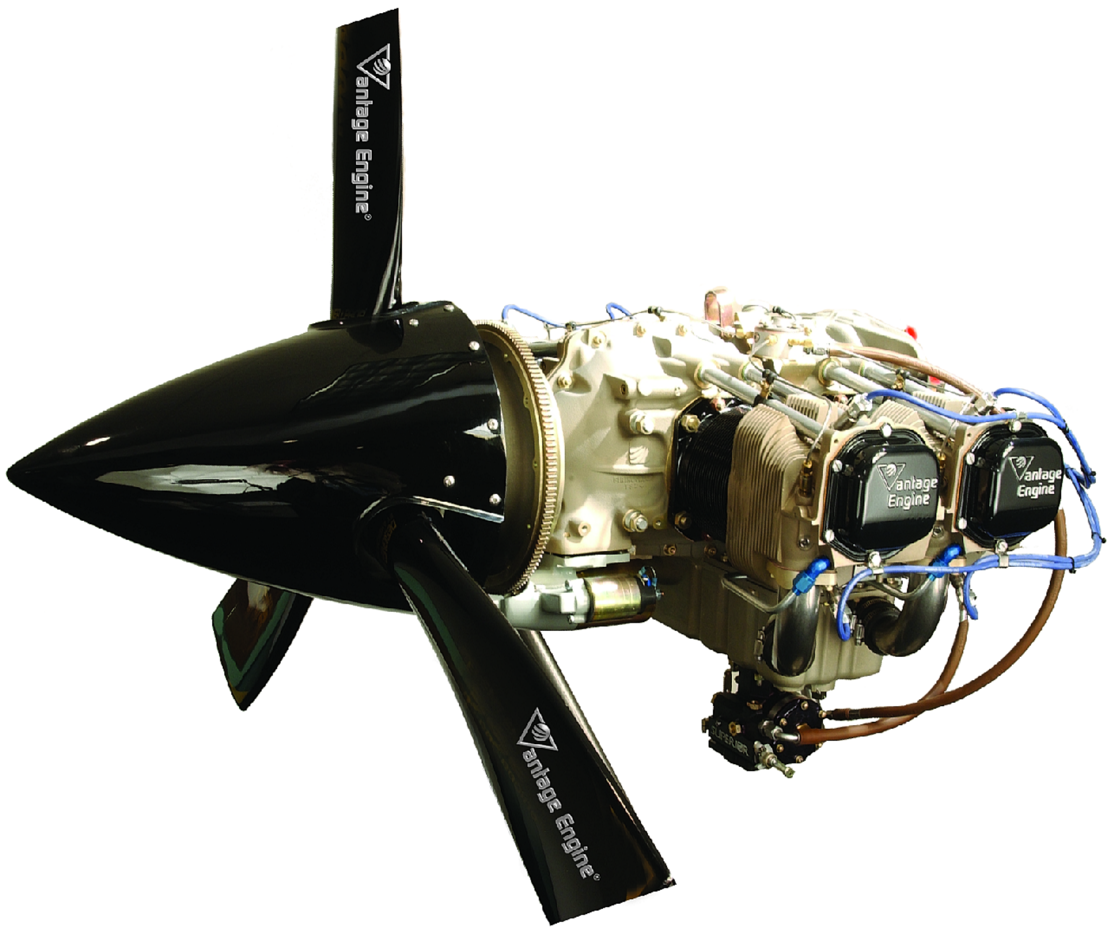
O-360 & IO-360 SERIES ENGINES

INSTALLATION & OPERATION MANUAL



SUPERIOR AIR PARTS, INC.

621 South Royal Lane, Suite 100 / Coppell, TX 75019 / 800-277-5168
www.superior-air-parts.com

P/N SVIOM01 Revision B, February, 2007
FAA Approved

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Table Of Contents

		Page Number
	Revision History	i
	List Of Figures	ii
	List Of Tables	iii
	Introduction	iv
	About This Manual	iv
	Related Publications	iv
	Installation Approval Requirements	iv
	Obtaining Service Information	v
Chapter 1	**Engine Description**	
	1. General Description	1
	2. Continued Airworthiness	1
	3. Model Designations	1
	4. Engine Components General Description	3
	5. Features And Operating Mechanisms	13
Chapter 2	**Airworthiness Limitations**	
Chapter 3	**Aircraft / Engine Integration Considerations**	
	1. General	1
	2. Induction System	1
	3. Fuel System	4
	4. Engine Cooling	7
	5. Exhaust	9
	6. Lubrication System	12
	7. Propeller Attachment	15
	8. Electrical System	16
	9. Engine Controls	18
	10. Engine Accessories	20
	11. Engine Mounting	22
Chapter 4	**Engine Installation**	
	1. General Instructions	1
	2. Preparing Engine For Service	1
	3. Installation of Engine	2
	4. Instrumentation Connections	2
Chapter 5	**Special Procedures**	
	1. General Break In Procedures	1
	2. Special Tools And Equipment	1
	3. Break In Procedures	1
	4. General Inspection Check	3
	5. Daily Pre Flight Inspection	3
Chapter 6	**Normal Operating Procedures**	
	1. General	1
	2. Engine Operation And Limits	1
	3. Operation Instructions	1

Table Of Contents (continued)

Chapter 7 **Abnormal Operating Procedures**

1. General 1
2. Engine Will Not Start 2
3. Rough Idling 2
4. Engine Not Able to Develop Full Power 3
5. Rough Engine Operation 3
6. Low Power and Engine Runs Rough 3
7. Low Oil Pressure On Engine Gage 4
8. High Oil Temperature 4
9. Excessive Oil Consumption 4

Chapter 8 **Servicing Requirements**

1. General 1
2. Lubricants 1
3. Fuels 2
4. Consumables 2

Chapter 9 **Engine Preservation And Storage**

1. Temporary Storage 1
2. Indefinite Storage 2
3. Inspection Procedures 2
4. Returning An Engine To Service After Storage 3

Appendix A O-360 Model Specification Data

Appendix B IO-360 Model Specification Data

Manual Number SVIOM01

Revision History

Revision Letter	Effective Date	Description	Pages Revised
A	03/29/04	Initial Release	All
B	02/28/07	-C, -D and -E models Added Celsius Temperature Added Celsius Temp and Models -C, -D and -E	Chapter 1, All Chapters 3,5,6 & 8 All Appendices A and B

WARNING
It is the users responsibility to insure that this is the current revision of this manual. Do not perform any operation, installation, maintenance, or other procedure until confirming this manual is current.

List Of Figures

Figure Number	Figure Description	Chapter	Page
1-1	Model Number Designation	1	1
1-2	O-360 Engine Front View	1	5
1-3	O-360 Engine Left Side View	1	6
1-4	O-360 Engine Top View	1	7
1-5	O-360 Engine Rear View	1	8
1-6	IO-360 Engine Front View	1	9
1-7	IO-360 Engine Left Side View	1	10
1-8	IO-360 Engine Top View	1	11
1-9	IO-360 Engine Rear View	1	12
3-1	Oil System Schematic	3	14
3-2	Ignition Wiring Diagram	3	17
3-3	Alternator Mounting Pad	3	21
3-4	#1 Dynafocal Mount Dimensions	3	23
3-5	#2 Dynafocal Mount Dimensions	3	23
3-6	Conical Mount Dimensions	3	24
3-7	Limit and Ultimate Engine Forces	3	26
3-8	Engine Mount Forcing Function for Engine Startup and Shutdown	3	27
3-9	Engine Mount Forcing Function for Steady State Conditions	3	27

List Of Tables

Table Number	Table Description	Chapter	Page
1-1	Manufacturer's General Specifications	1	3
1-2	Manufacturer's Physical Specifications	1	4
1-3	Views of the Engine	1	4
3-1	Accessory Drive Data	3	20
3-2	Lord Engine Mounts for Superior Vantage Engines	3	21
3-3	Limit and Ultimate Engine Mount Loads	3	25
4-1	Instrumentation Connections	4	2
6-1	Normal Starting Procedures	6	3
6-2	Starting A Flooded Engine	6	4
6-3	Ground Running / Fixed Wing Warm-Up	6	5
6-4	Ground Running / Rotorcraft Warm-Up	6	5
6-5	Fixed Wing - Pre-Takeoff Ground Check	6	6
6-6	Rotorcraft - Pre-Takeoff Ground Check	6	7
6-7	Fuel Mixture Leaning General Rules	6	8
6-8	Leaning with Exhaust Gas Temperature Gage	7	9
6-9	Leaning with Flowmeter	6	9
6-10	Leaning with Manual Mixture Control	6	9
6-11	Shut Down Procedure	6	9
7-1	Abnormal Operating Procedures	7	1
7-2	Engine Will Not Start	7	2
7-3	Rough Idling	7	2
7-4	Engine Not Able To Develop Full Power	7	3
7-5	Rough Engine Operation	7	3
7-6	Low Power & Engine Runs Rough	7	3
7-7	Low Oil Pressure On Engine Gage	7	4
7-8	High Oil Temperature	7	4
7-9	Excessive Oil Consumption	7	4
8-1	Oil Grades	8	1
8-2	Oil Sump Capacity	8	1
8-3	Minimum Octane Fuels	8	2
8-4	Consumables	8	2

Introduction

About This Manual
This engine installation and operation manual is provided as guidance for the installation and installation design of a Superior Vantage Engine to an airframe and to describe its' operational characteristics. Its purpose is to provide technical information to aid in designing and operating an effective engine installation so as to achieve maximum performance while providing for maximum service life.

Superior Air Parts has made clear and accurate information available for those who maintain, own and repair the Vantage O-360 and IO-360 Series Engines. Superior Air Parts values your input regarding revisions and additional information for our manuals. Please forward your comments and input to:

Superior Air Parts
Attn. Engineering Department
621 South Royal Lane Suite 100
Coppell, Texas 75019

Related Publications
The following are related engine and accessory publications.

O & IO-360 Maintenance Manual SVMM01
O & IO-360 Overhaul Manual SVOM01
O & O-360 Illustrated Parts Cat. SVIPC01
Unison Master Service Manual, F-1100
Precision RSA-5 Service Manual, 15-338
Precision MA-4-5 Manual, MSAHBK-1
Champion Aerospace Service Manual, AV-6R

Installation Approval Requirements
The engine warranty for a Vantage Engine installation is subject to the technical approval of Superior. Upon approval of an installation design, Superior will provide a letter that states in part that the installation design is acceptable and does not adversely effect the function of the engine with respect to engine longevity while the engine is operated in accordance with recommended procedures.

Superior requires certain technical data regarding the installation in order to determine its acceptability for warranty purposes. This data may include, but is not limited to drawings, photographs and test data. Approval of the installation for these purposes is limited to the installation design furnished by the airframe manufacturer to Superior. Modifications or changes to the installation design requires a new or amended letter of approval prior to the warranty becoming effective for that design.

Approval of the installation by Superior as described above is limited to engine warranty issues only. It does not in any way indicate approval of other aspects of the installation design such as structural integrity and manufacturability.

Superior Vantage Engines discussed in this document must be installed and operated in accordance with the limitations, conditions and operating procedures described in this document, the Model Specification Data and the Installation and Operation Manual. They must also be maintained in accordance with the applicable Overhaul Manual and other Instructions for Continued Airworthiness. Superior accepts no responsibility for airworthiness of any aircraft resulting from the installation of the engine or associated equipment.

Obtaining Service Information

All Vantage Series Engine manuals and service information may be downloaded at:
www.superior-air-parts.com

All Vantage Series Engine manuals and service information may also be purchased by contacting:

Superior Air Parts
621 South Royal Lane, Suite 100
Coppell, Texas 75019

or call: 972-829-4600

Accessory Information may be obtained at:

www.championaerospace.com

www.unisonindustries.com

www.skytecair.com

www.precisionairmotive.com

www.aeroaccessories.com

CHAPTER 1

Engine Description

1. GENERAL DESCRIPTION

Superior Vantage Engines are four-cylinder, horizontally opposed, air-cooled, direct drive powerplants incorporating a wet sump, bottom mounted induction, bottom exhaust with either carbureted or port injected fuel systems. Provisions exist for both front and rear mounted accessories. All engine components will be referenced as they are installed in the airframe. Therefore, the “front” of the engine is the propeller end and the “rear” of the engine is the accessory mounting drive area. The oil sump is on the “bottom” of the engine and the cylinder shroud tubes are on the “top”. The terms “left” and “right” are defined as being viewed from the rear of the engine looking toward the front. Cylinder numbering is from the front to the rear with odd numbered cylinders on the right side of the engine. The direction of crankshaft rotation is clockwise as viewed from the rear of the engine looking forward unless otherwise specified. Accessory drive rotation direction is defined as viewed from the rear of the engine looking forward.

2. CONTINUED AIRWORTHINESS

Vantage Engines discussed in this document must be installed and operated in accordance with the limitations, conditions and operating procedures described in this document. They must also be maintained in accordance with the applicable Overhaul Manual and other Instructions for Continued Airworthiness. The engine’s time between overhaul (TBO) period is initially defined as 1000 hours. A TBO extension program is in process.

3. MODEL DESIGNATIONS

The model number designation is defined in a way that the digits of the model number can easily identify the basic configuration of the engine as described in Figure 1-1.

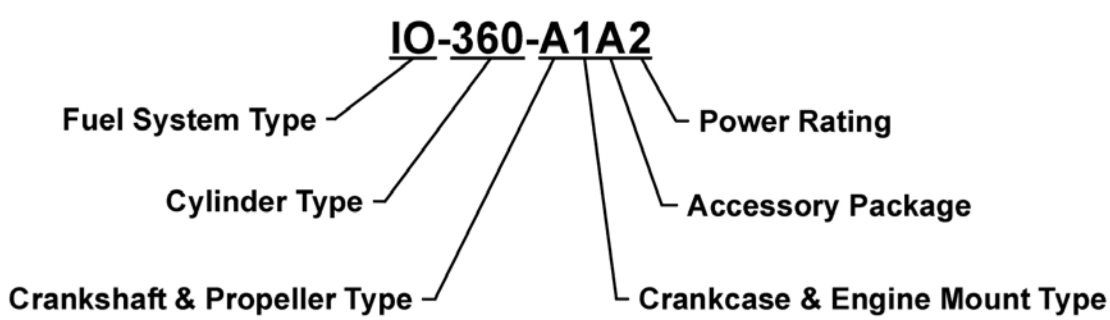


Figure 1-1 • Model Number Designation

Fuel System Type

IO Denotes Port Fuel Injection System and "opposed cylinder" arrangement.

O Denotes a carbureted system and "opposed cylinder" arrangement.

Cylinder Type

360 Parallel valve cylinder, 361 cubic inches.

Model Suffix Denotes detail engine configuration

1st Digit Crankshaft & 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

2nd Digit Crankcase & Engine Mount Type

1 #1 Dynafocal Mount
2 #2 Dynafocal Mount
3 Conical Mount

3rd Digit Accessory Package

	Ignition System	Fuel System	
		Carbureted	Fuel Injected
A	Unison Magnetos	Precision Carburetor	Precision Fuel Injection

4th Digit Power Rating: Piston Compression Ratio

	Cylinder Type	
	360	
	CR	HP
1*	-	-
2	8.5:1	180

***For Future Use**

4. ENGINE COMPONENTS GENERAL DESCRIPTION

The O-360 and IO-360 series engines are air-cooled, four cylinder, horizontally opposed, direct drive engines. See Table 1-1 for Manufacturer's General Specifications.

A. The complete engine includes the following components and assemblies:

1. Crankcase Assembly
2. Crankshaft Assembly
3. Camshaft Assembly
4. Valve Train Assembly
5. Cylinder Assemblies
6. Connecting Rod Assemblies
7. Oil Sump Assembly
8. Inter Cylinder Baffles
9. Starter
10. Lubrication System (includes oil filter)
11. Accessory Drive
12. Ignition System (includes spark plugs)
13. Fuel System
14. Starter Support Assembly
15. Oil Gage
16. Induction System
17. Accessories

Note: Complete engine does not include outer cylinder baffles, propeller governor, and airframe to engine control cables, attaching hardware, hose clamps, vacuum pump, exhaust system, fittings or alternator.

B. Specifications

The manufacturer's physical specifications are listed in Table 1-2 are applicable to the O-360 and IO-360 series engines. See Model Specification Data (MSD) for more specific information.

Table 1-1 • Manufacturer's General Specifications

Model		O-360 and IO-360
Rated Power	Hp	180
Rated Speed, RPM	RPM	2700
Bore, inches	In	5.125
Stroke, inches	In	4.375
Displacement cubic inches	In^3	361.0
Compression Ratio		8.5:1
Firing Order		1-3-2-4
Spark timing	°BTDC	25
Propeller drive ratio		1:1
Propeller drive rotation (viewed from rear)		Clockwise

Table 1-2 • Manufacturer's Physical Specifications				
Model	**Height** (In)	**Width** (In)	**Length** (In)	**Weight**
O-360	24.6	33.4	32.8	See MSD
IO-360	24.0	33.4	32.8	See MSD

Table 1-3 • Views of the Engine		
Engine View	**Figure Number**	**Location**
O-360 Engine Front View	Figure 1-2	p. 5
O-360 Engine Left Side View	Figure 1-3	p. 6
O-360 Engine Top View	Figure 1-4	p. 7
O-360 Engine Rear View	Figure 1-5	p. 8
IO-360 Engine Front View	Figure 1-6	p. 9
IO-360 Engine Left Side View	Figure 1-7	p. 10
IO-360 Engine Top View	Figure 1-8	p. 11
IO-360 Engine Rear View	Figure 1-9	p. 12

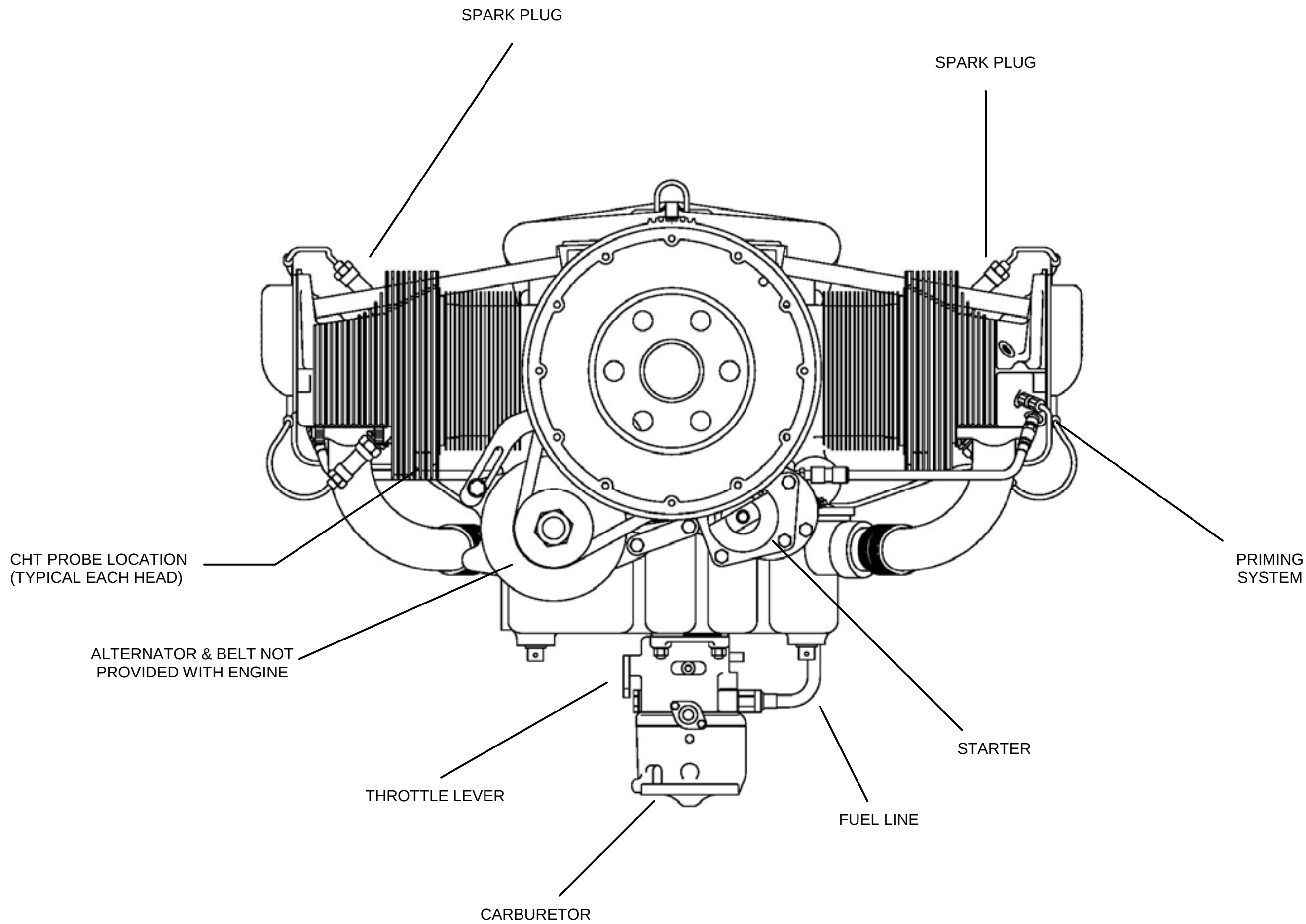


Figure 1-2 • O-360 Engine Front View

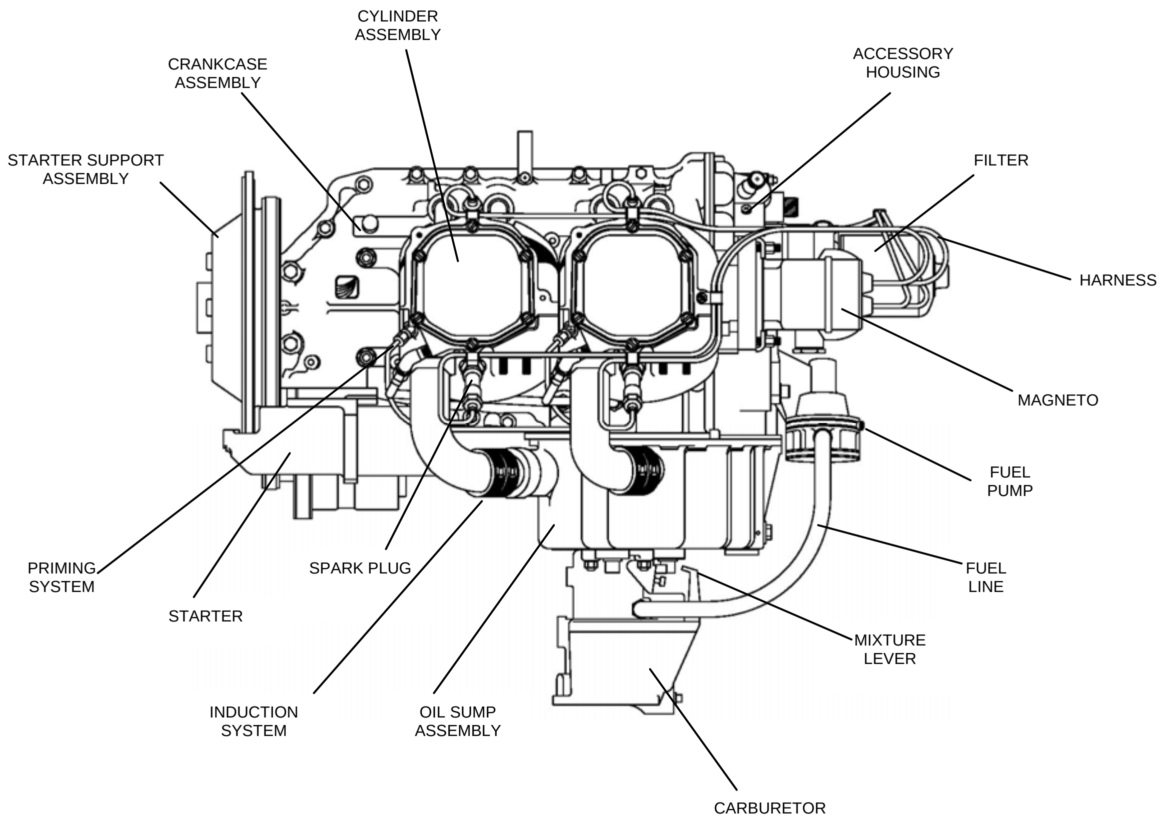


Figure 1-3 • O-360 Engine Left Side View

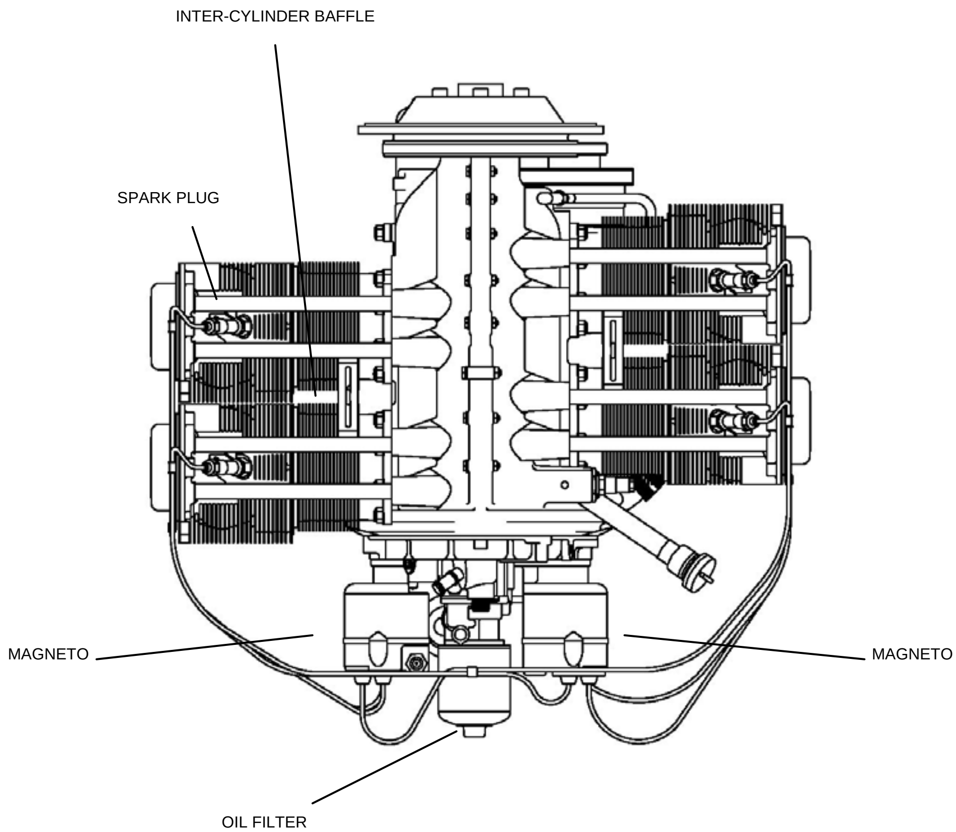


Figure 1-4 • O-360 Engine Top View

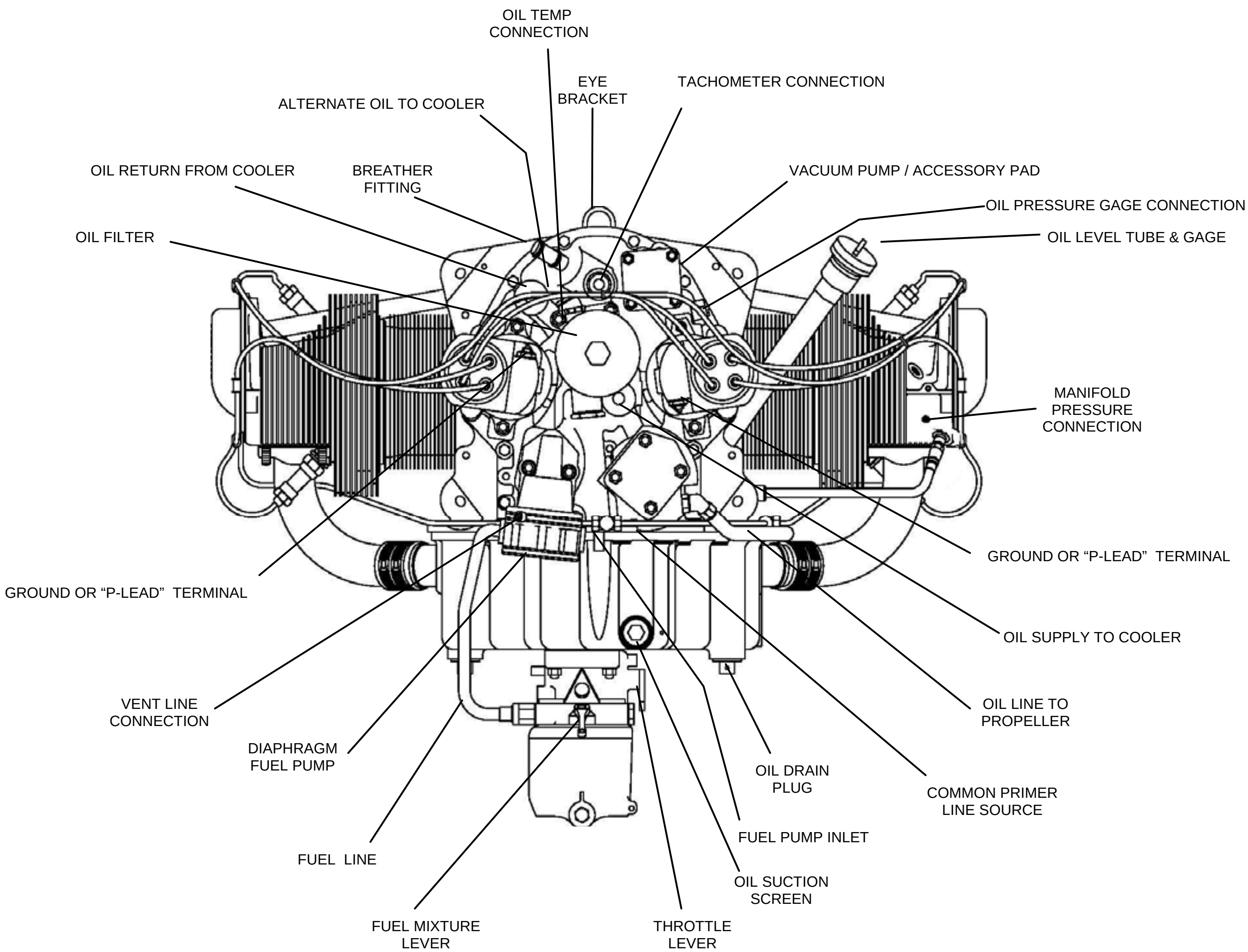


Figure 1-5 • O-360 Engine Rear View

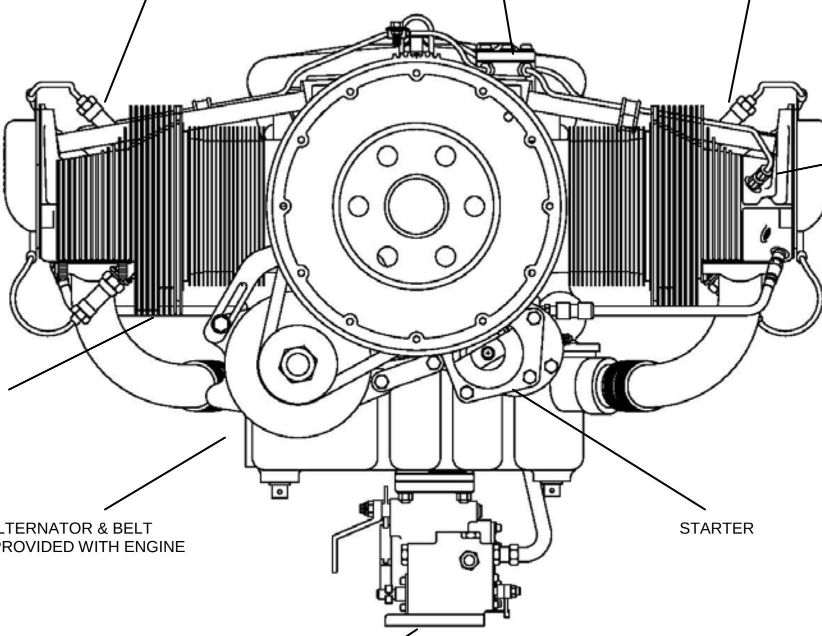


Figure 1-6 • IO-360 Engine Front View

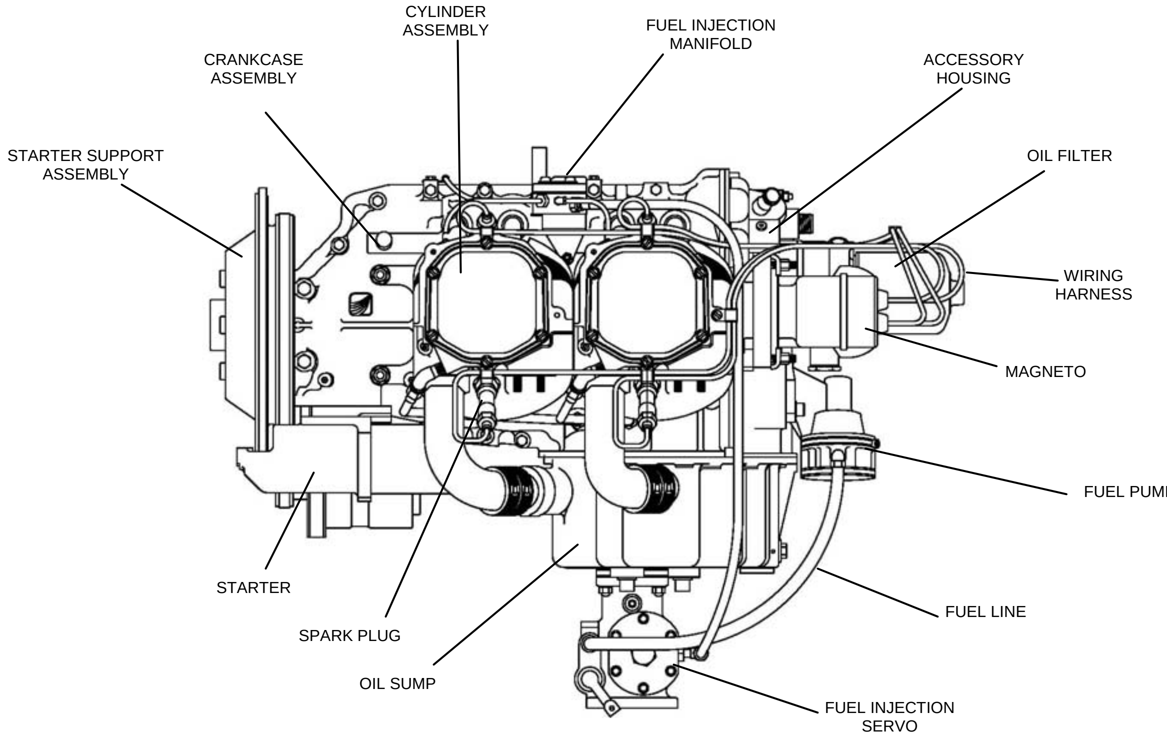


Figure 1- 7 • IO-360 Engine Left Side View

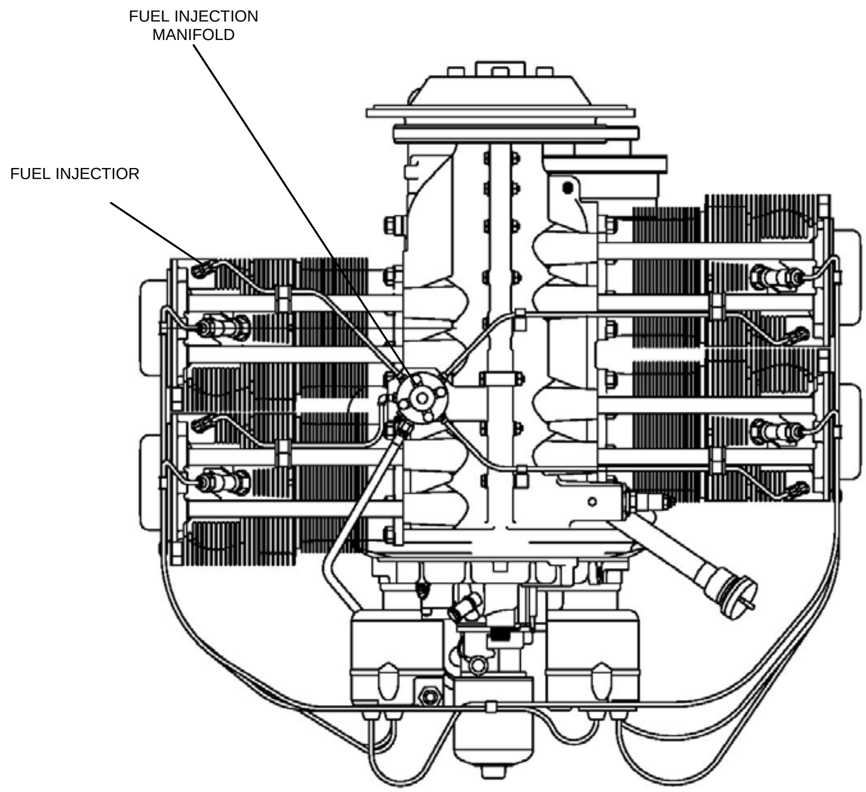


Figure 1- 8 • IO-360 Engine Top View

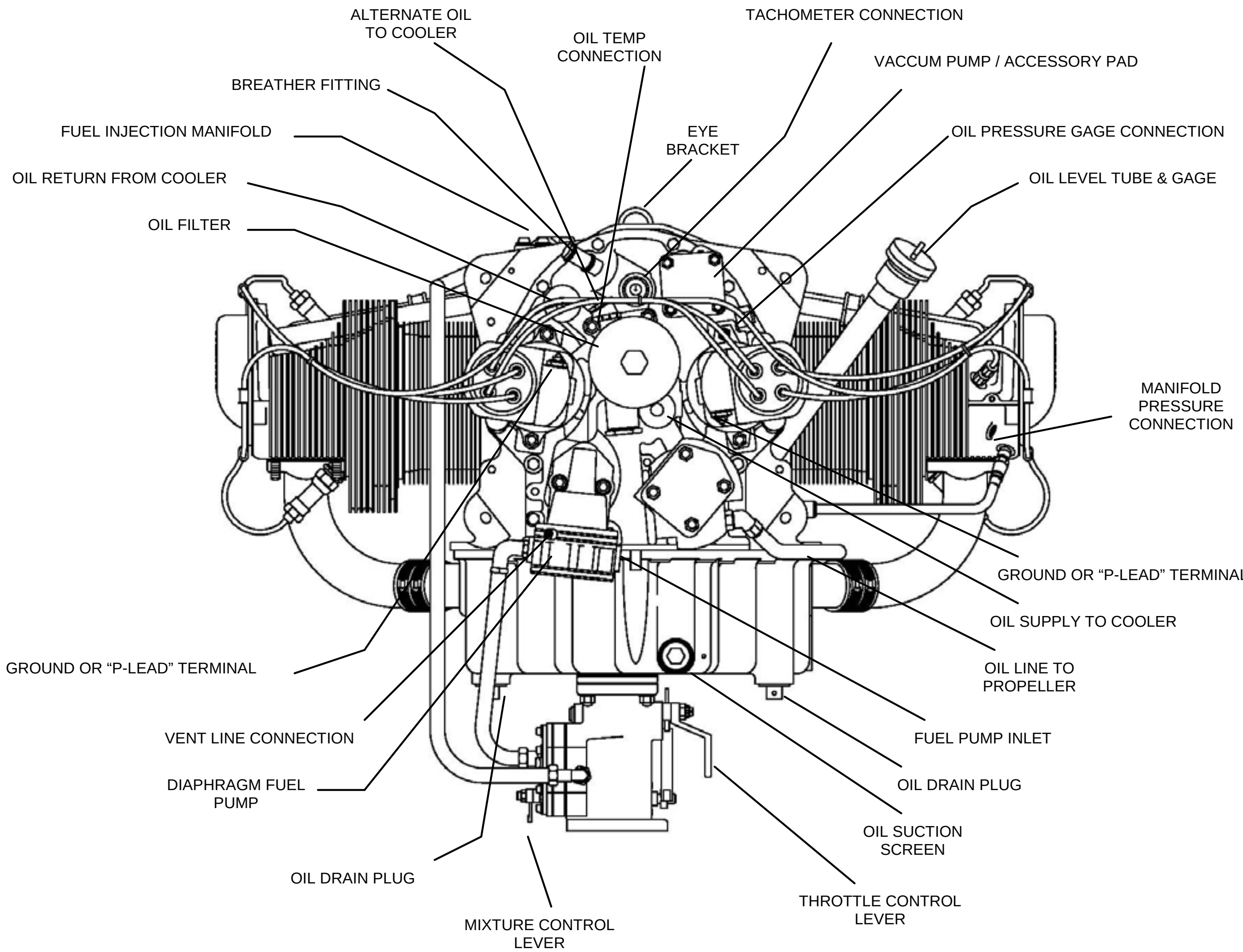


Figure 1- 9 • IO-360 Engine Rear View

5. FEATURES AND OPERATING MECHANISMS

Crankshaft - The crankshaft is made from aerospace grade SAE 4340 Vacuum-Arc-Remelt (V.A.R.) steel per AMS 6414. All bearing journal surfaces are nitrided.

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 bolts with self locking nuts per cap. Caps are tongue and groove type for improved alignment and rigidity.

Camshaft - Valve Operating Mechanism - The camshaft is located above and parallel to the crankshaft. The camshaft actuates hydraulic lifters that operate the valves through push rods and valve rockers.

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 alloy castings fastened together by means of studs, bolts, and nuts. The main bearing bores are machined for use with precision type main bearing inserts.

Accessory Housing - The accessory housing is made from an aluminum casting and is fastened to the rear of the crankcase and the top rear of the sump.

Oil Sump - The sump incorporates an oil drain plug, oil suction screen, mounting pad for carburetor or fuel injector, the intake riser, and intake pipe connections.

Cylinders - *Millennium®* Cylinders are used exclusively. These air-cooled cylinders are manufactured by screwing and shrinking the two major parts, head and barrel, together. The heads are made from AMS 4220 aluminum alloy casting material. All barrels are made from forgings produced to AMS 6382 forging specifications. They are internally choked and honed to allow optimal operating conditions for the rings and pistons at operating temperatures.

Pistons - The pistons are made from an aluminum alloy. The piston pin is 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.

Cooling System – Superior Vantage Engines are designed to be air-cooled. Baffles are provided to build up air pressure and force the air between the cylinder fins. The air is exhausted to the atmosphere through the rear of the cowling.

Induction System - The distribution of the air to each cylinder is through the center zone of the induction system. This is integral with the oil sump.

Fuel Systems

Carbureted - Superior Air Parts O-360 engines are equipped with a float type carburetor The MA-4-5 carburetors are of the single barrel float type equipped with a manual mixture control and an idle cut-off.

Fuel Injected - IO-360 series engines are equipped with a direct cylinder injected RSA-5 fuel injector. The fuel injection system schedules fuel flow in proportion to airflow. Fuel vaporization takes place at the intake ports. The RSA fuel injection system is 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.

Lubrication System - The full pressure wet sump lubrication system is supplied by a gear type pump. It is contained within the accessory housing.

Priming System - A manual primer system is provided on all engines using a carburetor. Fuel injected engines do not require a manual priming system, relying instead on the fuel injectors for priming.

Ignition System - Dual ignition is furnished by two Unison magnetos with two spark plugs per cylinder. Each magneto is equipped with impulse coupling for improved starting.

CHAPTER 2

Airworthiness Limitations

The Airworthiness Limitations Section is F.A.A. approved and specifies maintenance required under sections 43.16 and 91.403 of the Federal Aviation Regulations unless an alternate program has been FAA approved. This section is part of the type design of the O-360 and IO-360 engine series pursuant to certification requirements of the Federal Aviation Regulations.

1. MANDATORY REPLACEMENT TIME

Subject to additional information contained in F.A.A. Approved Mandatory Service Bulletins issued after the date of certification, the O-360 and IO-360 engine series do not contain any components having mandatory replacement times required for type certification.

2. MANDATORY INSPECTION INTERVALS

Subject to additional information contained in F.A.A. Approved Mandatory Service Bulletins issued after the date of certification, the O-360 and IO-360 engine series do not contain any components having mandatory inspection intervals.

3. OTHER MANDATORY INTERVALS OR PROCEDURES

Subject to additional information contained in F.A.A. Approved Mandatory Service Bulletins issued after the date of certification, the O-360 and IO-360 engine series do not have any inspection-related or replacement time-related procedures required for type certification.

4. DISTRIBUTION OF CHANGES TO AIRWORTHINESS

Changes to this Airworthiness Limitations Chapter constitute changes to the type design of the O-360 and IO-360 engine series and require F.A.A. approval pursuant to Federal Aviation Regulations. Such changes will be published in F.A.A. Approved Mandatory Service Bulletins. Superior Vantage Engine Service Bulletins may be obtained by writing to:

Superior Air Parts
621 South Royal Lane, Suite 100
Coppell, Texas 75019

or call: 972-829-4600

or on the web at **www.superior-air-parts.com**

CHAPTER 3

Aircraft / Engine Integration Considerations

1. GENERAL

The following sections in this chapter include a discussion of design practices to be considered during the integration of a Superior Vantage engine with an airframe and propeller. These discussions should be used IN ADDITION TO the applicable requirements of the FARs.

Superior requires that proper functioning of the system designs outlined in this chapter be proven prior to activation of the warranty.

Proper functioning of the installation design shall be proven by technical data such as test data, photographs, drawings and engineering calculations. Superior Air Parts Engineering Department will provide guidance regarding the specifics of these requirements as appropriate to the installation and on a case-by-case basis.

Throughout this chapter reference is made to data contained in the Model Specification Data. These documents are engine series specific and are contained in Appendices of this manual. Refer to the appropriate Model Specification Data for your engine model when consulting this data.

2. INDUCTION SYSTEM

The induction system design can significantly effect both performance and longevity of an aircraft engine installation. In addition to more obvious issues such as air filtration, seemingly insignificant design features can cause restrictions or other airflow disturbances resulting in flow loss or improper function of the fuel metering system. Induction systems which yield excessive intake air temperatures can promote engine detonation.

A. General Induction System Design

It is important that the induction system of naturally aspirated engines such as the Superior Vantage Series be capable of supplying clean, filtered, cool intake air to the engine at the maximum required flowrate and with maximum attainable pressure. The term “maximum attainable pressure” as used here refers to an air source that provides maximum intake air pressure, (including ram air effects) while minimizing restrictions and flow losses. A reduction in flowrate or total pressure, or increased temperature can cause power loss, reduced service ceiling and increased possibility of detonation during high power requirements.

Properly engineered intake systems for naturally aspirated engines should result in total intake air pressures that are greater than ambient air pressure. For example, air pressure in the intake system can be raised by directing the face of the air pickup into the relative wind of the aircraft. Further, by locating the air pickup within the propeller diameter, ram air effects can be increased. Care should be taken to position the air pickup as far as possible away from the propeller axis (but within the “propeller envelope”) so as to take advantage of the increased air velocities at the outer areas of the prop. Care should also be given to prevent “blanking” of the intake air pickup by the prop blade. Increasing the size of the air pickup, particularly in the direction perpendicular to the blade axis, can help reduce this potential. Care should also be given to designing an air pickup that maintains maximum frontal area during periods of high aircraft angle of attack. Typically, maximum power is required during flight conditions having high angle of attack and reductions in airflow will restrict maximum power capability.

The intake air system should be designed to minimize pressure and flow losses. Sharp elbows and abrupt duct expansions or contractions all contribute to system losses. Changes in duct sizing should be accompanied by tapered transitions to minimize these losses. Duct losses are a function of air velocity and can be significantly reduced by increasing duct size and thereby reducing the air velocity. Utilizing ducts with circular cross-sections or "square" cross-sections with the highest possible aspect ratio can also reduce duct losses. Turning vanes can be used to reduce losses in sharp corners when necessary.

The state of the airflow as it enters the carburetor or fuel injector servo body is critical to effective and efficient fuel mixing. Both carburetor and fuel injector servo bodies sense mass airflow and introduce fuel based on that measurement. If the airflow is turbulent during this process, inaccurate airflow sensing can occur resulting in improper fuel flow. Turbulence of the intake air in a carbureted system will also promote poor fuel / air mixing and large cylinder to cylinder mixture variations. The consequences of these conditions can be as simple as reduced power or as great as in-cylinder detonation.

Care should also be given to the placement of the intake system with respect to hot areas such as exhaust pipes and other engine components. Cooler intake air results in better power output and greater service ceilings. Intake systems that allow heating of the air reduce available engine power and can reduce service ceilings.

B. Intake Air Requirements and Filtration

The intake air and filtration system must be designed for both effective and efficient filtering with minimal flow loss. Studies have shown that particulates greater than about 10 microns in size are particularly harmful to engines; therefore the filtration system should be selected accordingly. Filter manufacturers can provide data regarding effectiveness, efficiency and capacity of their products including the effect of particulate size. Guidance regarding overall filter size, based on filter capacity, can be obtained from the filter manufacturer.

The size of the air filter must also consider the total engine airflow requirements and the maximum air velocity requirements of the filter. In general, filters are more effective for lower air velocities but practical considerations must be made based on space available. Intake air flow requirements of a Superior Vantage Engine are defined in Figure 1 of the Model Specification Data. It is recommended that the filter be sized to provide a minimum of 150% of this flow to minimize pressure drop for both clean and dirty filters.

C. Carburetor Heat

Due to the cooling effects of both fuel vaporization and airflow through the venturi, carburetor ice can form with outdoor air temperatures as high as 100°F (38°C). Therefore, it is necessary to provide a mechanism to introduce heat to the intake airstream, downstream of the air filter, to prevent this condition and to correct it if icing were to occur. This mechanism also serves the purpose of an alternate air source should the filter become unexpectedly blocked due to ice or debris. The minimum temperature rise required of the carb heat mechanism is specified in the FARs.

The design of the carb heat system should, in general, follow the same guidelines as the induction air system to minimize pressure loss and turbulence. For example the flow area should be as large as possible to reduce air velocity and therefore flow losses. Relatively slow-moving air across a heat source will also experience a higher temperature rise than faster-moving air over the same heat source. Good practice suggests that the carb heat duct should be at least 75% the size of the carburetor inlet.

The air source for the carb heat mechanism should be from a source other than the "standard" filtered intake air. It is common for the carb heat air to be drawn from within the lower cowl area. It is also conventional to omit the use of a traditional air filter at the carb heat source for several reasons including preventing the risk of filter blockage for alternate air. However, it is good practice to include a course screen to prevent ingestion of "large" foreign objects.

The carb heat air is normally introduced to the induction airstream by means of a mixing box. The mixing box includes a baffle door that is manually actuated by the pilot and governs the amount of filtered induction air or carb heat air that is supplied to the carburetor.

It is important that the design of the mixing box and damper door minimize pressure drop and turbulence of either filtered intake air or carb heat air. Some turbulence is unavoidable in this transition; however it is recommended that a "straight" section of duct be available after the transition to smooth the airflow. If possible, this section should be a length equivalent to 10 diameters. If this length is not possible due to geometry constraints then appropriate steps should be taken to straighten the flow. In either case, thorough testing should be performed to verify that both intake airflow and carb heat airflow is free of excessive pressure drop and turbulence to the extent that they do not degrade engine performance.

Good practice also dictates that the mixing box damper door be spring actuated to partially actuate automatically in the event of unexpected air filter blockage due to ice or debris. Care should be taken in the design of this mechanism to prevent "flutter" of the damper door during normal operation in either the filtered air or carb heat mode. The mechanism should also be designed to prevent unintended use of carb heat during the filtered air mode, including the effects of "normal" filter blockage. That is, the automatic spring mechanism should not be designed to be so sensitive that normal pressure drop due to filter use over time would cause carb heat air to be introduced.

D. Alternate Air Source

Fuel injected engines introduce fuel to the induction air at the heated cylinder port and do not present the same concerns regarding induction icing as the carbureted systems. However, provisions are required to provide an alternate induction air source for fuel injected systems to prevent engine stoppage in the event of filter blockage due to ice or debris. As with the design of the carb heat mechanism, this is conventionally done by drawing air from the heated lower cowl area and introducing this air downstream from the intake air filter. Although it is acceptable to use a mixing box device with flapper door mechanism as with the carb heat apparatus, this is not necessary. Where the carb heat mixing box must be designed so as to select between the two air sources, the alternate air source for fuel injected engines is simply the availability of alternate air. Therefore, it is not necessary to "block off" the normal filtered air source.

Like the carb heat mechanism, the alternate air source should be designed to minimize both flow losses and turbulence. An entrance area at least 75% of the fuel injector servo area is recommended as well as provisions to straighten the flow after introduction to the intake air duct. A screen to prevent ingestion of "large" foreign objects may be necessary.

The alternate air source mechanism should be manually controllable by the pilot. As with the carb heat mechanism, it is advised that the alternate air source be spring actuated so it will partially actuate automatically in the event of unexpected air filter blockage due to ice or debris. The mechanism should be designed to preclude flutter and unintended operation during the filtered air mode, including the effects of "normal" filter blockage. The automatic spring mechanism should not be designed to be so sensitive that normal pressure drop due to filter use over time would cause carb heat air to be introduced.

E. Backfire Tolerance

The induction system, carb heat mechanism and alternate air source must be designed to withstand "normal" induction backfire events without structural failure or fire.

3. FUEL SYSTEM

The fuel system design can significantly effect both performance and longevity of an aircraft engine installation. In addition to the obvious performance aspects, fuel systems that limit the fuel supply can promote engine detonation and vapor lock. Un-damped and extreme pressure pulsations can cause malfunction of the fuel metering systems.

A. Fuel System Requirements and Filtration

Superior Vantage Engines are supplied with positive displacement fuel pumps that are directly driven by the engine. These pumps are designed to provide the appropriate flow and pressure to the fuel metering devices according to their requirements. The aircraft fuel system should be capable of providing at least twice the maximum engine fuel flow requirements to minimize the potential for vapor formation. The fuel flow requirements are defined in Table 1 of the Model Specification Data.

The flow of fuel must be vapor free, water free and filtered to be free of foreign objects or debris. The foreign object filter requirements are defined in Table 2 of the Model Specification Data.

B. General Fuel System Design

The aircraft fuel system should be designed so flow restrictions do not occur in the piping system. Flow restrictions in this context refer to system conditions such as sharp radius bends, abrupt changes in pipe diameter (larger or smaller), tee and other fittings, valves, etc. In addition to limiting maximum fuel flow, flow restrictions increase the potential for vapor formation. Vapor formation, if extreme can cause engine stoppage due to lack of fuel.

Vapor formation in a minimal degree can cause lean operation of the engine that can lead to improper operation, service ceiling restrictions or engine detonation under certain conditions.

Note: When running fuel lines for use with unleaded fuel, do not use 90° fittings. Instead, use large radius bends 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.

Aircraft boost pumps (non-engine driven) may be used to supplement fuel flow to the engine driven fuel pump, prevent vapor lock and aid in priming of fuel injected systems. The maximum inlet pressure allowable at the engine driven fuel pump is defined in Table 3 of the Model Specification Data. Although the use of aircraft boost pumps are not required for engine operation (other than priming of fuel injection systems), Superior Air Parts recommends their use as a backup to the engine driven fuel pump and as an aid in preventing vapor lock, particularly when using motor gasoline. The fuel system should be designed such that the minimum acceptable fuel pressure is available to the engine driven fuel pump at all times without the use of an aircraft boost pump. The minimum acceptable fuel pressure is defined in Table 3 of the Model Specification Data. In addition, the fuel system should be capable of providing at least 150% the maximum required flow of fuel to the engine driven fuel pump without the need for an aircraft boost pump. (See Table 1 of the Model Specification Data.)

Fuel tanks should be vented to the atmosphere to prevent vacuum formation in the fuel tanks. If un-vented, the pressure in the fuel tank (as fuel is consumed) can reduce to the point that the pressure available at the pump inlet is below the cavitation limit of the pump. In this case, cavitation can occur and engine stoppage due to fuel starvation is possible.

Superior Air Parts recommends the use of fuel flow meters as an aid to the pilot for proper engine management. Two types of fuel flow meters are available for use in such systems; those that indicate flow based upon sensed pressure and those that sense flow directly.

Fuel flow meters that indicate flows based upon fuel system pressure can be less accurate than those that sense flow directly in times when abnormalities occur. For example, dirty fuel injectors or carburetor float malfunctions can cause increases or decreases to system pressure that would result in improper fuel flow indications for pressure-based flow meters. For this reason, Superior Air Parts recommends the use of direct sensing flow meters such as vane or turbine styles.

C. Carburetors

Carburetors used on Superior Vantage Engines are conventional single barrel float type systems with updraft induction and are equipped with manual throttle and mixture controls. In the full lean position, the manual mixture control serves as an idle cutoff control. The carburetor requires a low-pressure engine driven fuel pump (supplied).

Superior Vantage Carbureted Engines require a priming system. The engines are supplied with manual primer lines installed to the #1, #2 and #4 cylinder inlet ports and plumbing to feed from a common primer source. The aircraft priming system should be attached to this common primer source.

The carburetor system is part of the Superior Vantage Engine and therefore certified as part of the engine. No one may make significant changes to either flow settings or mechanical linkages without prior approval by Superior.

Proper functioning and mixture settings of the carburetor system must be made in flight and ground idle tests. These tests should include all envisioned flight attitudes and conditions as well as ground idle temperature variations. In addition to performance characteristics, exhaust gas and cylinder head temperatures must be monitored during these tests as a means of verifying the correctness of the carburetor system settings.

D. Fuel Injection Systems – Port Type

Fuel injector systems used on Superior Vantage Engines are direct port injection systems with a fuel-metering servo at the entrance to the intake manifold. The fuel-metering servo is equipped with manual throttle and mixture controls. In the full lean position, the manual mixture control serves as an idle cutoff control. The fuel injection system requires a high-pressure engine driven fuel pump (supplied).

Superior Vantage Fuel Injected Engines do not require a separate priming system. Priming is accomplished by operating an aircraft boost pump with the manual mixture control in the full-rich position. After priming, the manual mixture control should be moved to the idle cutoff position for engine start and then moved back to full rich after the engine has started.

Proper functioning and mixture settings of the fuel injection system must be made in flight and ground idle tests. These tests should include all envisioned flight attitudes and conditions as well as ground idle temperature variations. In addition to performance characteristics, exhaust gas and cylinder head temperatures must be monitored during these tests as a means of verifying the correctness of the fuel injection system settings.

E. Fuels
Superior Vantage Engines are certified for 100LL Avgas per ASTM D910, 91/98 (lead optional) Avgas per ASTM D910 and Motor Gasoline with a minimum antiknock index (R+M/2 method) of 91 per ASTM D4814. Higher octane fuel improves 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.

The use of auto fuel blended with alcohol (ethanol) is forbidden. Winter oxygenated ethanol fuel blends, or reformulated gasoline 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 to the fuel system. The use of an alcohol (and water) tester is recommended. Acceptable gasoline is specified per ASTM D-4814 (European EN228), again without alcohol.

When running fuel lines for an airplane intended for unleaded auto fuel operation, it is very important to address issues that can reduce the likelihood of vapor lock. For example, replace 90° fittings with smooth tubing bent to a larger radius and do not use expansion or contraction fittings. Locate the fuel boost pump as close to the fuel tank as possible. Non-metallic fuel system components should be manufactured from materials that are known to be compatible with auto fuels.

4. ENGINE COOLING

The engine cooling system design can significantly effect both performance and longevity of an aircraft engine installation. High engine temperatures can result in loss of power, fuel vapor lock, and can promote accelerated wear and even engine detonation.

A. General Cooling System Design

The Superior Vantage Engine is a horizontally opposed, air-cooled design. As such, all heat is removed from the engine either by airflow over the cylinders and crankcase or through an air-to-oil lubricant heat exchanger. The horizontally opposed cylinder arrangement is a space efficient design that allows maximum cooling airflow with minimum drag.

In general, air cooling of the engine heads and crankcase occurs by directed airflow over those components. Air is commonly received into the cowl in a plenum above the engine and directed downward between the cylinder and barrel fins to a volume within the lower cowl.

The cooling air normally exits the lower cowl through the exhaust tailpipe exit area. Airflow over the engine is governed by the pressure differential between the upper cowl and lower cowl areas. In high performance installations cowl flaps may be added to increase the cooling airflow.

Superior Vantage Engines are provided with inter-cylinder metal baffles to aid in the control of cooling airflow over the cylinders and barrels. In addition, the installation design must include baffles that attach to the engine and provide a seal to the interior of the cowl thus creating a separation between the upper and lower cowl volumes. This is typically done primarily with metal components for stiffness against the ram air pressure with flexible rubber seals to conform to the contours of the upper cowl and to allow for relative movement between the engine and cowl.

The lubricating oil for Superior Vantage Engines must be cooled by means of an air-to-fluid heat exchanger. Typically, this heat exchanger is mounted to the engine mount structure and fastened to a rear engine baffle(s), open to the upper plenum and facing the nose of the cowl. In this way, ram effect of the cooling air entering the upper plenum can be utilized to increase the airflow through the heat exchanger.

B. Airside Heat Rejection

Airside heat rejection, that is heat rejected through the cylinder heads, barrels and crankcase, etc., is a primary means for cooling the engine. The resulting temperature of the engine is in direct proportion to the amount and quality of cooling air that passes over the engine. The engine cowl baffles create an upper plenum, fed by incoming air from the front of the cowl that in turn provides cooling air between and around the barrels and cylinder heads as controlled by the inter-cylinder baffles. The amount of airflow over the engine is controlled by the pressure differential between the upper and lower cowl volumes. Figure 2 of the Model Specification Data provides detailed information concerning the mass airflow as a function of pressure differential over a Superior Vantage Engine.

Superior Vantage Engines are tested and calibrated for airside heat rejection on highly instrumented test stands. Table 4 of the Model Specification Data defines cooling airflow requirements as a function of power output.

C. Oil Heat Rejection

Engine oil is the other primary means of cooling the engine. Cooling of the engine oil occurs partly through heat transfer through the walls of the crankcase and oil sump and partly through a supplemental oil cooler. Supplemental oil coolers are oil to air heat exchanger designs and draw cooling air from the upper cowl plenum area as discussed previously.

Oil heat rejection requirements for Superior Vantage Engines are defined in Table 4 of the Model Specification Data. Superior Air Parts recommends that the oil cooler be sized to provide at least 150% of the required maximum heat transfer to provide an adequate margin of safety.

The reduction in temperature and density of the ambient air with increasing altitude can significantly effect the performance of the oil cooler and sizing should be chosen accordingly. Although the reduced temperature of the air can increase the efficiency of the cooler due to a larger temperature difference between the hot oil and the cooling air, the reduced air density is generally a larger consideration and will result in an overall reduction in cooler efficiency at higher altitudes. Therefore, cooler sizing calculations should be made with the air density appropriate for the maximum intended altitudes of the installation.

D. Accessory Cooling

Typically, engine cowl baffles effectively separate the upper cowl plenum from the lower cowl plenum through the axes of the cylinders. However, the rear cowl baffle is typically attached to the engine crankcase and therefore most engine accessories are “behind” the rear cowl baffle or below the cylinder axes and therefore part of the “lower” cowl plenum. Unless otherwise provided, these accessories are located in an area of relatively stagnant air that has already passed over the engine for airside cooling or has passed through the oil cooler. Because of the elevated temperature of the air surrounding these accessories and the relative lack of airflow around them, it is often necessary to add small, supplementary ducts to provide cooling air. The amount of supplementary cooling required for these engine accessories is installation specific and must be determined by testing. Temperature limits for these accessories are specified in the Model Specification Data

5. EXHAUST SYSTEM

The engine exhaust system's primary role is to transfer engine exhaust gasses from the cylinder heads overboard in a safe and efficient manner. Exhaust systems serve to reduce engine noise, provide heat sources for carburetor and cabin heaters and even act to enhance engine performance in terms of both power and fuel efficiency. Improperly designed exhaust systems can create health risks to aircraft occupants and can be detrimental to engine performance.

A. Health and Safety Issues

Carbon monoxide is a colorless, odorless gas that is potentially lethal and a basic by-product of internal combustion engines. The primary role of exhaust systems to safely conduct this gas from the combustion chamber away from persons on-board the aircraft cannot be overstated. Exhaust systems must be airtight with no potential for carbon monoxide leaks and must exit outside the aircraft in a location where gases will not be reintroduced to the airframe.

Due to the extreme temperature of exhaust system components (up to 1600°F (871°C)), care must also be taken to isolate combustible materials. This includes flammable liquids such as fuel, oil and hydraulic fluid as well as dry combustible materials.

B. Exhaust System Design and Sizing

Several styles of exhaust systems are commonly used in piston aircraft engines. Engines with smaller power ratings sometimes use "stub" or "direct" exhaust systems. These systems simply provide a short section of exhaust pipe to direct the exhaust gas away from the cylinder head and are not connected with each other. While these systems are typically the loudest and least beneficial in terms of performance enhancement, they can hold the benefit of being the lightest design. Although it is possible to use this type of system on Superior Vantage Engines it is not the recommended approach.

Another exhaust design style is to connect 2 or 4 of the exhaust tubes together before exiting the aircraft. Commonly referred to as 2-into-1 or 4-into-1 systems, these designs feature a space-efficient way to transport the exhaust gas safely overboard. Although these systems are not designed to add substantial performance benefits to the engine, they can rob power and efficiency if not properly designed. The intersections of the exhaust pipe segments must be designed such that pressure pulsations traveling down a given exhaust pipe do not adversely effect the operation of cylinders with intersecting pipes. If pressure pulsations traveled from one exhaust pipe and back "up" another, excessive pressure could be present as the second cylinder's exhaust valve opened and cause a disruption to the exhaust gas exit. High back pressure, whether caused from basic system flow restrictions or pressure waves of adjacent cylinders can have significant effects on volumetric efficiency and thereby on power output and fuel efficiency.

A third exhaust system style is commonly referred to as a crossover design. This style connects the exhaust pipes of two cylinders in such a manner as to enhance performance. In an ideal crossover system, as the pressure wave from one cylinder passes the connection point of the two exhaust pipes a slight suction is created in the exhaust pipe of the second cylinder. When properly tuned, this suction is caused as the exhaust valve of the second cylinder opens and aids in the emptying of the second cylinder. The pressure wave of the second cylinder then creates a slight suction in the exhaust pipe of the first cylinder, aiding in its emptying. This behavior improves the breathing of the cylinders and can have volumetric efficiency, power and fuel efficiency benefits.

For Superior Vantage Engines with 4 cylinders, crossover exhaust systems should couple cylinder 1 with cylinder 2 and cylinder 3 with cylinder 4. Crossover exhaust systems are typically less space efficient and a little heavier than other styles, but have the unique benefit of enhancing performance of the engine.

Regardless of the style employed, several factors should be considered to make an effective exhaust system.

(1.) Exhaust Pipe Exits
Exhaust exits should be positioned such that the gasses are released clear of the aircraft and not allowed to reenter the cabin. Also, the exhaust exits should be located far enough away from the aircraft structure to prevent corrosive byproducts of combustion from causing damage.

Enlarged exit pipes can be used to change the tone and volume of the exhaust sound. Care should be taken however not to enlarge the exit pipes so much as to create sound amplification as with a megaphone.

(2.) Limit Backpressure
As discussed earlier, high exhaust backpressure can have detrimental effects on engine performance. Other than acoustic, pressure wave effects backpressure can be minimized in the design by good piping design practices to limit flow losses. For example, exhaust pipe size should be kept as large as practicable and never less than the exhaust port size. Exhaust pipe lengths, other than being equal for tuning purposes, should be as short as practicable. Bends should be "large radius", smooth and as few as possible. Pipe intersections should be at acute angles whenever possible and never at "large" angles where acoustic waves might be oriented "backward" up an adjoining pipe.

Whenever possible, collector elements should be avoided due to their potential to reduce engine performance. If necessary, collectors should be designed to eliminate the potential for acoustic pressure waves to be reflected back through the exhaust system. This may include features internal to the collector such as damping plates, perforated pipes, etc. Such features necessarily increase flow losses through the system and therefore increase exhaust backpressure and care should be taken to minimize this problem. Also abrupt increases or decreases in piping size, such as in a collector, can increase flow losses and should be avoided.

(3.) Shrouds and Thermal Protection
Exhaust gas temperatures can be as high as 1600°F (871°C). Therefore, it is sometimes necessary to shield thermally sensitive components. Control cables, hoses, engine isolator components, nose gear tires, etc should be either located far enough from the exhaust pipes to not be damaged by the heat, insulated or shielded. Fuel lines should be insulated as appropriate to prevent safety concerns or vaporization of the fuel within the lines. Similar care should be given to oil or hydraulic lines. Also, intake air system components including carburetors and fuel injector servo bodies should be shielded either by distance or material from exhaust system heat.

(4.) Exhaust System Support
The exhaust system should be supported in such a way as to prevent vibration and thermal growth from imparting stress on the pipes. The exhaust system should be "hard mounted" to the cylinder head using the studs provided at the exhaust port and should have flexible mounts at or near the exit. Interim supports, if needed should be of a flexible style.

(5.) Joint Design
The exhaust system should be designed for ease of installation and also to provide flexibility for thermal growth during operation. Multiple piece exhaust systems are preferable to single piece designs for both of these reasons. Care should be given to the location of slip joints in the exhaust system so that their placement does not interfere with preferred locations for cabin heat muffs and also to provide for thermal growth between hot and cold sections. For example, large sections that are welded together without slip joints to allow for thermal variations can cause stresses in the system that can lead to early failure. The number of welded and slip joints should be minimized to limit the potential for exhaust leaks. Also, welds should be of superior quality to prevent metallurgical or fatigue failure and subsequent exhaust leaks.

(6.) EGT Probes
Exhaust gas temperature (EGT) probes are commonly added to engine installations to provide engine management information to the pilot. The location of the probes is important to the accuracy of their information. EGT probes should be located approximately 6" from the exhaust port flange and equidistant among all cylinders.

C. Exhaust System Materials
Exhaust pipes and mounting hardware should be made of corrosion resistant materials such as Inconel or 321 or 347 stabilized stainless steel. Other materials, such as 304 stainless steel are not stabilized for sustained high temperatures and may result in carbide precipitation and early fatigue failure. Wall thickness should be large enough to provide structural integrity yet thin enough to maintain reduced weight. Historically, some exhaust systems have been made with thicker material to withstand material loss due to scaling and oxidation. Proper material selection however has been shown to be a more effective solution allowing for lighter weight exhaust systems.

D. Exhaust Gaskets
Superior recommends the use of metal gaskets in the installation of exhaust systems. Metal gaskets improve the seal to the exhaust port reducing the possibility for exhaust gas leakage as well as noise leaks. Gaskets also improve the thermal conductivity from the head to the exhaust pipe that helps to remove heat from the exhaust area of the head. Exhaust gaskets should be made of corrosion resistant materials such as Inconel or stainless steel and should be designed to withstand the pressure of exhaust backfire events.

6. LUBRICATION SYSTEM

The engine lubrication system is responsible for the reduction in friction between components, removal of combustion by-products and other contaminants, and the removal of heat from internal engine components. A continuous supply of clean, cooled oil of the proper grade and specification is essential to this process. Failure to do so can result in a wide variety of problems ranging from increased wear to engine stoppage.

A. Lubricating Oil Requirements

Superior recommends the use of high quality 100% mineral oil during the break-in period. After engine break-in, high quality ashless dispersant engine oil per MIL-L-22851 or SAE J-1899 should be used in Superior Vantage Engines. Ashless dispersant oils are used to prevent the formation of sludge, aid in the neutralization of corrosive acids and prevent ash deposits on cylinder walls that can become hot spots and sources for pre-ignition. The grade or viscosity of oil should be chosen based upon the climate where the engine will be operated as shown in Table 8-1.

Superior Vantage Engines are provided with a suction screen filter, sometimes referred to as a “finger filter” to prevent large contaminants from being drawn into the pressurized portion of the oil system. In addition, Superior Vantage Engines are provided with a full-flow oil filter to maintain contaminant free oil and promote long engine life. Superior recommends changing the full-flow oil filter, inspecting / cleaning the suction screen filter and changing the oil in accordance with published maintenance schedules.

In addition to clean oil of the proper viscosity, it is important to ensure that the oil is free of aeration and foam in the pressurized portion of the oil system. This can become an issue at high altitudes as the vapor pressure of the oil exceeds the ambient pressure. Severe aeration within the anticipated flight altitudes of a Superior Vantage normally aspirated engine, but must be verified through flight testing.

B. Lubricating System Components

The lubricating system of Superior Vantage Engines is composed in general of an oil sump or reservoir, an oil cooler circuit, an internal pressurized circuit and for installations with constant speed propellers a propeller governor circuit. A schematic of the lubricating system is provided in Figure 3-1.

(1.) Oil Sump

Superior Vantage Engines utilize a “wet sump” design. That is, the engine oil sump is the primary reservoir for engine oil as opposed to a remote reservoir as is done in many aerobatic installations. However, provisions exist to attach an aerobatic oil system to the Superior Vantage Engine if desired. For more information regarding aerobatic installations contact Superior Air Parts.

The maximum capacity of the oil sump is 8 U.S. quarts. Oil quantities in excess of this amount can cause loss of engine efficiency due to “splashing” and fluid drag of internal components through the oil and also “pumping” of the oil out the crankcase breather fitting. Minimum oil capacity is governed by the ability of the oil pump to draw full oil (i.e. no entrained air) from the sump in various flight attitudes.

(2.) Oil Pump and Pressure Control Valve

Superior Vantage Engines employ a high flow, positive displacement gear pump to provide oil throughout the engine. The pump is capable of producing oil flow and pressure values much higher than those required by the engine as a safety measure to ensure that the necessary oil is always available to the engine. Because of this, a pressure control valve is used to govern the maximum oil pressure in the system. Oil pressures that are too high will promote external leaks that would not otherwise occur.

The oil pressure control valve is adjustable so that the operator may ensure that the oil pressure is within specified limits. If oil pressure under normal operating conditions always exceeds the maximum or minimum specified limits as defined in Table 5 of the Model

Specification Data, the valve may be adjusted as follows:
With the engine warmed up and running at 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, inward (clockwise) to increase pressure or outward (counter-clockwise) to decrease pressure. See Table 5 of the Model Specification Data for specific oil pressure data.

(3.) Vernatherm and Oil Cooler
Automatic oil temperature control valves (Vernatherm valves) are used to govern the flow of oil through the external oil cooler. These valves are set at the time of assembly and are not serviceable by the operator. When the engine is cool, the vernatherm valve is open and oil is free to flow directly through the engine without being routed through the external oil cooler. As the oil temperature reaches its desired limits however some or all of the oil is routed through the oil cooler circuit.

The oil cooler circuit is the only part of the lubrication circuit that is controlled by the installation design. It is necessary to maintain good hydraulic practices in the design of the oil cooler circuit to minimize flow and pressure losses. These include using large diameter hoses and avoiding sharp bends and restrictive couplings whenever possible. Flow and pressure losses in the oil system not only cause inefficiencies in the overall engine system but also add to the potential for aeration during high altitude flight.

C. Crankcase Ventilation
Pressure is generated within the crankcase during normal engine operation primarily as a result of piston ring blow-by. If the crankcase pressure were not controlled nose seal and other seal failures would occur leading to loss of oil. Superior Vantage Engines utilize crankcase breather circuits as a means of controlling crankcase pressure. See Table 4 of the Model Specification Data for specific measurements defining crankcase pressures.

The installation design should include provisions to connect a crankcase ventilation hose to the engine breather fitting on the rear of the engine.

The purpose of this hose is to direct the crankcase gas safely overboard. It is recommended that an air-oil separator be used to prevent oil entrained in the gas flow from getting on the airframe. If an air-oil separator is used, the oil drain may be connected into a cylinder head drain back tube or other location as approved by Superior Air Parts.

Care should be taken in the location of the breather tube exit so as not to create a positive or negative pressure in the breather circuit. A positive pressure would serve to aggravate seal leakage and a negative pressure could increase the flowrate out of the crankcase and cause loss of engine oil.

Superior recommends installation of an air-oil separator as part of a vacuum pump installation. The oil drain may be connected into a cylinder head drain back tube or other location as approved by Superior Air Parts.

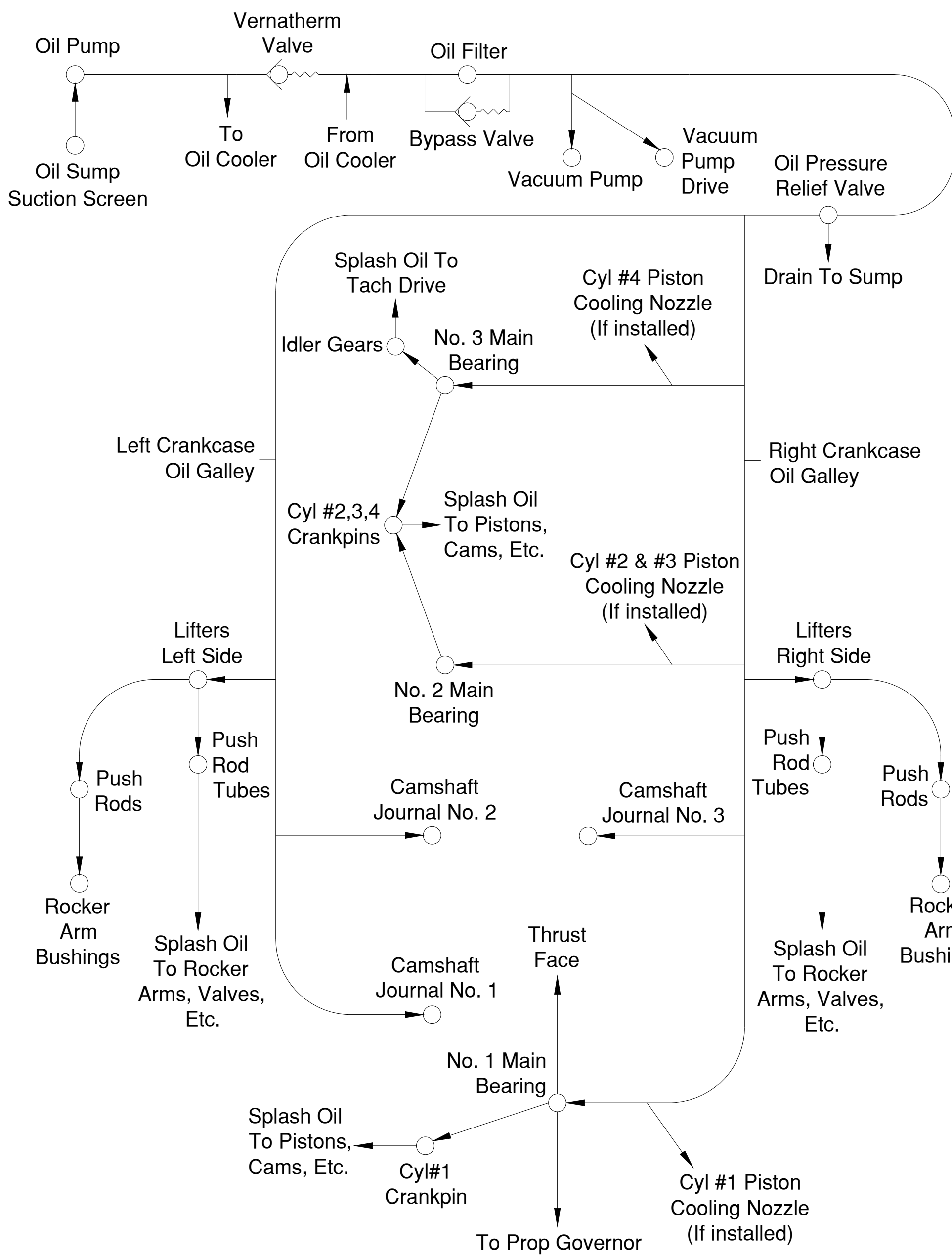


Figure 3-1 • Oil System Schematic

7. PROPELLER ATTACHMENT

The flange for attaching the propeller to the crankshaft is a modified SAE Type 2 Propeller Flange per AS127 with ½” bolts. The nut and bolt specifications, torque specs and methodology, size and use of safety wire, etc. are to be specified by the propeller manufacturer.

8. ELECTRICAL SYSTEM

The engine electrical system is responsible for three (3) primary duties. They are ignition, starting and power supply to the aircraft. Superior Vantage Engines are supplied with two (2) magnetos that have been properly timed at the factory as well as an engine starter. Other than electrical connections little is required in terms of installation design for the ignition or starting systems. Alternators are not provided for Superior Vantage Engines due to the variation in requirements from one airframe to another. Specification of an alternator and its connection to the airframe electrical system is the responsibility of the installation design.

A. Ignition System

Superior Vantage Engines are supplied with two (2) impulse magnetos, high-tension leads and spark plugs. Impulse magnetos provide both a stronger and a retarded spark during low RPM start conditions. Superior provides impulse magnetos for both positions to give the best possible start conditions.

The installation of the engine requires connection of the P-lead (or grounding lead) to the left and right magnetos per the following procedure.

- Attach the ignition P-lead terminal to the condenser stud using the lock-washer and nut on the magneto.
- Torque the P-lead terminal nut to 13-15 inch-pounds.
- Attach the 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.

The firing order and ignition system wiring diagram for the Superior Vantage Engine is provided in Figure 3-2.

B. Engine Starting System

Superior Vantage Engines are provided with a 12-volt lightweight starter as standard equipment. Little is required during installation regarding the starting system except to connect the power wire from the starting relay to the terminal of the starter motor. The connection should be torqued to 50-60 inch-pounds.

C. Electrical System

The specification and installation of an engine driven alternator is the responsibility of the airframe manufacturer due to the wide range of electrical system requirements among aircraft. A mounting pad is provided on the crankcase near the nose of the engine for this purpose. A V-belt pulley is also provided as part of the flywheel. Tension of the belt should be adjusted per manufacturer's recommendations. See page 22 for V-belt and alternator installation information.

Firing Order

Clockwise Rotation 1-3-2-4

Ignition Wiring Diagram

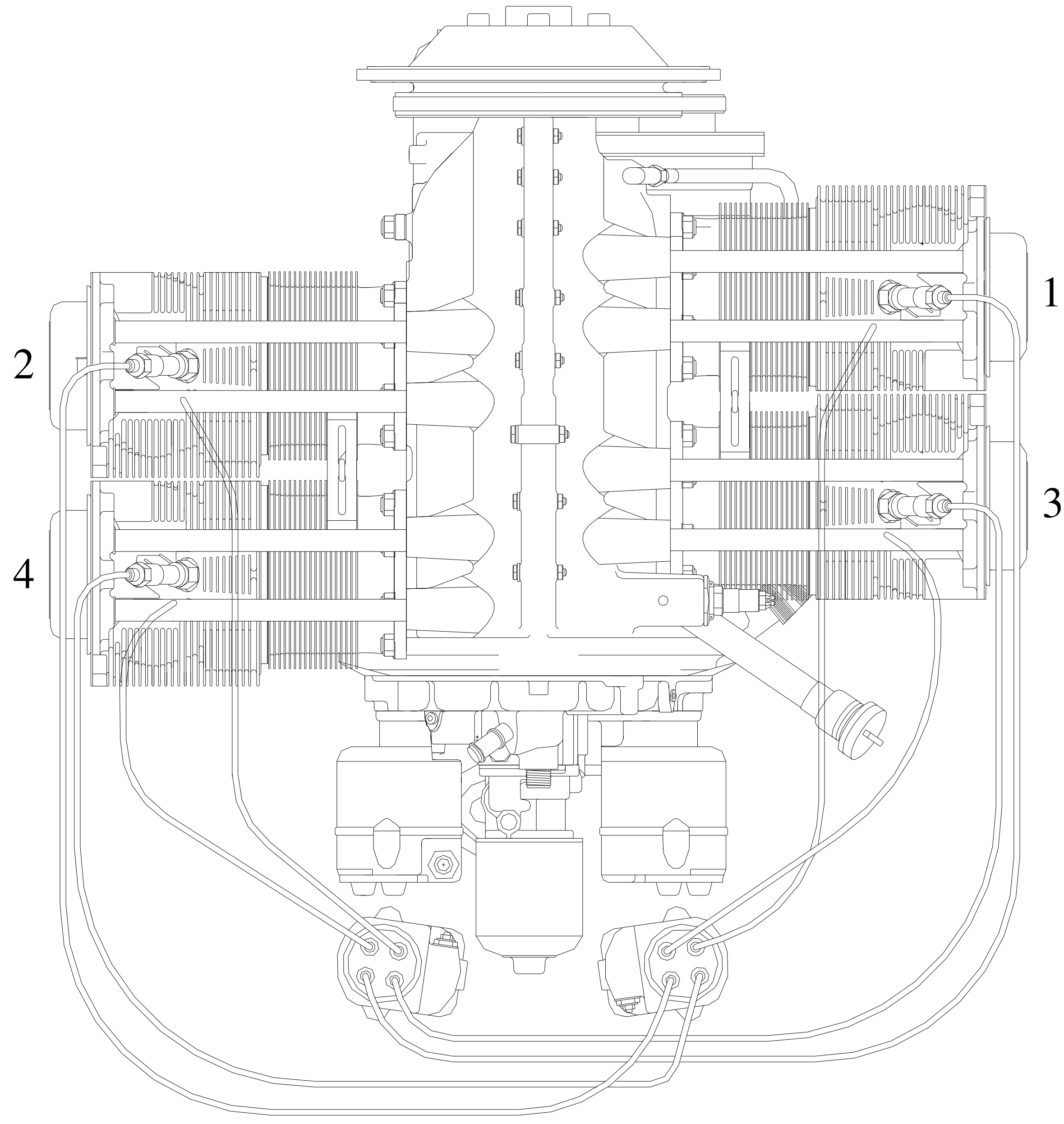


Figure 3-2 • Ignition Wiring Diagram

9. ENGINE CONTROLS

Some manually operated controls are required to operate a Superior Vantage Engine. These include mechanical controls, electrical controls and fuel controls.

A. Throttle and Mixture Control
Mechanical controls are required to actuate the throttle and mixture levers for both carbureted and fuel injected Superior Vantage Engines. Many methods may be used to accomplish this as long as the following issues are addressed.

(1.) Individual controls are supplied for throttle and mixture levers.

(2.) The control allows the throttle lever to contact the idle stop screw.

(3.) The control allows the throttle lever to reach "full open".

(4.) The control allows the mixture lever to contact the idle cutoff stop.

(5.) The control allows the mixture lever to reach "full rich".

(6.) Superior recommends that the "full open" throttle position and "full rich" mixture position be limited by the forward motion of the control and not the lever touching the stop on the carburetor or fuel injector servo. This is to prevent binding and excessive compression within the control itself should the lever hit its stop before the control hits it full forward potential.

(7.) Superior recommends a vernier style mixture control for improved control during leaning.

(8.) The control does not bind or have "slack" so as to cause delays in response during actuation.

(9.) Control cables should be the minimum possible length, avoiding loops or "S-turns".

(10.) Control cables should be securely fastened at both ends and at intermediate points to prevent excess vibration and improve responsiveness.

(11.) Superior recommends the use of ball joints or similar apparatus at the lever attachment points to eliminate the potential for binding during actuation.

B. Propeller Control
A mechanical control is required to actuate the propeller governor for installations with constant speed propellers. The control design should address the same issues as listed above for the throttle and mixture controls.

C. Ignition and Starter Switch
An electrical switch or switches must be provided to control each magneto. This switch(s) must be capable of opening and closing the P-lead grounding circuit for each magneto and must provide capability to check the operation of each magneto individually.
An electrical switch must be provided to engage the engine starter. Superior recommends that this be a momentary switch to prevent the possibility of leaving the starter engaged for long periods of time.

D. Engine Primer
Priming of Superior Vantage Engines occurs in two (2) primary ways. For fuel injected engines, priming is accomplished by momentary actuation of the aircraft boost pump with the mixture control in the full rich position. Carbureted engines require a manual primer pump that can be actuated by the pilot. This primer pump conventionally draws fuel from the fuel line feeding the engine driven fuel pump and feeds the common primer line source at the rear of the engine. Figure 1-5 illustrates the common primer line source for a typical Superior Vantage carbureted engine.

Note: Manual primer pumps should include a positive lock feature to prevent the pump from inadvertently actuating during flight.

E. Carburetor Heat Control
A mechanical control to actuate the carburetor heat mechanism is required for carbureted Superior Vantage Engines. The control design should address the same issues as listed above for the throttle and mixture controls.

F. Alternate Air Control
A mechanical control is required to actuate the alternate induction air system for fuel injected Superior Vantage Engines. The control design should address the same issues as listed above for the throttle and mixture controls.

10. ENGINE ACCESSORIES

Superior Vantage Engines are provided complete with several accessories. Provisions are available for mounting and driving of additional accessories whose specification is more installation dependent.

A. Supplied Accessories
Superior Vantage Engines are supplied with several accessories as specified in Table 6 of the Model Specification Data.

(1.) Lightweight starter

(2.) Two (2) magnetos with impulse couplings

(3.) Engine driven fuel pump

(4.) Propeller governor adapter (if so equipped)

(5.) Full flow oil filter

(6.) Spark Plugs & Ignition Harness

(7.) Fuel System (Carburetor or Fuel Injection)

B. Accessory Drive Data
Table 3-1 lists the drive data for the accessories.

C. Accessory / Vacuum Pump
An AND20000 drive pad is provided for the installation of an engine driven vacuum pump or alternator. The mounting pad includes lubricating holes to provide engine oil to and from the vacuum pump for internal lubrication.

D. Alternator
A mounting pad is provided for an alternator on the front of the crankcase with 5/16-18UNCF x 0.7" tapped holes as shown in Figure 3-3 . This mounting pad and the V-belt drive pulley on the flywheel are designed to accept standard, front-pulley general aviation alternators. The V-belt and pulley are SAE Size 0.380 in accordance with SAE J636. Typically these alternators include a fan to cool the internal components of the alternator. However, depending upon the power output of the alternator and the installation design additional cooling may be required. Supplemental cooling may easily be provided through the use of "blast tubes" to direct ram air to a specific area(s) of the alternator. Care should be given during the design of blast tubes that they do not inadvertently degrade the airflow to other areas of the engine or installation.

E. Propeller Governor
An AND20010 drive pad is provided for the installation of an engine driven propeller governor. The mounting pad includes lubricating holes to provide engine oil to and from the governor for internal lubrication.

Table 3-1 • Accessory Drive Data

Accessory	Drive Ratio	Direction of Rotation*
Starter	16.556 : 1	Counter-Clockwise
Alternator(not supplied)	3.250 : 1	Clockwise
Tachometer	0.500 : 1	Clockwise
Vacuum Pump	1.300 : 1	Counter-Clockwise
Propeller Governor	0.866 : 1	Clockwise
Fuel Pump –Plunger Operated	0.500 : 1	Reciprocating

<u>**Note:**</u> Direction of rotation for accessories is listed as viewed from the rear of the engine.

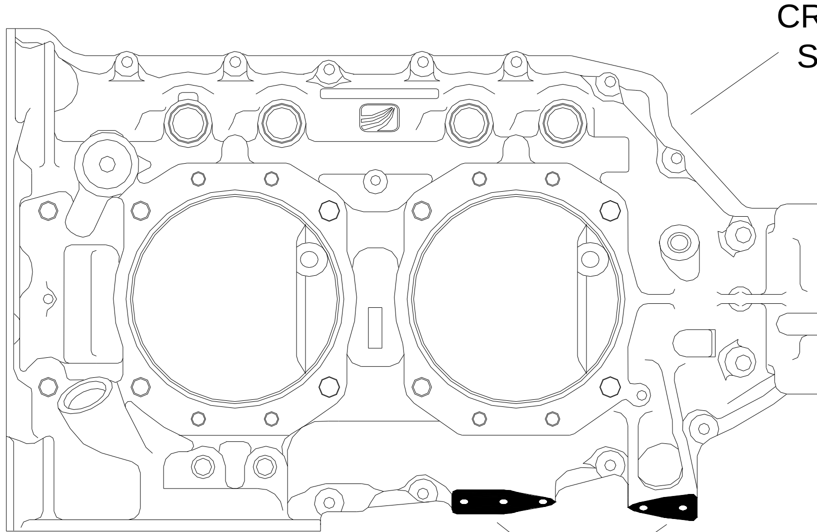


Figure 3-3 • Alternator Mounting Pad

11. ENGINE MOUNTING

Superior Vantage Engines are designed for use with a conventional rear four (4) point engine mount. Mounting attachment points are provided as part of the engine crankcase and are available for conical or Dynafocal isolator styles. Because the engine mount requirements are unique to each airframe application, the design of the mount is the responsibility of the airframe manufacturer. However, the following data is provided for the Vantage Engine to aid in that process.

A. Mount Design and Construction

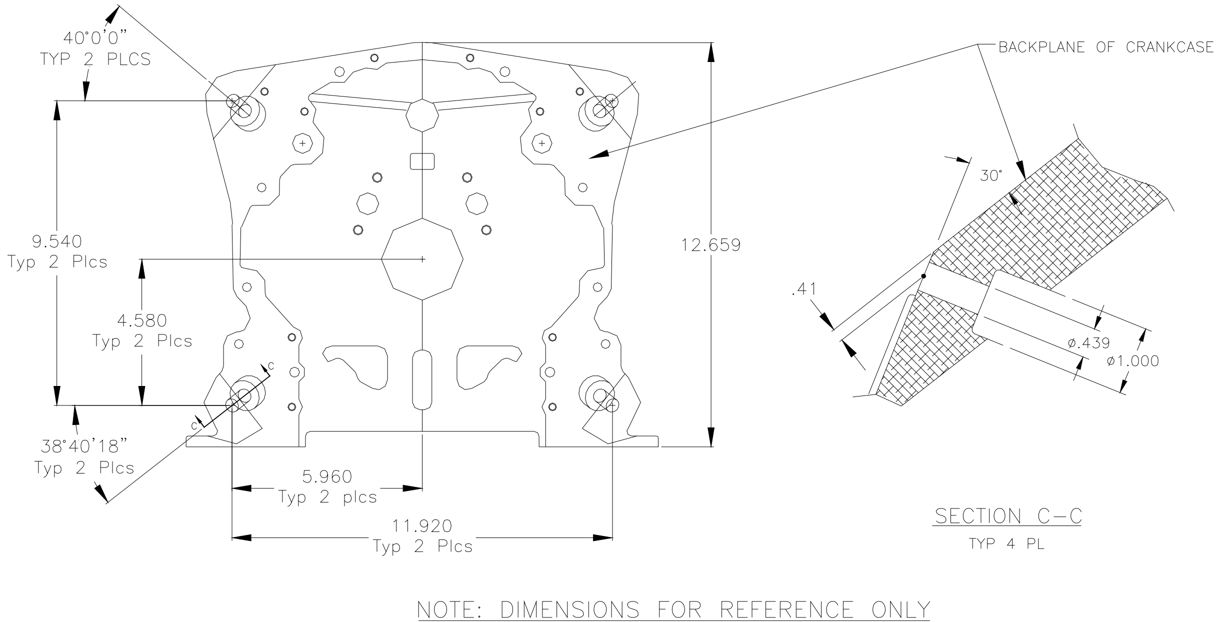
The Superior Vantage Engine is designed for a conventional rear type ring mount. Although welded steel tube construction is anticipated due to the benefits in both strength and cost, other construction methods are acceptable.

Considerations during the design of the mount should include, in addition to structural strength, minimum obstruction to cooling airflow, weight, the location and method of installing the oil cooler, accessories and accessory cooling and obstruction of intake and exhaust systems.

Superior Vantage Engines are designed to accommodate modern isolation systems to minimize the vibration levels transmitted to the airframe. Both conical and Dynafocal suspension systems are available as identified in the model listing of Chapter 1. Dynafocal suspension systems are designed to minimize the dynamic coupling of the installation and therefore result in minimal vibration levels transmitted to the airframe structure. Lord Manufacturing Company has developed this technology and provides isolator components. The Superior Vantage Engines are designed to accommodate the Lord mounts for conical as well as #1 Dynafocal and #2 Dynafocal suspension styles. Table 3-2 lists the Lord Mounting Kit part number for the Superior Vantage Engine mount options.

Table 3-2 • Lord Engine Mounts for Superior Vantage Engines

Superior Vantage Engine Model Series	Mount Style	Figure	Lord Mounting Kit Part Number
O/IO-360-x1xx	#1 Dynafocal	3-4	J-9613-40
O/IO-360-x2xx	#2 Dynafocal	3-5	
O/IO-360-x3xx	Conical	3-6	J-6230-1



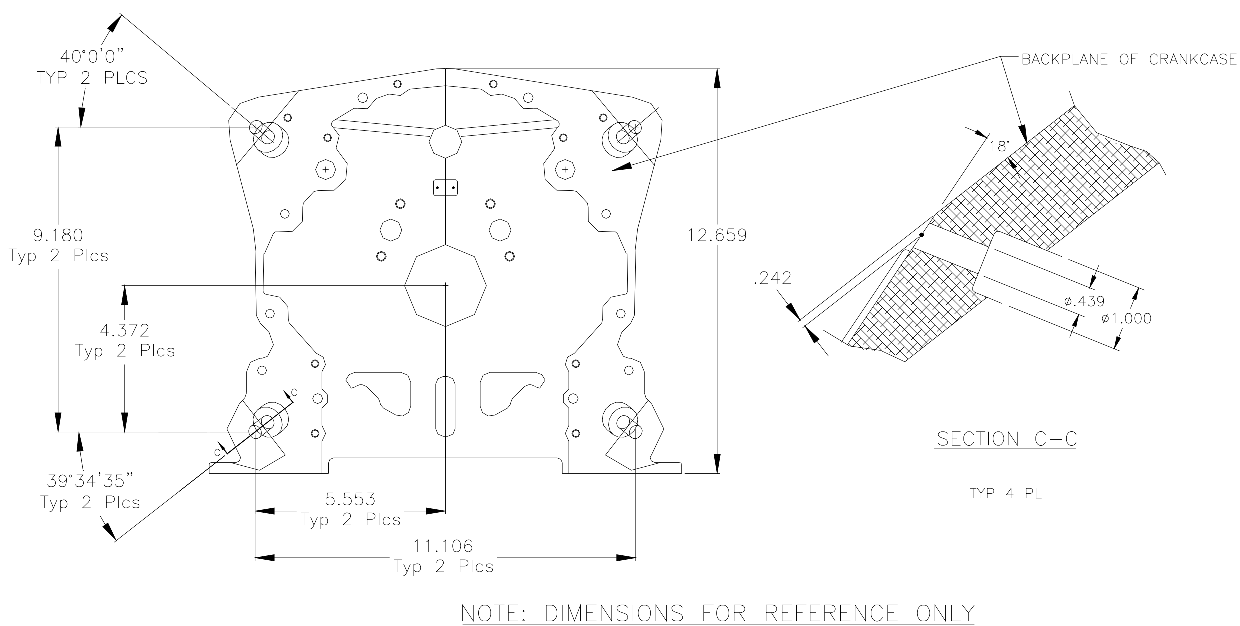


Figure 3-4 • #1 Dynafocal Mount Dimensions

Figure 3-5 • #2 Dynafocal Mount Dimensions

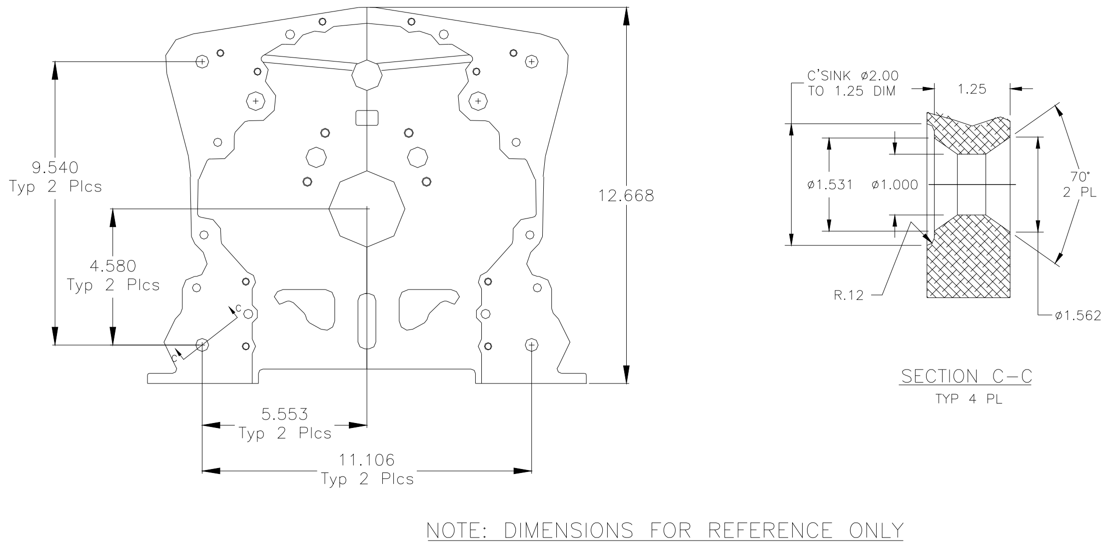


Figure 3-6 • Conical Mount Dimensions

B. Engine CG and Moment of Inertia

The engine weight and location of the center of gravity are specified in Table 7 of the Model Specification Data. Definitions for the variables used in Table 7 are illustrated in Figure 3a. & 3b. of the Model Specification Data. Moments of inertia are defined in Table 8 of the Model Specification Data.

The location of the center of gravity is defined with respect to the crankshaft centerline (lateral and vertical dimensions) and with respect to the crankcase backplane for the longitudinal dimension. This data, together with the appropriate data for additional components such as propeller assembly, oil cooler, and other engine and engine mount supported items provide sufficient information to locate the center of gravity with respect to the airframe.

C. Engine Mount Design Loads

Superior Vantage Engines are certified to meet the requirements of FAR 23 Acrobatic Category load factors for most engine and propeller combinations. Table 3-3 lists the limit and ultimate load limits for the engine.

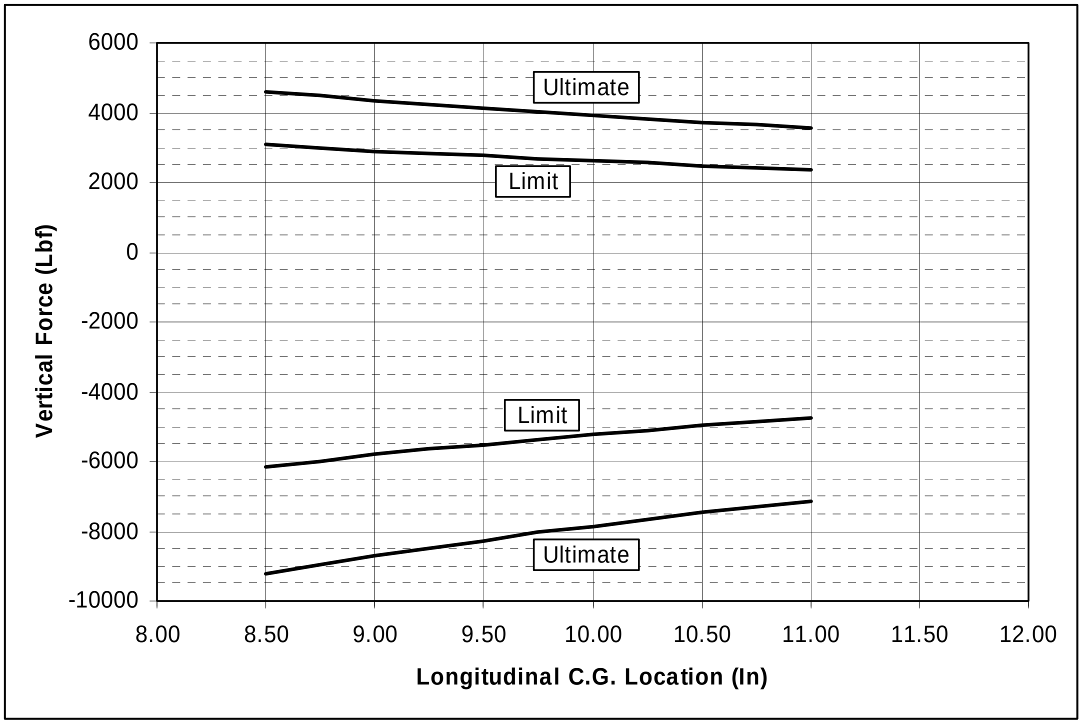
The term "maneuvering moment" of Table 3-3 relates to the force-couple or moment produced by the weight of the engine, propeller and accessories attached directly to the engine and the distance from the center of gravity of that assembly to the backplane of the crankcase. These values represent the maximum moments (limit and ultimate) that may be imposed on the engine mount structure.

The installation of an engine per 14CFR Part 23 (FAR 23) includes the use of several Factors of Safety. When performing the engine installation design for a Superior Vantage Engine, the weight and location for the center of gravity of the engine, propeller and all engine mounted accessories must be considered together with the appropriate Factors of Safety from FAR 23 for the flight category desired. The resulting positive and negative maneuvering loads for the installation must be within the limits shown in Table 3-3. For convenience, Figure 3-7 illustrates the above load limits (Table 3-3) in terms of vertical forces as a function of the longitudinal center of gravity. The term "engine torque" in Table 3-3 relates to the average output torque of the engine at maximum rated speed plus design factors as required by 14CFR Part 33. When performing the engine installation design for a Superior Vantage Engine it is required that the average output torque at maximum rated speed and power be below these values. The limit load engine torque of 1634 Ft-Lb$_f$ corresponds to a power output of approximately 210 Hp at 2700 RPM including design factors.

Table 3-3 • Limit and Ultimate Engine Mount Loads

		Load Limit	
		Positive	**Negative**
Limit Load	**Maneuvering Moment**	**-4361 Ft-Lb$_f$**	**2181 Ft-Lb$_f$**
	Engine Torque	**1634 Ft-Lb$_f$**	**1634 Ft-Lb$_f$**
Ultimate Load	**Maneuvering Moment**	**-6542 Ft-Lb$_f$**	**3271 Ft-Lb$_f$**
	Engine Torque	**2451 Ft-Lb$_f$**	**2451 Ft-Lb$_f$**

Note: Positive maneuvering moment values result in a downward force on the engine and negative values result in an upward force.



Note: The location of the center of gravity in Figure 3-7 is based from the crankcase backplane and can be modified to describe the mounting gage point specific to a given mount style as described in Figures 3-4 through 3-6 above.

Figure 3-7 • Limit and Ultimate Engine Forces

D. Engine Mount Vibration

The use of isolators in the design of the engine mount reduces the magnitude of vibratory loads and Superior has designed the Vantage Engine for state of the art isolation systems. However, no isolation system is perfect and some loads are transmitted from the engine / propeller system to the airframe. It is important during the installation design to consider these loads and ensure that natural frequencies of the airframe do not match these forcing functions during prolonged operation. Although these loads will vary depending upon choices of mount style, propeller and accessories Superior has measured the transmitted vibratory loads for a typical installation. Figures 3-8 and 3-9 illustrate forcing functions produced by the engine on the engine on a typical engine mount design. Data is presented for startup and shutdown sequences in Figure 3-8 and steady state power settings in Figure 3-9. Proper installation design requires that testing be performed to verify that vibratory loads are acceptable for the specific airframe, isolator style, engine, propeller and accessories. Further, the stresses introduced to the engine mount must be verified to assure proper function and resistance to fatigue. This is separate from the issue of propeller limitations based on strain gauge testing of the engine crankshaft.

Engine Forcing Functions on Firewall
Start-Up & Shut-Down Operation
Superior Vantage O/IO-360

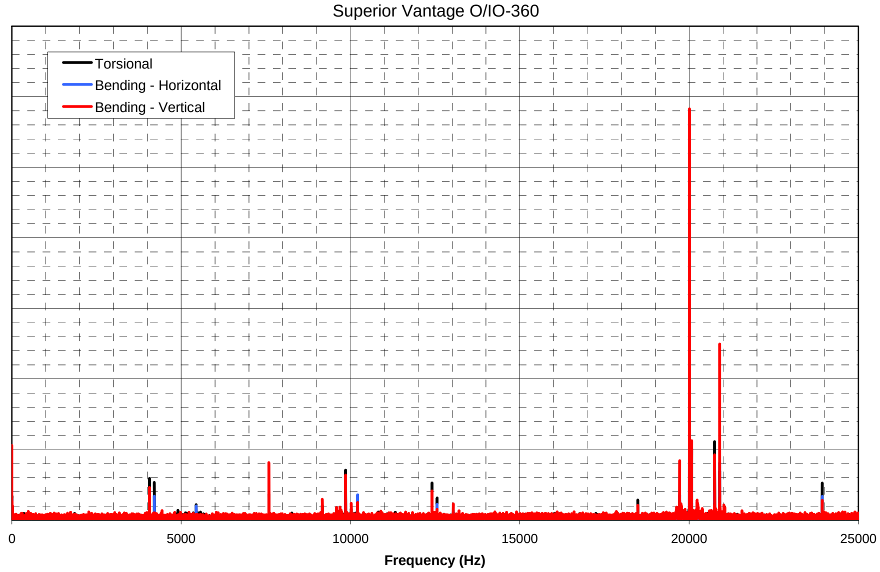


Figure 3-8 • Engine Mount Forcing Function for Engine Startup and Shutdown

Engine Forcing Functions on Firewall
Steady State Operation
Superior Vantage O/IO-360

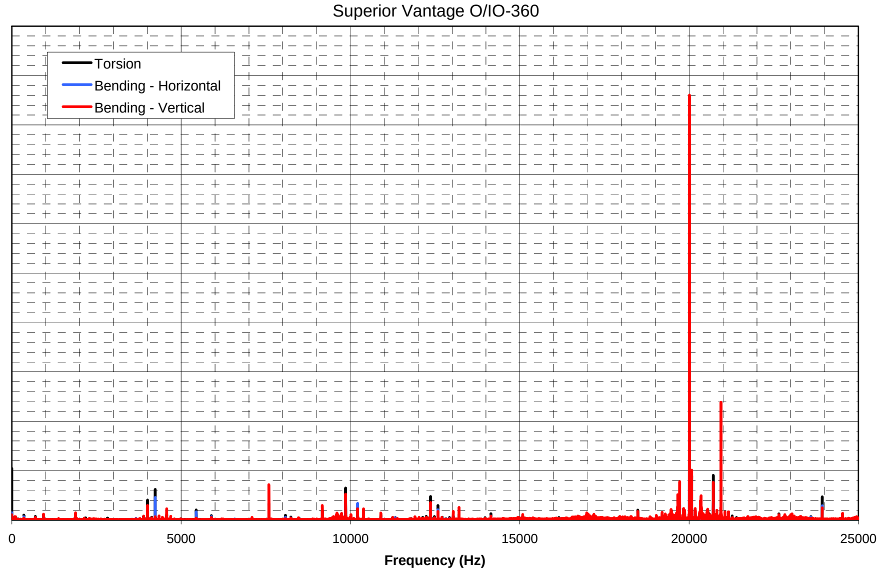


Figure 3-9 • Engine Mount Forcing Function for Steady State Conditions

CHAPTER 4

Engine Installation

1. GENERAL INSTRUCTIONS

Superior Vantage Engines are carefully packaged to prevent shipping damage and preserved for extended storage. These measures include the use of metal shipping fixtures, isolation mounts and desiccant plugs (when preserved for extended storage). These items are not intended for further use and should be discarded when the engine is unpacked. Superior Air Parts recommends particular attention to the discard of hardware used to secure the engine during shipment and in the attachment of the engine to the shipping fixture. This hardware is not suitable for the structural requirements of an engine installation and it is important to verify that it is not used in that regard.

A lifting eye bracket is installed on the "backbone" of each engine crankcase for the purposes of hoisting the engine.

Note: This is the only means by which the engine should be lifted. Lifting the engine by any other means may result in damage to the engine and is not covered by warranty.

The following includes a discussion of general engine installation practices. This discussion should be used IN ADDITION TO the applicable requirements of the FARs.

2. PREPARING ENGINE FOR SERVICE

If the engine has been preserved for extended storage, 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 if any abnormal condition is noted.

Engines that have been subjected to a cold environment for long periods of time should be placed into at least 70ºF atmosphere for 24 hours or more before attempting to drain the preservative oil. Alternatively, the cylinders may be heated with heating lamps before attempting to drain the engine.
Remove exhaust port protective plugs. Service the lubrication system in accordance with instructions from Chapter 5, Section 3 A.

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. Attach with plain washers, new lock washers and torque the nuts to 204 in-lbs.

Align the spline of the 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.

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.

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

3. INSTALLATION OF ENGINE

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.
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.

<u>WARNING:</u> 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 CAN CAUSE ERRATIC FUEL SYSTEM OPERATION AND DAMAGE TO ITS COMPONENTS.

<u>WARNING:</u> DO NOT INSTALL THE IGNITION HARNESS "B" NUTS ON THE SPARK PLUGS UNTIL THE PROPELLER INSTALLATION IS COMPLETED. *FAILURE TO COMPLY COULD RESULT IN BODILY INJURY WHEN THE PROPELLER IS ROTATED DURING INSTALLATION.*

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

Outline Drawings for the installation design are located in the Model Specification Data. These illustrations are provided by engine series and therefore include reference dimensions only. Full size, detailed installation drawings may be obtained from Superior Air Parts Engineering.

4. INSTRUMENTATION CONNECTIONS

Superior Vantage Engines are provided with accommodations for standard engine monitoring instrumentation. Table 4-1 describes these instrument connections.

Table 4-1 • Instrumentation Connections

Instrument	Qty	Connection	O	IO
Cylinder Head Temperature	4	3/8-24 UNF Thread with 1.0" deep hole to receive AN4076-1 or equivalent thermocouple. Fitting type "J" Thermocouple recommended.	Fig. 1-2	Fig. 1-6
Oil Temperature	1	5/8-18 UNF Thread with 2 7/16" deep hole to receive MS28034-1 Oil Temperature Sensor or equivalent.	Fig. 1-5	Fig. 1-9
Oil Pressure	1	1/8-27 NPT	Fig. 1-5	Fig. 1-9
Manifold Pressure	1	1/8-27 NPT	Fig. 1-5	Fig. 1-9
Tachometer Drive	1	Standard Tach Drive Connection: 5/32 Square Drive Socket with 7/8-18 UNS Cap Threads	Fig. 1-5	Fig. 1-9
Fuel Pressure	1	1/8-27 NPT	App A Table 3	App B Table 3

CHAPTER 5

Special Procedures

1. GENERAL BREAK-IN PROCEDURES

This section provides the Break-In Procedures to achieve satisfactory ring seating and long cylinder life. On all new Vantage engines, after top overhaul or major engine overhaul, break-in is critical. Always refer to the latest Superior Service Data on Break-In instructions.

Note: Refer to the engine warranty. Violation of these procedures will void the engine's warranty.

2. SPECIAL TOOLS AND EQUIPMENT

Standard aviation shop tools are required.

The aircraft can be a suitable test stand for running-in cylinders.

3. BREAK-IN PROCEDURES

WARNING: OPERATION OF A DEFECTIVE ENGINE WITHOUT A PRELIMINARY EXAMINATION CAN CAUSE FURTHER DAMAGE TO A DISABLED COMPONENT AND POSSIBLE INJURY TO PERSONNEL. MAKE SURE THOROUGH INSPECTION AND TROUBLESHOOTING PROCEDURES ARE ACCOMPLISHED. THIS WILL HELP TO PREVENT INJURIES TO PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT.

A. Prior to Break-In Start-Up:

(1.) Engine oil sump should be filled with 100% straight weight mineral oil. Use MIL-L-6082, grade 100. Refer to chapter seven for fluid requirements.

(2.) Engine must be pre-oiled and oil pressure obtained prior to start-up.

(a.) To pre-oil an engine, do the following:

(i) Attach pressure oiling equipment to one end of the main gallery and force appropriate type of oil through the gallery at 35 psi until oil flows from the opposite gallery with the plug removed from the front end of the opposite galley.

(ii) Engine baffles and seals must be in good condition and properly installed.

(iii) Verify accuracy of instruments required for engine operation.

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 (82° AND 88°C).

B. Break-In Ground Run:

(1.) Flight propeller may be used if test club is not available.

(2.) Head aircraft into the wind.

(3.) Start engine and observe oil pressure. Oil pressure should be indicated within 30 seconds. If this does not occur, shut down engine and determine cause.

(4.) Run engine just long enough to confirm all components are properly adjusted and secured. There must be no fuel and/or oil leaks.

(5.) Install cowling.

(6.) Operate engine at 1000 -1200 RPM until oil has reached minimum operating temperature 120 °F.

(7.) Check magneto drop at normal RPM.

(8.) If engine is equipped with a controllable pitch propeller, cycle only to a 100 RPM drop.

(9.) Shut down engine and check for fuel and/or oil leaks and repair any discrepancies.

(10.) At no time should cylinder head temperature be allowed to exceed recommended maximum cruise limit of 430°F (221°C).

C. Break-In Flight Operation:

(1.) Perform normal pre-flight and run-up in accordance with Chapter 6 Section 3 (remember: cycle controllable pitch prop to only a 100 RPM drop). Keep ground runs to a minimum.

(2). Conduct normal take-off at full power, full rich mixture, to a safe altitude.

Note: In certain geographic locations and weather conditions (eg; high density altitudes) “Full Rich” operation may not be practical. In this event, substitute the requirement of “Full Rich” as discussed in this chapter with the “richest practical setting”.

(3.) Lean fuel mixture and maintain shallow climb. Use caution to not overheat the cylinders. Should overheating occur, reduce power and/or enrichen mixture.

(4.) Monitor RPM, oil pressure, oil temperature and cylinder temperature.

(5.) 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%.

(6.) Avoid long descents at cruise RPM and low manifold pressure (could cause ring flutter).

(7.) Continue flying at 65-75% power and full rich mixture on subsequent flights, while monitoring RPM, Oil Pressure, Oil Temperature, Cylinder Head Temperature and oil consumption. Continue until oil consumption stabilizes and cylinder head temperatures drop (and stabilize). These are indications that the piston rings have seated and the cylinders are broken in.

(8.) At no time should cylinder head temperature be allowed to exceed recommended maximum cruise limit 430°F (221°C).

(9.) After landing, check again for any fuel and/or oil leaks, or other discrepancies, and repair.

D. Post Break-In Procedures:

(1.) After break-in, drain all mineral oil. Examine this oil for foreign matter or metal particle content.

(2.) Install ashless dispersant of the appropriate grade for the expected normal operating conditions and ambient temperature.

4. GENERAL INSPECTION CHECK

Perform periodic Inspection/Check procedures. Refer to Inspection/Check section of the Vantage Maintenance Manual for Periodic Inspections intervals.

NOTE: The following inspection does not constitute a complete aircraft inspection. It applies to the engine only. Refer to the airframe manufacturer's instructions for additional information regarding airframe inspections.

WARNING: FUEL IS TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. USE IN A WELL VENTILATED AREA FREE FROM SPARKS, FLAME, OR HOT SURFACES. PUT ON SPLASH GOGGLES, SOLVENT-RESISTANT GLOVES, AND OTHER PROTECTIVE GEAR. IN CASE OF EYE CONTACT, FLUSH WITH WATER FOR 15 MINUTES AND SEEK MEDICAL ATTENTION. IN CASE OF SKIN CONTACT, WASH WITH SOAP AND WATER.

5. DAILY PRE-FLIGHT INSPECTION

A. The Daily Pre-Flight Inspection Check

This 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.

B. Perform Inspection/Checks as follows:

(1.) Be sure all switches are in the "Off" position.

(2.) Be sure magneto ground wires are connected.

(3.) Visually inspect the engine and propeller for any damage, oil or fuel leaks, security, and proper servicing.

(4.) Check oil level in sump, add oil as necessary.

(5.) See that fuel tanks contain fuel of the proper type and quantity (see Chapter 3, section 3 E.).

(6.) Check fuel and oil line connections. Repair any leaks before aircraft is flown.

NOTE: Record any minor discrepancies for further inspection at the next 50 hour Inspection.

(7.) Drain a quantity of fuel from all sumps and strainers into a clean container. If water or foreign matter is noted, continue draining until only clean fuel appears.

(8.) 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.

(9.) Check controls for general condition, security, and freedom of travel and operation.

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

CHAPTER 6

Normal Operating Procedures

1. GENERAL

This section has the necessary procedures to operate the O-360 and IO-360 series engines. Complying with these instructions will optimize life, economy and operation of the Vantage series engines.

Note: The following operator instructions do not constitute a complete aircraft's operator's instructions, and applies to the engine only. Refer to the airframe manufacturer's instruction for additional information.

2. ENGINE OPERATION AND LIMITS

Data for the following limits may be found in the Model Specification Data in the appropriate Appendices. These Engine Operational Limits should be reviewed by the operator prior to any initial operations of the O-360 or IO-360 Engine Series.

A. Propeller Load and Full Throttle Curve

B. Altitude Performance at Best Power

C. Cruise Performance Maps

D. Fuel Mixture Curves

E. Minimum Oil Quantity

F. Fuel Pressure and Flow Requirements

G. Fuel Grade Requirements

H. Oil Pressure and Temperature Limits

I. Operating Conditions

J. Accessory Temperature Limits

3. OPERATION INSTRUCTIONS

Note: The Vantage series engines have been carefully run-in by Superior Air Parts, but requires further break-in until oil consumption has stabilized. After this period, a change to approved ashless dispersant oil should be made. Refer to the Special Procedures Chapter Five, Break-in Instructions.

Superior Vantage Engines are certified for 100LL Avgas per ASTM D910, 91/98 (lead optional) Avgas per ASTM D910 and Motor Gasoline with a minimum antiknock index (R+M/2 method) of 91 per ASTM D4814.

The Vantage series engine can operate and perform at a rated power using auto fuel of at least 91 Octane (R+M/2), without alcohol. The higher the octane the greater the detonation margin during high power and/or hot operation. When operating on unleaded fuel, Superior Air Parts recommends using fresh premium, 91 minimum Octane, auto fuel available at major brand stations.

Due to the higher vapor pressure of auto fuel, carburetor icing and vapor lock are more likely. The use of motor gasoline is prohibited with fuel temperatures over 85°F (29°C) altitudes at 12,500 feet MSL and over 110°F at Sea Level.

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

<u>WARNING:</u> THE USE OF A LOWER OCTANE RATED FUEL CAN CAUSE PRE-IGNITION AND/OR DETONATION WHICH CAN DAMAGE AN ENGINE THE FIRST TIME HIGH POWER IS APPLIED. THIS CAN POSSIBLY CAUSE ENGINE FAILURE. THIS WOULD MOST LIKELY OCCUR ON TAKEOFF. IF THE AIRCRAFT IS INADVERTENTLY SERVICED WITH THE WRONG GRADE OF FUEL, THE FUEL MUST BE COMPLETELY DRAINED AND THE TANK PROPERLY SERVICED, PRIOR TO FURTHER ENGINE OPERATION.

<u>Note:</u> For added safety when using 91 Octane motor fuel, 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.

OPERATION INSTRUCTIONS CONTINUED

A. Preflight - Before starting the aircraft engine for the first flight of the day, perform a Daily Pre-Flight Inspection. Refer to Chapter Five, Section 5. Daily Pre-Flight Inspection.

B. Starting Procedures - The following starting procedures are recommended, however, the starting procedures for different installations will require some variation from these procedures. Refer to your airframe operator's manual.

Table 6-1 • Normal Starting Procedures

Engine Equipped With Float Type Carburetors	Engines Equipped With Fuel Injectors
1. Set Carburetor heat control in the "Off" position.	**1.** Set propeller governor control in the "Low Pitch, Full RPM" position (where applicable).
2. Set propeller governor control in the "Low Pitch, Full RPM" position (where applicable	**2.** Turn fuel valves "On"
3. Turn fuel valves "On"	**3.** Open throttle approximately ¼ travel.
4. Move mixture control to "Full Rich"	**4.**Turn on Master Switch
5. Turn on Master Switch	**5.** Turn on Boost Pump
6. Turn on Boost Pump (if installed)	**6.** Open throttle to wide open. Move mixture control to "Full Rich" until a slight but steady fuel flow is noted (approximately 3 to 5 seconds). Return mixture control to "Idle Cut-off".
7. Open throttle approximately ¼ travel. Prime with 1 to 3 strokes of manual priming pump or activate electric primer for 1 to 2 seconds.	**7.** Set magneto selector switch (consult airframe manufacturer's handbook for correct position).
8. Set magneto selector switch (consult airframe manufacturer's handbook for correct position.	**8.** Engage Starter.
9. Engage Starter	**9**. Release starter when engine fires. If both magnetos are not on, switch to "Both"
10. Release starter when engine fires, open throttle slightly to keep the engine running. If both magnetos are not on, switch to "Both."	**10**. Move mixture control slowly and smoothly to "Full Rich" and retard the throttle to desired idle speed.
11. Check oil pressure gage. If minimum oil pressure is not indicated within thirty seconds, stop engine and troubleshoot	**11**. Check oil pressure gage. If minimum oil pressure is not indicated within thirty seconds, stop engine and troubleshoot

HOT STARTS USE THE SAME PROCEDURE AS A NORMAL START WITH THE EXCEPTION OF PRIMING – OMIT PRIMING

Table 6-2 • Starting A Flooded Engine
1. Set mixture control to IDLE CUT OFF
2. Set throttle to ½ open.
3. Turn Magneto/start switch to START.
4. When engine starts, return the magneto/start switch to BOTH. Retard the throttle and slowly advance the mixture control to FULL RICH position.

C. 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.

D. Ground Run 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.

Ground Running - Any ground check that requires full throttle operation must be limited to three minutes, or less, the cylinder head temperatures should not exceed the maximum CHT of 500°F (260°C).

Table 6-3 • Ground Running / Fixed Wing Warm-Up
1. Head the Aircraft into the wind.
2. Leave mixture control "Full Rich" for the entire warm up period. This setting is dependent upon flight elevation (pressure altitude).
3. Operate only with the propeller in "Low Pitch" setting.
4. Operate at approximately 1000-1200 RPM for at least one minute in warm weather and as required during cold weather to prevent cavitation in the oil pump and to assure adequate lubrication. Avoid prolonged idling and do not exceed 2200 RPM on the ground.
5. Advance throttle slowly until tachometer indicates an engine speed of approximately 1200 RPM. Allow additional warm-up time at this speed depending on ambient temperature. This time may be used for taxiing to takeoff position. The minimum allowable oil temperature for run-up is 75°F (24°C).
CAUTION DO NOT OPERATE THE ENGINE AT RUN-UP SPEED UNLESS OIL TEMPERATURE IS 75°F (24°C) MINIMUM AND OIL PRESSURE IS WITHIN SPECIFIED LIMITS OF 50 – 95 PSI. **CAUTION:** OPERATION OF THE ENGINE AT HIGH RPM BEFORE REACHING MINIMUM OIL TEMPERATURE MAY CAUSE LOSS OF OIL PRESSURE AND ENGINE DAMAGE.
6. Perform all ground operations with cowling flaps, if installed, fully open and propeller control set for maximum RPM except for brief testing of propeller governor (if so equipped).
7. Restrict ground operations to the time necessary for warm-up and testing.
8. Engine is warm enough for take-off when the oil temperature exceeds 75° F (24°C) and the engine does not hesitate with throttle advancement.

Table 6-4 • Ground Running / Rotorcraft Warm-Up
1. Head the aircraft into the wind.
2. Leave mixture control "Full Rich" for the entire warm up period. This setting is dependent upon field elevation (pressure altitude).
3. Warm-up at approximately 1,900 - 2,100 RPM with rotor engaged in accordance with manufacturer's instructions until all systems are properly warmed.
4. Engine is warm enough for take-off when the oil temperature exceeds 75°F (24°C) and the engine does not hesitate with throttle advancement.

E. Pre-Takeoff Ground Check

Table 6-5 • Fixed Wing – Pre-Takeoff Ground Check
1. Warm-up as stated above in Table 6-3
2. Mixture control "Full Rich", check oil pressure and oil temperature.
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. Magneto Check - Factors other than the ignition system affect magneto drop. Some factors include load-power output and mixture strength. Make the magneto check in accordance with the following procedures:
CAUTION: ABSENCE OF RPM DROP WHEN CHECKING MAGNETOS MAY INDICATE A MALFUNCTION IN THE IGNITION CIRCUIT. SHOULD THE PROPELLER BE MOVED BY HAND (AS DURING PREFLIGHT) THE ENGINE MAY START AND CAUSE INJURY TO PERSONNEL. THIS TYPE OF MALFUNCTION SHOULD BE CORRECTED PRIOR TO CONTINUED OPERATION OF THE ENGINE. **CAUTION:** DO NOT UNDERESTIMATE THE IMPORTANCE OF PRE-TAKEOFF MAGNETO CHECK. WHEN OPERATING ON SINGLE IGNITION, SOME RPM DROP SHOULD BE NOTED. NORMAL INDICATIONS ARE 25 – 75 RPM DROP AND SLIGHT ENGINE ROUGHNESS AS EACH MAGNETO IS SWITCHED OFF. AN RPM DROP IN EXCESS OF 150 RPM MAY INDICATE A FAULTY MAGNETO OR FOULED SPARK PLUGS.
4A. Controllable pitch propeller - Check for ignition problems with propeller in "Low Pitch, High RPM", and set the throttle to approximately 1700 RPM. A. Move propeller governor control toward low RPM position and observe tachometer. Engine speed should decrease to minimum governing speed (200-300 RPM drop). Return governor control to high speed position. Repeat this procedure two or three times to circulate warm oil into the propeller hub. B. Where applicable, move propeller control to “feather” position. Observe for 300 RPM drop below minimum governing RPM, then return control to “full increase” RPM position.
4B. Fixed pitch propeller - Aircraft that are equipped with fixed pitch propellers may check magneto drop-off with engine operating at approximately 1700 RPM.
5. Check magnetos: Move the ignition switch first to “R” position and note engine RPM, then move switch back to “BOTH” position to clear the other set of spark plugs. Move the switch to “L” position and note RPM. The difference between the two magnetos operated individually should not differ more than 25-75 RPM with a maximum drop for either magneto of 150 RPM. Slight engine roughness is expected during this test. However, excessive roughness may indicate spark plug fouling or other ignition system problem. **Note:** Minor spark plug fouling can usually be cleared with magnetos on and holding throttle at 2200 RPM.
6. Mixture – Move toward idle cutoff until RPM peaks and hold for ten seconds. Return mixture to full rich.

Table 6-6 • Rotorcraft – Pre-Takeoff Ground Check
1. Warm-up as stated above in Table 6-4
2. Mixture control "Full Rich", check oil pressure and oil temperature.
3. Magneto Check Raise collective pitch control to obtain 15 inches of manifold pressure and 2,000 RPM. 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.

F. Operation In Flight

Note: See airframe manufacturer's instructions for recommended power settings and limits.

Note: Move the controls slowly and smoothly.

Table 6-7 • Fuel Mixture Leaning General Rules
1. Improper fuel/air mixture during flight is a contributing factor to engine problems, particularly during elevated take-off and climb power settings. The procedures described in this manual provide proper fuel/air mixture when leaning Vantage engines. It is therefore, recommended that operators of all Vantage engines utilize the instructions in this publication any time the fuel/air mixture is adjusted during flight.
2. Manual leaning may be monitored by exhaust gas temperature indication, fuel flow indication, and by observation of engine speed and/or airspeed. Regardless of the instruments used in monitoring the mixture, the following general rules should be observed by the operator of Superior Air Parts aircraft engines.
3. Never exceed the maximum red line cylinder head temperature limit of 500°F (260°C).
4. For maximum service life, cylinder head temperatures should be maintained below 430°F during high performance cruise operation and below 400°F (204°C) for economy cruise powers
5. Do not lean engines with automatically controlled fuel systems
6. On engines with manual mixture control, maintain mixture control in "Full Rich" position for rated take-off, climb and maximum cruise powers (above approximately 80% power). In case of a take-off from a high elevation airport or during subsequent climb, adjust mixture control only enough to obtain smooth operation - not for economy.
7. 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.
8. 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 owner's manual.
9. During descent it may be necessary to manually lean carbureted or fuel injected engines to obtain smooth operation.

Table 6-8 • Leaning with Exhaust Gas Temperature Gage
Normally aspirated engines with fuel injectors or carburetors.

Maximum Power Cruise (above 80% power) – Superior Vantage Engines should not be leaned when operating above 80% power.	**Best Economy Cruise** (approximately 80% power and below) - Do not lean below peak EGT on carbureted engines. Do not lean beyond 50°F lean of peak on fuel injected engines.

Table 6-9 • Leaning with 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.

Table 6-10 • Leaning with Manual Mixture Control
Economy cruise, 80% power or less without flowmeter or EGT gage.

Carbureted Engines	Fuel Injected Engines
Slowly lean mixture control from "Full Rich" position.	Slowly lean mixture control from "Full Rich" position.
Lean until engine roughness is noted.	Continue leaning until slight loss of power is noted and/or is accompanied by roughness.
Enrich until engine runs smoothly. Slight additional enrichment is recommended to ensure adequate performance.	Enrich until engine power is regained and/or runs smoothly. Slight additional enrichment is recommended to ensure adequate performance

Table 6-11 • Shut Down Procedure *

1. Set propeller governor control to "Low Pitch, High RPM" (when applicable).
2. Idle until there is a definite reduction in cylinder head temperature.
3. Move mixture control to "Idle Cut-Off".
4. When engine stops, turn off switches.

**Omit step one for Rotorcraft shut down.*

G. Use of Carburetor Heat Control

(**1**.) Under certain damp atmospheric conditions and temperatures of 20°F to 100°F (-6°c to 38°C) 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 or a drop in RPM in installations with fixed pitch propellers. The engine may stop if not corrected. To avoid this, carbureted installations are equipped with a system for preheating the incoming air supply.

(**2**.) 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 many preheated installations, the heated air does not pass through the air filter.

(**3**.) Take-Off **-** All take-off and full throttle operations should be made with carburetor heat in the "Cold" or "Off" position.

(**4**.) 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.

(**5**.) Cruise Flight **-** During normal cruise flight, leave the carburetor air heat control in the "Cold" position.

(**7**.) If the presence of carburetor ice 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.

(**8**.) If equipped with a carburetor air temperature gage, partial heat may be used to keep the mixture temperature above freezing. Constant high temperatures are to be avoided because of a loss in power and variation of mixture. High intake air temperatures also favor detonation and pre-ignition, both of which are to be avoided if normal service life is to be expected from the engine.

<u>CAUTION:</u> USE CAUTION WHEN OPERATING WITH PARTIAL CARBURETOR HEAT ON AIRCRAFT THAT DO NOT HAVE A CARBURETOR AIR TEMPERATURE GAGE. IT IS RECOMMENDED TO USE EITHER FULL HEAT OR NO HEAT IN AIRCRAFT THAT ARE NOT SO EQUIPPED.

(**9**.) Approach and Landing

> **Note:** During a landing approach, the carburetor heat should normally be in the "Hot" or "Full On" position.
>
> 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 as full power is applied. Under certain hot and dry ambient conditions, carburetor heat may not be required. See the aircraft flight manual for specific instructions.

CHAPTER 7

Abnormal Operating Procedures

Table 7-1 • Abnormal Operating Procedures

1. GENERAL

This section provides the Fault Isolation procedures as a guide. Review all probable causes given. Testing is limited to the continuity checks of the ignition wiring harness. The fault isolation sequence is in order of approximate ease of checking, not necessarily in order of probability.

WARNING: OPERATION OF A DEFECTIVE ENGINE WITHOUT A PRELIMINARY EXAMINATION CAN CAUSE FURTHER DAMAGE TO A DISABLED COMPONENT AND POSSIBLE INJURY TO PERSONNEL. MAKE SURE THOROUGH INSPECTION AND TROUBLESHOOTING PROCEDURES ARE ACCOMPLISHED. THIS WILL HELP TO PREVENT INJURIES TO PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT.

WARNING: FUEL IS TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. USE IN A WELL VENTILATED AREA FREE FROM SPARKS, FLAME, OR HOT SURFACES. PUT ON SPLASH GOGGLES, SOLVENT-RESISTANT GLOVES, AND OTHER PROTECTIVE GEAR. IN CASE OF EYE CONTACT, FLUSH WITH WATER FOR 15 MINUTES AND SEEK MEDICAL ATTENTION. IN CASE OF SKIN CONTACT, WASH WITH SOAP AND WATER.

WARNING: HOT OIL MAY CAUSE BURNS TO EYES AND SKIN. PUT ON SPLASH GOGGLES, INSULATED GLOVES, AND OTHER PROTECTIVE GEAR. IN CASE OF EYE CONTACT, FLUSH WITH WATER FOR 15 MINUTES AND SEEK MEDICAL ATTENTION. IN CASE OF SKIN CONTACT, WASH WITH SOAP AND WATER.

Symptom	Table
Engine will not start	7.1
Rough Idling	7.2
Engine Not Able to Develop Full Power	7.3
Rough Engine Operation	7.4
Low Power and Engine Runs Rough	7.5
Low Oil Pressure On Engine Gage	7.6
High Oil Temperature	7.7
Excessive Oil Consumption	7.8

2. ENGINE WILL NOT START

Table 7-2 • Engine Will Not Start	
Probable Cause	**Correction**
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	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.
Internal failure	Check oil screens for metal particles. If found, complete overhaul of the engine may be required.

3. ROUGH IDLING

Table 7-3 • Rough Idling	
Probable Cause	**Correction**
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

4. ENGINE NOT ABLE TO DEVELOP FULL POWER

Table 7-4 • Engine Not Able To Develop Full Power

Probable Cause	Correction
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
Faulty ignition	Tighten all connections. Check system with tester. Check ignition timing.

5. ROUGH ENGINE OPERATION

Table 7-5 • Rough Engine Operation

Probable Cause	Correction
Broken engine mount	Replace or repair mount.
Mounting bushings worn	Install new mounting bushings.
Unstable compression	Check compression.

6. LOW POWER & ENGINE RUNS ROUGH

Table 7-6 • Low Power & Engine Runs Rough

Probable Cause	Correction
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 may be required by authorized personnel.
Mixture too lean; indicated by overheating or back firing	Check fuel lines for dirt or other restrictions. Readjustment of fuel injector or carburetor may be required by authorized personnel.
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 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.

7. LOW OIL PRESSURE ON ENGINE GAGE

Table 7-7 • Low Oil Pressure On Engine Gage

Probable Cause	Correction
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 defective gage.
Stoppage in oil pump intake passage	Check line for obstruction. Clean suction strainer.

8. HIGH OIL TEMPERATURE

Table 7-8 • High Oil Temperature

Probable Cause	Correction
Insufficient air cooling	Check air inlet and outlet for deformation or obstruction.
Insufficient oil supply	Fill to proper level with specified oil.
Low grade of oil	Replace with oil conforming to specifications.
Clogged oil lines or strainers	Remove and clean oil strainers.
Excessive blow-by	Check condition of engine rings. Replace if worn or damaged.
Failing or failed bearing	Examine sump for metal particles. If found, engine overhaul may be required.
Defective temperature gage	Replace gage.

9. EXCESSIVE OIL CONSUMPTION

Table 7-9 • Excessive Oil Consumption

Probable Cause	Correction
Low grade of oil	Fill tank with oil of proper weight and grade.
Failing or failed bearings	Check sump oil 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 Procedures, Special Procedures Section Chapter 5.

CHAPTER 8

Servicing Requirements

1. GENERAL

This section specifies the fuel and lubricants required to operate the Vantage series engines. For aircraft servicing, refer to the aircraft manufacturer's manual.

2. LUBRICANTS

A. Oil grades are listed in Table 8-1.

B. Oil sump capacity is listed in Table 8-2.

Table 8-1 • Oil Grades

All Models Average Ambient Air	Recommended Grade Oil
All Temperatures	SAE 15W50 or 20W50
Cold (<30°F) (-1°C)	SAE 30 or 10W30
Standard (30° - 90°F) (-1° - 32°C)	SAE 40
Hot (>60°F) (16°C)	SAE 50

Notes:

(1) For Break-In Operation (see Chapter 5.3.A) straight mineral oil meeting MIL-L-6082 should be used. After Break-In, Ashless Dispersant Oils meeting MIL-L-22851 or SAE J-1899 are to be used.

(2) (Semi-Synthetic Oils may be used after break-in provided that they meet MIL-L-22851 or J-1899.

Table 8-2 • Oil Sump Capacity

Maximum Oil Capacity	8 U.S. Quarts
Minimum Safe Quantity in the sump	2.5 U.S. Quarts

3. FUELS

Superior Vantage Engines are certified for 100LL Avgas per ASTM D910, 91/98 (lead optional) Avgas per ASTM D910 and Motor Gasoline with a minimum antiknock index (R+M/2 method) of 91 per ASTM D4814.

Minimum octane fuels are listed in Table 8-3.

A. The minimum aviation fuel grade is 91/98 Octane Avgas, lead optional. Under no circumstances should aviation fuel of a lower octane rating be used.

B. 91 Octane Motor Fuel

The Vantage series engine can operate and perform at a rated power with unleaded automotive fuel without alcohol of at least 91 Octane. When operating with unleaded automotive fuel, use only 91 minimum octane premium grade fuel.

Table 8-3 • Minimum Octane Fuels

Minimum Octane	
Aviation Grade	Motor Fuel
91/98 Avgas (Lead Optional)	91 (R+M/2) (No Alcohol)

4. CONSUMABLES

The Vantage Series Engines are equipped with spark plugs and a spin on oil filter. Table 8-4 specifies these consumable items and their corresponding part number.

Table 8-4 • Consumables

Spark Plugs	Champion Aviation P/N REM40E Unison Industries P/N UREM40E
Oil Filter	Champion Aviation P/N CH48108 & CH48108-1

CHAPTER 9

Engine Preservation And Storage

There is no practical procedure that will ensure corrosion prevention on installed aircraft engines. The degree of corrosion is influenced by geographical locations, season and usage. The owner/operator is responsible for recognizing the conditions that are conducive to corrosion and for taking appropriate precautions.

Corrosion can occur in engines that are flown only occasionally regardless of geographical location. In coastal areas and areas of high humidity corrosion can occur in as little as a few days. The best method for reducing the likely hood of corrosion is to fly the aircraft at least once every week for a minimum of one hour.

Note: Corrosion may reduce engine service life. Of primary concern are cylinders, piston rings, camshaft and lifters.

1. TEMPORARY STORAGE

A. Preparation for Storage

(1.) Remove oil sump drain plug and drain oil. Replace drain plug, torque and safety. Remove oil filter. Install new oil filter, torque and safety. Service engine to proper sump capacity with MIL-C-6529 Type II oil. This oil is not to be used as a lubricant.

(2.) On aircraft: Perform a ground run-up. Perform a pre-flight inspection and correct any discrepancies. Fly the aircraft for at least one hour or run on ground until 180^{0}F operating temperature is reached. Don't exceed 400^{0}F (204°C) cylinder head temperature.

(3) On test cell: Perform run-up to warm engine to operating temperature. Run at operating temperature for a minimum of 15 minutes.

WARNING: TO PREVENT POSSIBILITY OF SERIOUS BODILY INJURY OR DEATH, BEFORE MOVING THE PROPELLER DO THE FOLLOWING:

(A.) DISCONNECT ALL SPARK PLUG LEADS.

(B.) VERIFY MAGNETO SWITCHES ARE CONNECTED TO MAGNETOS AND THAT THEY ARE IN THE "OFF" POSITION AND THE "P" LEADS ARE GROUNDED.

(C.) THROTTLE POSITIONS "CLOSED."

(D.) MIXTURE CONTROL "IDLE-CUT OFF."

(E.) SET BRAKES AND BLOCK AIRCRAFT WHEELS. ENSURE THAT AIRCRAFT TIE DOWNS ARE INSTALLED AND VERIFY THAT THE CABIN DOOR LATCH IS OPEN.

(F.) DO NOT STAND WITHIN THE ARC OF THE PROPELLER BLADES WHILE TURNING THE PROPELLER.

(4.) After operation verify all spark plug leads are removed and remove the top spark plugs. Protect the ignition lead ends with AN-4060 Protectors. Using a common garden sprayer or equivalent, spay atomized preservative oil MIL-P-46002, Grade I at room temperature through the upper spark plug hole of each cylinder with the piston at bottom dead center position. Rotate crankshaft as opposite cylinders are sprayed. Stop crankshaft with none of the pistons at top dead center.

(5.) Drain preservative oil. Re-spray each cylinder. To thoroughly cover all surfaces of the cylinder interior move the nozzle or spray gun from the top to the bottom of the cylinder.

(6.) Install top spark plugs but do not install spark plug leads.

(7.) Seal all engine openings exposed to the atmosphere using suitable plugs and covers.

(8.) On aircraft, tag each propeller in a conspicuous place with the following notation on the tag, or if new or overhauled on the propeller flange: "Do Not Turn Propeller – Engine Preserved – (Preservation Date)"

Note: If the engine is not returned to flyable status on or before the 90 day expiration it must be preserved in accordance with "Indefinite Storage" procedures in this section.

2. INDEFINITE STORAGE

A. Preparation for Storage

(1.) Remove oil sump drain plug and drain oil. Replace drain plug, torque and safety. Remove oil filer. Install new oil filter, torque and safety. Service engine to proper sump capacity with MIL-C-6529, Type II oil.

(2.) On aircraft: Perform a ground run-up. Perform a pre-flight inspection and correct any discrepancies. Fly the aircraft for at least one hour or run on ground until 180^0F operating temperature is reached. Don't exceed 400^0F (204°C) cylinder head temperature.

(3) On test cell: Perform run-up to warm engine to operating temperature. Run at operating temperature for a minimum of 15 minutes.

WARNING: TO PREVENT POSSIBILITY OF SERIOUS BODILY INJURY OR DEATH, BEFORE MOVING THE PROPELLER DO THE FOLLOWING:

(A.) DISCONNECT ALL SPARK PLUG LEADS.

(B.) VERIFY MAGNETO SWITCHES ARE CONNECTED TO MAGNETOS AND THAT THEY ARE IN THE "OFF" POSITION AND "P" LEADS ARE GROUNDED.

(C.) THROTTLE POSITION "CLOSED."

(D.) MIXTURE CONTROL "IDLE-CUT OFF."

(E.) SET BRAKES AND BLOCK AIRCRAFT WHEELS. ENSURE THAT AIRCRAFT TIE DOWNS ARE INSTALLED AND VERIFY THAT THE CABIN DOOR LATCH IS OPEN.

(F.) DO NOT STAND WITHIN THE ARC OF THE PROPELLER BLADES WHILE TURNING THE PROPELLER.

(4.) After flight remove all spark plug leads and remove the top spark plugs. Protect the ignition lead ends with AN-4060 Protectors. Install protective plugs in bottom spark plug holes. Using a common garden sprayer or equivalent, spay atomized preservative oil MIL-P-46002, Grade I at room temperature through the upper spark plug hole of each cylinder with the piston at bottom dead center position. Rotate crankshaft as opposite cylinders are sprayed.

Stop crankshaft with none of the pistons at top dead center.

(5.) Re-spray each cylinder. To thoroughly cover all surfaces of the cylinder interior move the nozzle or spray gun from the top to the bottom of the cylinder.

(6.) Install dehydrator plugs (MS27215-2 or AN4062-1) in each of the upper spark plug holes. Make sure each plug is blue in color when installed.

(7.) Before engine has cooled install desiccant bags in exhaust pipes. Attach a red "Remove Before Flight" streamer to each bag of desiccant in the exhaust pipes and seal the openings.

(8.) Seal all engine openings exposed to the atmosphere using suitable plugs and covers.

(9.) On aircraft, tag each propeller in a conspicuous place with the following notation on the tag, or if new or overhauled on the propeller flange: "Do Not Turn Propeller – Engine Preserved – (Preservation Date)"

3. INSPECTION PROCEDURES

A. Aircraft prepared for indefinite storage must have the cylinder dehydrator plugs visually inspected every 15 days. The plugs must be changed as soon as they indicate other than a dark blue color. If the dehydrator plugs have changed color in one-half or more of the cylinders, all desiccant material on the engine must be replaced.

B. The cylinder bores of all engines prepared for indefinite storage must be re-sprayed with corrosion preventive mixture every 90 days.

4. RETURNING AN ENGINE TO SERVICE AFTER STORAGE

A. Remove all seals and all desiccant bags.

B. Remove cylinder dehydrators and plugs or spark plugs from upper and lower spark plug holes.

C. Remove oil sump drain plug and drain the corrosion preventive mixture. Replace drain plug, torque and safety. Remove oil filter. Install new oil filter torque and safety. Service the engine with oil in accordance with the manufacturer's instructions.

<u>WARNING:</u> TO PREVENT THE POSSIBILITY OF SERIOUS BODILY INJURY OR DEATH, BEFORE MOVING THE PROPELLER DO THE FOLLOWING:

(A.) VERIFY ALL SPARK PLUG LEADS ARE DISCONNECTED.

(B.) VERIFY MAGNETO SWITCHES ARE CONNECTED TO MAGNETOS AND THAT THEY ARE IN THE "OFF" POSITION AND "P" LEADS ARE GROUNDED.

(C.) THROTTLE POSITIONS "CLOSED."

(D.) MIXTURE CONTROL "IDLE-CUT OFF."

(E.) SET BRAKES AND BLOCK AIRCRAFT WHEELS. ENSURE THAT AIRCRAFT TIE DOWNS ARE INSTALLED AND VERIFY THAT THE CABIN DOOR LATCH IS OPEN.

(F.) DO NOT STAND WITHIN THE ARC OF THE PROPELLER BLADES WHILE TURNING THE PROPELLER.

D. Rotate propeller by hand several revolutions to remove preservative oil.

E. Service and install spark plugs and ignition leads in accordance with the manufacturer's instructions.

F. Service engine and aircraft in accordance with the manufacturer's instructions.

G. Thoroughly clean the aircraft and engine. Perform visual inspection.

H. Correct any discrepancies.

I Conduct a normal engine start.

J. Perform a test flight in accordance with "Operation Instructions" of the O-360 and IO-360 Engine Series Installation and Operation Manual."

K. Correct any discrepancies.

L. Perform a test flight in accordance with airframe manufacturer's instructions.

M. Correct any discrepancies prior to returning aircraft to service.

N. Change oil and filter after 25 hours of operation.

O-360 SERIES ENGINE

MODEL SPECIFICATION DATA

APPENDIX A

APPENDIX A
TABLE OF CONTENTS

		Page Number
Figures		
1	Induction Airflow Requirements	1
2	Inter-Cylinder Baffle Performance	2
3a	Location of Engine Center of Gravity - Horizontal	3
3b	Location of Engine Center of Gravity - Vertical	4
4	O-360 Installation Drawing Front View	5
5	O-360 Installation Drawing Top View	6
6	Carburetor Installation Drawing	7
7	Propeller Load And Full Throttle Curves	8
8	Altitude Performance At Best Power	9
9	Cruise Performance Map-80% Power	10
10	Cruise Performance Map-70% Power	11
11	Cruise Performance Map-60% Power	12
12	Fuel Mixture Curve-75% Power	13
13	Fuel Mixture Curve-65% Power	14
14	Minimum Oil Quantity	15
Tables		
1	Maximum Fuel Flow Requirements	16
2	Fuel Filter Requirements	16
3	Fuel Pump Inlet Pressure Limits	16
4	Oil Heat Rejection, Airside Heat Rejection, Crankcase Pressure	16
5	Oil Pressure Limits	17
6	Engine Accessories	17
7	Engine Weight & Location of Center of Gravity	17
8	Engine Moment of Inertia	17
9	Oil Temperature Limits	18
10	Fuel Grade Requirements	18
11	Operating Conditions	18
12	Accessory Temperature Limits	19

Induction Air Flow

Superior Vantage O/IO-360 Series

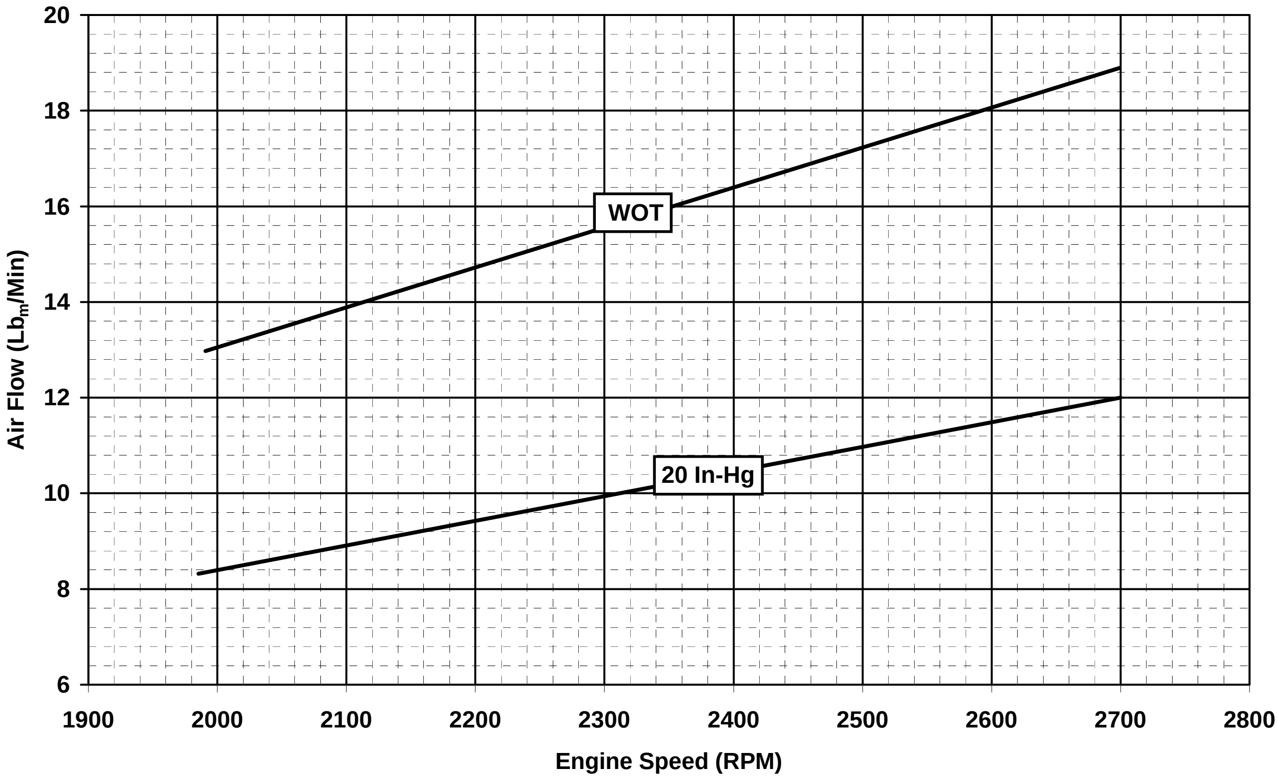


Figure 1 • Induction Air Flow Requirements

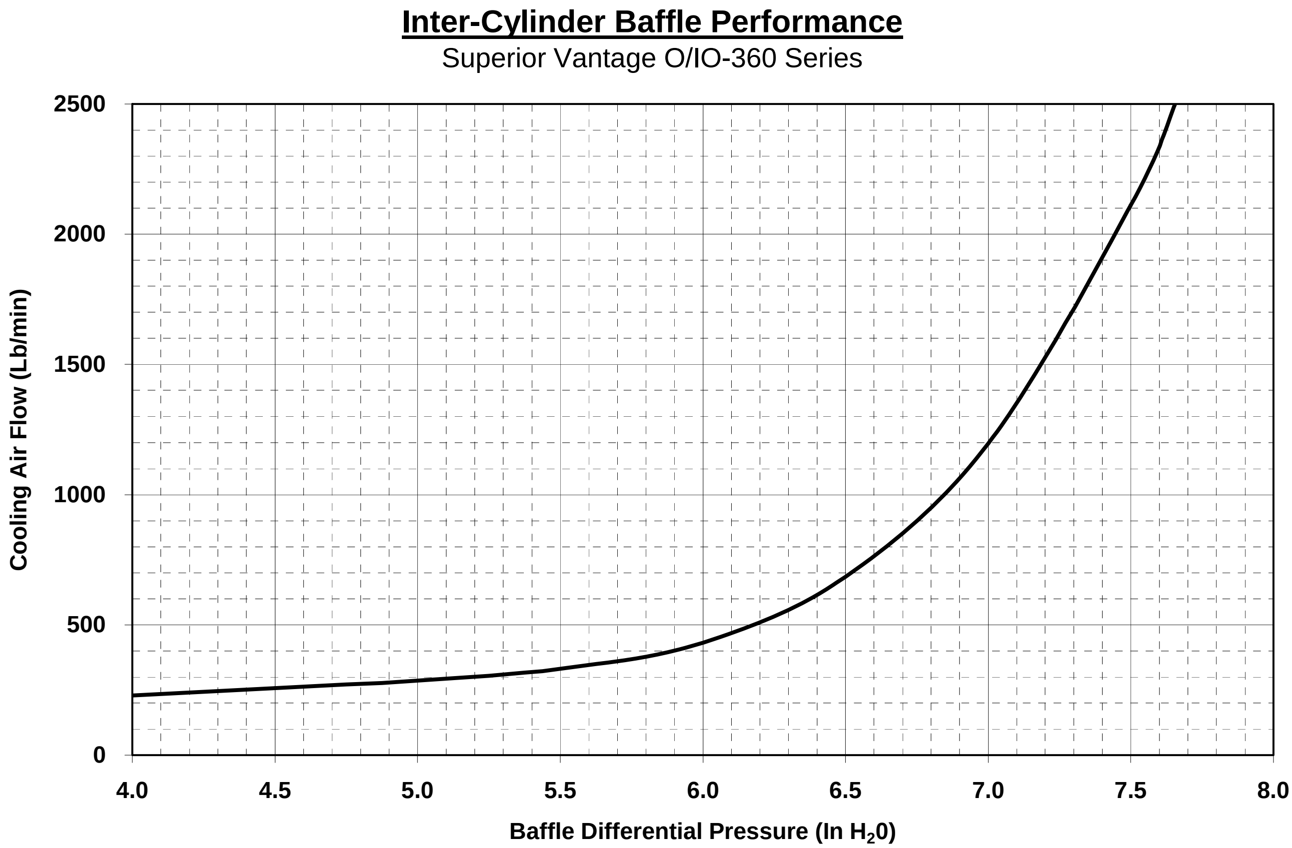


Figure 2 • Inter-Cylinder Baffle Performance

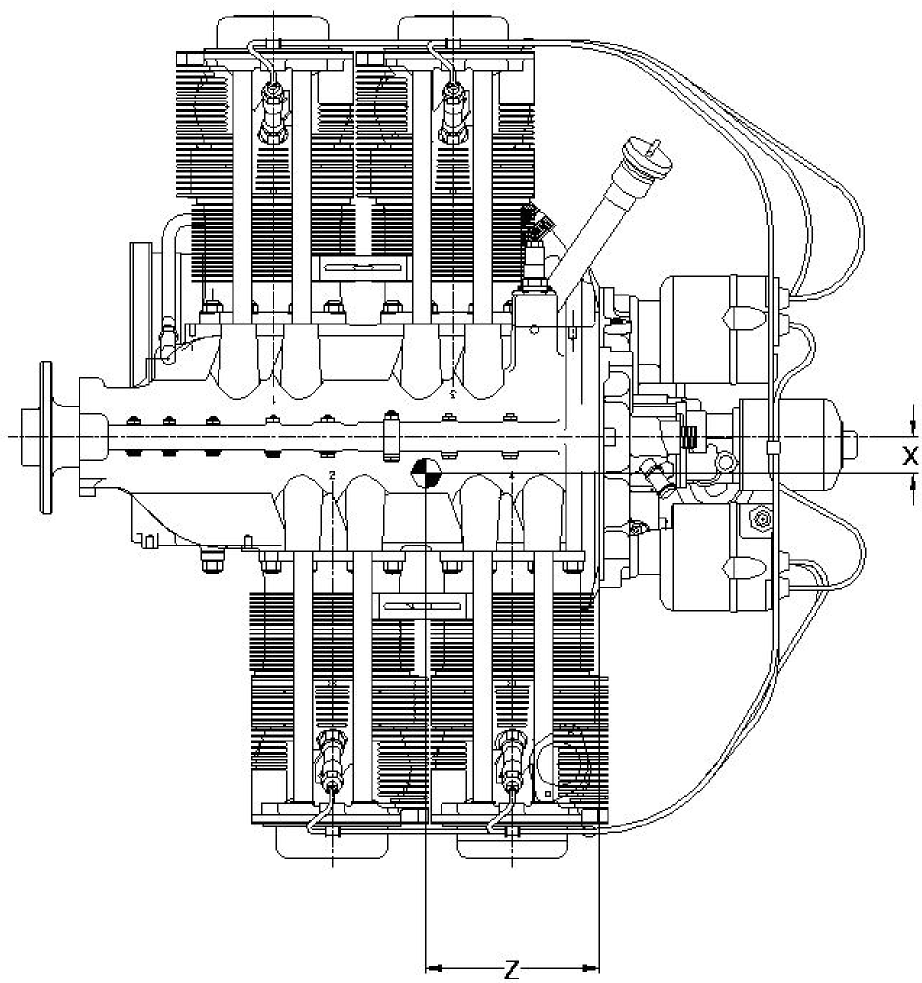


Figure 3a • Location of Engine Center of Gravity - Horizontal

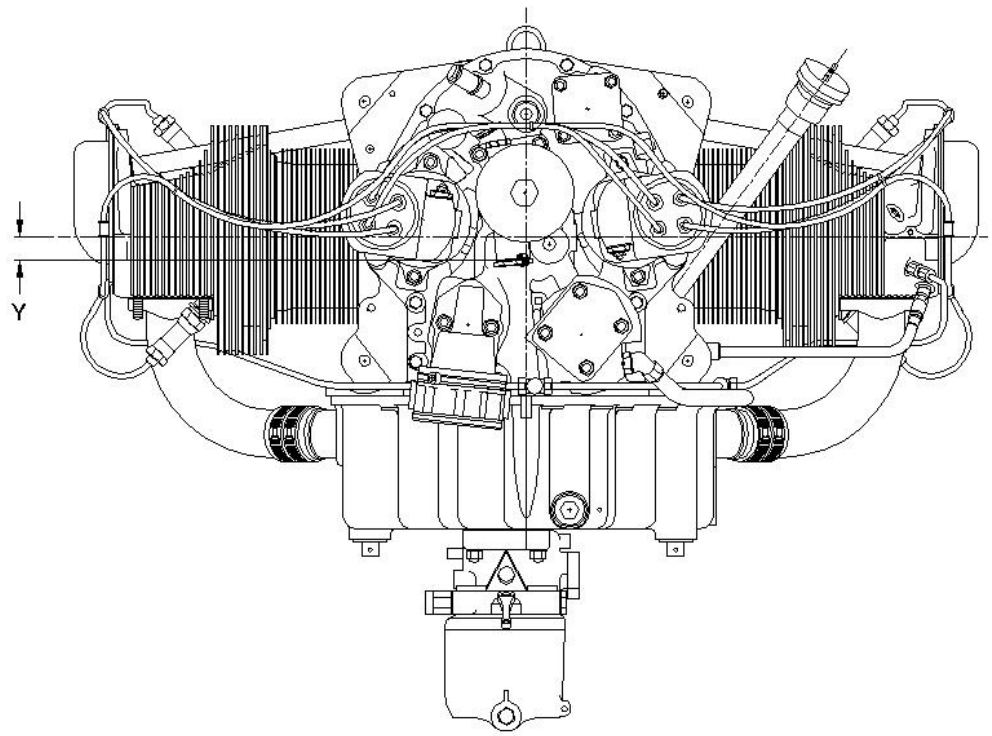


Figure 3b • Location of Engine Center of Gravity - Vertical

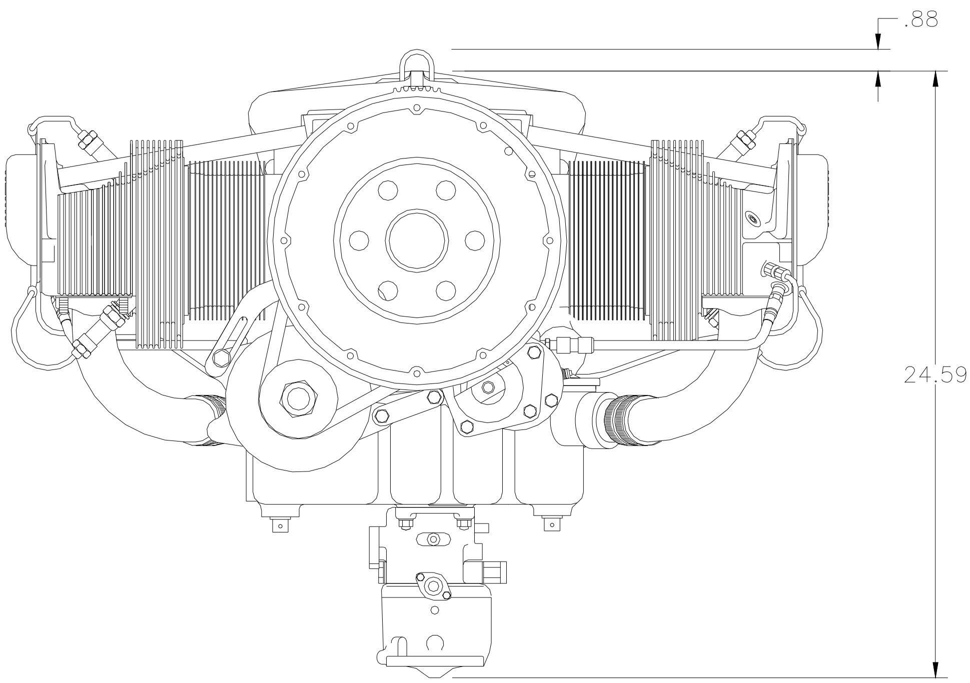


Figure 4 • O-360 Installation Drawing Front View

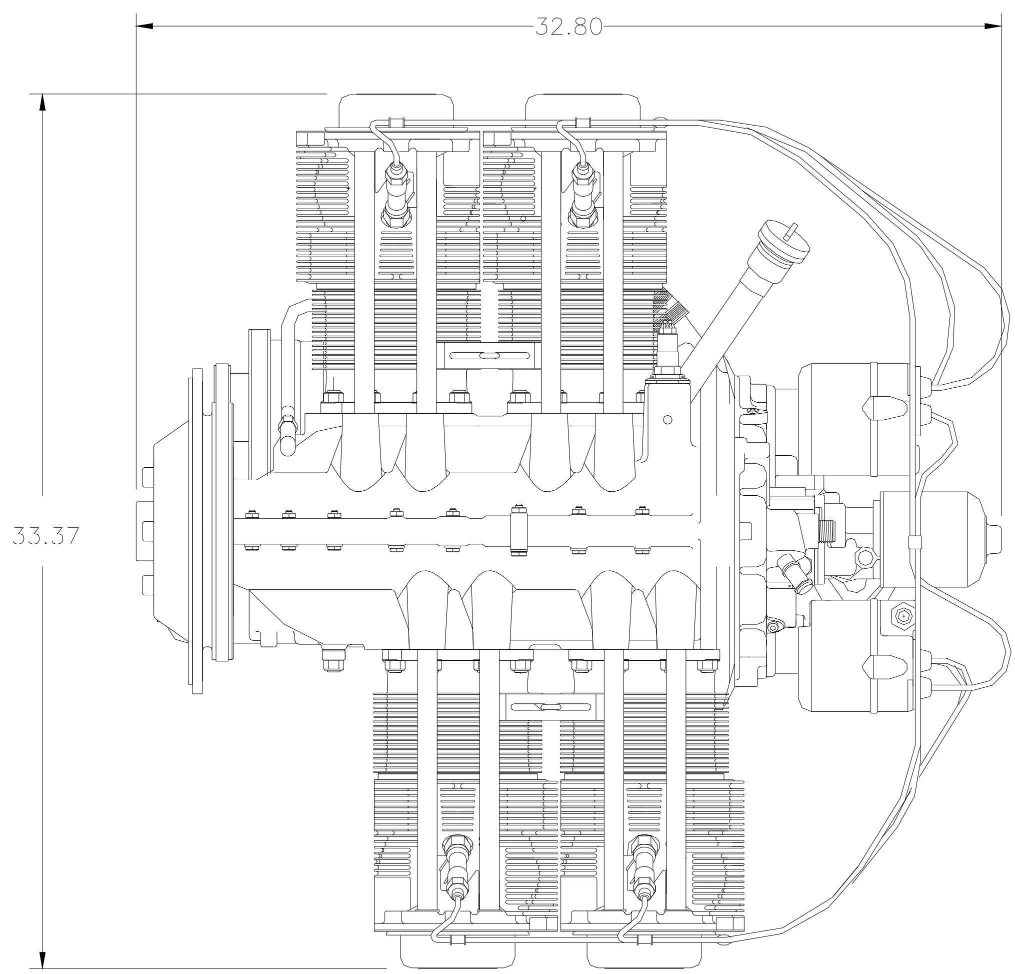
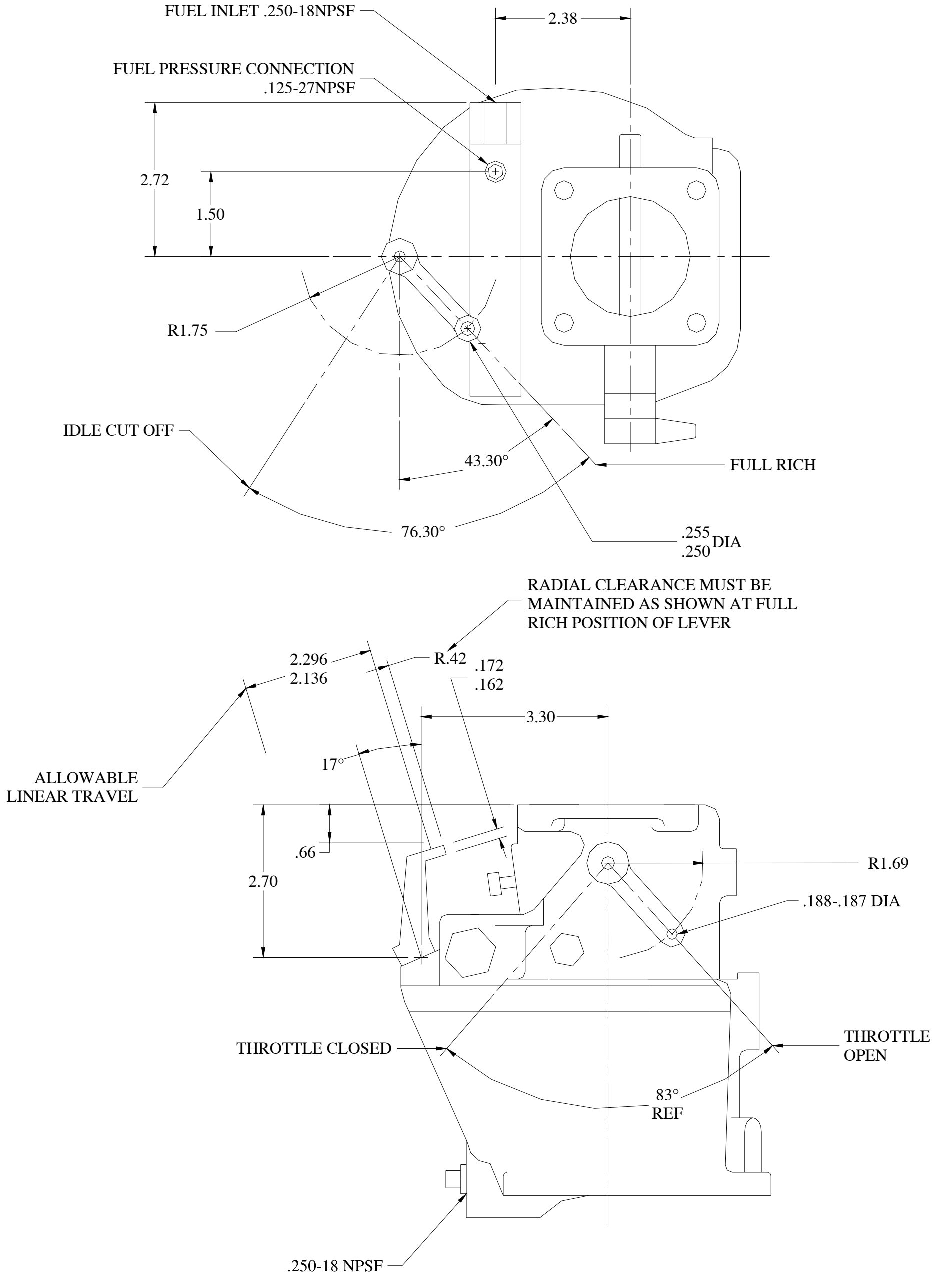


Figure 5 • O-360 Installation Drawing Top View



Fuel Metering System
Carburetor

Figure 6 • Carburetor Installation Drawing

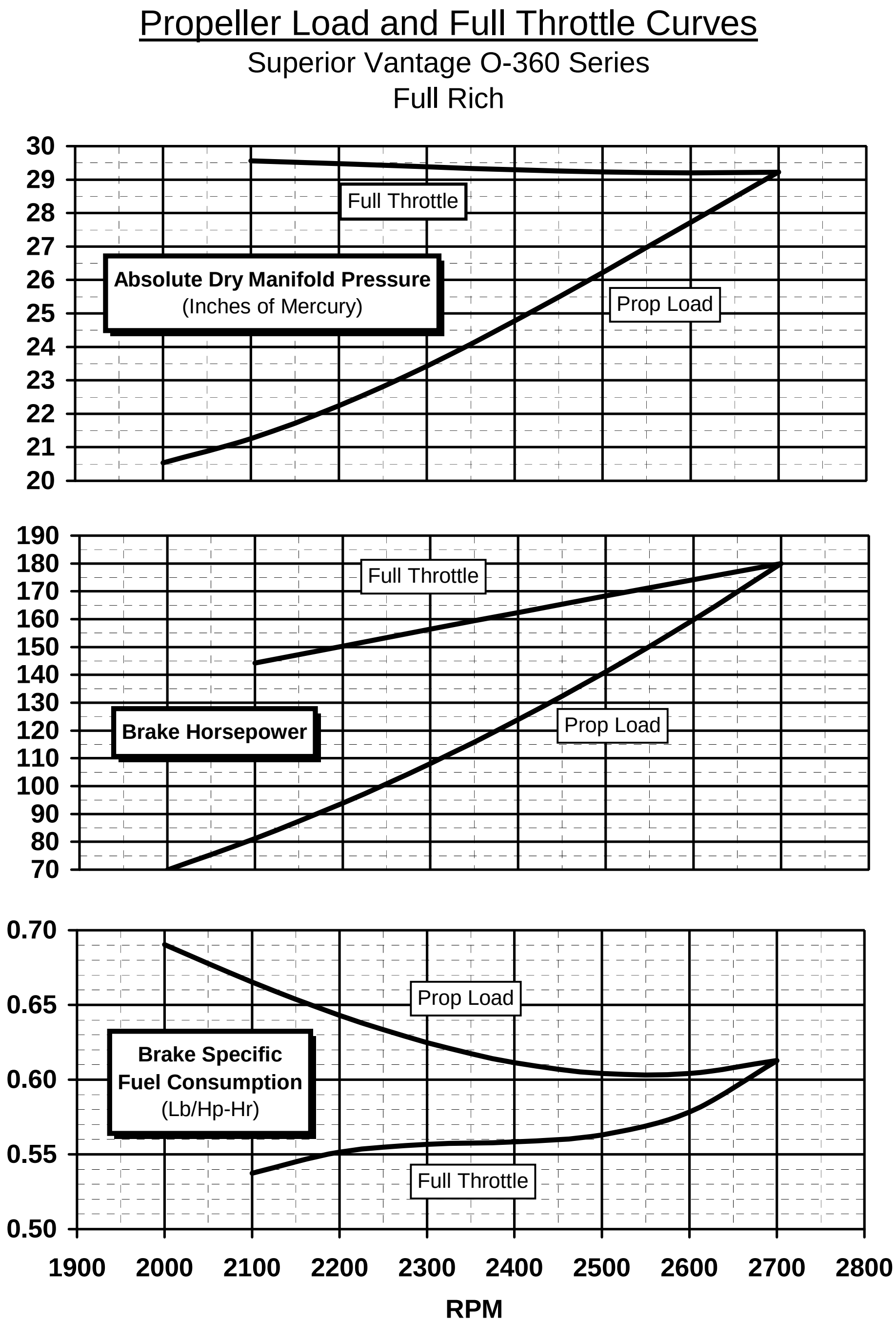


Figure 7 • Propeller Load And Full Throttle Curves

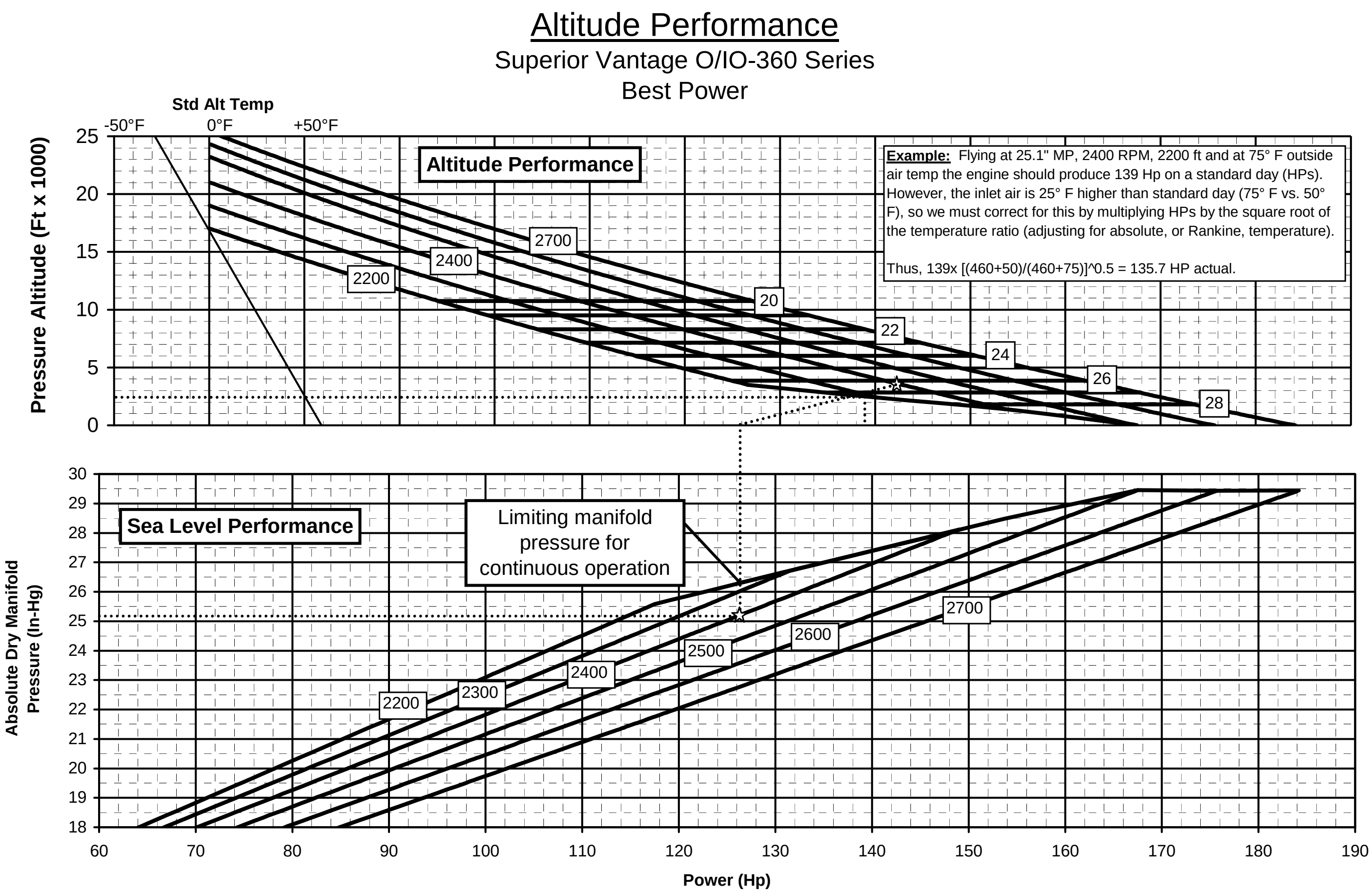


Figure 8 • Altitude Performance At Best Power

Cruise Performance

Superior Vantage O/IO-360 Series
80% Power (144 Hp) - Rich of Peak Operation

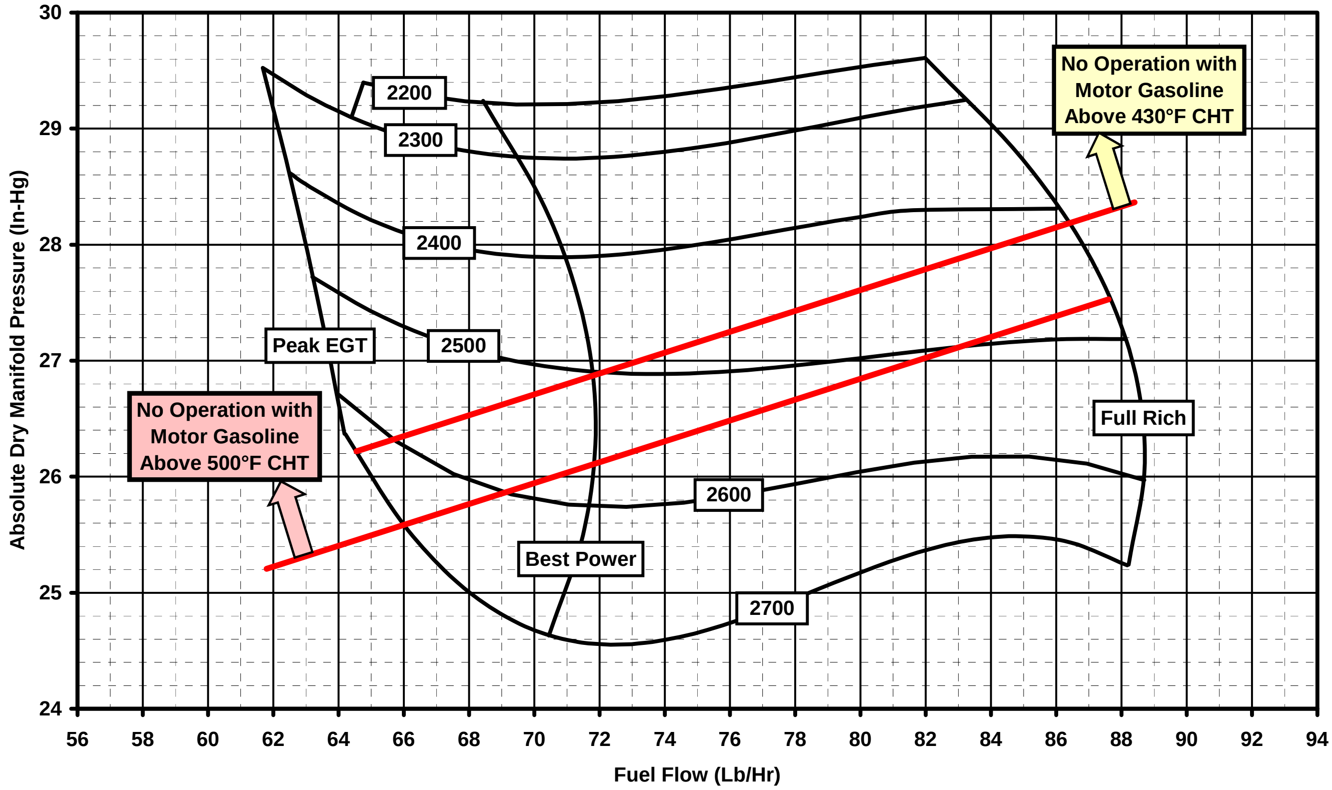


Figure 9 • Cruise Performance Map-80% Power

Cruise Performance

Superior Vantage O/IO-360 Series
70% Power (126 Hp) - Rich of Peak Operation

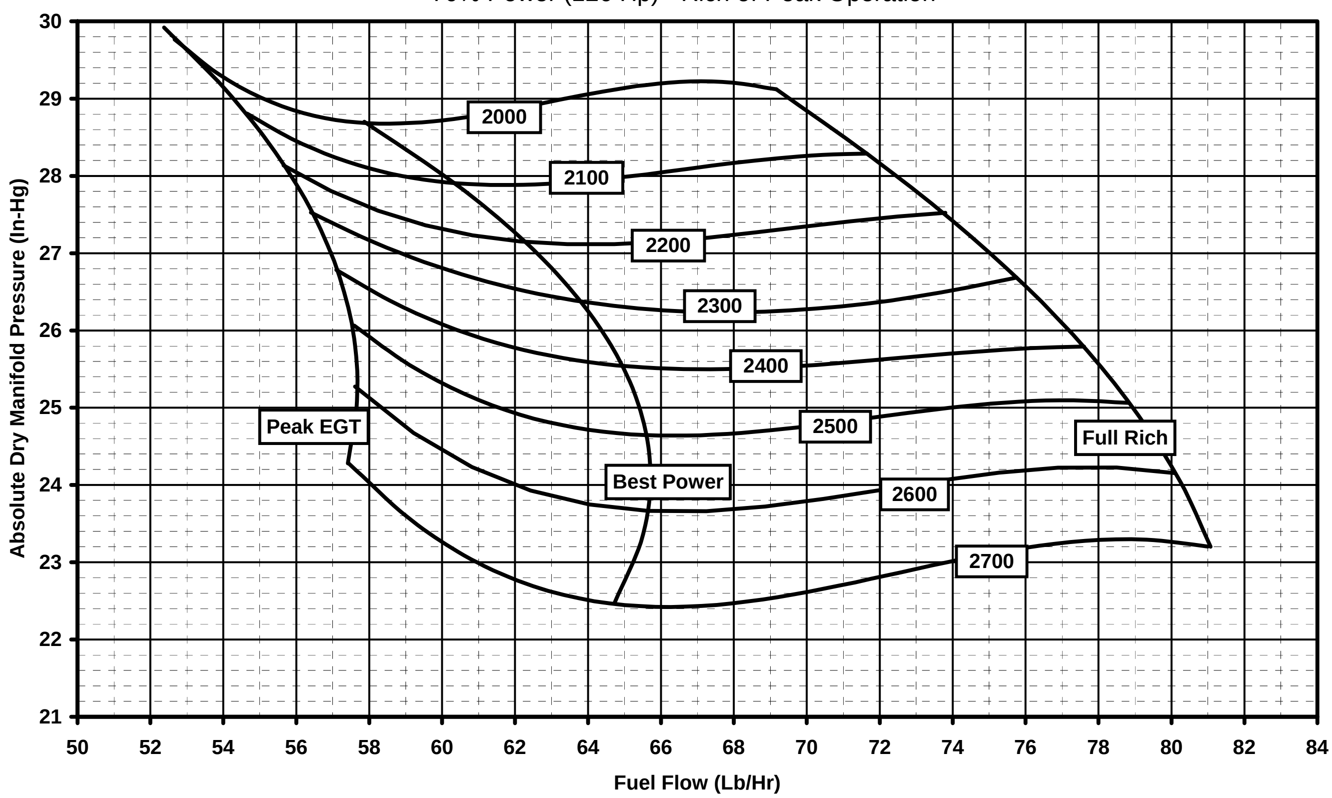


Figure 10 • Cruise Performance Map-70% Power

Cruise Performance

Superior Vantage O/IO-360 Series
60% Power (108 Hp) - Rich of Peak Operation

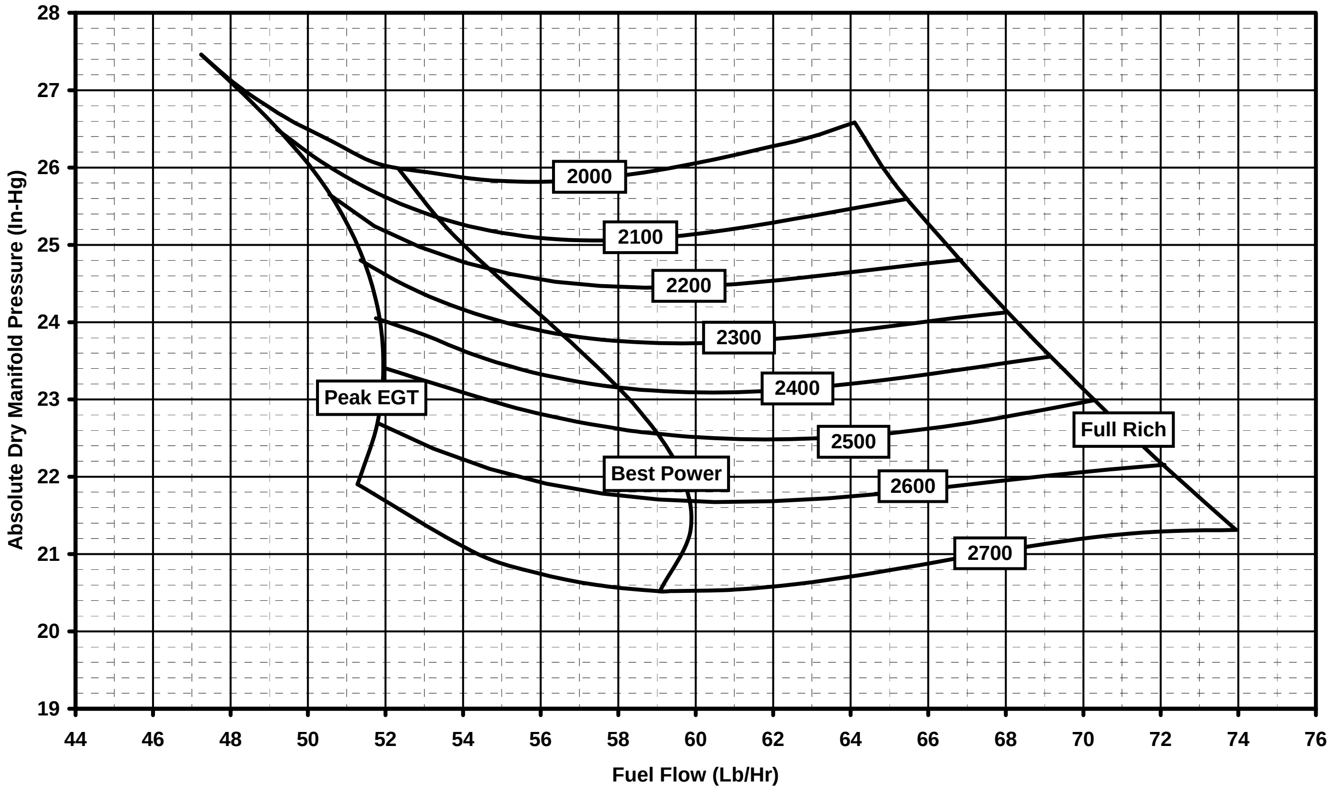


Figure 11 • Cruise Performance Map-60% Power

Performance Cruise Fuel Mixture Curve

Superior Vantage O-360 Series
26 in-Hg x 2400 RPM

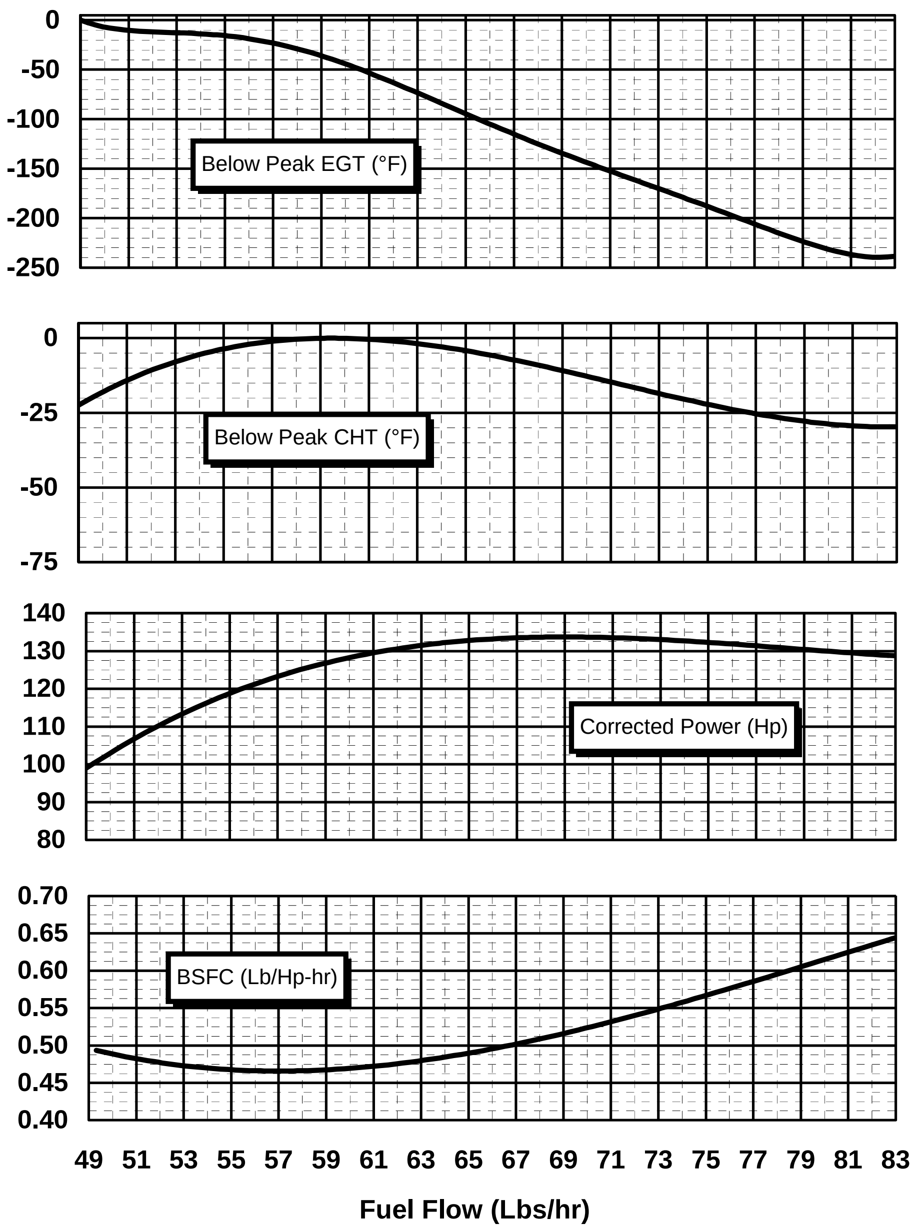


Figure 12 • Fuel Mixture Curve-75% Power

Economy Cruise Fuel Mixture Curves

Superior Vantage O-360 Series
24 in-Hg x 2400 RPM

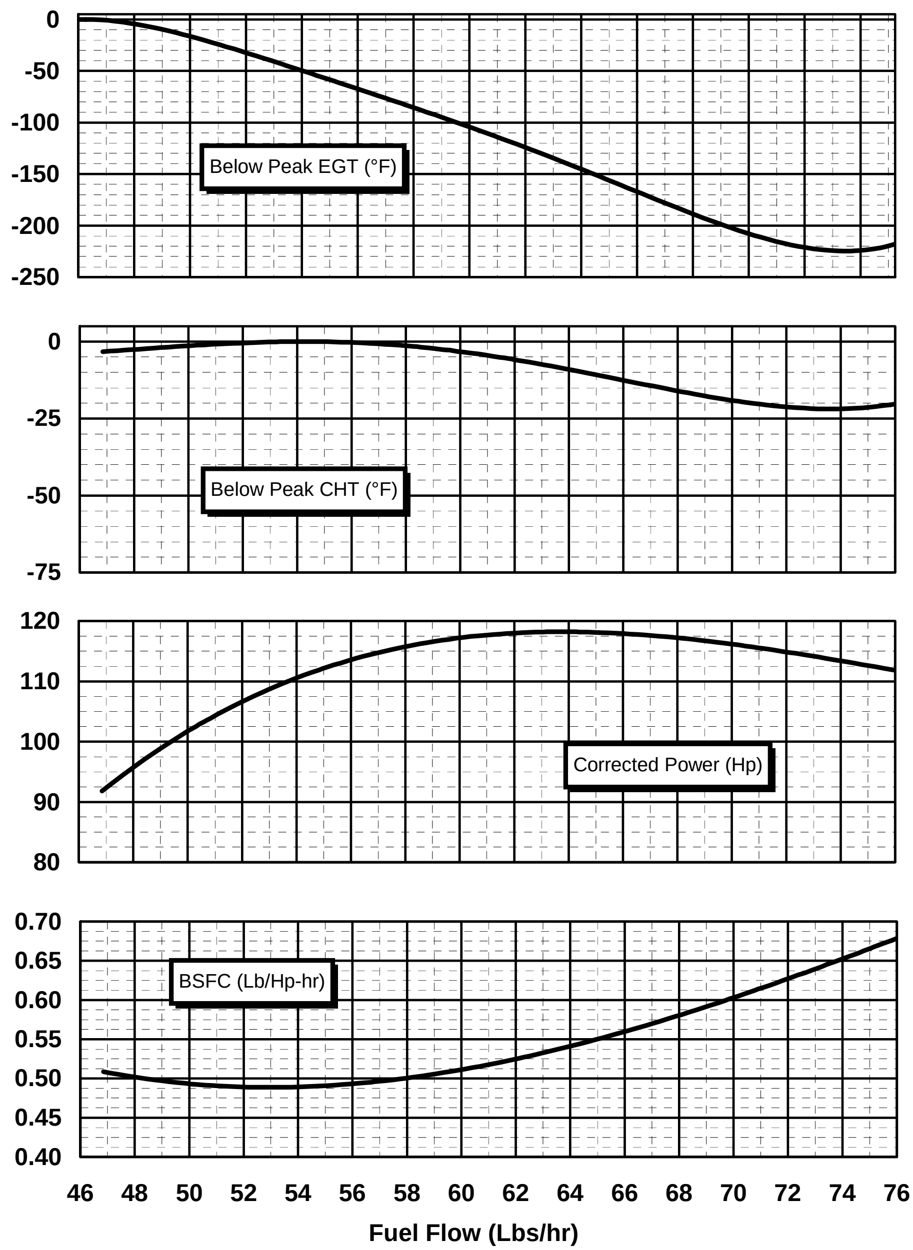


Figure 13 • Fuel Mixture Curve-65% Power

Minimum Oil Quantity

Superior Vantage O/IO-360 Series

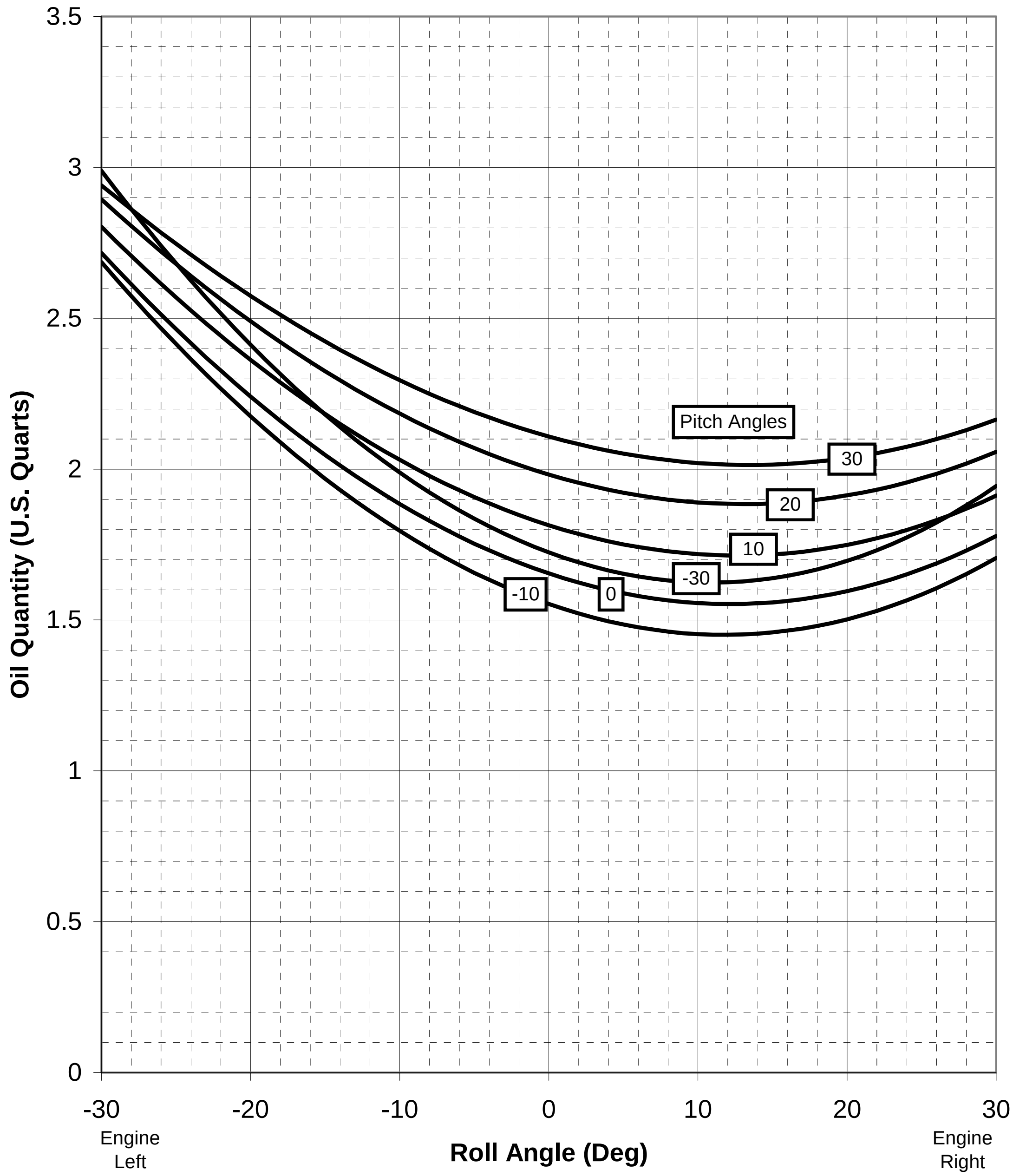


Figure 14 • Minimum Oil Quantity

Table 1 • Maximum Fuel Flow Requirements	
	Max Rich Fuel Flow Required (Pounds Per Hour)
O-360	108

Table 2 • Fuel Filter Requirements	
100 Mesh Screen	0.005 Max Particle Size

Table 3 • Fuel Pump Inlet Pressure Limits		
	Minimum (PSIG)	Maximum (PSIG)
O-360	+0.5	+8

Table 4 • Oil Heat Rejection, Airside Heat Rejection, Crankcase Pressure		
Oil Heat Rejection	Typical (1)	450 BTU/Minute
	Maximum (2)	1000 BTU/Minute
Cylinder Cooling Airflow	Minimum	1800 Ft^3/Min (Sea Level) (6.3 In-H_2O Baffle Press Drop)
	Recommended	2200 Ft^3/Min (Sea Level) (6.5 In-H_2O Baffle Press Drop)
Crankcase Pressure	Maximum	4.0 In-H_2O

Notes: (1) Typical Heat Rejection In Cruise
(2) Maximum Heat Rejection at Full Power and Limiting Oil Temperature

Table 5 • Oil Pressure Limits			
Operational Pressures	**Max.**	**Min.**	**Idling**
Normal Operating	95	55	20
Cold	115	-	-

Table 6 • Engine Accessories						
Model	**Left Magneto**	**Right Magneto**	**Carburetor**	**Fuel Pump**	**Starter**	**Spark Plug Harness**
O-360	Unison 4371	Unison 4371	Precision MA-4-5	Aero Acc. AF15472	SkyTec 149-12LS	Unison M4001

Table 7 • Engine Weight & Location of Center of Gravity *				
		Center of Gravity		
Engine	**Weight (Lb)**	**X (In)**	**Y (In)**	**Z (In)**
O-360-Axxx	288	-.44	2.74	7.10
O-360-Bxxx	291	-.50	2.80	7.05
O-360-Cxxx	291	-.44	2.74	7.11
O-360-Dxxx	294	-.50	2.80	7.06
O-360-Exxx	295	-.44	2.74	7.15

***For definition of "X", "Y" and "Z" see figures 3a & 3b**

Table 8 • Engine Moment of Inertia			
	Moment of Inertia About the Center of Gravity		
Engine Model	**Roll (In-Lb$_f$-Sec^2)**	**Pitch (In-Lb$_f$-Sec^2)**	**Yaw (In-Lb$_f$-Sec^2)**
O-360-Axxx	49.0	40.2	65.9
O-360-Bxxx	49.2	49.5	67.1
O-360-Cxxx	49.0	40.6	66.6
O-360-Dxxx	49.2	50.0	67.8
O-360-Exxx	49.0	41.0	67.2

Table 9 • Oil Temperature Limits	
Minimum for Take-off	75°F (24°C)
Maximum Allowable	240°F (116°C)
Recommended Cruising	130°F - 200°F (54° - 93°C)

Table 10 • Fuel Grade Requirements

Model	Aviation Grade Fuel – Minimum Octane	Motor Fuel
O-360	91 / 98 Lead Optional	91

Table 11 • Operating Conditions

Operation	RPM	MAP	HP	Fuel Cons. Lbs./Hr.	Max. Oil Cons. Qts./Hr.	Max. Cyl. Head Temp.
Maximum Rated	2700	WOT	180	108 (Best Pwr)	.75	500°F (260°C)
Performance Cruise 80% Rated	2500	26”	144	72 (Best Pwr)	.50	500°F (260°C)
Economy Cruise 60% Rated	2400	24”	108	52 (Peak EGT)	.40	500°F (260°C)

Table 12 • Accessory Temperature Limits	
Magnetos	185°F (82°C) (Ambient)
Starter	None
Fuel Pump	See Chapter 6 Operating Instructions for Fuel Temp. Limits

IO-360 SERIES ENGINE

MODEL SPECIFICATION DATA

APPENDIX B

APPENDIX B
TABLE OF CONTENTS

Page Number

Figures

1	Induction Airflow Requirements	1
2	Inter-Cylinder Baffle Performance	2
3a	Location of Engine Center of Gravity - Horizontal	3
3b	Location of Engine Center of Gravity - Vertical	4
4	IO-360 Installation Drawing Front View	5
5	IO-360 Installation Drawing Top View	6
6	Fuel Injection Installation Drawing	7
7	Propeller Load And Full Throttle Curves	8
8	Altitude Performance At Best Power	9
9	Cruise Performance Map-80% Power	10
10	Cruise Performance Map-70% Power	11
11	Cruise Performance Map-60% Power	12
12	Fuel Mixture Curve-75% Power	13
13	Fuel Mixture Curve-65% Power	14
14	Minimum Oil Quantity	15

Tables

1	Maximum Fuel Flow Requirements	16
2	Fuel Filter Requirements	16
3	Fuel Pump Inlet Pressure Limits	16
4	Oil Heat Rejection, Airside Heat Rejection, Crankcase Pressure	16
5	Oil Pressure Limits	17
6	Engine Accessories	17
7	Engine Weight & Location of Center of Gravity	17
8	Engine Moment of Inertia	17
9	Oil Temperature Limits	18
10	Fuel Grade Requirements	18
11	Operating Conditions	18
12	Accessory Temperature Limits	18

Induction Air Flow

Superior Vantage O/IO-360 Series

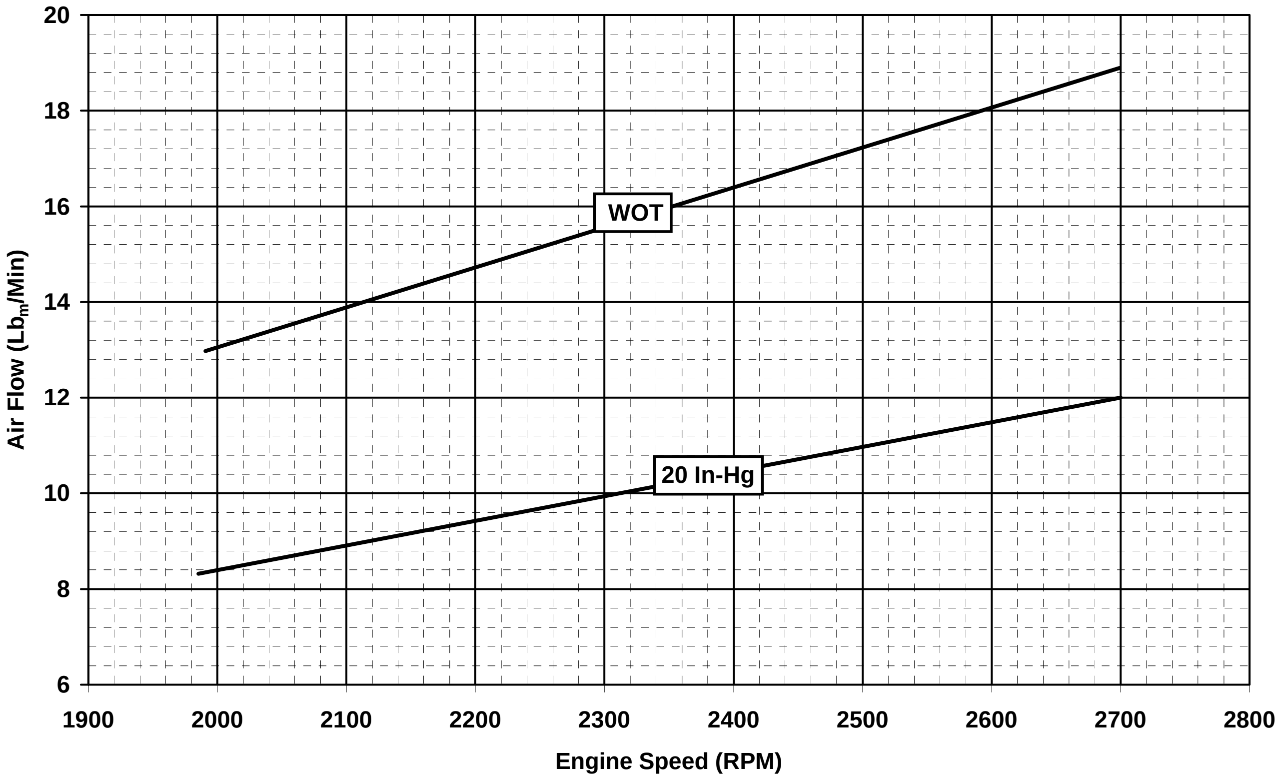


Figure 1 • Induction Air Flow Requirements

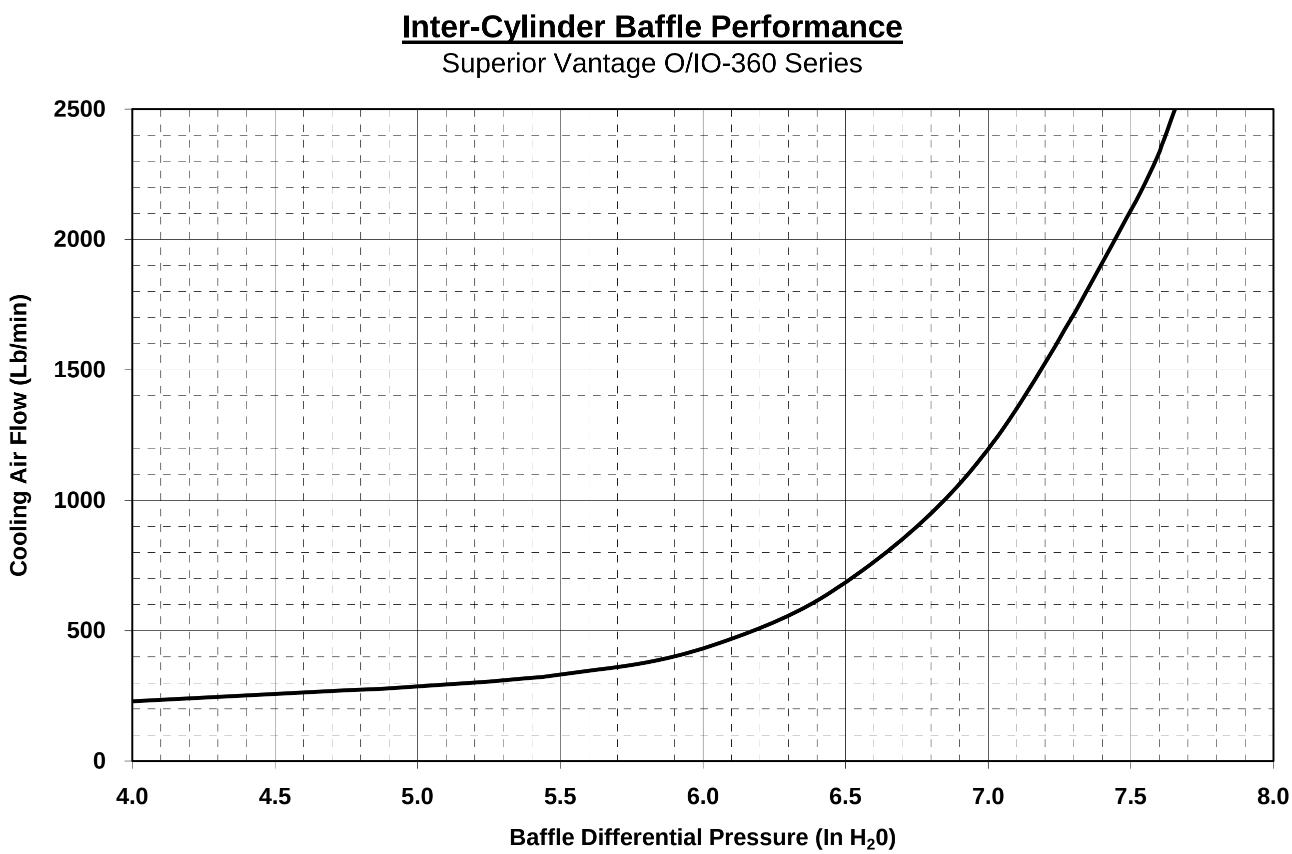


Figure 2 • Inter-Cylinder Baffle Performance

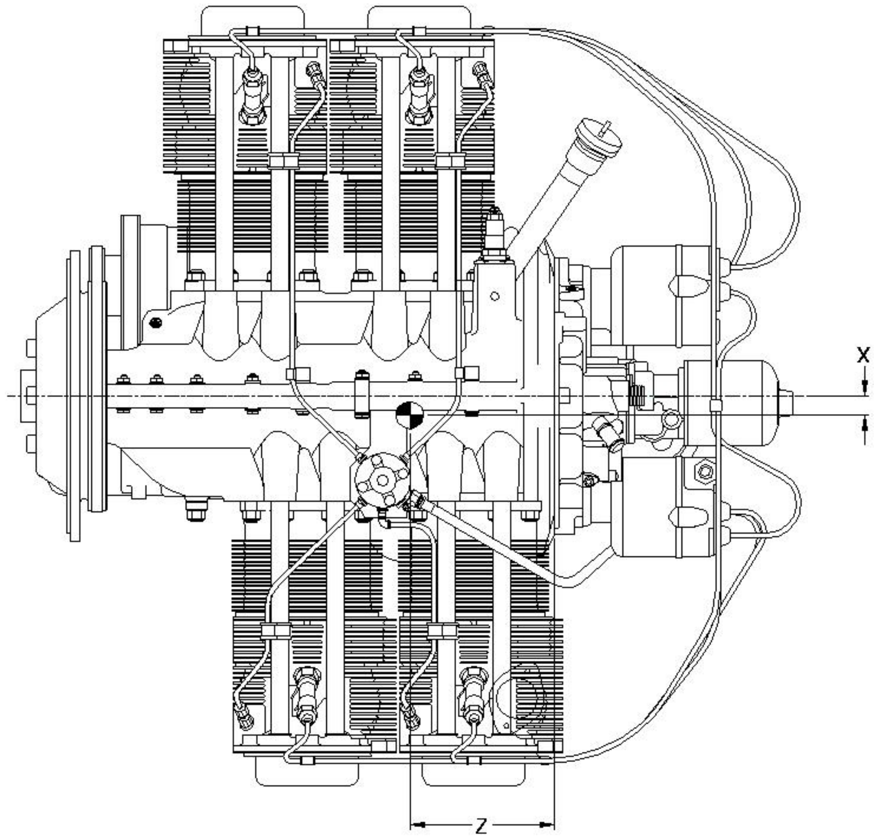


Figure 3a • Location of Engine Center of Gravity - Horizontal

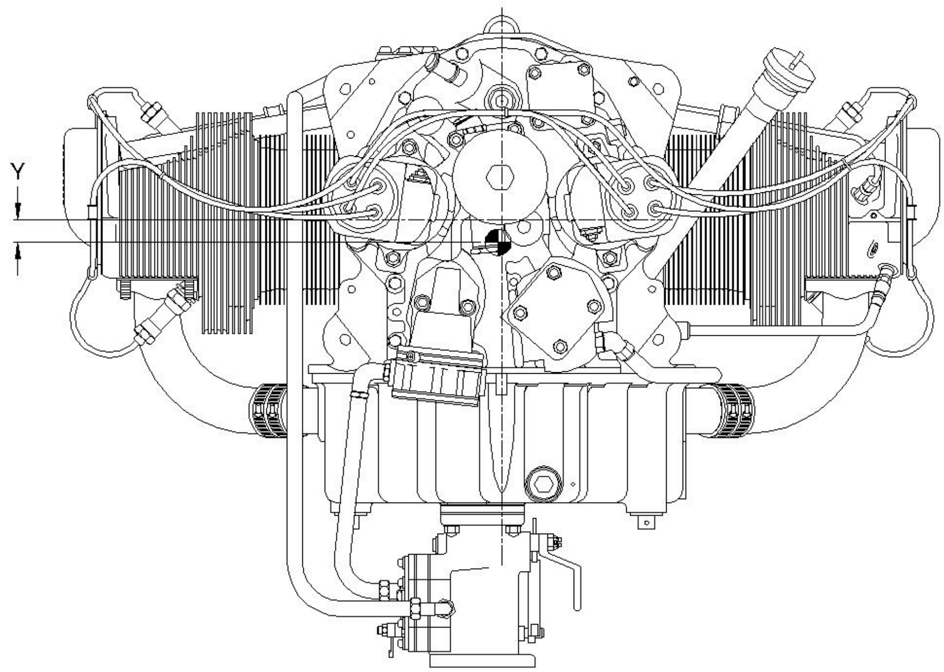


Figure 3b • Location of Engine Center of Gravity - Vertical

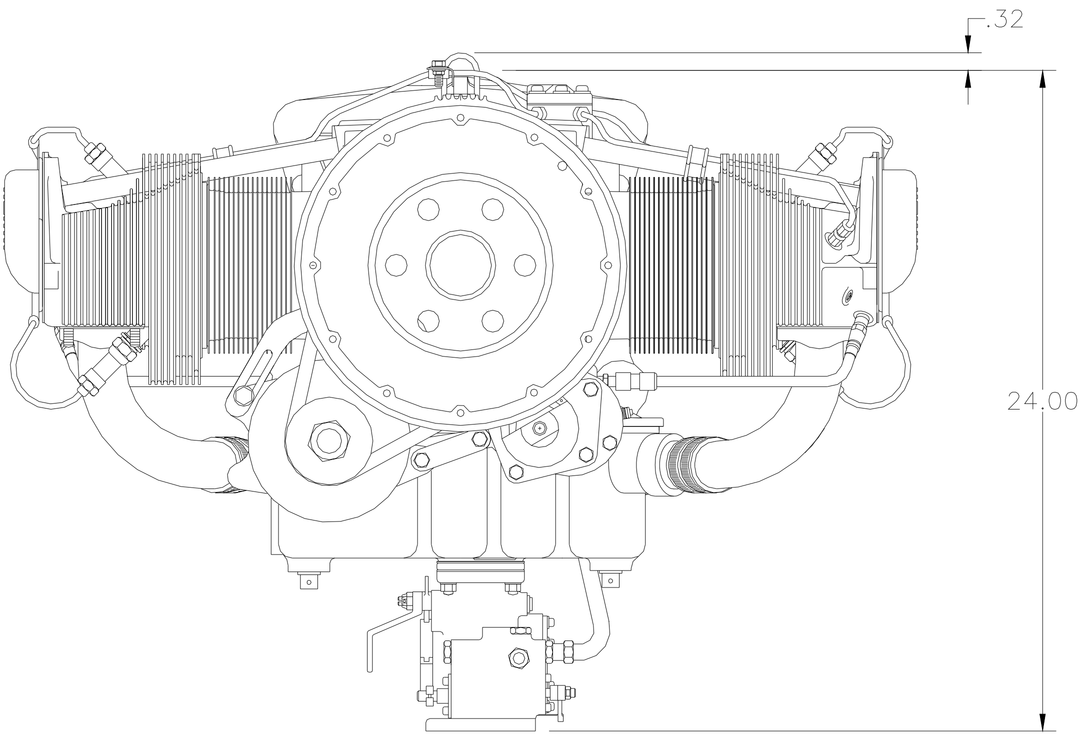


Figure 4 • IO-360 Installation Drawing Front View

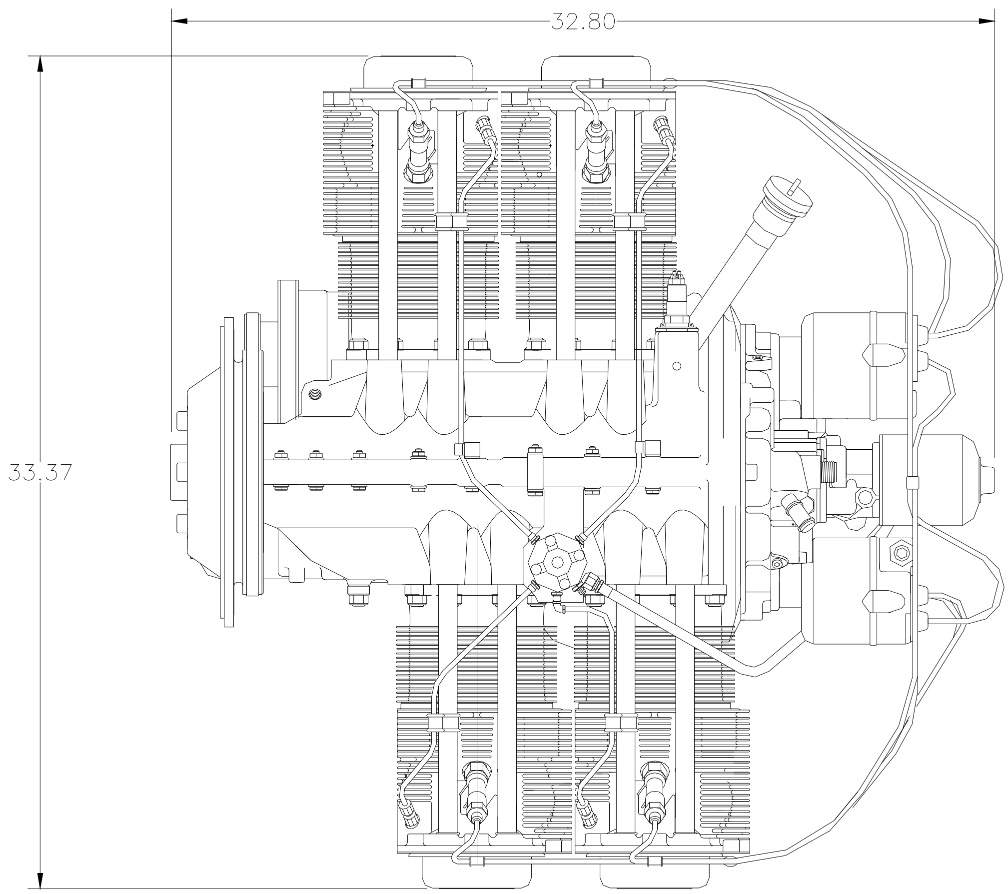
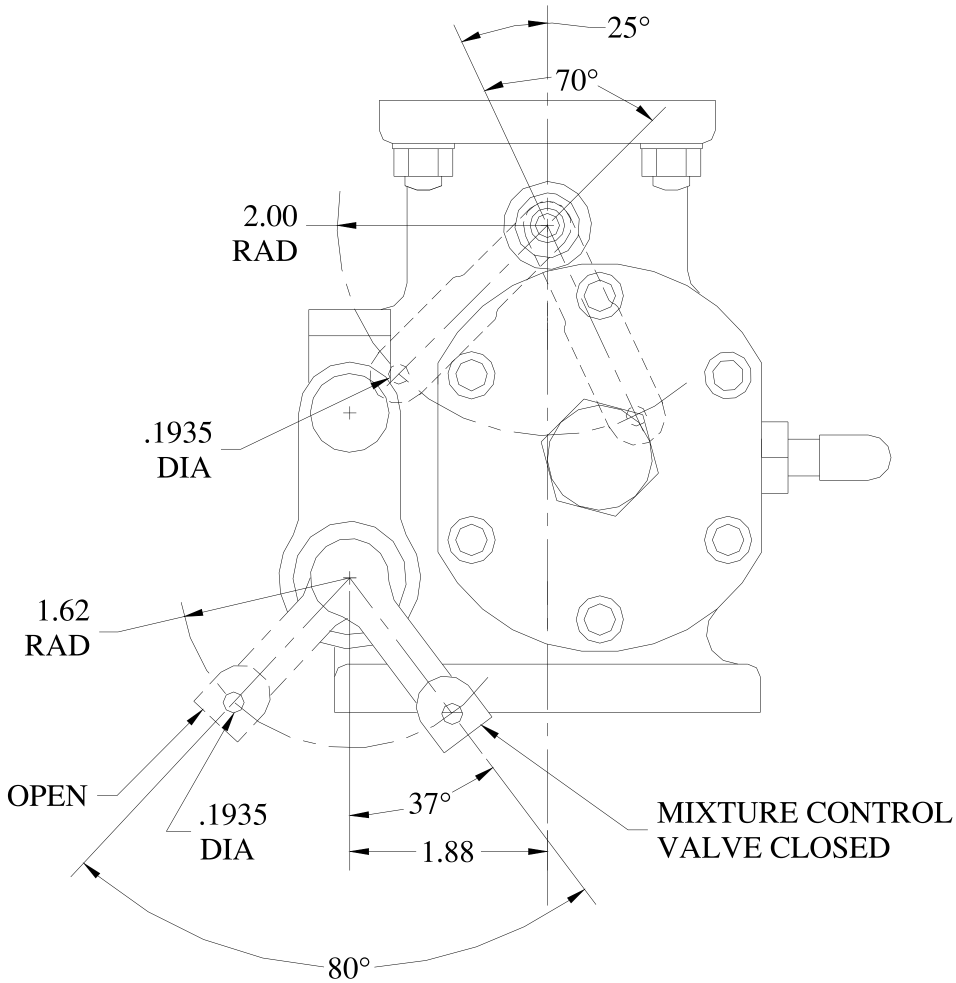


Figure 5 • IO-360 Installation Drawing Top View



Fuel Metering System
Fuel Injector

Figure 6 • Fuel Injection Installation Drawing

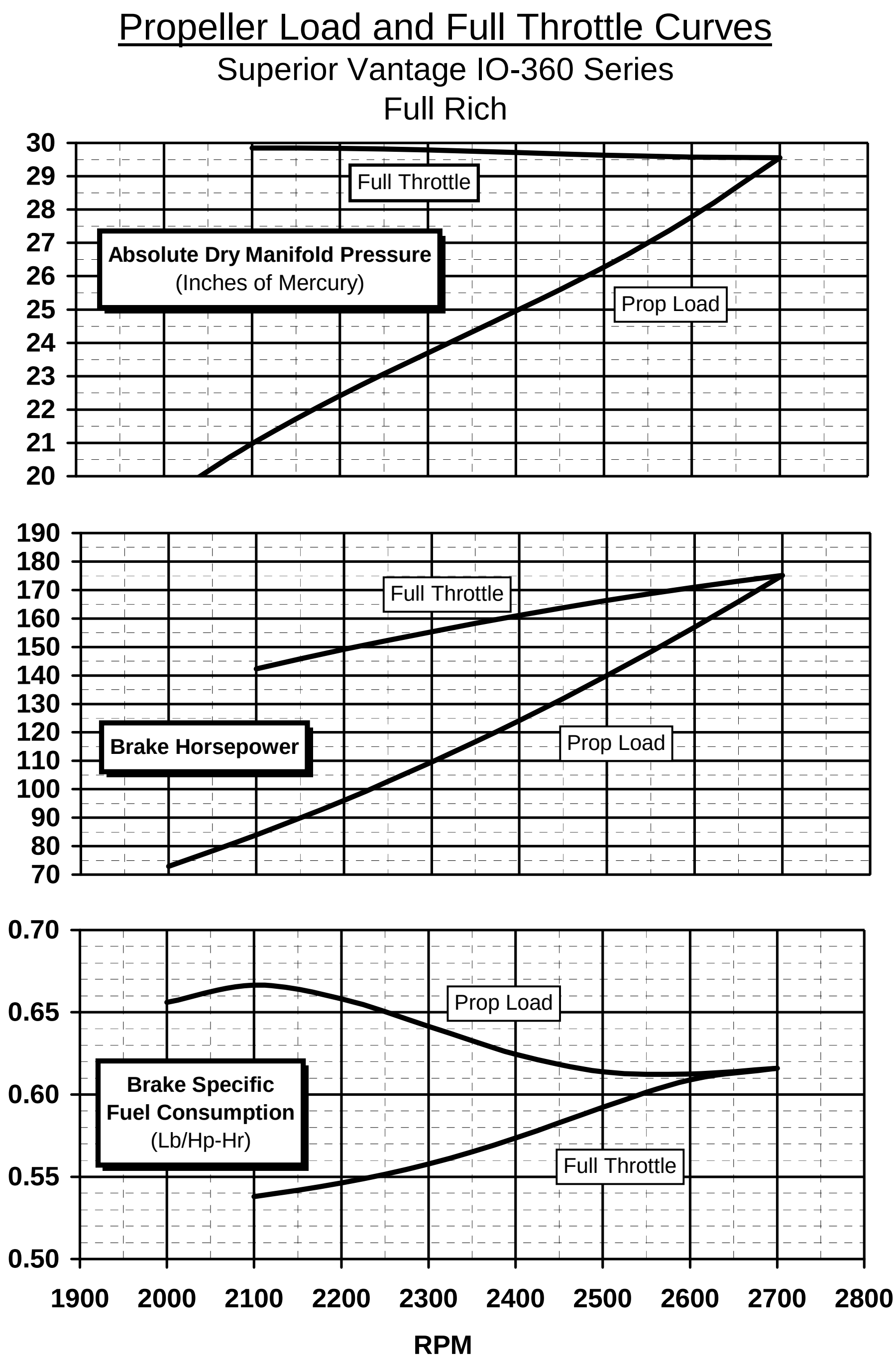


Figure 7 • Propeller Load And Full Throttle Curves

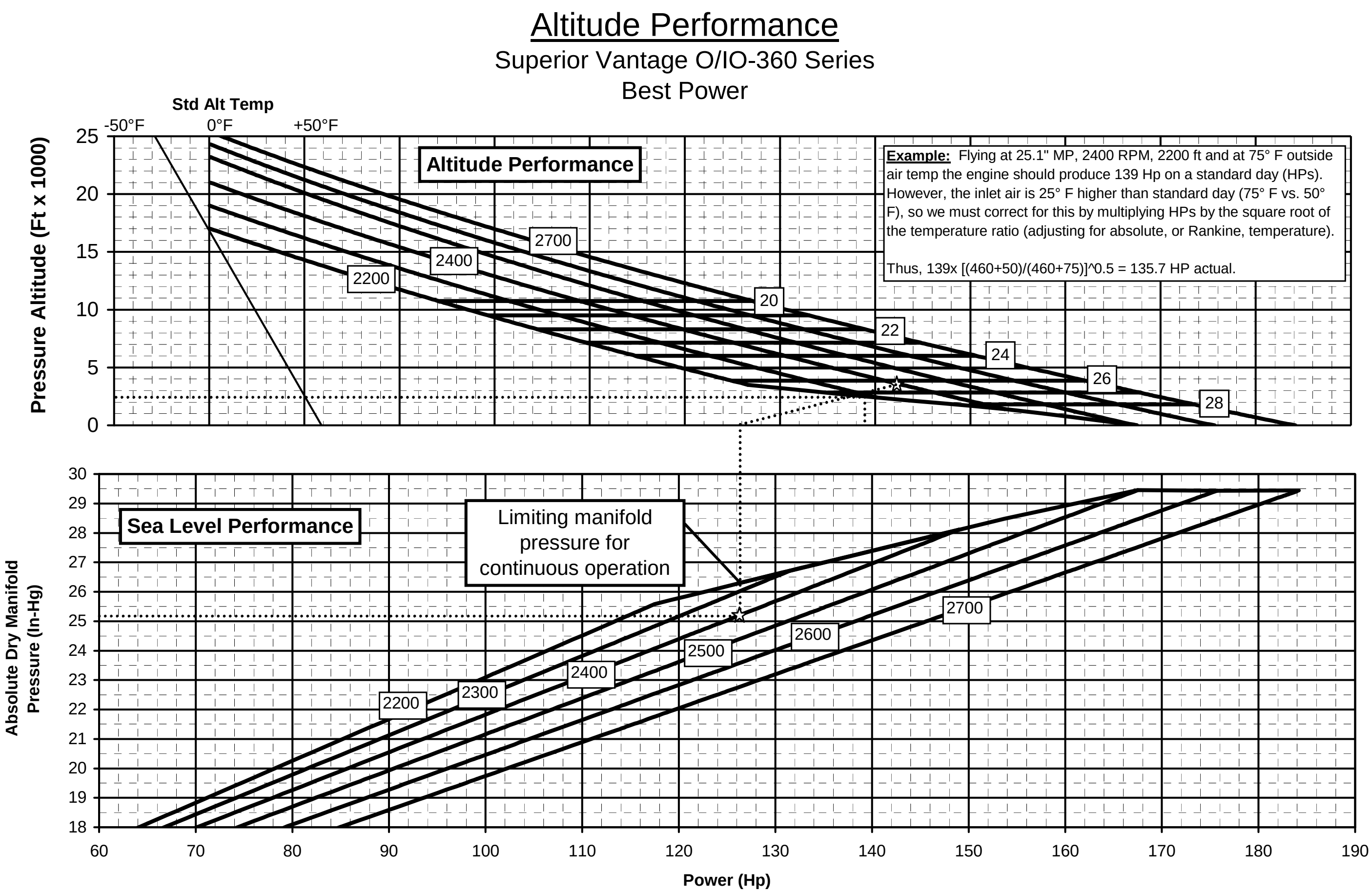


Figure 8 • Altitude Performance At Best Power

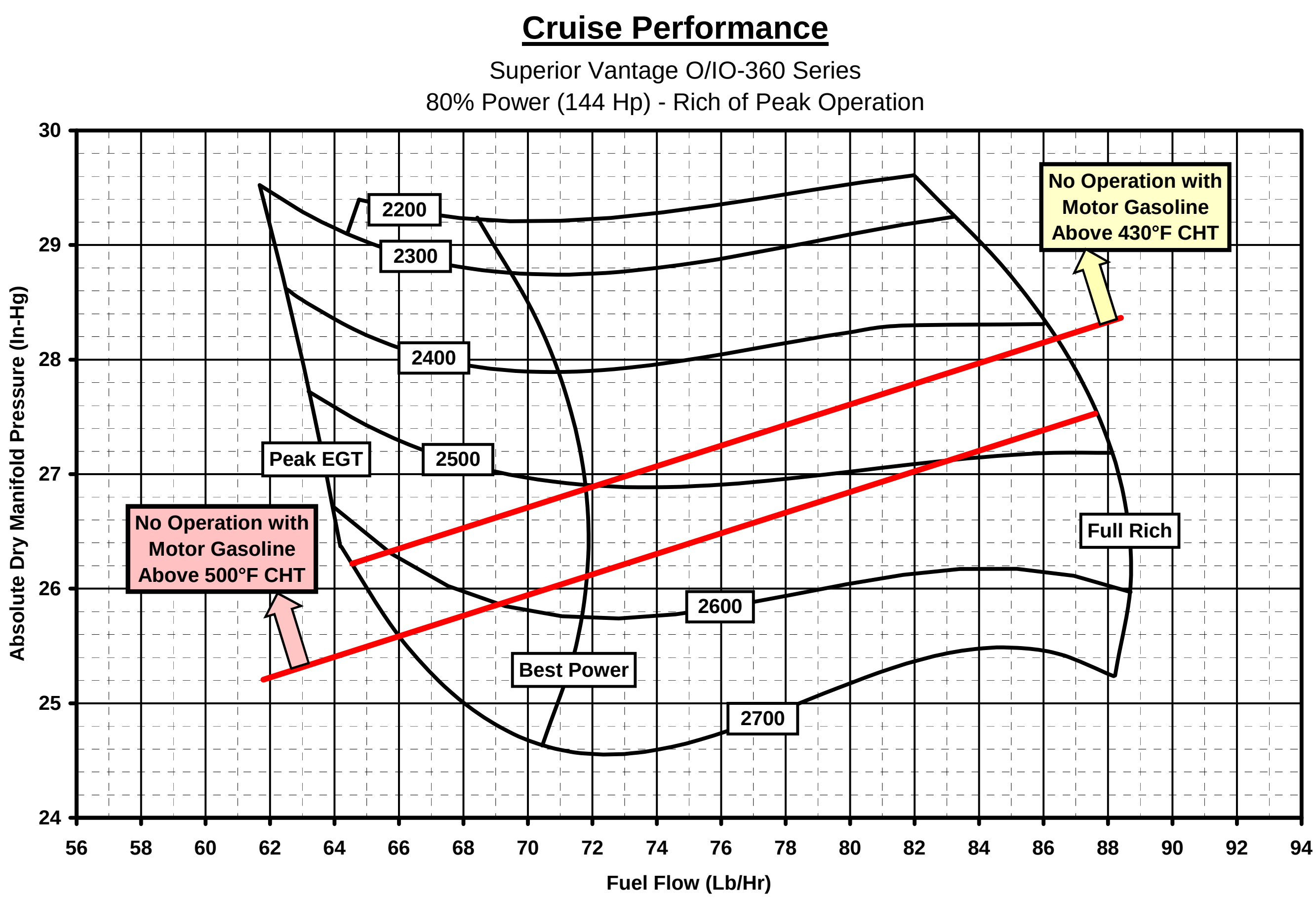


Figure 9 • Cruise Performance Map-80% Power

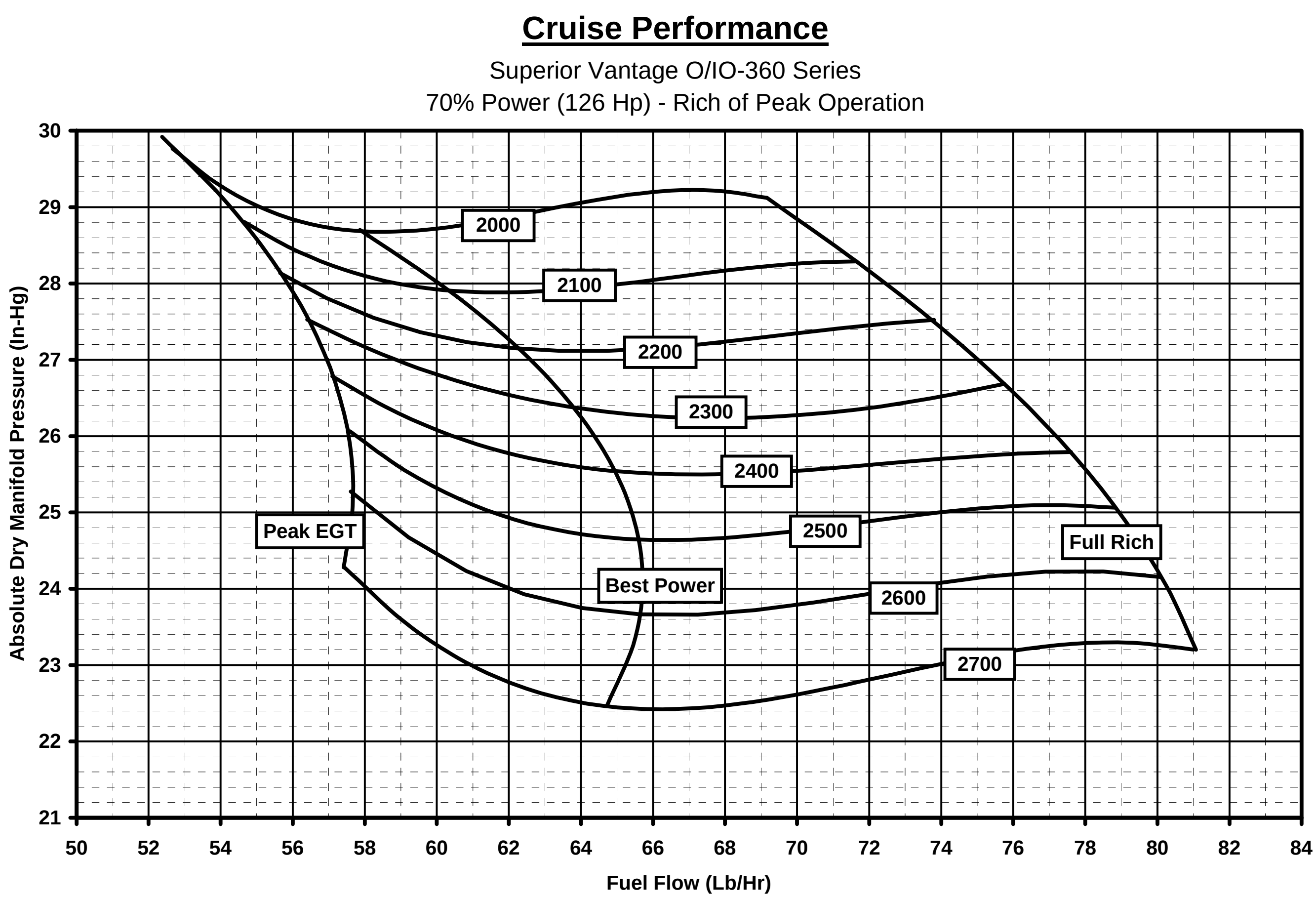


Figure 10 • Cruise Performance Map-70% Power

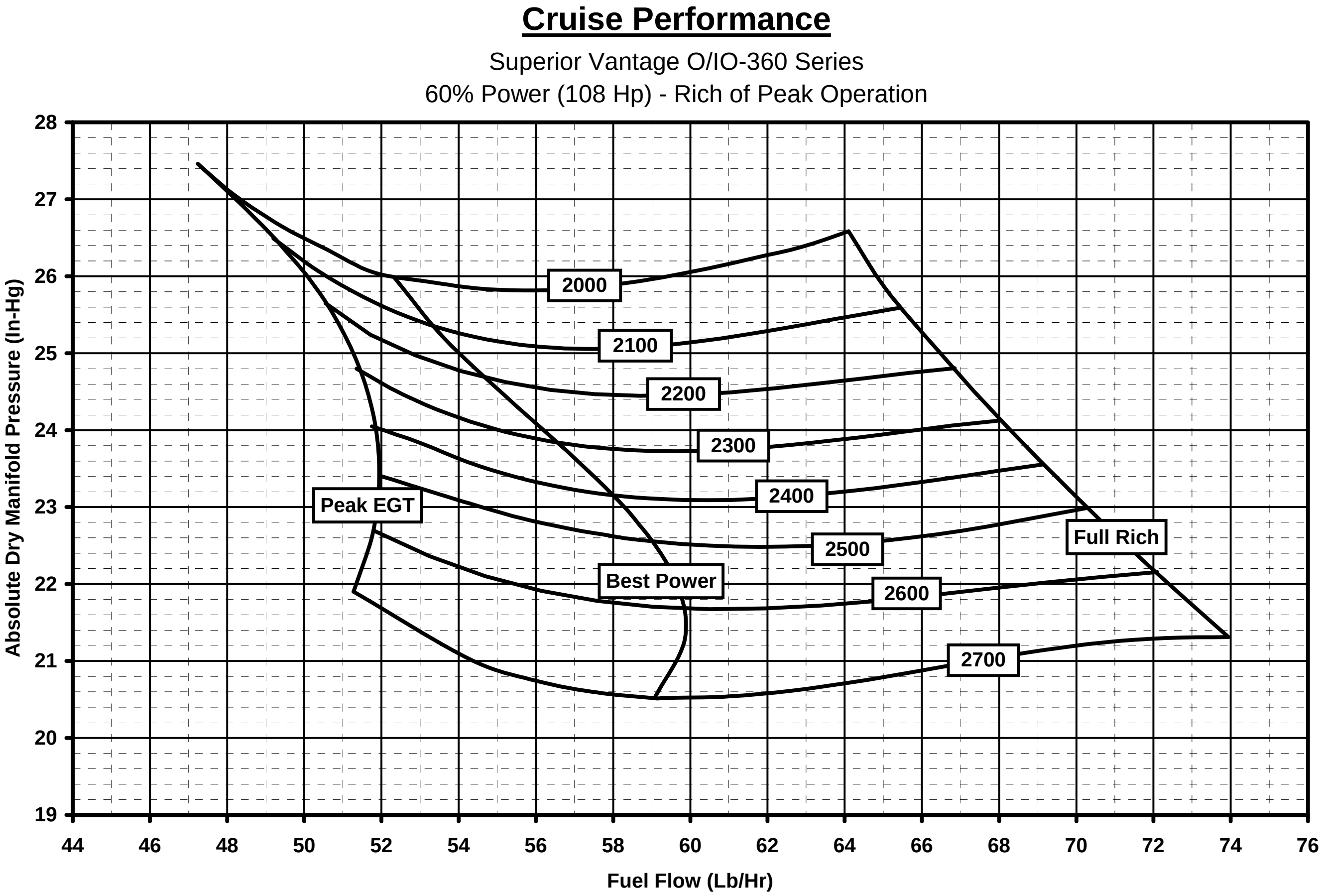


Figure 11 • Cruise Performance Map-60% Power

Performance Cruise Fuel Mixture Curve

Superior Vantage IO-360 Series
26 in-Hg x 2400 RPM

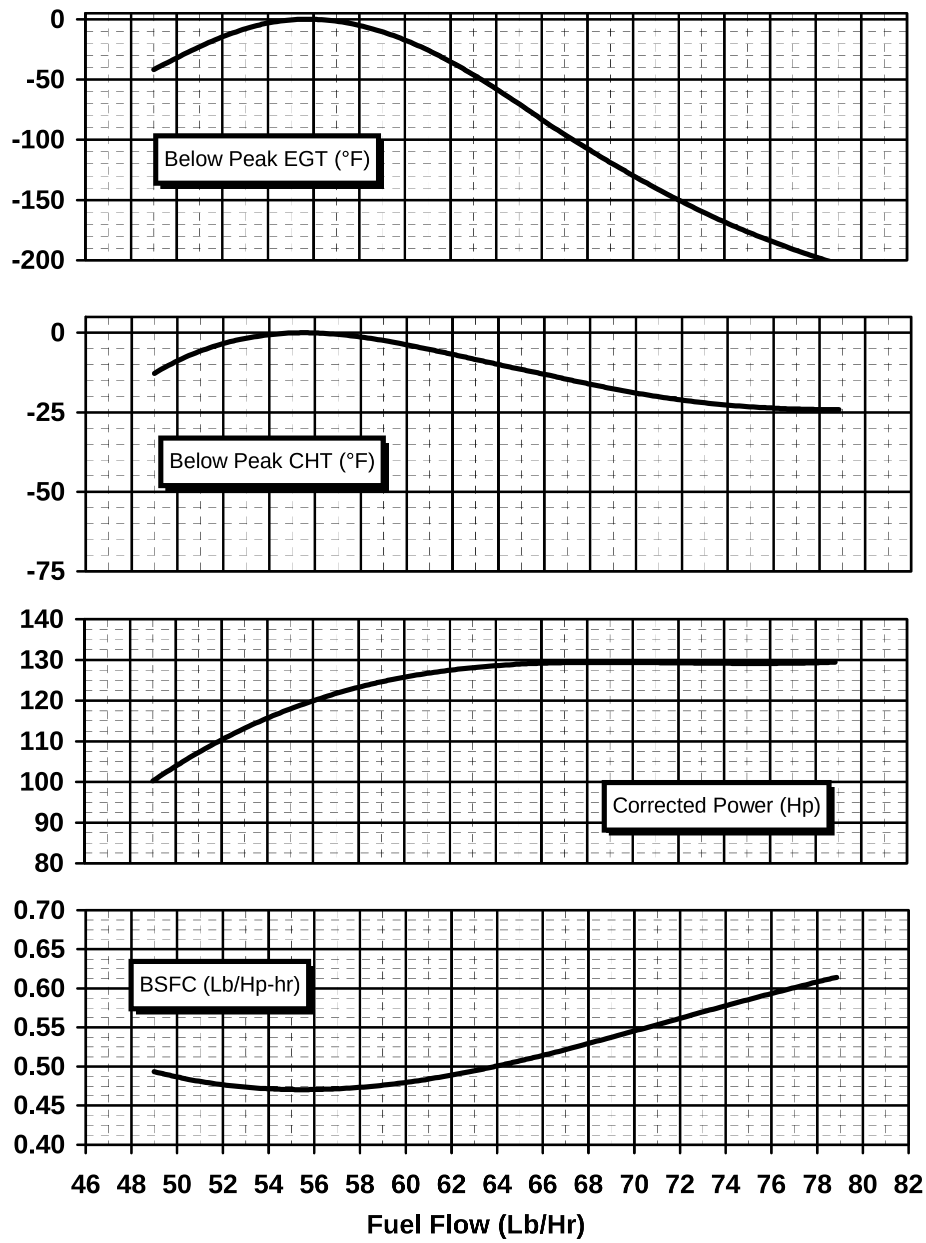


Figure 12 • Fuel Mixture Curve-75% Power

Economy Cruise Fuel Mixture Curve

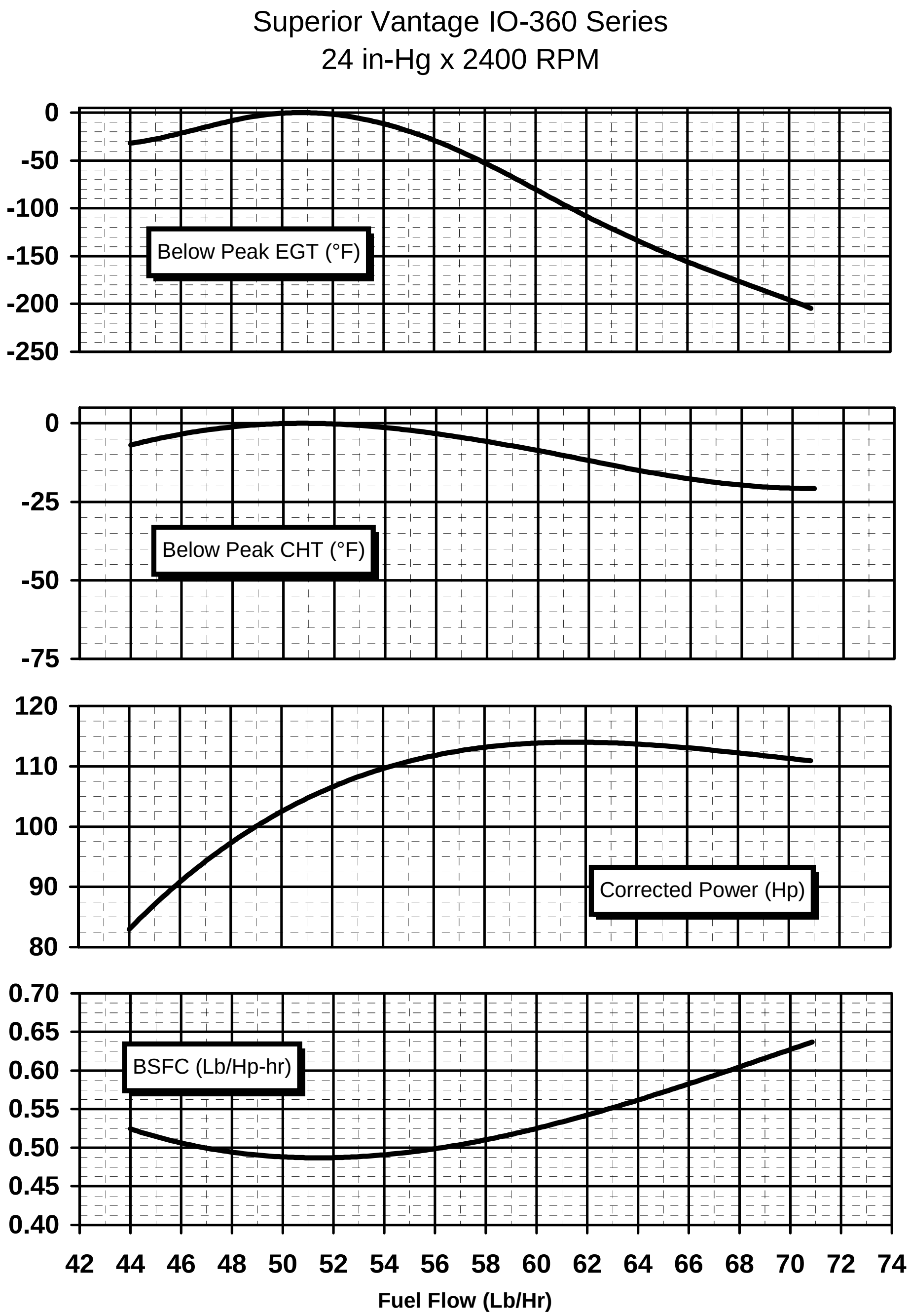


Figure 13 • Fuel Mixture Curve-65% Power

Minimum Oil Quantity

Superior Vantage O/IO-360 Series

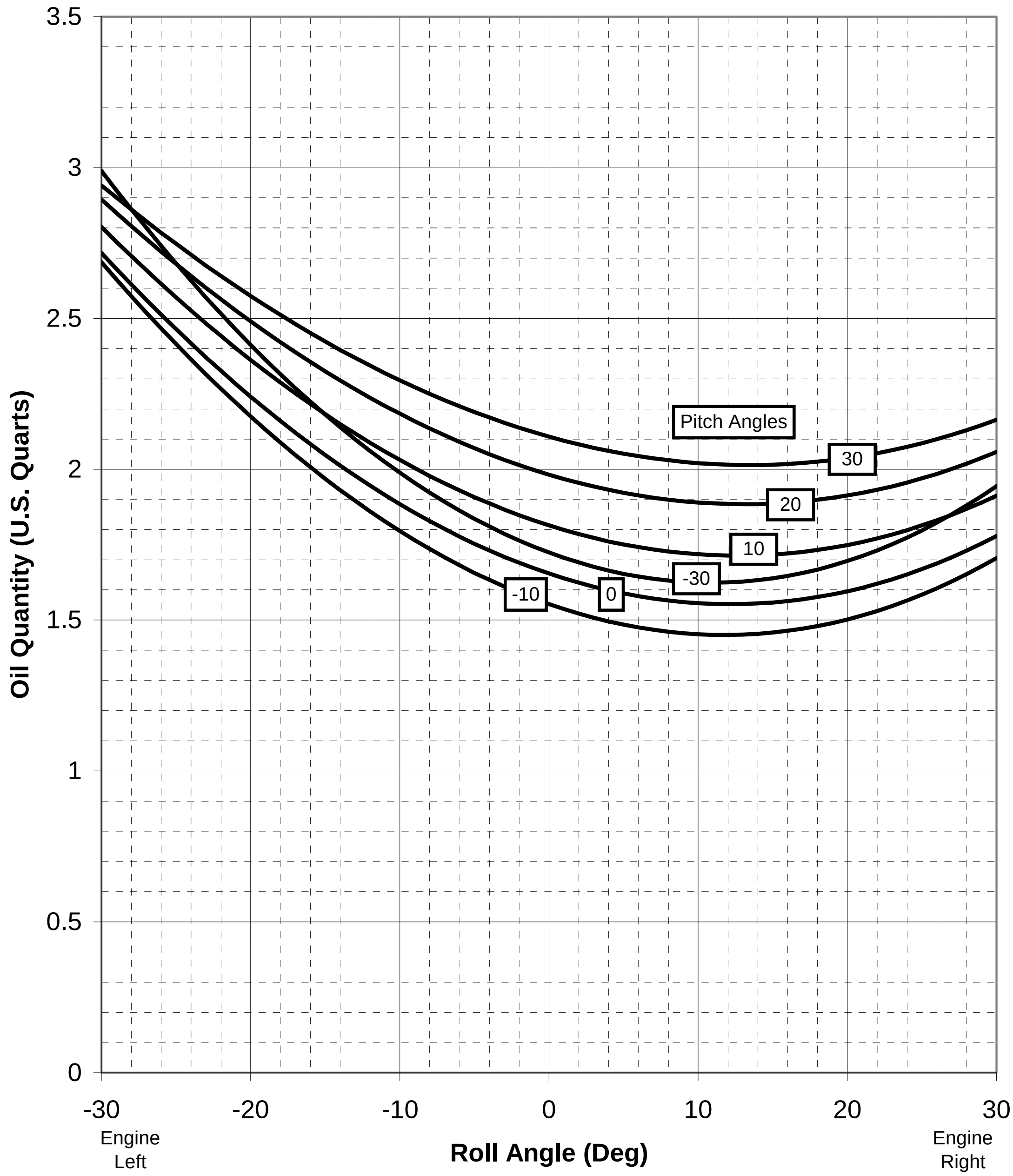


Figure 14 • Minimum Oil Quantity

Table 1 • Maximum Fuel Flow Requirements

	Max Rich Fuel Flow Required (Pounds Per Hour)
IO-360	108

Table 2 • Fuel Filter Requirements

100 Mesh Screen	0.005 Max Particle Size

Table 3 • Fuel Pump Inlet Pressure Limits

	Minimum (PSIG)	Maximum (PSIG)
IO-360	-2.0	+35.0

Table 4 • Oil Heat Rejection, Airside Heat Rejection, Crankcase Pressure

Oil Heat Rejection	Typical (1)	450 BTU/Minute
	Maximum (2)	1000 BTU/Minute
Cylinder Cooling Airflow	Minimum	1800 Ft^3/Min (Sea Level) (6.3 In-H_2O Baffle Press Drop)
	Recommended	2200 Ft^3/Min (Sea Level) (6.5 In-H_2O Baffle Press Drop)
Crankcase Pressure	Maximum	4.0 In-H_2O

Notes: (1) Typical Heat Rejection In Cruise
(2) Maximum Heat Rejection at Full Power and Limiting Oil Temperature

Table 5 • Oil Pressure Limits			
Operational Pressures	**Max.**	**Min.**	**Idling**
Normal Operating	95	55	20
Cold	115	-	-

Table 6 • Engine Accessories						
Model	**Left Magneto**	**Right Magneto**	**Carburetor**	**Fuel Pump**	**Starter**	**Spark Plug Harness**
IO-360	Unison 4371	Unison 4371	Precision RSA--5	Aero Acc. AF15473	SkyTec 149-12LS	Unison M4001

Table 7 • Engine Weight & Location of Center of Gravity *				
		Center of Gravity		
Engine	**Weight (Lb)**	**X (In)**	**Y (In)**	**Z (In)**
IO-360-Axxx	290	-.39	2.69	7.10
IO-360-Bxxx	293	-.44	2.75	7.05
IO-360-Cxxx	293	-.39	2.69	7.11
IO-360-Dxxx	296	-.44	2.75	7.06
IO-360-Exxx	297	-.39	2.69	7.15

***For definition of “X”, “Y” and “Z” see figures 3a & 3b**

Table 8 • Engine Moment of Inertia			
	Moment of Inertia About the Center of Gravity		
Engine Model	**Roll ($In\text{-}Lb_f\text{-}Sec^2$)**	**Pitch ($In\text{-}Lb_f\text{-}Sec^2$)**	**Yaw ($In\text{-}Lb_f\text{-}Sec^2$)**
IO-360-Axxx	50.2	40.5	64.7
IO-360-Bxxx	50.5	49.8	67.4
IO-360-Cxxx	50.2	40.9	65.3
IO-360-Dxxx	50.5	50.3	68.1
IO-369-Exxx	50.2	41.3	66.0

Table 9 • Oil Temperature Limits	
Minimum for Take-off	75°F (24°C)
Maximum Allowable	240°F (116°C)
Recommended Cruising	130°F - 200°F (54°C – 93°C)

Table 10 • Fuel Grade Requirements		
Model	**Aviation Grade Fuel – Minimum Octane**	**Motor Fuel**
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Table 11 • Operating Conditions

Operation	RPM	MAP	HP	Fuel Cons. Lbs./Hr.	Max. Oil Cons. Qts./Hr.	Max. Cyl. Head Temp.
Maximum Rated	2700	WOT	180	108 (Best Pwr)	.75	500°F
Performance Cruise 80% Rated	2500	26"	144	72 (Best Pwr)	.50	500°F
Economy Cruise 60% Rated	2400	24"	108	52 (Peak EGT)	.40	500°F

Table 12 • Accessory Temperature Limits	
Magnetos	185°F (85°C) (Ambient)
Starter	None
Fuel Pump	See Chapter 6 Operating Instructions for Fuel Temp. Limits