Operator's Manual

Superior XP-360 Engine®

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1. Introduction

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1. Introduction

The XP-360 Engine® series are air-cooled, four cylinder, horizontally opposed, direct drive engines for experimental aircraft available in a variety of configurations and accessory options. Depending on engine model, the majority, if not all, of the engine's components are FAA approved parts, except as noted.

1.1 Models

XP-360 Engine® Model Designations

Example: IO-360-B1AC3

Fuel System Type

⇨ IO Denotes the "opposed" arrangement. Fuel "Injection" system installed
O Denotes the "opposed" arrangement, defaults to carbureted

Cylinder Type

⇨ 360 Parallel valve cylinder (361 cu.in.)

Model Suffix Denotes detail engine configuration

1st Digit Crankshaft and Propeller Type

A Fixed-Pitch, Thin-wall front main
⇨ B Constant-Speed, Thin-wall front main
C Fixed-Pitch, Heavy-wall front main
D Constant-Speed, Heavy-wall front main
E Fixed-Pitch, Solid front main

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2nd Digit — Crankcase & Engine Mount Type

⇨ 1 #1 Dynafocal Mount
2 #2 Dynafocal Mount
3 Conical Mounts

3rd Digit — Accessory Package

		Ignition	Fuel System	
			Carbureted	Fuel Injected
⇨	A	Slick Magnetos	Precision Carburetor	Precision Fuel Injection**
	C	Lightspeed EIS*	Precision Carburetor	Precision Fuel Injection**
	D	Slick Magnetos	-	Airflow Performance*
	F	Lightspeed EIS*	-	Airflow Performance*
	G	Dual P-Mag	-	Airflow Performance*
	H	Dual P-Mag	Precision Carburetor	Precision Fuel Injection**

4th Digit — Induction System

None Updraft Induction
A Lightweight, Cold-Air, Horizontal Front Induction* (FI only)
B Lightweight, Cold-Air, Horizontal Rear Induction * (FI only)
⇨ C Lightweight, Hot-Air, Updraft Induction, Roller Lifter*
D Lightweight, Cold-Air, Horizontal Front Induction, Roller Lifter *(FI only)

5th Digit — Power Rating: Piston Compression Ratio and Minimum Rated HP

		Cylinder Type	
		360	
		CR	HP
	1	7.2:1	170
	2	8.5:1	180
⇨	3	9:1	185

* Components Not FAA Approved ** Available as FAA Approved or Experimental

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1.2 GENERAL

All engine components will be referenced as they are installed in the airframe. Therefore, the prop end is the front and the rear would be where the accessory drive is mounted. The sump is on the bottom and the cylinder's shroud tubes are on the top. All reference to the left and right sides are made from the rear looking forward toward the front of the engine. Cylinder numbering is from the front to rear and the odd numbers are on the right. The direction of the crankshaft rotation is viewed from the rear and is clockwise. Accessory drive rotations are determined by facing the drive pad.

1.3 FEATURES

1.3.1 Crankshaft – The crankshaft is made from aerospace grade Electro Slag Remelt (E.S.R.) steel. All bearing journal surfaces are nitrided. Crankshafts are available in thin-wall, heavy-wall, or solid front main bearing journal inner diameters. These variations are designed to address torsional stress demands of various installations, such as higher compression ratios, higher horsepower, or aerobatic applications. Non-solid crankshafts have oil plugs installed inside the hollow front main to establish if the crankshaft is a constant-speed or fixed-pitch application.

1.3.2 Connecting Rods – The connecting rods are made from aerospace grade SAE 8740 forgings per AMS 6325. They have replaceable bearing inserts in the crankshaft ends and bronze bushings in the piston ends. The bearing caps on the crankshaft ends are retained by two rod bolts and nuts. Specific connecting rods are designed for use with specific types of crankshafts.

1.3.3 Camshaft – Valve Operating Mechanism – The camshaft is located over and parallel to the crankshaft. The camshaft actuates hydraulic lifters, which operate the valves through push rods and valve rocker arms.

1.3.4 Crankcase – The crankcase is made from aerospace grade AA C355-T71 stabilized structural aluminum alloy per AMS 4214. The assembly consists of two reinforced aluminum castings, fastened together by means of studs, bolts, and nuts. The main bearing bores are machined for use of precision type main bearing inserts. All crankcases have been manufactured with the capability of installing piston oil cooling nozzles for high power applications.

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1.3.5 Accessory Housing – The accessory housing is made from aerospace grade AA C355-T71 stabilized structural aluminum alloy per AMS 4214. The machined aluminum casting is fastened to the rear of the crankcase and the top rear of the sump. It forms a housing for the oil pump, oil system, various accessory drives, and gear train.

1.3.6 Oil Sump – The oil sump incorporates an oil drain plug, oil suction screen, and integral induction system with intake riser and intake pipe connections and mounting pad for carburetor or fuel injector. Sump and induction systems are available as standard updraft or lightweight cold-air front or rear mount. Standard sump and induction systems are made from cast aluminum alloy.

1.3.7 Cylinders – The XP-360 Engine® uses Millennium® Cylinders exclusively. These air-cooled cylinder assemblies are manufactured by screwing together the head and barrel with a thermal interference fit. The heads are made from AMS 4220 aluminum alloy casting material. All barrels, machined from AMS 6382 forgings, are internally choked and honed to allow optimal operation of the rings and pistons at operating temperatures.

1.3.8 Pistons – The pistons are made from a high temperature aluminum alloy, either cast or forged. The piston pin is of a full floating type with a plug located in each end of the pin. The piston is a 3-ring type, with 2 compression rings and 1 oil control ring. Pistons are available in a variety of compression ratios, based on cylinder type.

1.3.9 Cooling System – These engines are designed to be cooled by air. Baffles are provided to build up air pressure to force the air through the cylinder fins. The air is then exhausted to the atmosphere through the rear of the cowling.

1.3.10 Induction System – The distribution of the air to each cylinder is through the center zone of the induction system. The induction system is integrated with the oil sump. The standard updraft induction system is submerged in oil. Front and rear mount induction systems are cold-air systems and do not pass the intake air through the engine oil. Induction systems are available as standard updraft or lightweight cold-air front or rear mount. Lightweight, cold-air induction systems are available only as fuel injected. Cold-air induction systems incorporate a “sniffle” or fuel drain valve to prevent excess fuel from accumulating in the induction system and a quick-drain oil plug. Standard sump and induction systems are made from cast aluminum alloy.

1.3.11 Fuel Systems

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1.3.11.1 Carbureted – O-360 engines are equipped with a float type MA4-5 vertical (FAA-certified) carburetor. These systems require carburetor heat to prevent icing, a priming system, and a low pressure fuel pump.

The MA-4-5 carburetors are of the single barrel float type equipped with a manual mixture control and idle cut-off.

1.3.11.2 Fuel Injected – IO-360 series engines are equipped with a direct-port injected RSA-5A (FAA-certified) or EX360-1 (experimental) Precision Airmotive fuel injection system, or Airflow Performance FM-200 fuel injection system (for more information see www.airflowperformance.com). These fuel injection systems schedule fuel flow in proportion to air flow and fuel vaporization takes place at the intake ports. These fuel injection systems utilize a high pressure fuel pump.

These fuel injection systems are based on the principle of measuring airflow and, using the air pressure in a stem type regulator, converting the air pressure into a fuel pressure. The fuel pressure (fuel pressure differential) when applied across the fuel metering section (jetting system) makes fuel flow proportional to airflow.

1.3.12 Lubrication System – The full pressure wet sump lubrication system is supplied by an impeller type pump contained within the accessory housing. Oil for rotating and wear components of the engine is supplied through oil galleys in both sides of the crankcase. All engines come with an oil filter adapter and Champion CH48108 oil filter.

1.3.13 Priming System – A 3-cylinder primer system (cylinders 1,2,3) is provided on all engines using a carburetor. Fuel injected engines do not require a priming system.

1.3.14 Ignition System – Dual ignition is furnished by either two Unison Slick 4371 impulse magnetos (FAA-certified), or E-Mag Electronic Ignition the "P" Model (P-Mag), or Lightspeed Plasma electronic ignition systems (see www.lsecorp.com for more information). Spark energy is delivered via a Unison or Champion ignition harness and spark plugs.

1.3.15 Starter – All engines are equipped with a 12V lightweight starter.

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2. Specifications

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2. Specifications

The specifications of the XP Engine® listed in this section are applicable to the O and IO-320 and O and IO-360 engines.

2.1 COMPLETE ENGINE INCLUDES:

Crankcase assembly, crankshaft assembly, camshaft assembly, valve drive train, cylinder assemblies, connecting rod assemblies, oil sump assembly, inter-cylinder baffling, starter, lubrication system (includes oil filter), accessory drives, ignition system (includes spark plugs), fuel system, starter support assembly, oil gage and induction system, and accessories. Also included with the engine are this Operator's Manual, a copy of the warranty policy, a registration form, and a change of address form.

2.2 COMPLETE ENGINE DOES NOT INCLUDE:

Outer cylinder baffling, propeller governor, airframe to engine control cables, attaching hardware, hose clamps, vacuum pump, exhaust system, fittings, and alternator.

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2.3 O/IO-360 Series Engines

Rated speed, RPM 2700
Bore, inches 5.125
Stroke, inches 4.375
Displacement, cubic inches 361
Firing order 1-3-2-4
Spark occurs, degrees BTC 25
Valve rocker clearance (hydraulic tappets collapsed) .... .028-.080
Propeller drive ratio 1:1
Propeller drive rotation (viewed from rear) .... Clockwise

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2.4

Minimum Rated Power vs. Compression Ratio

Model Power Suffix	Cylinder Type	
	360	
	CR	HP
1	7.2:1	170
2	8.5:1	180
3	9:1	185

2.5

Accessory Drive Data

Accessory	Drive Ratio	Direction of Rotation
Starter	16.556:1	Counter-Clockwise
Alternator (not included)	3.250:1	Clockwise
Tachometer	.500:1	Clockwise
Magneto	1.000:1	Clockwise
Vacuum Pump (not included)	1.300:1	Counter-Clockwise
Propeller Governor Rear (not included)	.866:1	Clockwise
Propeller Governor Front (not included)	.895:1	
Fuel Pump - Plunger Operated	.500:1	Reciprocating

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2.6

Installation Data

2.6.1

Dimensions

Model	Height*	Width	Length
O-360 Series	24.6”	33.4”	32.8”
IO-360 Series	24.0”	33.4”	32.8”

* Horizontal front or rear-mount induction height is approx. 4.5” less, final installed height depends on installation.

2.6.2

Weight*

Model	Lbs.
O-360-A	279
O-360-B	283
O-360-C	282
O-360-D	286
O-360-E	286
IO-360-A	286
IO-360-B	290
IO-360-C	289
IO-360-D	293
IO-360-E	293

* Weight with standard accessory package “A”. Lightweight induction system & oil sump weighs 8 lbs. less.

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3. Installation Instructions

Figures

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3. Installation Instructions

3.1 PREPARING ENGINE FOR SERVICE

3.1.1 If your engine has been preserved, remove the shipping plugs installed in the lower spark plug holes and turn the crankshaft through at least twice in order to remove the cylinder preservation oil from the cylinders. Remove the shipping plugs installed in the upper spark plug holes and inspect the cylinder bores for rust or contamination. Contact Superior Air Parts, Inc. if any abnormal condition is noted.

3.1.2 Engines that have been subjected to a cold environment for long periods of time should be placed into at least 70ºF (21ºC) atmosphere for 24 hours or more before attempting to drain the preservative oil. If this can not be done, heat the cylinders with heating lamps before attempting to drain the engine.

3.1.3 Remove exhaust port protective plugs. Service the lubrication system with mineral (non-detergent) oil.

3.1.4 Remove the shipping plate from the propeller governor pad as required for governor installation. Lubricate the governor shaft splines with engine oil, install a new gasket and then install the propeller governor control. Align the spline of governor drive gear and be sure that the governor is fully seated to the adapter prior to installing the attaching hardware. This eliminates the possibility of misalignment. Attach with plain washers, new lock washer and torque the nuts to 200 inch-pounds.

3.1.5 Optional accessories such as vacuum pumps, hydraulic pumps, etc., may be installed on the accessory drive pads located on the rear of the accessory housing. Remove the accessory drive covers and install new gaskets. Install accessories in accordance with the manufacturer's instructions.

3.1.6 Install all airframe manufacturers' required cooling baffles, hoses, fittings, brackets and ground straps in accordance with airframe manufacturer's instructions.

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3.2 INSTALLATION OF ENGINE

3.2.1 Install per airframe manufacturer's instructions. Only the lifting eye bracket installed on the backbone of the crankcase should be used to hoist the engine.

3.2.2 Consult airframe manufacturer's instructions for engine to airframe connections. Remove all protective covers, plugs, caps and identification tags as each item is connected or installed.

3.2.3 The aircraft fuel tanks and lines must be purged to remove all contamination prior to installation of the main fuel inlet line to the fuel pump. Failure to comply may cause erratic fuel injection system operation and damage to its components.

3.2.4 Do not install the ignition harness "B" nuts on the spark plugs until the propeller installation is completed. Failure to comply may result in bodily injury when the propeller is rotated during installation.

3.2.5 Install the approved propeller in accordance with the manufacturer's instructions.

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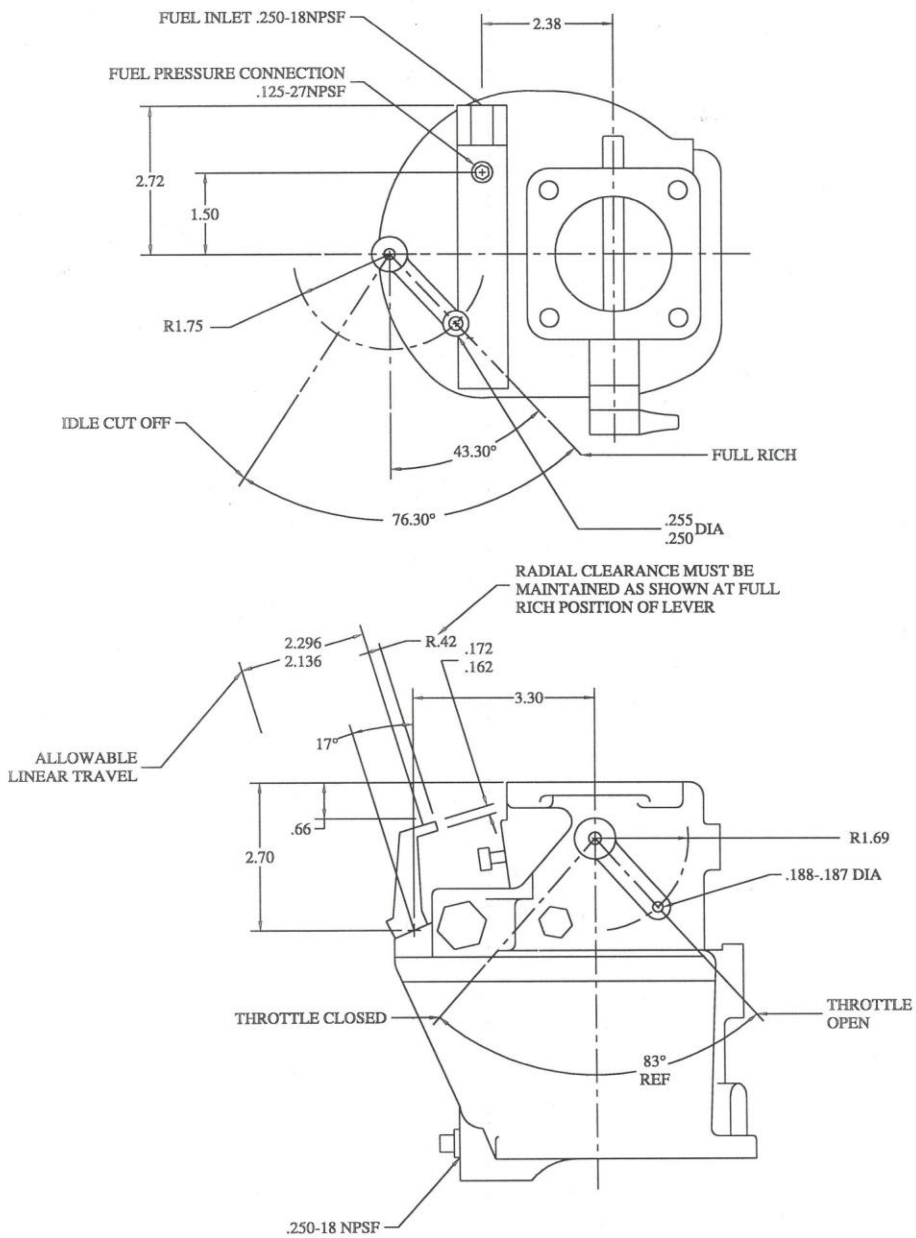

Fuel Metering System
Carburetor

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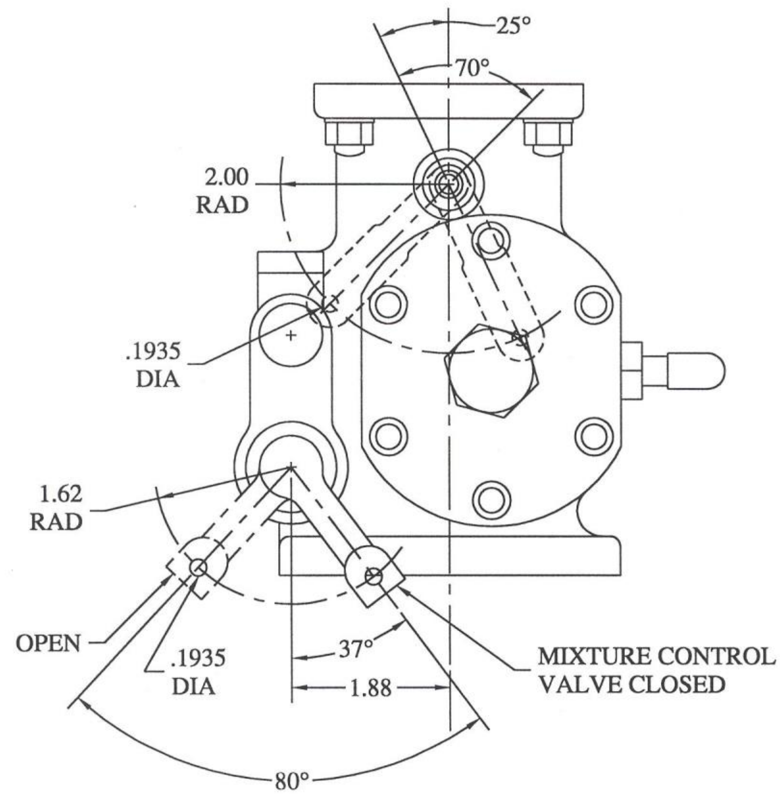

Fuel Metering System
Fuel Injector

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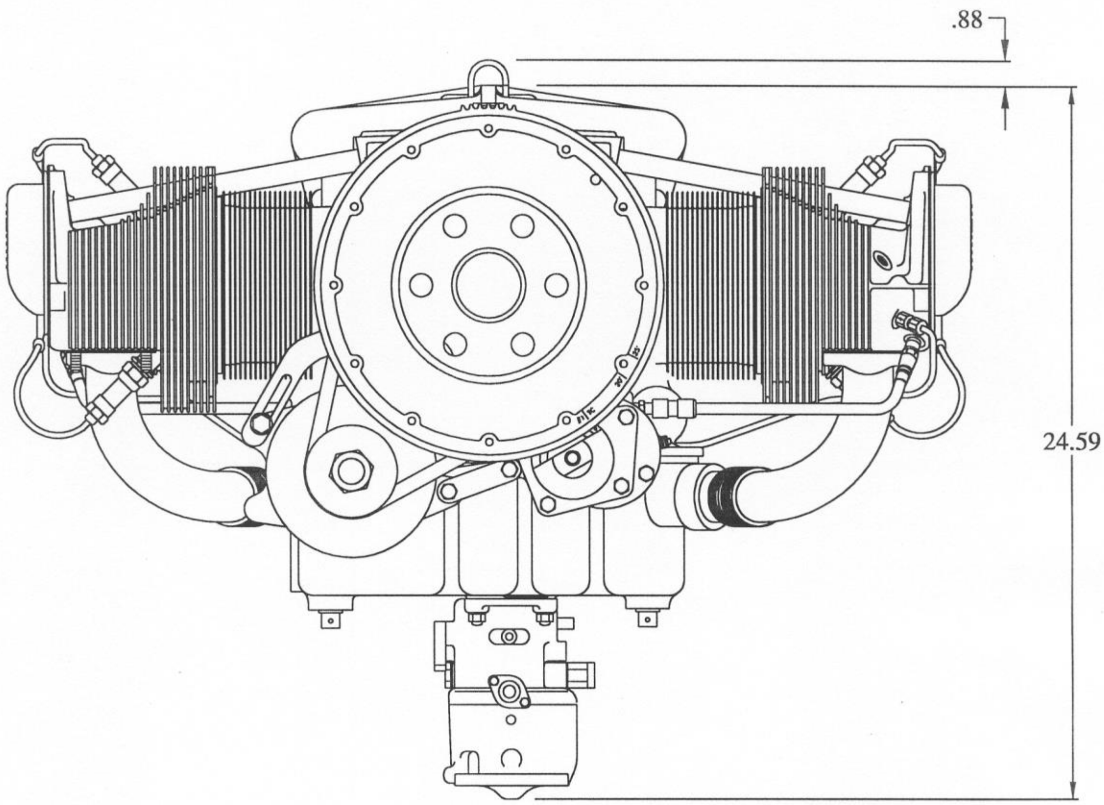

Installation Drawing
Front View
O-360

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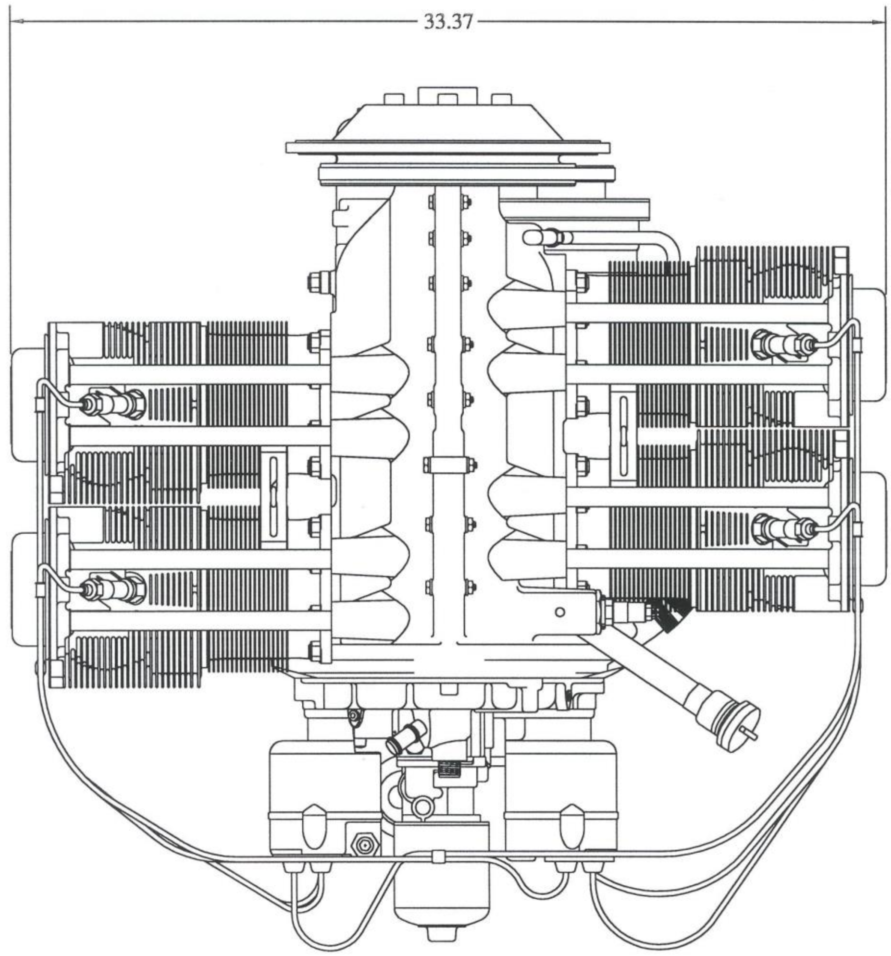

Installation Drawing
Top View
O-360

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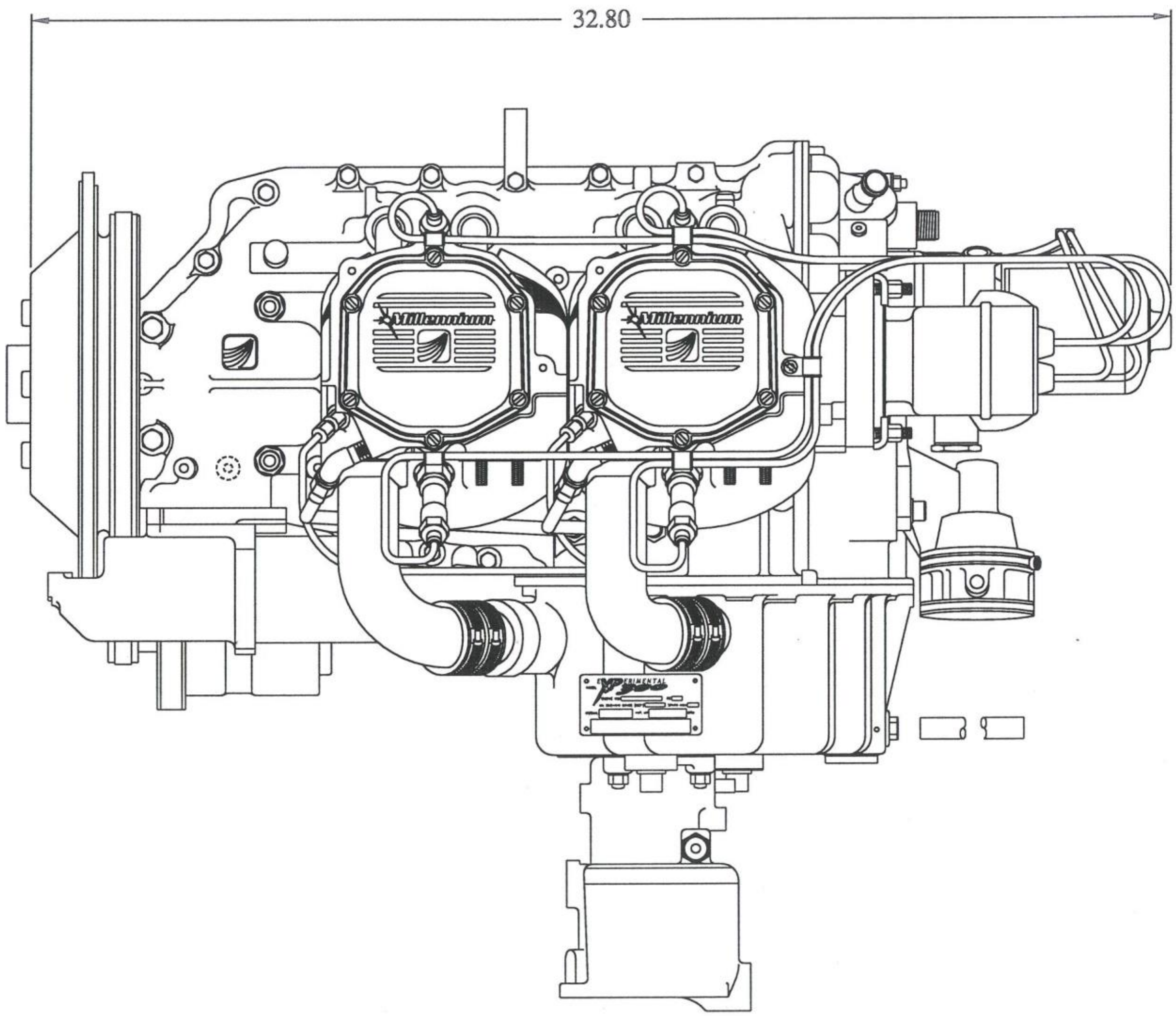

Installation Drawing
Side View
O-360

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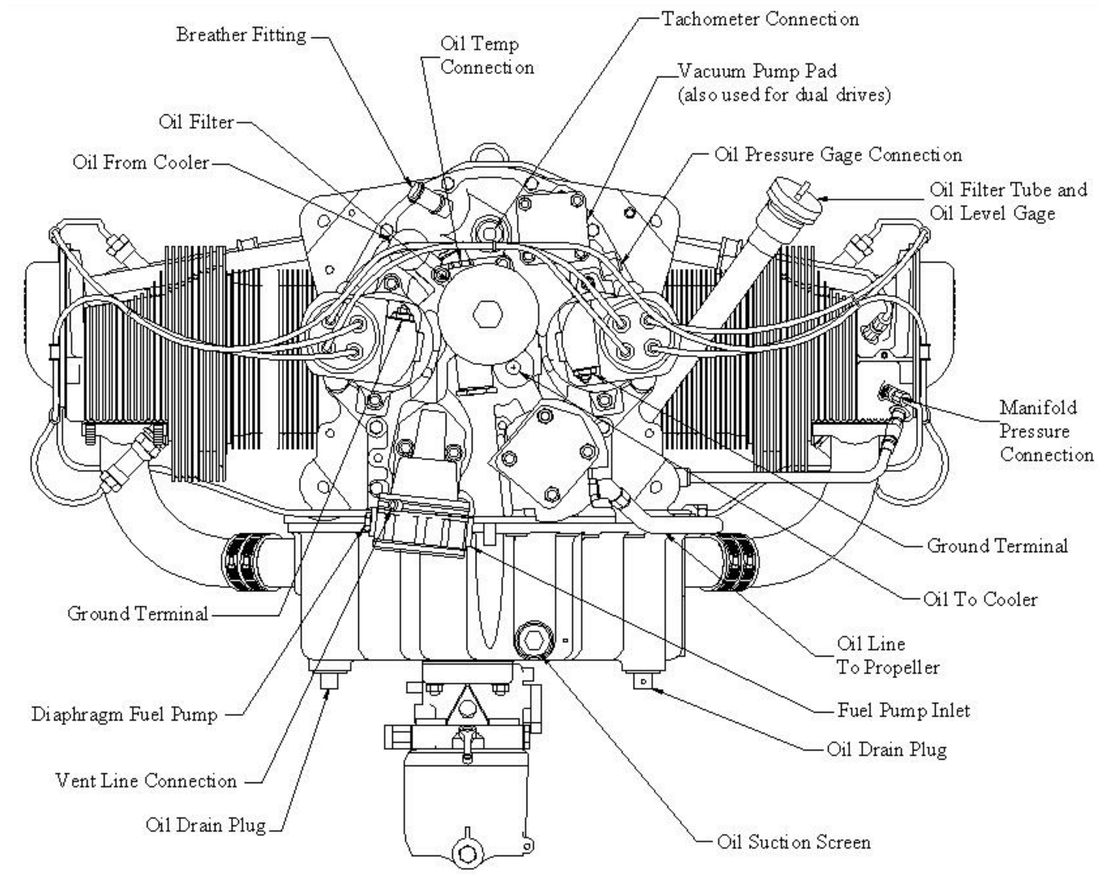

Installation Drawing
Back View
O-360

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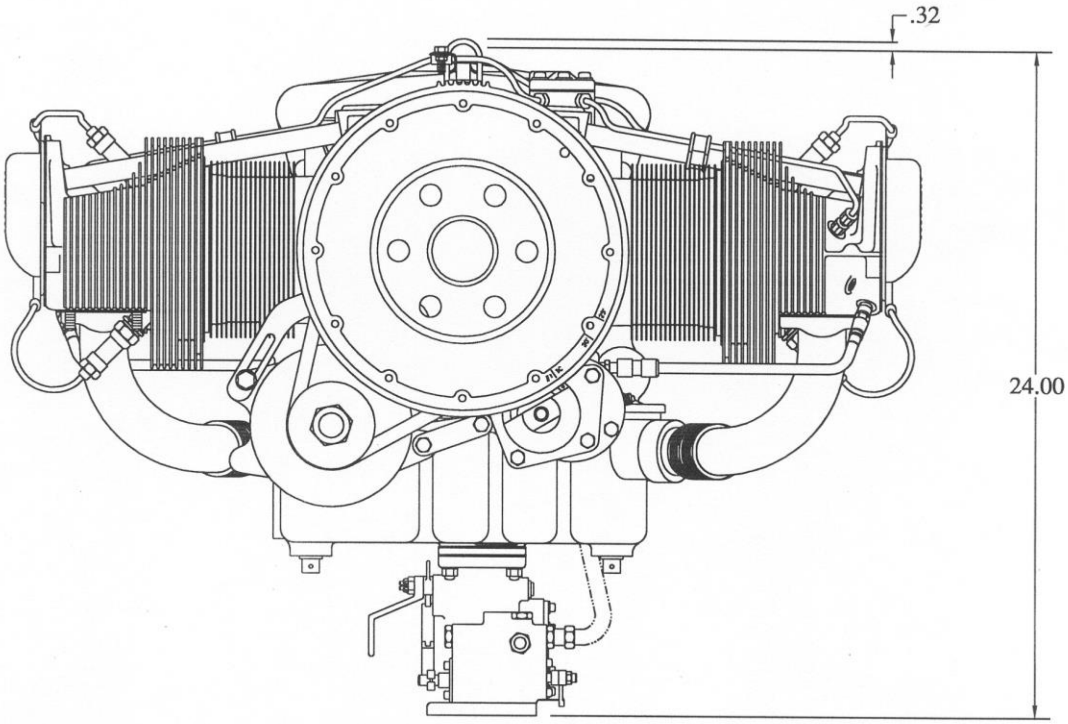

Installation Drawing
Front View
IO-360

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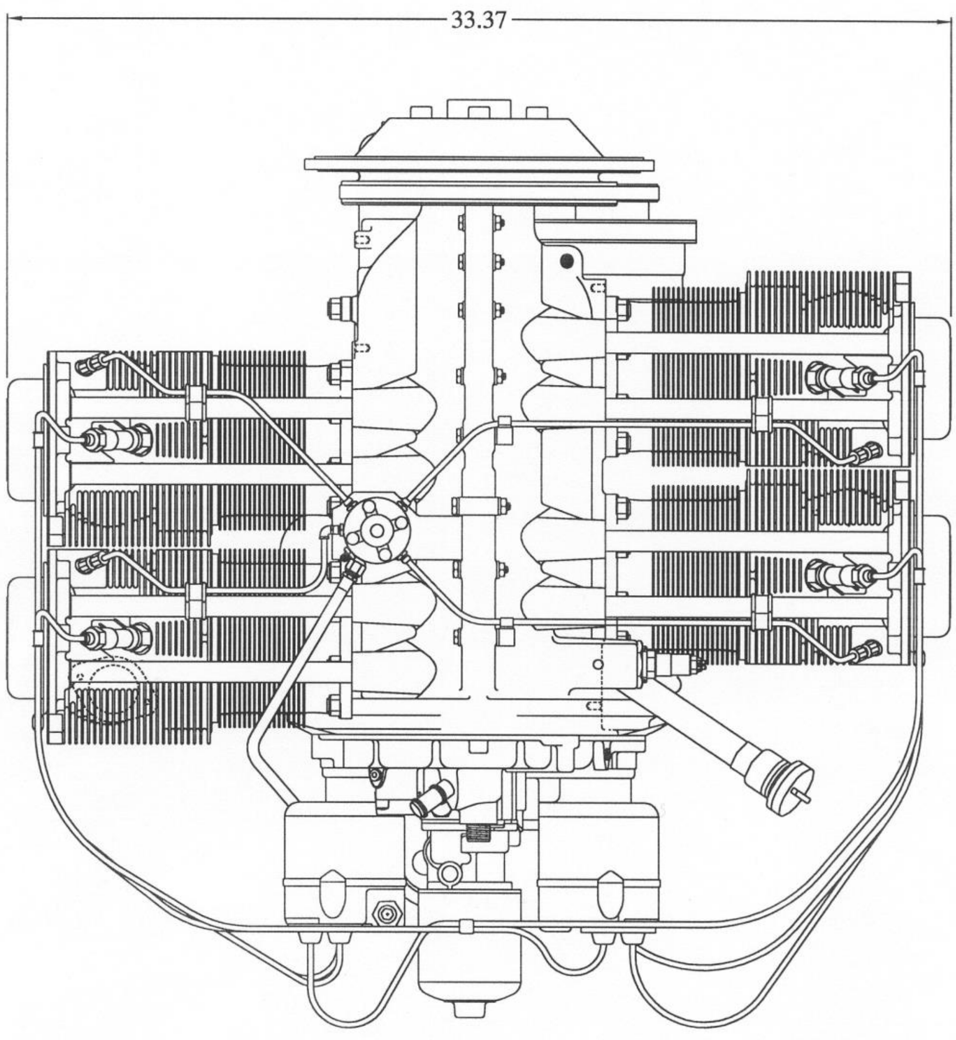

Installation Drawing
Top View
IO-360

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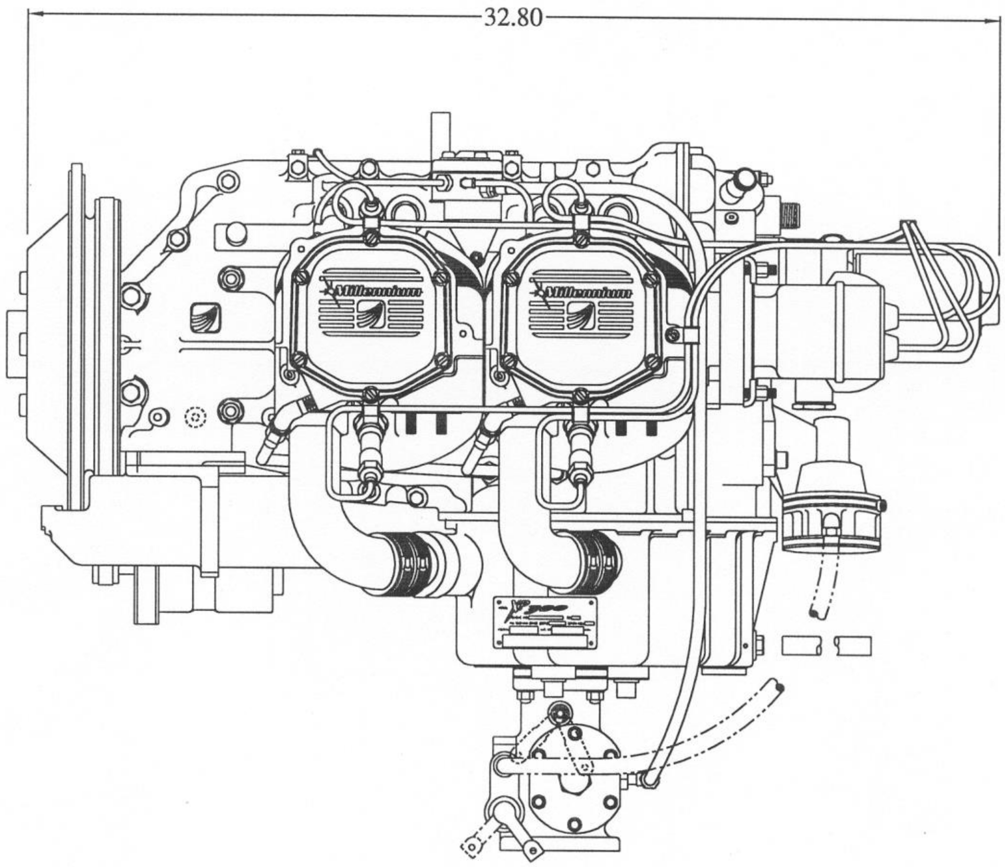

Installation Drawing
Side View
IO-360

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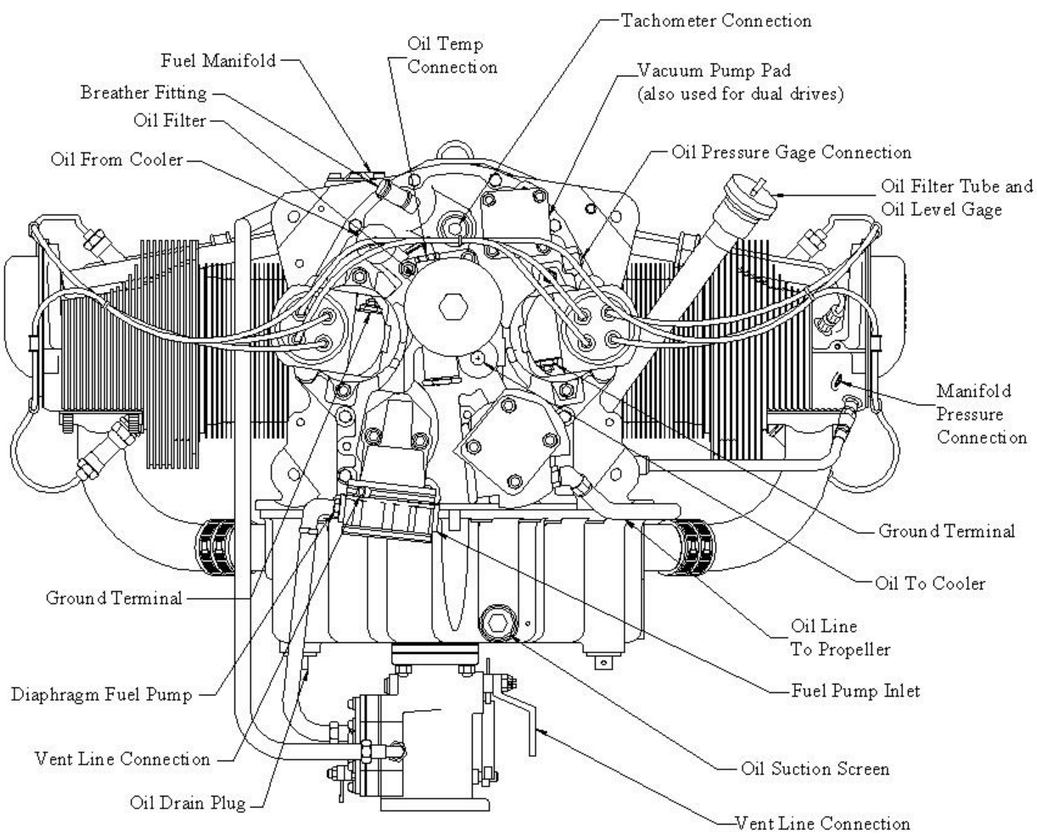

Installation Drawing
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4. Operating Instructions

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4. Operating Instructions

4.1 GENERAL – Complying with these instructions will optimize life, economy and operation of the XP-360 Engine®. The XP-360 Engine® has been carefully run-in by Superior Air Parts, but it requires further break-in until oil consumption has stabilized. After this period, a change to an approved ashless dispersant oil should be made. Consult the Break-In Instructions, Section 8.

PLEASE READ THE ENGINE WARRANTY. VIOLATION OF THESE OPERATING INSTRUCTIONS WILL VOID THE ENGINE'S WARRANTY.

The minimum aviation fuel grade is 100 octane, under no circumstances should aviation fuel of a lower octane rating be used. If operating with unleaded fuel, consult the Unleaded Fuel Operating Instructions.

4.2 PREFLIGHT – 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 6.1 under, Daily Pre-Flight Inspection. They must be observed before the engine is started.

4.3 NORMAL STARTING PROCEDURES

The following starting procedures are recommended, however, the starting procedure of various installations will necessitate some variation from these procedures, please refer to your airframe operator’s manual.

CAUTION: A greater possibility exists of engine kickback in the start cycle on aircraft engines incorporating permanent magnet lightweight starters and electronic ignition systems. The primary cause is marginal voltage supply, such as a low battery, weak or loose cabling, or insufficient ground. Sky-Tec will not honor warranty claims for damaged or failed starters that resulted from engine kickback. Please be advised Superior Air Parts, Inc. is not able to extend starter warranty on Sky-Tec starters to customers who suffer starter failure due to engine kickback.

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4.3.1 Engines Equipped with Float Type Carburetors

4.3.1.1 Perform pre-flight inspection.

4.3.1.2 Set carburetor heat control in the “Off” position.

4.3.1.3 Set propeller governor control in the “Low Pitch, Full RPM” position (where applicable).

4.3.1.4 Turn fuel valves “On”.

4.3.1.5 Move mixture control to “Full Rich”.

4.3.1.6 Turn on boost pump (if installed).

4.3.1.7 Open throttle approximately ¼ travel.

4.3.1.8 Prime with 1 to 3 strokes of manual priming pump or activate electric primer for 1 to 2 seconds. A delay of approximately 30 seconds is necessary after priming and before engaging starter to allow excess fuel to drain from the intake manifold. Failure to do so could result in significant engine damage in the event of an induction backfire.

4.3.1.9 Set magneto selector switch (consult airframe manufacturer’s handbook for correct position).

4.3.1.10 Engage starter.

4.3.1.11 Release starter when engine fires, if both magnetos are not on, switch to “Both”.

4.3.1.12 Check oil pressure gage. If minimum oil pressure is not indicated within thirty seconds, stop engine and troubleshoot.

4.3.2 Engines Equipped with Fuel Injectors

4.3.2.1 Perform pre-flight inspection.

4.3.2.2 Set alternate air control in the “Off” position.

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4.3.2.3 Set propeller governor control in the “Low Pitch, Full RPM” position (where applicable).

4.3.2.4 Turn fuel valve “On”.

4.3.2.5 Open throttle approximately ¼ travel.

4.3.2.6 Turn boost pump “On” (if installed).

4.3.2.7 Move mixture control to “Full Rich” until a slight but steady fuel flow is noted (approximately 3 to 5 seconds) and return mixture control to “Idle Cut-off”.

4.3.2.8 Set magneto selector switch (consult airframe manufacturer’s handbook for correct position).

4.3.2.9 Engage starter.

4.3.2.10 Release starter when engine fires, if both magnetos are not on, switch to “Both”.

4.3.2.11 Move mixture control slowly and smoothly to “Full Rich”.

4.3.2.12 Check oil pressure gage. If minimum oil pressure is not indicated within thirty seconds, stop engine and troubleshoot.

4.4 ABNORMAL START PROCEDURES

4.4.1 COLD WEATHER STARTING – During extreme cold weather, below freezing, it may be necessary to preheat the engine and oil before starting. Preheating normally takes 20 to 30 minutes to assure that all lines and all parts of the engine are uniformly warmed. Warm air should be forced up through the bottom of the cowl to reach the oil filter, sump area and intake manifold. Additional heated air should be directed over the top of the engine to reach the cylinders and cooler. Once an engine is preheated, it can be started but should be run for 5 to 10 minutes at idle settings, not to exceed 1,000 RPM. Verify oil pressure, which can take up to 45 seconds to rise to the minimum of 20 psi. If a full minute goes by without reaching a proper oil pressure setting, the engine should be shut down and inspected.

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4.4.2 HOT STARTING – Engine hot start procedures are the same as described in sections 4.3.1 (Carbureted Engines) and 4.3.2 (Fuel Injected Engines) except for the following.

4.4.2.1 Omit priming.
4.4.2.2 Set throttle control to approximately ½ travel and reduce to idle when engine starts.

4.5 GROUND RUNNING AND WARM-UP – The engines covered in this manual are air-cooled and depend on the forward speed of the aircraft to cool properly. It is recommended that the following precautions be observed to prevent overheating.

4.5.1 Ground Running – Any ground check that requires full throttle operation must be limited to three minutes, or less, and the cylinder head temperatures should not exceed the maximum as stated in this manual.

4.5.2 Fixed Wing Warm-up

4.5.2.1 Head the aircraft into the wind.

4.5.2.2 Leave mixture control "Full Rich".

4.5.2.3 Operate only with the propeller in "Low Pitch" or "High RPM" setting.

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

4.5.2.5 Engine is warm enough for take-off when the oil temperature exceeds 75°F and the engine does not hesitate with throttle advancement.

4.5.3 Rotorcraft Warm-Up – Warm-up at approximately 1,900 – 2,100 RPM with rotor engaged in accordance with manufacturer's instructions.

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4.6 GROUND CHECK

4.6.1 Fixed Wing

4.6.1.1 Warm-up as stated above in Section 4.5.

4.6.1.2 Mixture control “Full Rich”, check oil pressure and oil temperature.

4.6.1.3 Propeller Check – Cycle the propeller through its complete operating range to check operation and return to full low pitch position. Full feathering check on a twin engine aircraft on the ground is not recommended, but the feathering action can be checked by running the engine between 1000-1500 RPM, then momentarily pull the propeller control into the feathering position. Do not allow the RPM to drop more than 500 RPM.

4.6.1.4 Magneto Check – Factors, other than the ignition system, affect magneto drop. Such as load-power output, collective pitch, and mixture strength. Make the magneto check in accordance with the following procedures:

4.6.1.4.1 Controllable pitch propeller – Check for ignition problems with propeller in “Low Pitch, High RPM”, set the engine to produce 50-65% power as indicated by manifold pressure gage.

4.6.1.4.2 Fixed pitch propeller – Aircraft that are equipped with fixed pitch propellers, or not equipped with manifold pressure gage, may check magneto drop-off with engine operating at 1800-2000 RPM.

4.6.1.4.3 Switch from both magnetos to one and note drop. Return to both until engine regains speed and switch to the other magneto and note drop. Drop should not exceed 175 RPM. Drop-off spread between magnetos should not exceed 50 RPM.

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4.6.2 Rotorcraft

4.6.2.1 Warm-up as stated above in Section 4.5.

4.6.2.2 Mixture control “Full Rich”, check oil pressure and oil temperature.

4.6.2.3 Magneto check.

4.6.2.3.1 Raise collective pitch stick to obtain 15 inches of manifold pressure and 2,000 RPM.

4.6.2.3.2 Switch from both magnetos to one and observe drop-off, switch back to both until the engine regains its speed and then switch to the other magneto and note drop-off. At no time should this drop-off exceed 175 RPM. Difference between the drop-offs of the two magnetos should never exceed 50 RPM. If a smooth drop-off past normal is observed it is usually a sign that the mixture is either too lean or too rich.

4.7 OPERATION IN FLIGHT

4.7.1 See airframe manufacturer’s instructions for recommended power settings.

4.7.2 Move the controls slowly and smoothly.

4.7.3 Fuel Mixture Leaning Procedure – Improper fuel/air mixture during flight is a contributing factor to engine problems, particularly during take-off and climb power settings. The procedures described in this manual provide proper fuel/air mixture when leaning an XP-360 Engine®. It is therefore recommended that operators of all Superior Air Parts aircraft powerplants utilize the instructions in this publication any time the fuel/air mixture is adjusted during flight.

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4.8 GENERAL RULES

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

4.8.1 Never exceed the maximum red-line cylinder head temperature limit of 500°F (260°C). For maximum service life, cylinder head temperatures should be maintained below 430ºF (221ºC) during high performance cruise operation and below 400ºF (204ºC) for economy cruise operation, with 300-400ºF (149-204ºC) optimal.

4.8.2 Oil temperature should be maintained between 120-220ºF (49-116ºC) in cruise flight, with 130-200ºF (54-93ºC) optimal, never exceed 240°F (104°C).

4.8.3 On engines with manual mixture control, maintain mixture control in "Full Rich" position for rated take-off, climb and maximum cruise powers (above approximately 75% power), except during take-off from a high elevation airport or during subsequent climb. 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 altitude above 5,000 feet.

4.8.4 Operate the engine at maximum power mixture for performance cruise power and at best economy mixture for economy cruise power, unless otherwise specified in the airplane owners' manual.

4.8.5 During decent it may be necessary to manually lean carbureted or fuel injected engines to obtain smooth operation.

4.9 LEANING TO EXHAUST GAS TEMPEARTURE GAGE – Normally aspirated engines with fuel injectors or carburetors.

4.9.1 Maximum Power Cruise (above 75% power) – Never lean below 75ºF on rich side of peak EGT. Monitor cylinder head temperatures.

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4.9.2 Best Economy Cruise (approximately 75% power and below) – Do not lean below peak EGT on carbureted engines. Lean to peak EGT to 50°F lean of peak on fuel injected engines.

4.10 LEANING TO FLOWMETER – Lean to applicable fuel-flow values. Because of air-fuel mixture variations on carbureted engines, this is recommended for fuel injected engines only, unless otherwise recommended by airframe manufacturer.

4.11 LEANING WITH MANUAL MIXTURE CONTROL – Economy cruise, 75% power or less without flowmeter or EGT gage.

4.11.1 Carbureted Engines

4.11.1.1 Slowly lean mixture control from “Full Rich” position.

4.11.1.2 Lean until engine roughness is noted.

4.11.1.3 Enrich until engine runs smoothly.

4.11.2 Fuel Injected Engines

4.11.2.1 Slowly lean mixture control from “Full Rich” position.

4.11.2.2 Continue leaning until slight loss of power is noted and/ or is accompanied by roughness.

4.11.2.3 Enrich until engine power is regained and/or runs smoothly.

4.11.3 Use of Carburetor Heat Control – Under certain damp atmospheric conditions and temperatures of 20 to 90ºF (-7 to 32ºC), it is possible for ice to form in the induction system. A loss of power is reflected by a drop in manifold pressure in installations equipped with constant speed propellers and a drop in manifold pressure and RPM in installations with fixed pitch propellers. The engine may stop if not corrected. To avoid this, many installations are equipped with a system for preheating the incoming air supply to the carburetor, when necessary.

4.11.3.1 Ground Operation – Use of the carburetor air heat on the ground must be held to an absolute minimum and only to verify it is functioning properly. On some preheated installations, the air does not pass through the air filter.

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4.11.3.2 Take-Off – All take-off and full throttle operations should be made with carburetor heat in the “Cold” or “Off” position.

4.11.3.3 Climbing – When climbing at throttle power settings of 75% or above, the carburetor heat control should be set in the “Cold” or “Off” position. If carburetor heat is necessary, it may produce an over-rich air mixture. When this occurs lean the mixture with the mixture control enough to produce smooth engine operation.

4.11.3.4 Cruise Flight – During normal cruise flight, leave the carburetor air heat control in the “Cold” position. Carburetor icing will be noted by a loss in manifold pressure and/or RPM or both.

If this is noted, apply full carburetor air heat and open the throttle to limiting manifold pressure and/or RPM. A slight additional drop in manifold pressure, which is normal, will be noted. This will be restored as the ice is melted. The carburetor heat control should then be returned to the “Cold” or “Off” position. If equipped with a carburetor air temperature gage, partial heat may be used to keep the mixture temperature above freezing (32ºF). Constant high temperatures are to be avoided because of a loss in power and variation of mixture. High inlet air temperature also favors detonation and pre-ignition, both of which are to be avoided if normal service life is to be expected from the engine.

Caution must be taken when operating with partial heat on aircraft that do not have a carburetor air temperature gage. It is recommended to use either full heat or no heat in carbureted aircraft that are not equipped with an air temperature gage.

4.11.3.5 Landing – During a landing approach, the carburetor heat should be in the “Cold or “Off” position. However, if icing conditions are suspected, full carbureted heat should be applied. If full power is required under these conditions, as for an aborted landing, the carburetor heat should be returned to the “Cold” or “Off” position after full power application. See the aircraft flight manual for specific instructions.

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4.12 SHUT DOWN PROCEDURE – Fixed wing

4.12.1 Set propeller governor control to “Low Pitch, High RPM” (when applicable).

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

4.12.3 Move mixture control to "Idle Cut-Off".

4.12.4 When engine stops, turn off switches.

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4.13 Engine Flight Chart

4.13.1

Fuel

Approved Fuel	Aviation Grade Fuel - Minimum Octane*
All Models	100 LL

* For Unleaded Fuel Operation see Section 9

Fuel Pressure	Max.	Desired	Min.
Carbureted Models, psi	8.0	3.0	0.5
Fuel Injected Models - Inlet to fuel pump, psi	35		2

4.13.2

Lubrication

Average Ambient Air	Recommended Grade Oil MIL-L-22851 or SAE J-1899 Ashless Dispersant Grades
All Temperatures	SAE 15W50 or 20W50
Cold (<30°F, <0°C)	SAE 30 or 20W30
Standard (30°-90°F, 0°-30°C)	SAE 40
Hot (>60°F, >15°C)	SAE 50 or SAE 60

Oil Pressure, psi	Max.	Min.
Normal Operating (1800 - 2700 RPM)	95	50
Start and Warm-up	115	
Idling		20

Oil Sump Capacity

Updraft Induction models	8 U. S. Quarts
Lightweight Front and Rear-mount Induction models	8 U. S. Quarts
Minimum Safe Quantity in the sump	2 U. S. Quarts

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4.13.3

Rated Horsepower

29” MP x 2700 RPM

Model Power Suffix	Cylinder Type 360	
	CR	HP
1	7.2:1	170
2	8.5:1	180
3	9:1	185

4.13.4

Fuel and Oil Consumption

All Models

Operation	Specific Fuel Consumption Lbs./HP-Hr.	Max. Oil Cons. Qts./Hr.	Max. Cyl. Head Temp.
Full Rated Power	Full Rich over .55	1.0	500°F (260°C)
Cruise Power: 65% to 75% Rated	Leaned to Peak EGT .43 75°F Rich of Peak EGT .50	.50	500°F (260°C)

4.14

Fuel Mixture and Performance Curves

On the following pages, Fuel Mixture, Prop Load and Full Throttle, and Altitude Performance reference curves are given for a constant-speed, fuel injected, 180 HP, XP-360, with 8.5:1 pistons. Fuel consumption for carbureted engines may be slightly higher for a given power due to less exact air-fuel distribution. Fuel mixture for fixed-pitch models will be similar, but power as a function of RPM is determined by propeller design, contact propeller manufacturer for HP/RPM performance data. Variation in accessories, such as electronic ignition and fuel systems, may result in somewhat different curves. Different compression ratio pistons, cylinder and engine designs and displacements will also vary the following data and, in all such cases, these charts should be used for reference only.

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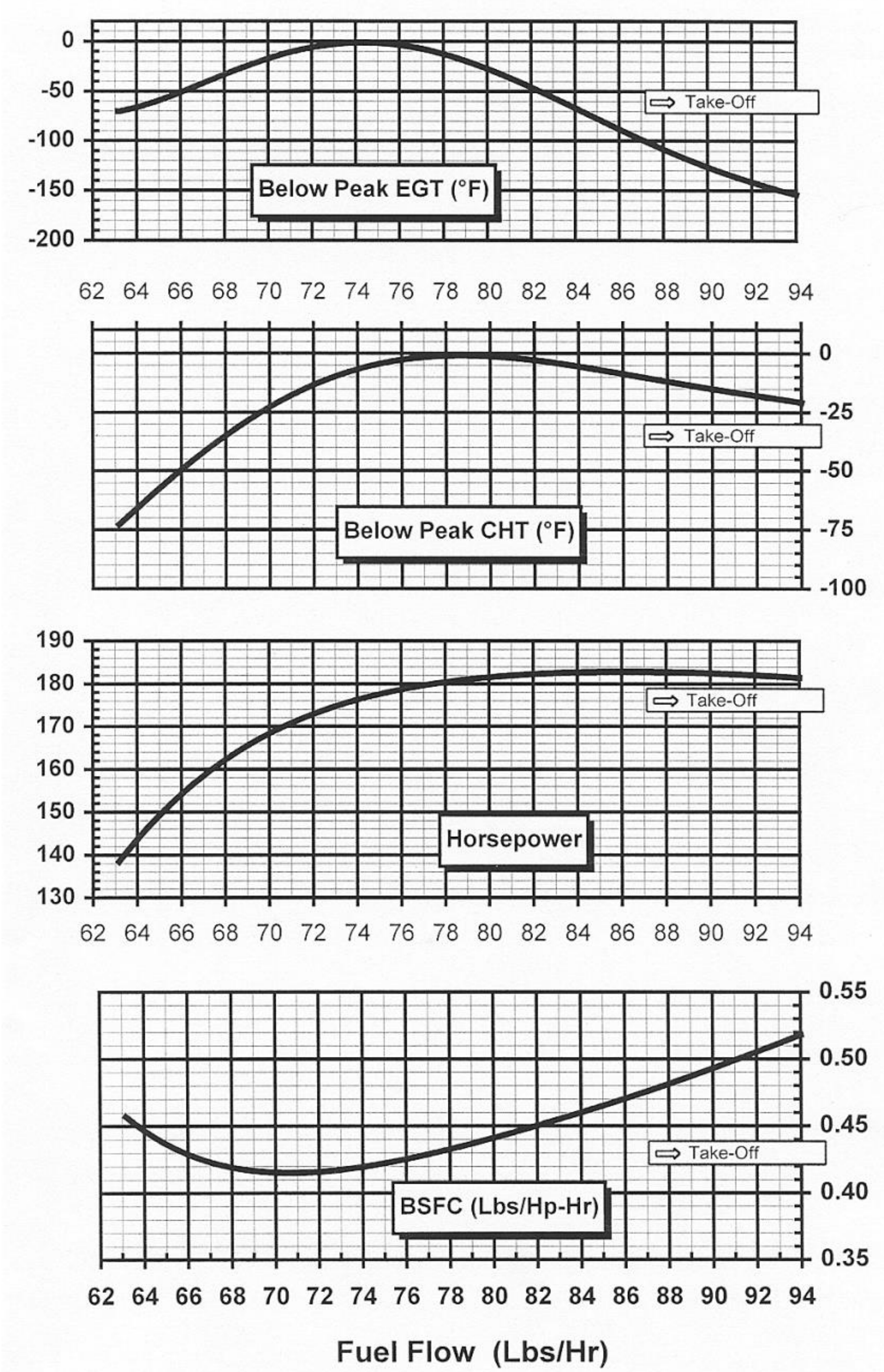
Take-Off Power Fuel Mixture Curves

Superior IO-360-B1A2 @ 29" MP x 2700 RPM



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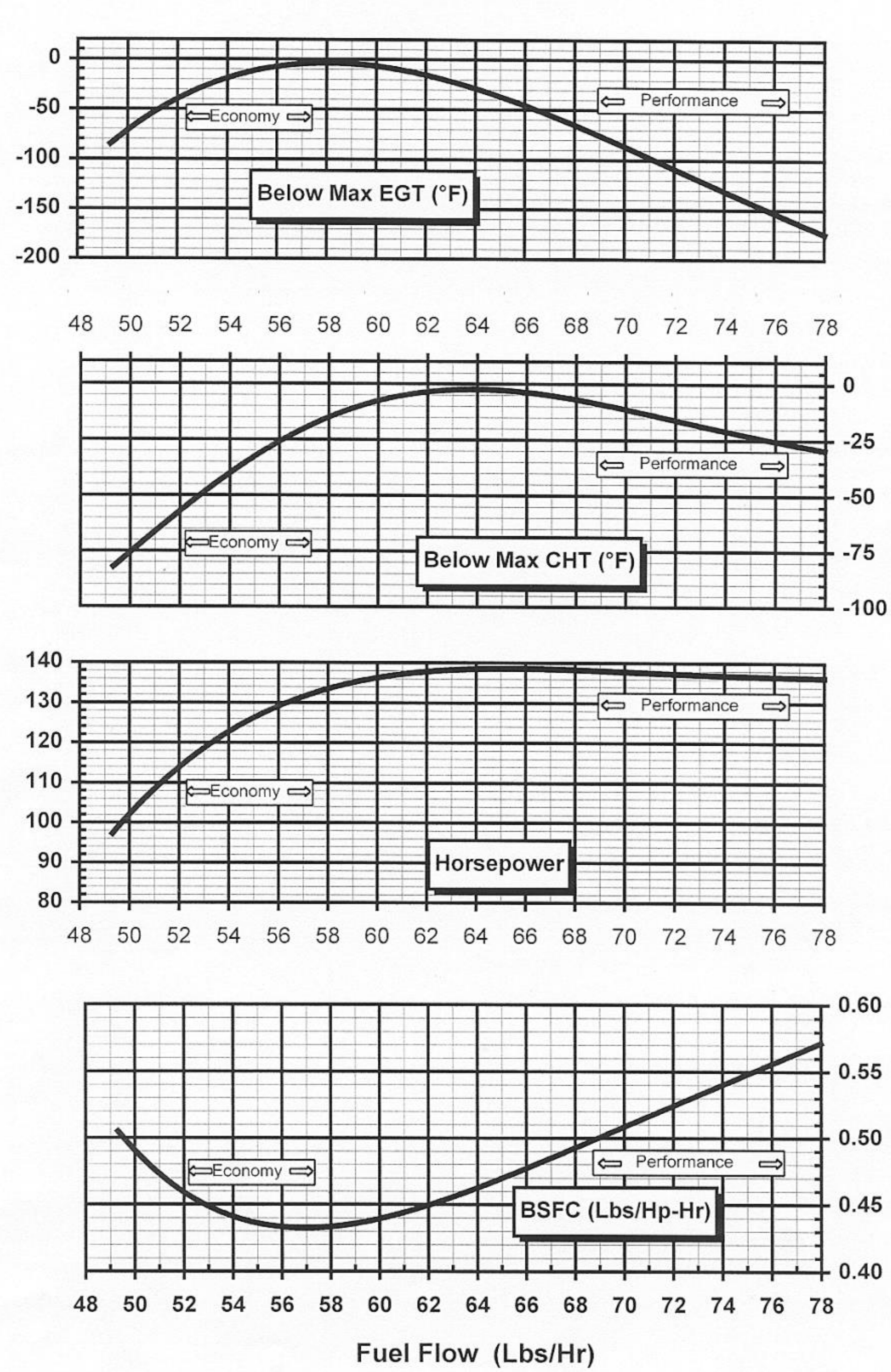
Performance Cruise Fuel Mixture Curves

Superior IO-360-B1A2 @ 25" MP x 2400 RPM



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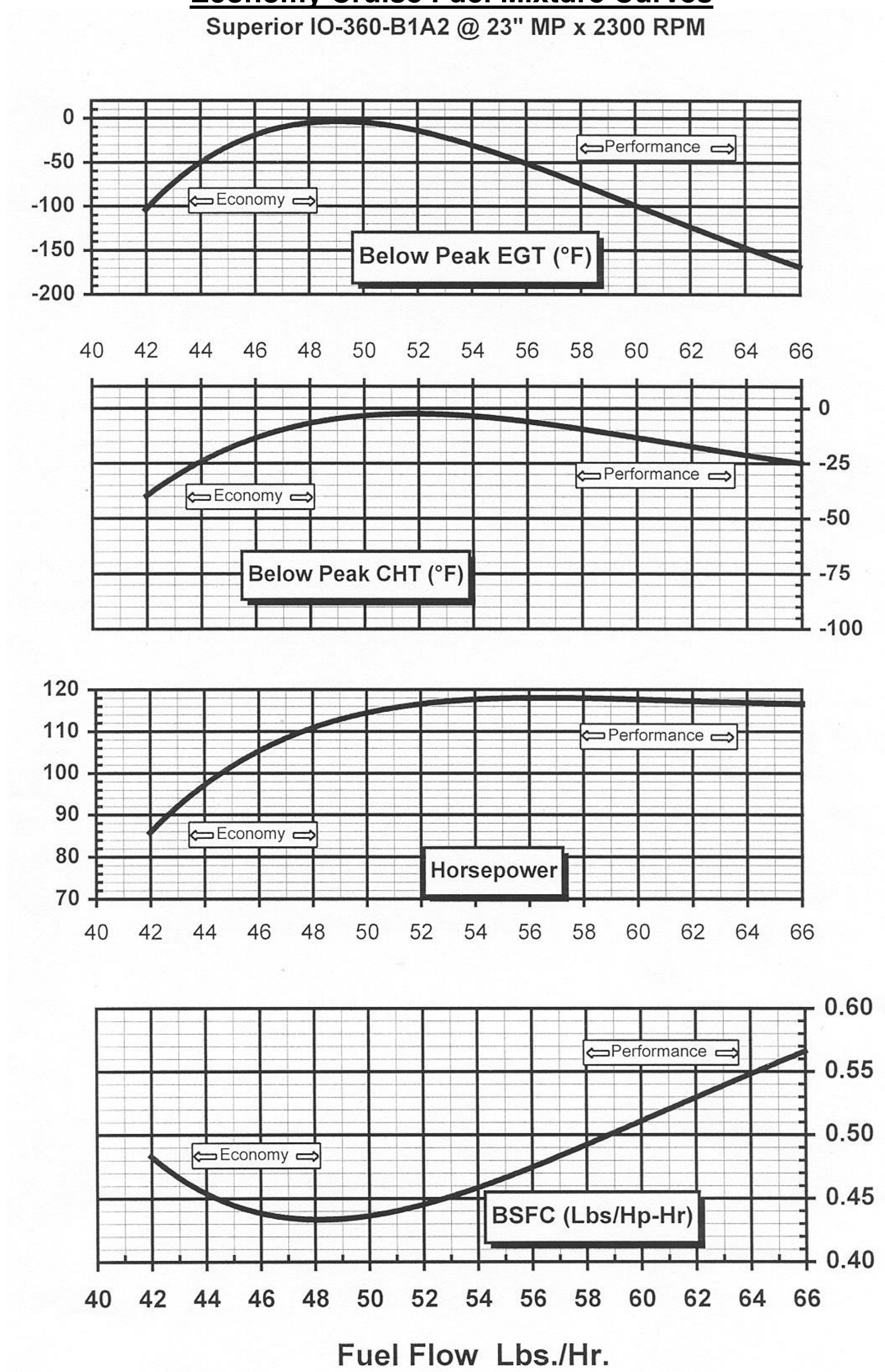
Economy Cruise Fuel Mixture Curves



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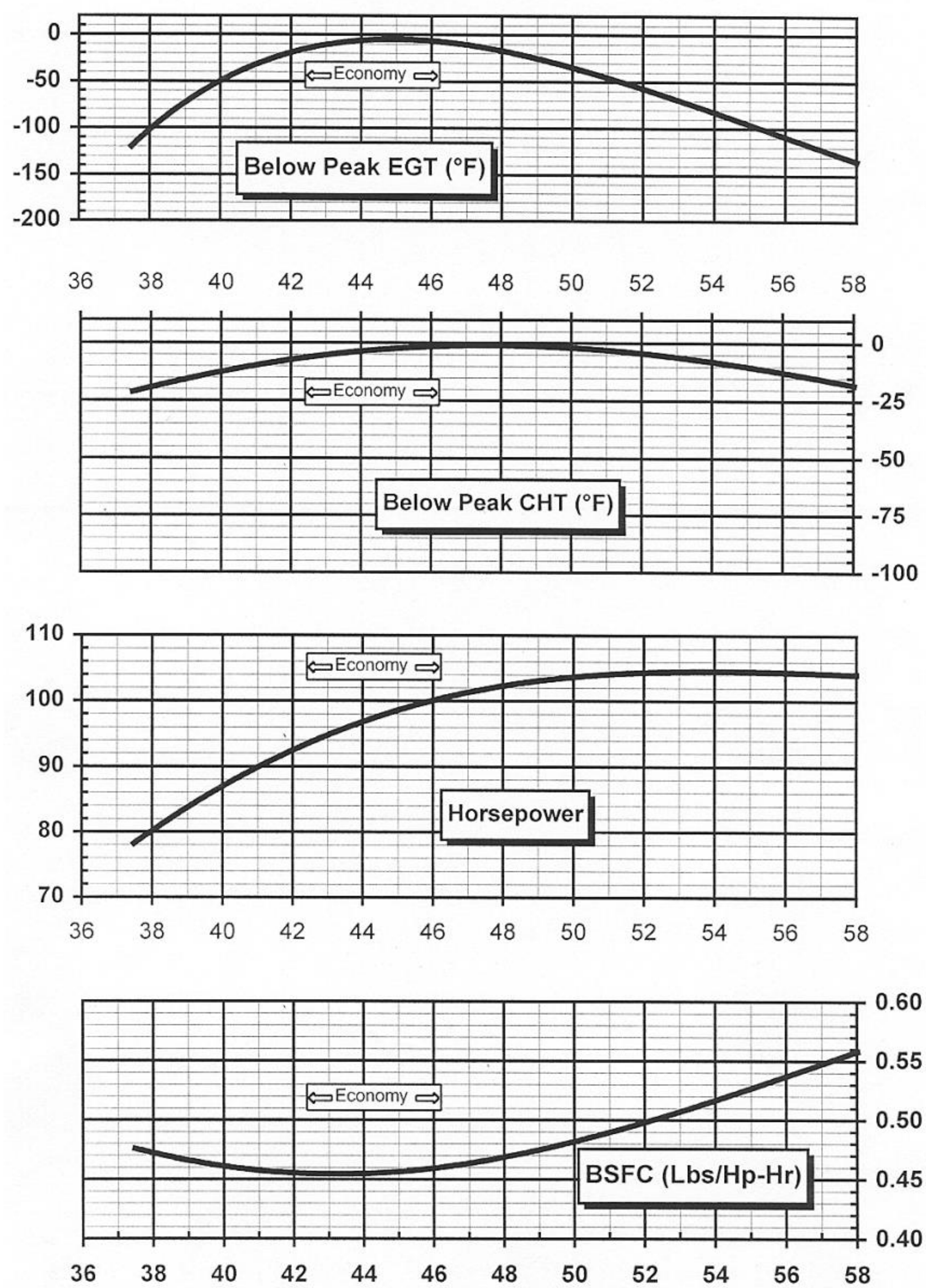
Low Power Cruise Fuel Mixture Curves

Superior IO-360-B1A2 @ 21" MP x 2300 RPM



Fuel Flow (Lbs/Hr)

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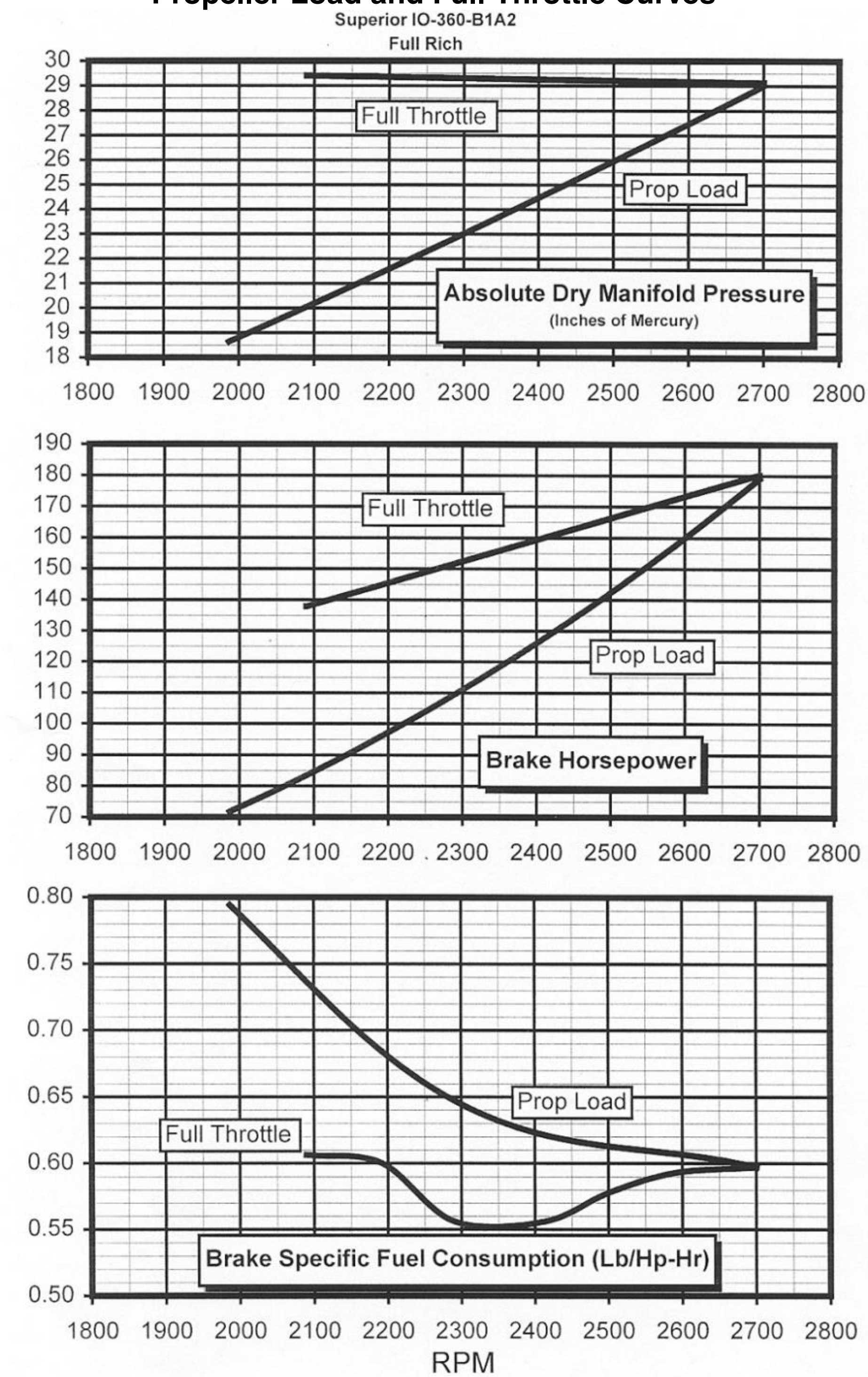
Propeller Load and Full Throttle Curves



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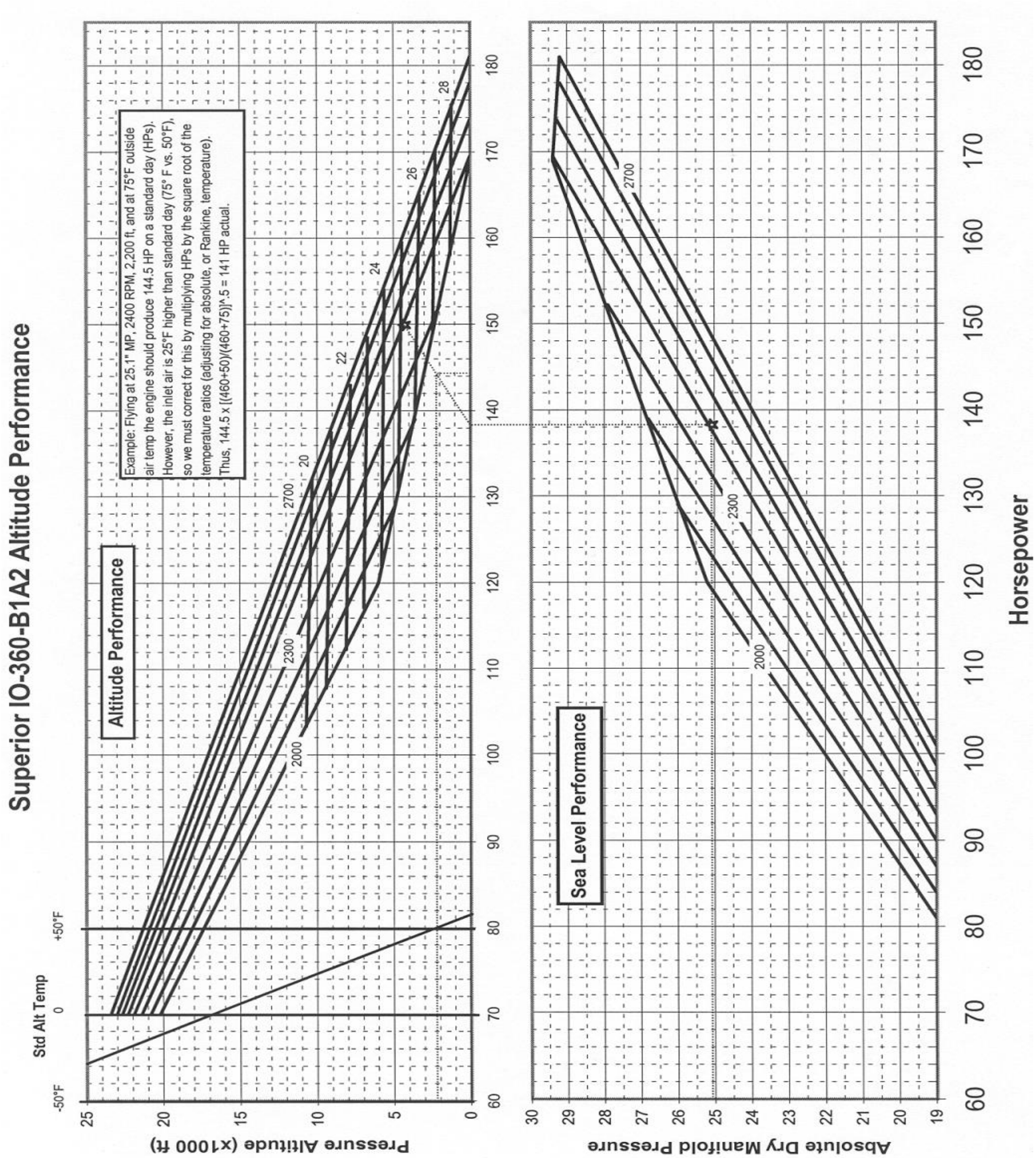
Altitude Performance Chart



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5. Maintenance & Servicing Information

This section describes instruction and directions for performing the maintenance that may be required by the periodic inspections listed in the next section.

5.1 IGNITION AND ELECTRICAL SYSTEM

5.1.1 Ignition Harness and Wire Replacement – If an ignition harness or an individual lead needs to be replaced, be sure to refer to the ignition harness wiring diagram to be sure that the harness is installed correctly. Also, to be sure that the replacement clamps are in the correct locations, mark the previous locations of the clamps and clips.

5.1.2 Timing Magnetos to Engine – Remove one spark plug from the No. 1 cylinder and place a thumb over the spark plug hole. Rotate the crankshaft clockwise until the compression stroke is reached; this will be noted when the pressure inside the cylinder pushes your thumb off the spark plug hole. Continue to rotate the crankshaft until the timing mark on the front of the starter support is in alignment with the small hole on the front face of the starter housing. The ring gear is marked at 20º and 25º BTDC. Consult engine specifications for correct timing mark for your installation. At this point, the engine is ready for assembly of the magnetos

5.2 TIMING SLICK MAGNETOS

5.2.1 Align magneto rotor shaft to fire cylinder # 1.

5.2.2 Insert the T-118 timing pin provided in the L hole (for left-hand or counter-clockwise rotation) of the distributor block.

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5.2.3 Turn rotor shaft clockwise until the timing pin inserts to the pin shoulder or 7/8-inch into the distributor block. The timing pin will seat against the distributor block when properly installed. If the timing pin is not seated 7/8-inch into the distributor block and the rotor shaft can't be turned, remove the pin and turn the rotor shaft 1/8 turn and reinsert the timing pin. With the timing pin fully seated in the distributor block, the magneto is aligned to fire cylinder # 1. Caution: rotating the magneto rotor shaft with the timing pin inserted into the magneto distributor block may damage the magneto.

5.3 INSTALL MAGNETOS

5.3.1 Clean the magneto flange. Install the appropriate gasket onto the magneto mounting flange.

5.3.2 Install the magneto onto the engine. Caution: rotating the magneto rotor shaft or the propeller with the timing pin inserted into the magneto distributor block may damage the magneto.

5.3.3 Secure the magneto using the appropriate nuts and/or bolts and mounting clamps provided. Tighten the nuts and/or bolts sufficiently to hold the magneto loosely in position.

5.3.4 Remove the timing pin from the distributor block.

5.4 TIMING MAGNETOS TO ENGINE

5.4.1 Attach a timing light to the magneto condenser stud according to the timing light manufacturer's instructions.

5.4.2 Rotate the magneto clockwise, until the timing light indicates the breaker points are open. Most timing lights indicate open points with a light-on condition or an audible signal.

5.4.3 Slowly rotate the magneto counter-clockwise until the light goes out or the audible signal stops.

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5.4.4 Fasten the magneto to the engine by tightening the magneto mounting clamps.

5.4.4.1 Alternately tighten the engine mounting clamp nuts to 8 ft./lbs. of torque.

5.4.4.2 Continue to tighten both nuts in alternating steps to 17 ft./lbs. of torque.

5.4.4.3 Remove the timing light from the magneto condenser stud.

5.5 ATTACH THE IGNITION P-LEAD TERMINAL

5.5.1 Attach the ignition P-lead terminal to the condenser stud using the lock-washer and nut on the magneto.

5.5.2 Torque the P-lead terminal nut to 13-15 inch-pounds.

5.5.3 Attach P-lead ground shield, if applicable, to the ground screw on the side of the magneto. Torque the P-lead ground shield screw to 18-20 inch-pounds.

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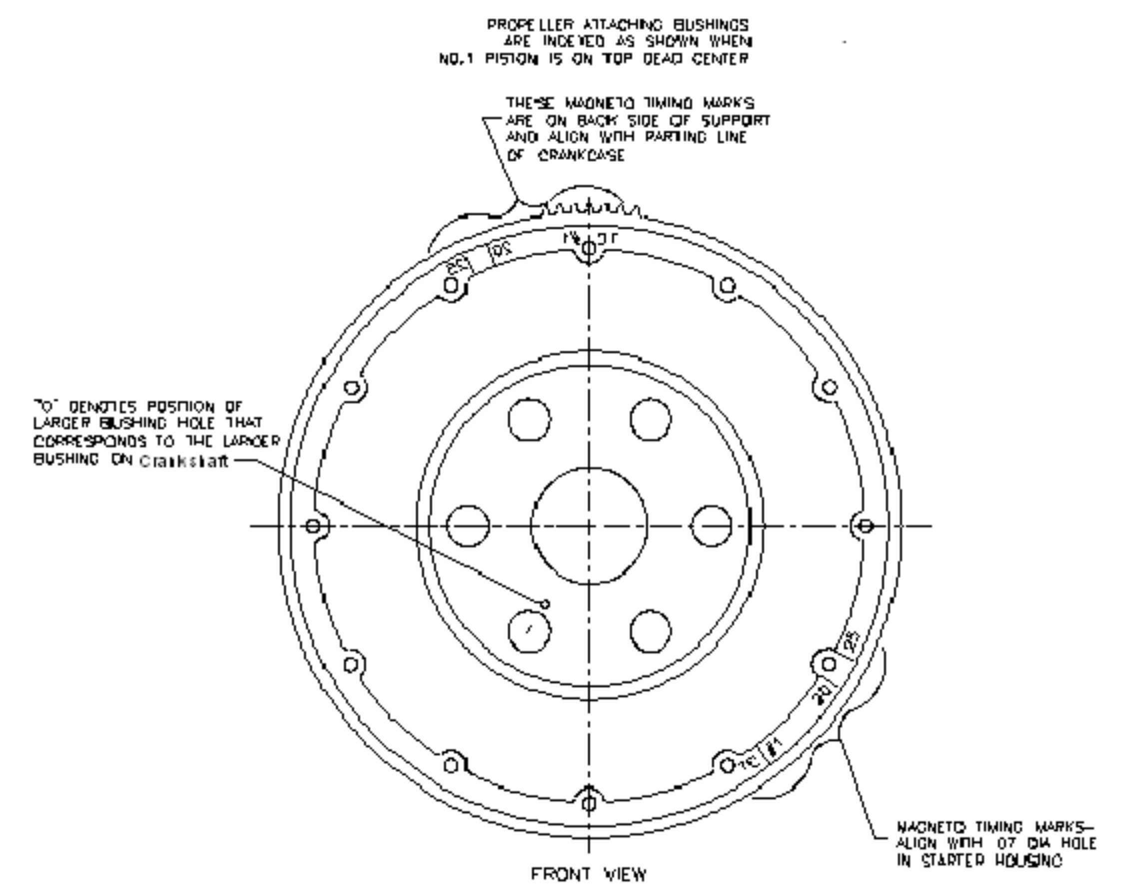
Timing Diagram

Spec AS-127, Type 2 Mod



TIMING DIAGRAM
SPEC AS-127, TYPE 2. MOD

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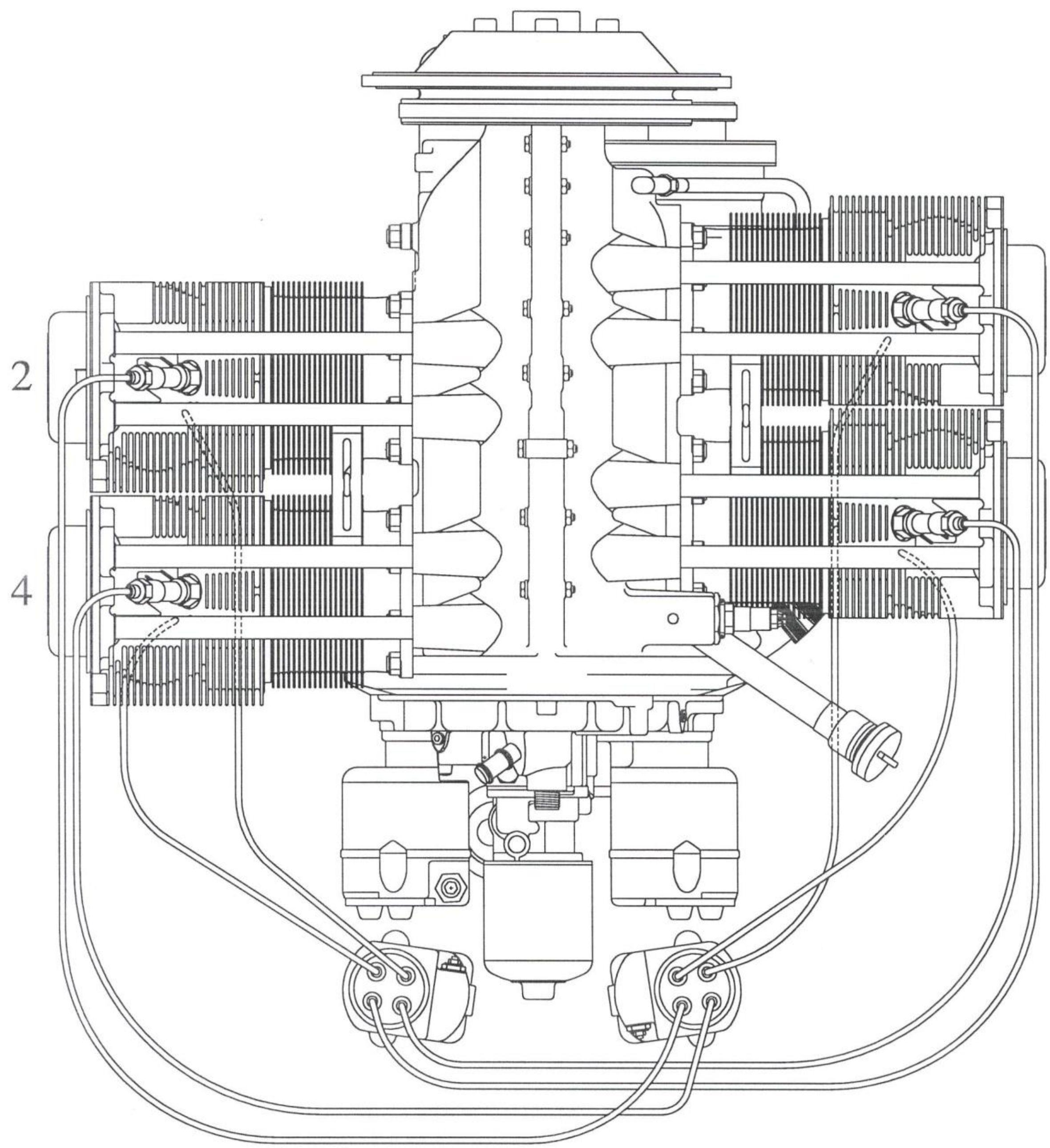
Firing Order

Clockwise Rotation 1-3-2-4

Ignition Wiring Diagram



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5.6 FUEL SYSTEM

5.6.1 Fuel Systems Leaks – Only use a fuel soluble lubricant such as clean engine oil or Loctite Hydraulic Sealant on tapered threads when replacing a fuel line or fitting. Do not use any other form of thread compound.

5.6.2 Carburetor or Fuel Injector Fuel Inlet Screen Assembly –Remove the assembly and check the screen for gaps or distortion. If either of these conditions exists, you must replace the screen. Clean the screen assembly in solvent and dry with compressed air. Reinstall the fuel inlet screen assembly and torque to 35-40 inch-pounds on carburetors and 65-70 inch-pounds on fuel injectors. Torque the hex head plug on pressure carburetors to 160-175 inch-pounds.

5.6.3 Fuel Grades and Limitations – The recommended aviation grade fuel is 100 LL. Lower octane aviation grade fuel must not be used. Refer to Section 9 if unleaded 91 octane autogas is to be used.

5.6.4 Air Intake Filters and Ducts – Check all air intake ducts for dirt or other blockage. Inspect and service air filters as instructed in the airframe manufacturer's handbook.

5.6.5 Idle Speed and Mixture Adjustment

5.6.5.1 Start the engine and warm up in the usual manner until oil and cylinder heads reach normal temperatures.

5.6.5.2 Check the magnetos. If the "mag-drop" is normal, proceed with idle adjustment.

5.6.5.3 Set throttle stop screw so the engine idles at the airframe manufacturer's recommended RPM. If the RPM changes appreciably after making the following idle mixture adjustment, readjust the idle speed to the correct RPM.

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5.6.5.4 Once the idling speed has been stabilized, move the cockpit mixture control lever with a smooth pull toward the “Idle-Cut-Off” position and observe the tachometer for any change during the “leaning out” process. Be sure to return the mixture control to the “Full Rich” position before the RPM drops to where the engine stops. An over 50 RPM increase while “leaning out” indicates an excessively rich idle mixture. An instant decrease in RPM (if not preceded by a brief increase) indicates that the idle mixture is too lean.

5.6.5.5 If the above procedure indicates that the idle adjustment is either too rich or too lean, turn the idle mixture adjustment in the appropriate direction and check this setting by repeating the above steps. The goal is to find a setting that will obtain maximum RPM with minimum manifold pressure. Make added adjustments until the above check results in a momentary pick-up of about 50 RPM. Every time the idle is adjusted, the engine should be run up to 2000 RPM to clear the engine before proceeding with the RPM check. Make the final tuning of the idle speed adjustment with a closed throttle. If the setting does not remain stable, check the idle linkage. Loose linkage can cause erratic idling. Considerations for the effect of weather conditions and altitude on idling adjustment must be made.

5.7 LUBRICATION SYSTEM

5.7.1 Oil Grades & Limitations – Service the engine in accordance with the recommended grade oil as specified in Section 4.

5.7.2 Oil Suction & Oil Pressure Screens – At each 50 hour inspection, remove, inspect for metal particles, clean and reinstall.

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5.7.3 Adjustable Oil Pressure Relief Valve – The adjustable oil pressure relief valve enables the operator to maintain engine oil pressure within specified limits. If oil pressure under normal operating conditions always exceeds the maximum or minimum specified limits, adjust the valve as follows:

With the engine warmed up and running at about 2000 RPM, observe the oil pressure gage reading. If the pressure is above maximum or below minimum specified limits, stop the engine and turn the adjusting screw, with either a flathead screwdriver or a 9/16-inch box wrench, outward to decrease pressure or inward to increase pressure.

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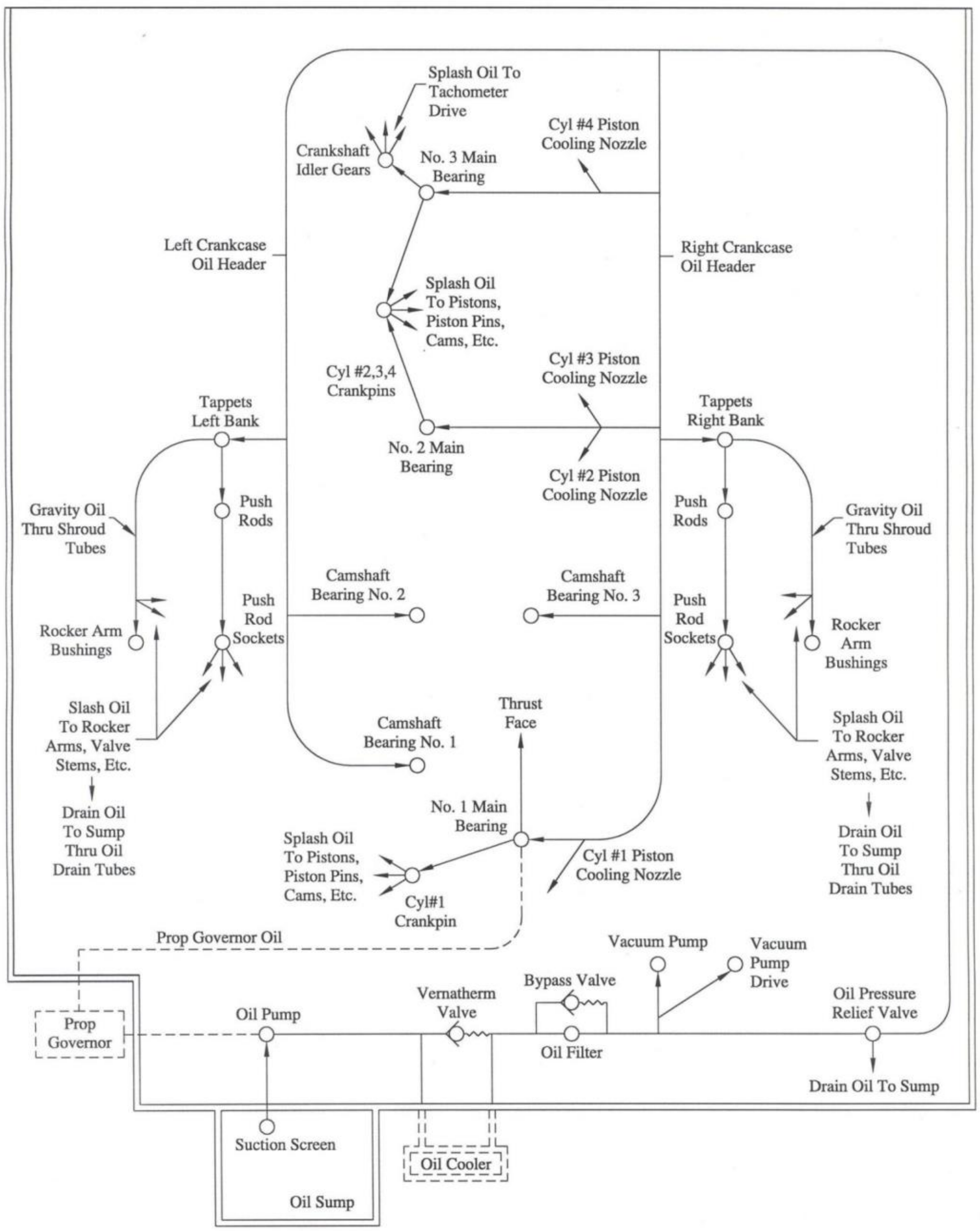
Oil System Schematic

Superior 4-Cylinder Engine



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5.8 CYLINDERS – As a field operation, cylinder maintenance should be limited to the replacement of the entire assembly and only as an emergency measure. For valve replacement, consult the overhaul manual.

5.8.1 Removal of Cylinder Assembly

5.8.1.1 Remove the exhaust manifold.

5.8.1.2 Remove the rocker box drain tube, intake pipe, baffle and any clips interfering with the cylinder removal.

5.8.1.3 Disconnect the ignition cables and remove the bottom spark plug.

5.8.1.4 Remove the rocker box cover and rotate the crankshaft clockwise until the compression stroke is reached; this will be noted when the pressure inside the cylinder pushes your thumb off the spark plug hole.

5.8.1.5 Slide the valve rocker shafts from the cylinder head and remove the valve rockers. The valve rocker shafts can be removed when the cylinder is removed from the engine. Remove the rotator cap from the exhaust valve stem.

5.8.1.6 Remove the pushrods by holding the ball end and pulling the rod out of the shroud tube. Detach the shroud tube spring and the lock plate and pull the shroud tubes through the holes in the cylinder head.
Note the original location of the hydraulic tappets, push rods, rocker arms and valves. These must be reassembled and put back in the same locations.

5.8.1.7 Remove the cylinder base nuts, then, by pulling directly away from the crankcase, remove the cylinder. Do not allow the piston to drop out of the cylinder and hit the crankcase.

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5.8.1.8 Remove the piston pin from the connecting rod. Support the connecting rod with a heavy rubber band. Do not allow the connecting rod to rest on the cylinder bore of the crankcase. Discarded the cylinder base oil ring seal.

5.8.2 Removal of Hydraulic Tappet Sockets and Plunger Assemblies – To check dry tappet clearance when reinstalling the cylinder assembly it is necessary to remove and bleed the hydraulic tappet plunger assembly. This is accomplished in the following manner:

5.8.2.1 Remove the hydraulic tappet push rod socket by inserting a finger into the concave end of the socket and withdrawing. If the socket cannot be removed this way, try grasping the edge of the socket with a pair of needle nose pliers, do not scratch the socket.

5.8.2.2 To remove the hydraulic tappet plunger assembly, form a hook in the end of a short piece of safety wire and insert so that the hook engages the spring of the plunger assembly. Then gently pull the wire, drawing the plunger assembly out of the tappet body. Do not use a magnet to remove hydraulic plunger assemblies from the crankcase, as this may cause the check ball to remain off its seat, rendering the unit inoperative.

5.8.3 Assembly of Hydraulic Tappet Plunger Assemblies – To assemble the unit, unseat the ball by inserting a thin clean wire through the oil inlet hole. With the ball off its seat, insert the plunger and twist clockwise so that the spring catches. Remember that all oil must be removed before the plunger is inserted.

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5.8.4 Assembly of Cylinder and Related Parts – Rotate the crankshaft so that the connecting rod of the new cylinder is at the top of the compression stroke. To make sure it is at the top, place two fingers on the intake and exhaust tappet bodies and rotate the crankshaft back and forth over the top center. If the tappet bodies do not move, the crankshaft is at the top of the compression stroke.

5.8.4.1 Place each plunger assembly in its appropriate tappet body and assemble the socket on top of the plunger assembly.

5.8.4.2 Assemble the piston with the rings so that the number stamped on the piston pin boss is toward the front of the engine. The piston pin should be a hand-push fit. Use a generous quantity of oil in the piston hole and on the piston pin during assembly.

5.8.4.3 Place a new rubber oil seal ring around the cylinder skirt. Coat the inside of the cylinder, piston, and rings generously with oil.

5.8.4.4 Using a piston ring compressor, assemble the cylinder over the piston with the intake port at the bottom of the engine. Push the cylinder all the way on; catch the ring compressor as it is pushed off. Before installing the cylinder hold-down nuts, lubricate crankcase through stud threads with either 90% SAE 50W engine oil and 10% STP (or Parker Thread Lube), or 60% SAE 30W engine oil and 40% Parker Thread Lube.

5.8.4.5 Assemble cylinder base hold down nuts and tighten as follows. It is necessary to re-torque the through studs on the cylinder on the opposite side of the engine any time a cylinder is replaced. Tighten the 1/2-inch nuts to 300 inch-pounds torque, using the sequence shown in the following figure, Sequence of Tightening Cylinder Base Nuts. Using the same sequence, tighten the 1/2-inch nuts to 600 inch-pounds torque. Tighten the 3/8-inch hold down nuts to 300 inch-pounds torque in any sequence. As a final check, hold the torque wrench on each nut for about five seconds. If the nut does not turn, it is tightened to the correct torque.

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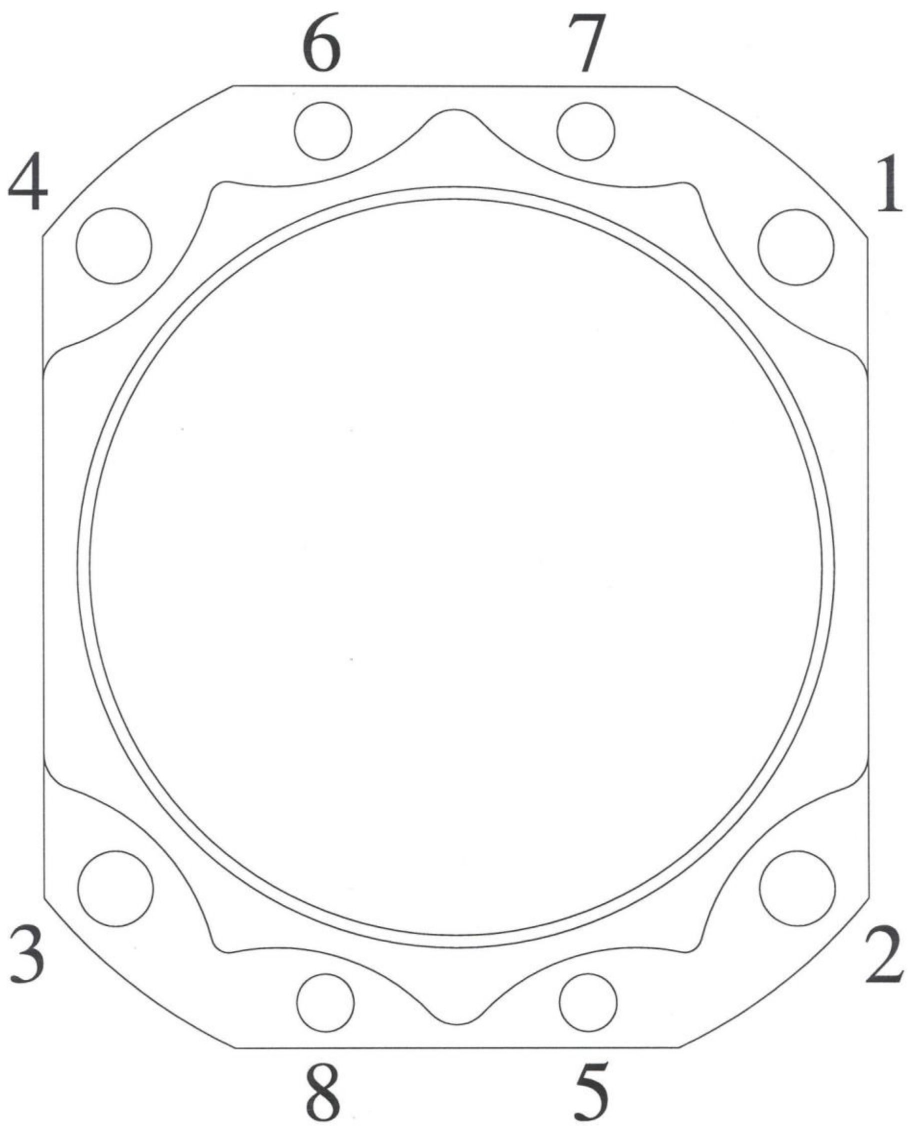

Sequence of Tightening
Cylinder Base Nuts

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5.8.4.6 Install new shroud tube oil seals on both ends of the shroud tube. Install the shroud tube and lock it in place as required for the type of cylinder.

5.8.4.7 Install each push rod in its respective shroud tube. Install each rocker arm in its respective position by placing the rocker arm between the bosses and sliding the rocker shaft in place to retain the rocker arm. Install thrust buttons in the ends of the rocker shaft. Place the rotator cap over the end of the exhaust valve stem before installing the exhaust valve rocker.

5.8.4.8 Be sure that the piston is at top center of the compression stroke and that both valves are closed. Check the clearance between the valve stem tip and the valve rocker. Check the clearance by pushing your thumb down on the rocker push rod end and compressing the hydraulic tappet spring. While holding the spring compressed, the valve clearance should be between .028 and .080 inch. Replace pushrod with a longer or shorter pushrod, if required, to correct the clearance.

5.8.4.9 Install inter-cylinder baffles, rocker box covers, intake pipes, rocker box drain tubes and exhaust manifold.

5.9 GENERATOR OR ALTERNATOR DRIVE BELT TENSION – Check the tension of a new belt 25-hours after installation.

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6. Periodic Inspections and Scheduled Maintenance

Periodic inspections and scheduled maintenance are very important to the safety and durability of the engine. Regular checks and prompt repair are vital to the continued health of the engine. The following items do not constitute a complete aircraft inspection, but for the engine only. Refer to the airframe manufacturer's instructions for additional information.

6.1 **DAILY PRE-FLIGHT –** The daily pre-flight inspection is a check of the aircraft's general condition prior to the first flight of the day. A proper pre-flight inspection is essential for flight safety.

6.1.1 Be sure all switches are in the "Off" position.

6.1.2 Be sure magneto ground wires are connected.

6.1.3 Check oil level.

6.1.4 See that fuel tanks are full.

6.1.5 Check fuel and oil line connections, note minor indications for repair at 50 hour inspection. Repair any leaks before aircraft is flown.

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

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

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

6.1.9 Induction system air filter should be inspected and serviced in accordance with the airframe manufacturer's recommendations.

6.2 **25 HOUR INSPECTION –** After the first 25 hours operating time, new engines should undergo a 50 hour inspection including draining and renewing lubricating oil.

6.3 **50 HOUR INSPECTION** – In addition to the items listed for daily pre-flight inspection, the following maintenance checks should be made after every 50 hours of operation.

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6.3.1 Ignition System

6.3.1.1 If fouling of spark plugs has been apparent, rotate bottom plugs to upper position.

6.3.1.2 Examine spark plug leads of cable and ceramics for corrosion and deposits. This can be evidence of either leaking spark plugs, improper cleaning of the spark plug walls or connector ends. When this condition is found, clean the cable ends, spark plug walls and ceramics with a dry, clean cloth or a clean cloth moistened with MEK or Acetone. All parts should be clean and dry before reassembly.

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

6.3.2 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, clamp attachment and lubricate if necessary. Check the air intake ducts for leaks, security and/or filter damage. Evidence of dust or other solid material in the ducts is an indication of inadequate filter care or a damaged filter. Check vent lines for evidence of fuel or oil seepage; the fuel pump may require replacement.

6.3.3 Lubrication System

6.3.3.1 Replace external full flow oil filter element. (Check used element for metal particles). Drain and renew lubricating oil.

6.3.3.2 Remove oil suction screen & oil pressure screen and clean thoroughly. Note carefully for presence of metal particles that are indicative of internal engine damage.

6.3.3.3 Check oil lines for leaks. Pay particularly attention to connection attachments and for wear from rubbing or vibration, and for dents and cracks.

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6.3.4 Exhaust System – Check exhaust port flanges for evidence of leakage. If they are loose or distorted, they must be removed and machined flat before they are reassembled and tightened. Examine the general condition of the exhaust manifolds.

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

6.3.6 Cylinders – Check rocker box covers for evidence of oil leaks. If found, replace gasket and tighten screws to specified torque. Check cylinders for evidence of excessive heat, indicated by discoloration of the cylinder. This condition indicates possible internal damage to the cylinder and the source must be determined and corrected before the aircraft resumes operation.

6.3.7 Carburetor – Check throttle body attaching screws for tightness, tighten to 40-50 inch-pounds.

6.4 100 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**.**

6.4.1 Electrical System

6.4.1.1 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.

6.4.1.2 Remove spark plugs; test, clean and regap. Replace if necessary.

6.4.2 Magnetos – Check magneto to engine timing. The timing procedure is described in Section 5.

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

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6.4.5 Cylinders – Check cylinders visually for cracked or broken fins.

6.4.5 Engine Mounts – Check engine mounting bolts and bushings for security and excessive wear. Replace any bushings that are excessively worn.

6.4.6 Fuel Injection Nozzles and Fuel Lines – Check fuel injector nozzles for tightness, tighten to 60 inch-pounds torque. Check fuel line for fuel dye stains at connections, indicating leakage, and for proper attachment of the line. Repair or replacement must be accomplished before the aircraft resumes operation.

6.5 500 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 after every 500 hours of operation.

6.5.1 Magneto Inspection – Inspect magnetos in accordance with the latest revision of Slick Service Bulletin SB 2-80.

6.6 NON-SCHEDULED INSPECTIONS – Occasionally Service Bulletins or Service Instructions are issued by Superior Air Parts that require inspections that are not listed in this manual. The publications are usually limited and may become obsolete after corrective action has been accomplished.

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7. Trouble-Shooting

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7. Trouble-Shooting

This engine trouble-shooting chart is provided as a guide. Review all probable causes given, check other listings of troubles with similar symptoms. Items are presented in sequence of the approximate ease of checking, not necessarily in order of probability.

TROUBLE	PROBABLE CAUSE	CORRECTION
Engine will not start	No Fuel	Fill with fuel.
	Excessive Priming	Leave ignition “Off” and mixture control in “Idle Cut-Off”, open throttle and clear cylinders by cranking a few seconds. Turn ignition switch “On” and proceed to start
	Defective ignition wire	Check with electric tester, and replace any defective wires.
	Dead battery	Charge or replace battery.
	Malfunction of magneto breaker	Clean points. Check internal timing of magnetos.
	Lack of sufficient fuel flow	Disconnect fuel line and check fuel flow
	Water in fuel injector or carburetor	Drain fuel injector or carburetor and fuel lines.

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TROUBLE	PROBABLE CAUSE	CORRECTION
Engine will not start (cont.)	Internal failure	Check oil screens for metal particles. If found, complete overhaul of the engine may be required.
Rough Idling	Incorrect idle mixture	Adjust mixture.
	Leak in the induction system	Tighten all connections in the induction system. Replace any damaged parts.
	Incorrect idle adjustment	Adjust throttle stop to obtain correct idle.
	Uneven cylinder compression	Check condition of piston rings and valve seats.
	Faulty ignition system	Check entire ignition system
Low Power and Engine Runs Rough	Mixture too rich indicated by sluggish engine operation, red exhaust flame at night. Extreme cases indicated by black smoke from exhaust.	Readjustment of fuel injector or carburetor by authorized personnel may be required.
	Mixture too lean; indicated by overheating or back firing	Check fuel lines for dirt or other restrictions. Readjustment of fuel injector or carburetor by authorized personnel may be required.

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TROUBLE	PROBABLE CAUSE	CORRECTION
Low Power and Engine Runs Rough (cont.)	Leaks in induction system	Tighten all connections. Replace damaged parts.
	Defective spark plugs	Clean and gap or replace spark plugs.
	Improper fuel	Drain and refill tank with fuel of proper grade.
	Magneto breaker points not working properly	Clean points. Check internal timing of magnetos.
	Defective ignition wire	Check wire with electric tester. Replace defective wire.
	Defective spark plug terminal connectors	Replace connectors on spark plug wire.
Engine Not Able to Develop Full Power	Leak in the injection system	Tighten all connections and replace damaged parts
	Throttle lever out of adjustment	Adjust throttle lever.
	Improper fuel flow	Check strainer, gage and flow at the fuel inlet.
	Restriction in air scoop	Examine air scoop and remove restrictions.
	Improper fuel	Drain and refill tank with proper fuel.

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TROUBLE	PROBABLE CAUSE	CORRECTION
Engine Not Able to Develop Full Power (cont.)	Faulty ignition	Tighten all connections. Check system with tester. Check ignition timing.
Rough Engine	Broken engine mount	Replace or repair mount
	Mounting bushings worn	Install new mounting bushings
	Unstable compression	Check compression
Low Oil Pressure On Engine Gage	Lack of oil	Add to proper level
	Air lock or dirty relief valve	Clean relief valve
	Leak in line	Inspect gasket between accessory housing and crankcase.
	High oil temperature	See “High Oil Temperature” in “Trouble” column
	Defective pressure gage	Replace
	Stoppage in oil pump intake passage	Check line for obstruction. Clean suction strainer.
High Oil Temperature	Insufficient air cooling	Check air inlet and outlet for deformation or obstruction.
	Insufficient oil supply	Fill to proper level with specified oil.

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TROUBLE	PROBABLE CAUSE	CORRECTION
High Oil Temperature (cont.)	Low grade of oil	Replace with oil conforming to specifications
	Clogged oil lines or strainers	Remove and clean oil strainers.
	Excessive blow-by	Usually caused by worn or stuck rings.
	Failing or failed bearing	Examine sump for metal particles. If found, engine overhaul may be required.
	Defective temperature gage	Replace gage.
Excessive Oil Consumption	Low grade of oil	Fill tank with oil conforming to specification
	Failing or failed bearings	Check sump for metal particles
	Worn piston rings	Install new rings
	Incorrect installation of piston rings	Install new rings
	Failure of rings to seat on new cylinders	Use mineral base oil. Climb to cruise altitude at full power and operate at 75% cruise power setting until oil consumption stabilizes. See Break-In Instructions, Section 8

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On-Aircraft Engine Break-in Procedures

APPLICATION: All engines with newly installed Millennium cylinders that are to be broken-in on the aircraft.

To achieve satisfactory ring seating and long cylinder life, after top overhaul or major engine overhaul, break-in is critical. The aircraft can be a suitable test stand for running-in cylinders. All original equipment manufacturer's and Superior Air Parts service information should be followed for a successful break-in. The following are some general guidelines for break-in.

PRIOR TO START-UP:

- Engine should be filled, according to the operator's manual, with 100% mineral oil (specific grade depending on ambient temperature).
- Engine must be pre-oiled and oil pressure obtained prior to start-up. See appropriate service data for procedures.
- Engine baffles and seals must be in good condition and properly installed.
- Verify accuracy of instruments.

GROUND RUN:

- Flight propeller may be used if test club is not available.
- Head aircraft into the wind.
- Start engine and observe oil pressure. Oil pressure should be indicated within 30 seconds – if not, shut down engine and determine cause.
- Run engine just long enough to confirm everything is properly adjusted, secured and there are no fuel and/or oil leaks.
- Install cowling.
- Operate engine at 1000 RPM until oil has reached minimum operating temperature.
- Check magneto drop at normal RPM.
- If engine is equipped with a controllable pitch propeller, cycle only to a 100 RPM drop.
- Shut down engine and check for fuel and/or oil leaks and repair any discrepancies.
- At no time should cylinder head temperature be allowed to exceed original airframe equipment manufacturer recommended maximum cruise limit.

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BREAK-IN FLIGHT OPERATION:

- Perform normal pre-flight and run-up in accordance with engine operators manual (remember: only cycle prop to a 100 RPM drop if you have a controllable pitch propeller). Keep ground runs to a minimum.
- Conduct normal take-off at full power, full rich mixture, to a safe altitude.
- Maintain shallow climb, use caution to not overheat the cylinders, should overheating occur, reduce power and adjust mixture appropriately. Refer to Pilot's Operating Handbook for specific procedures and temperatures.
- Monitor RPM, oil pressure, oil temperature & cylinder temperature.
- During the first hour of operation, maintain level flight at 75% power. Vary the power setting every 15 minutes during the second hour between 65-75%.
- Avoid long descents at cruise RPM and low manifold pressure (could cause ring flutter).
- After landing, check again for any fuel and/or oil leaks, or other discrepancies, and repair.
- Continue flying at 65-75% power and lean mixture to approx. 75°F rich of peak EGT on subsequent flights until rings have seated, oil consumption stabilizes, and cylinder head temperatures drop - this is a sign that the cylinders are broken in.
- After break-in, oil may be changed to ashless dispersent of the proper grade.
- At no time should cylinder head temperature be allowed to exceed original airframe equipment manufacturer recommended maximum cruise limit.

NOTE:

Verify that crankcase breather and vent lines are correctly installed and positioned. Excessive oil discharge through the breather can often be directly related to an improperly installed or restricted breather line.

CAUTION:

Break-in of an engine in frigid conditions can lead to cylinder glazing and failed break-in due to low oil temperature. It is recommended that oil temperature be maintained between 180° and 190°F.

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9. Unleaded Auto Fuel Operating Instructions

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9. Unleaded Fuel Operating Instructions

The XP-360 Engine® series, when operated with pistons of 8.5:1 or lower compression ratio, can operate and perform at rated power using unleaded auto fuel. Engines with a compression ratio of 8.5:1 must be operated on a minimum of 91 Octane auto fuel. Engines with compression ratios of 7.2:1 or lower can operate on a minimum of 87 Octane auto fuel. Of course, the higher the octane used in the XP-360 Engine®, the greater the detonation margin during high power and/or hot operation. When operating on unleaded fuel, Superior recommends using fresh, premium, auto fuel available at a major brand, reputable gas station.

9.1 VAPOR PRESSURE – Due to the higher vapor pressure of auto fuel, carburetor icing and vapor lock are more likely. Avoid fuel temperatures over 85°F at altitudes over 12,500 feet.

9.2 ETHANOL – Use of auto fuel blended with ethanol, or gasohol, is forbidden. Winter oxygenated ethanol fuel blends, or reformulated gasolines, are typically most available during the colder months for smog reduction. Ethanol (alcohol) mixed with unleaded fuel can cause vapor lock, carburetor ice, reduction in range, carburetor problems, and damage the fuel system. The use of an alcohol (and water) tester is recommended. Acceptable gasolines are specified per ASTM D-439 and D-4814 (European EN228), again without alcohol. The following states require compliance with D-4814, or require critical specified values per ASTM D-4814:

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Maryland, Minnesota, Mississippi, Montana, Nevada, New Mexico, North Carolina, North Dakota, Oklahoma, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Virginia, Wisconsin, Wyoming

9.3 RUN-IN – Superior runs-in the XP-360 Engine® on 100LL leaded avgas to provide initial lubricating lead to the internal components. It is also recommended that 100LL be run during break-in (see Section 8). No additional leaded fuel needs to be run after break-in. However, Leaded 100LL avgas can be run, or mixed with unleaded auto fuel, in the XP-360 Engine® and is encouraged when available.

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9.4 ENGINE INSTALLATION – When running fuel lines for your unleaded fuel airplane, it is important to remember to not use 90° fittings and/or to use smooth bending tubing to reduce the likelihood of vapor lock. Also, try to locate the fuel boost pump as close to the fuel tank as possible. Periodically inspect non-metallic fuel system components for degradation. For added safety, the use of a Reid Vapor Pressure (RVP) tester, such as a Hodges Volatility Tester (which gives a go or no-go reading), is also recommended. For consistent operation with unleaded auto fuel and added safety, Superior also recommends retarding the timing to 22° (from 25°) BTDC. Unleaded auto fuel burns slightly faster than leaded aviation fuel, so it's important to delay the ignition by a few degrees for best performance and detonation margin when operating purely on unleaded auto fuel.

9.5 OPERATION WITH UNLEADED AUTO FUEL – Engine operation of the XP-360 Engine® with unleaded auto fuel is the same as with aviation grade fuel. Insure all operations at over 75% power are at "Full Rich" mixture.

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