
1/8	.125	.0123	3.175	5/8	.625	.3068	15.875
5/32	.1562	.0192	3.969	21/32	.6562	.3382	16.669
11/64	.1719	.0232	4.366	43/64	.6719	.3545	17.065
3/16	.1875	.0276	4.762	11/16	.6875	.3712	17.462
7/32	.2187	.0376	5.556	23/32	.7187	.4057	18.256
15/64	.2344	.0431	5.593	47/64	.7344	.4235	18.653
1/4	.25	.0491	6.350	3/4	.75	.4418	19.050
9/32	.2812	.0621	7.144	25/32	.7812	.4794	19.844
19/64	.2969	.0692	7.540	51/64	.7969	.4987	20.241
5/16	.3125	.0767	7.937	13/16	.8125	.5185	20.637
11/32	.3437	.0928	8.731	27/32	.8437	.5591	21.431
23/64	.3594	.1014	9.128	55/64	.8594	.5800	21.828
3/8	.375	.1105	9.525	7/8	.875	.6013	22.225
13/32	.4062	.1296	10.319	29/32	.9062	.6450	23.019
27/64	.4219	.1398	10.716	59/64	.9219	.6675	23.416
7/16	.4375	.1503	11.112	15/16	.9375	.6903	23.812
15/32	.4687	.1725	11.906	31/32	.9687	.7371	24.606
31/64	.4844	.1842	12.303	63/64	.9844	.7610	25.003