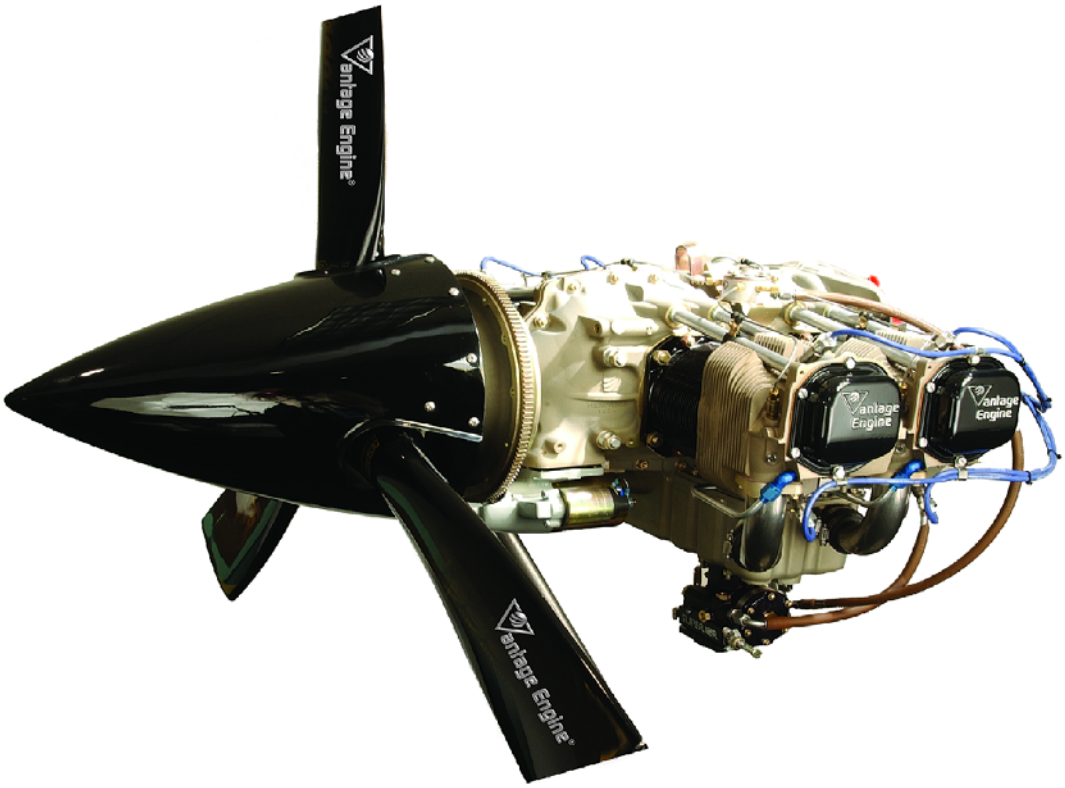
O-360 & IO-360 SERIES ENGINES

OVERHAUL MANUAL



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Manual P/N SVOHM01 Revision A, March 2005

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Manual Number SVOHM01

Revision History

Revision Letter	Effective Date	Description	Pages Revised
A	08/31/04	Initial Release	All

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SAFETY ADVISORY

WARNING: **BEFORE MATERIALS CALLED OUT IN THIS PUBLICATION ARE USED, KNOW THE HANDLING, STORAGE AND DISPOSAL PRECAUTIONS RECOMMENDED BY THE MANUFACTURER OR SUPPLIER. FAILURE TO COMPLY WITH THE MANUFACTURERS' OR SUPPLIERS' RECOMMENDATION CAN RESULT IN PERSONAL INJURY.**

The user must know the manufacturer or supplier information and keep to the procedures, recommendations, warnings and cautions set forth for the use, handling, storage, and disposal of materials. The WARNINGS used in this manual inform the user about dangerous materials or equipment that can cause injury; they do not replace the manufacturer's instructions.

This Safety Advisory has all the warnings included in this manual.

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 INA A WELL VENTILATED AREA FREE FROM SPARKS, FLAME, OR HOT SURFACES.AVOID EYE AND SKIN CONTACT. 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 AND 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.**

WARNING: **ENGINE OIL IS HAZARDOUS AND MAY CAUSE INJURY TO SKIN AND EYES. PUT ON PERSONNEL PROTECTIVE GEAR.**

WARNING: **USE THE CORRECT PERSONAL PROTECTION. HEATED PARTS WILL CAUSE BURNS.**

WARNING: **WHEN YOU USE COMPRESSED AIR TO CLEAN OR DRY PARTS, MAKE SURE THAT THE PRESSURE IS NOT MORE THAN 30 PSI. DO NOT DIRECT THE AIRSTREAM AT PERSONNEL OR LIGHT OBJECTS. PUT ON GOGGLES OR A FACE SHIELD TO PROTECT YOUR EYES. IF YOU GET AN EYE INJURY, GET MEDICAL ATTENTION.**

WARNING: **LUBRICANTS ARE TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. BEFORE YOU USE, READ THE MATERIAL SAFETY DATA SHEET (MSDS) FROM THE MANUFACTURER OR SUPPLIER. USE IN A WELL VENTILATED AREA FREE FROM SPARKS. WEAR 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: **USE THE CORRECT PERSONAL PROTECTION. POLISHING WILL CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.**

WARNING: **PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.**

WARNING: **USE THE CORRECT PERSONAL PROTECTION EQUIPMENT TO AVOID INJURY. ENSURE AREA IS FREE OF MOVABLE OBJECTS THAT COULD IMPACT BY PROPELLER AIR BLAST.**

WARNING: **ADHESIVE SEALANT IS TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. AVOID EYE AND SKIN CONTACT. USE 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: **SOLVENT IS TOXIC. USE IN WELL-VENTILATED AREA. PREVENT EYE AND SKIN CONTACT AND DO NOT BREATHE VAPORS. 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: **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.**

WARNING: **IF ONE SURFACE IS POLISHED TO UNDERSIZE, ALL CORRESPONDING SURFACES MUST BE POLISHED TO THE SAME SIZE.**

WARNING: **PLACE A SUITABLE STAND UNDER THE AIRCRAFT TAILCONE IF NEEDED BEFORE REMOVING THE ENGINE. THE LOSS OF WEIGHT MAY CAUSE THE AIRCRAFT TAIL TO DROP.**

WARNING: **DO NOT DAMAGE THE NITRIDED SURFACES OF THE CRANKSHAFT.**

WARNING: **USE CORRECT PERSONAL PROTECTION. SOME CHEMICAL SOLUTIONS CAN CAUSE EYE, SKIN, AND LUNG DAMAGE. FOLLOW THE MANUFACTURER'S INSTRUCTIONS FOR EACH STRIPPING SOLUTION.**

WARNING: **USE THE CORRECT PERSONAL PROTECTION. USE OF A HAMMER CAN CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.**

WARNING: **DO NOT ROTATE ENGINE OR CRANKSHAFT BEFORE REMOVAL OF TIMING LOCATOR PINS.**

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

- **VERIFY ALL SPARK PLUG LEADS ARE DISCONNECTED.**
- **VERIFY MAGNETO SWITCHES ARE CONNECTED TO MAGNETOS AND THAT THEY ARE IN THE "OFF" POSITION AND "P" LEADS ARE GROUNDED.**
- **THROTTLE POSITION "CLOSED."**
- **MIXTURE CONTROL "IDLE-CUT OFF."**
- **SET BRAKES AND BLOCK AIRCRAFT WHEELS. ENSURE THAT AIRCRAFT TIE DOWNS ARE INSTALLED AND VERIFY THAT THE CABIN DOOR LATCH IS OPEN.**
- **DO NOT STAND WITHIN THE ARC OF THE PROPELLER BLADES WHILE TURNING THE PROPELLER.**

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INTRODUCTION

About This Manual
The purpose of this Overhaul Manual is to provide the necessary instructions for major repair and replacement of Superior Vantage O-360 and IO-360 series engines. Maintenance information may be found in the Maintenance Manual, SVMM01.

The information in this publication is based on data available at the time of publication and is updated, supplemented, and automatically amended by Service Bulletins and Publication Revisions that are issued by Superior Air Parts Inc.

This manual is divided into separate sections relating to the general and specific overhaul instructions required for the engine. These general and specific instructions are generally organized and numbered per the recommendations of the General Aviation Manufacturers Association (GAMA). In this way, information may be located in a conventional manner to aid in both accuracy and timeliness.

Page numbering is organized within each section. The section number (e.g., 72-00-01) is displayed in the right hand section of the footer on each page. The page number is displayed in the center of the footer on each page.

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 Installation and Operation Manual, SVIOM01
O & IO-360 Maintenance Manual, SVMM01
O & O-360 Illustrated Parts Catalog, SVIPC01
Unison Master Service Manual, F-1100
Unison Autolite Manual, L-1710A
Precision RSA-5 Service Manual, 15-338
Precision MA-4-5 Manual, MSAHBK-1
Champion Aerospace Service Manual, AV-6R
Kelly Aerospace Service Manual, OE-A2

Obtaining Service Information
All Vantage Series Engine manuals and service information may be downloaded at: www.superiorairparts.com

All Vantage Series Engine manuals and service information may 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

www.kellyaerospace.com

Abbreviations
A list of abbreviations used in this manual is shown in Table 01-00-00.1 below.

Table 01-00-00.1 • Abbreviations

Abbreviation	Definition
AMS	Aerospace Material Standard
Assy	Assembly
BTC / BTDC	Before Top Center / Before Top Dead Center
CHT	Cylinder Head Temperature
DIA	Diameter
F	Fahrenheit
Fig.	Figure
Ft-Lb	Foot-Pounds
IAW	In Accordance With
I.D.	Inside Diameter
In-Lb	Inch-Pounds
Lb	Pounds
No.	Number
NPT	National Pipe Thread
O.D.	Outside Diameter
Oz.	Ounce
P/N	Part Number
Prop	Propeller
PSI	Pounds per Square Inch
RPM	Revolutions Per Minute
SAE	Society of Automotive Engineers
TIR	Total Indicator Reading
UNF	Unified National Fine
°	Degree

Consumable Materials List

Refer to Table 01-00-00.2 below for consumable materials used during repair of the Vantage O-360 and IO-360 series engines.

NOTE: Equivalent substitutes may be used.

Table 01-00-00.2 • Consumable Materials

Material	Source
Acetone or Methyl Ethyl Ketone (MEK)	Commercially Available
Assembly Grease – Lubriplate No. 105	Commercially Available
Cleaning Solvent	Commercially Available
Copper Based Anti-seize, Fel-Pro™ C5-A	Commercially Available
Fuelube™	Ohio Industrial Lubricants
Isopropyl alcohol	Commercially Available
Loctite™ 271, P/N 27183	Commercially Available
Loctite™ No. 2 Gasket Sealant P/N 30514	Commercially Available
Lubricating Oil, SAE 10	Commercially Available
Lubricating Oil, SAE 50	Commercially Available
Mineral Oil (MIL-L-6082), SAE 50 weight	Commercially Available
Permatex™, P/N 27100	Commercially Available
Pliobond™ #20	Commercially Available
Pre-Lube Mixture – approx. 15% pre-lubricant (STP™ brand or equivalent) plus 85% SAE 50 straight weight mineral oil	Locally Prepared Mixture
Preservative oil mix (MIL-C-6529, type 1 plus MIL-L-6082)	Locally Prepared Mixture
RTV™ 102 Silicon Sealant	General Electric
Safety Wire (0.032) Type 304 Stainless Steel, P/N MS20995 C32	Commercially Available
Safety Wire (0.041) Type 304 Stainless Steel, P/N MS20995 C41	Commercially Available
Silastic™ 140 Sealant	Commercially Available
Silk thread, size 00 (100% Silk)	Commercially Available
STP™ High Viscosity Oil Treatment	Commercially Available
TitesealTM No. 2 Gasket and Joint Compound P/N T2-01	Commercially Available
Phthalate resin-type enamel AMS3125C or equivalent MIL-E-7729 Randolph Black (#303)	Commercially Available
Toluene or equivalent AMS3180 (or equivalent Federal Spec TT-T-548)	Commercially Available
Zinc Chromate Primer	Commercially Available

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DESCRIPTION AND OPERATION

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.

Continued Airworthiness
Vantage Engines discussed in this document must be installed and operated in accordance with the limitations, conditions and operating procedures described in the Installation and Operation Manual (SVIOM01). They must also be maintained in accordance with this manual and the applicable Overhaul Manual (SVOHM01) 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.

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 02-00-00.1.

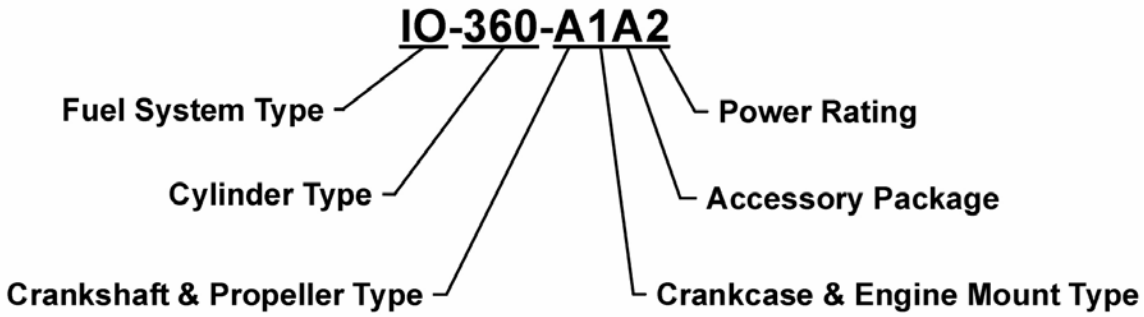

Figure 02-00-00.1 • Engine Model Number Designation

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 (O-360)	Fuel Injected (IO-360)
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

Engine Components General Description
The O-360 and IO-360 series engines are air-cooled, four cylinder, horizontally opposed, direct drive engines. See Table 02-00-00.1 for Manufacturer's General Specifications.

The complete engine includes the following components and assemblies:

Crankcase Assembly
Crankshaft Assembly
Camshaft Assembly
Valve Train Assembly
Cylinder Assemblies
Connecting Rod Assemblies
Oil Sump Assembly
Intercylinder Baffles
Starter
Lubrication System (Includes Oil Filter)
Accessory Drive
Ignition System (Includes Spark Plugs)
Fuel System
Starter Support Assembly
Oil Gage
Induction System
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, or fittings. Fuel pump is included, unless otherwise specified, on carbureted engines. Alternator may be included, if specified.

Specifications
The manufacturer's physical specifications are listed in Table 02-00-00.2 and are applicable to the O-360 and IO-360 series engines. Accessory Drive Specifications are provided in Table 02-00-00.2 and is also applicable for both O-360 and IO-360 models. Table 02-00-00.3 lists Physical Specifications for the engines and Accessories are provided in Table 02-00-00.4. The Model Specification Data (MSD) provides more specific information by engine type and is available from Superior Air Parts, Inc.

Illustrated views of the O-360 and IO-360 engines identifying key components and sub-assemblies are provided in Figures 02-00-00.1 thru 02-00-00.9 of this section and are listed Table 02-00-00.5 for convenience. Figure 02-00-00.10 illustrates the engine wiring diagram and Figure 02-00-00.11 illustrates the oil system schematic.

Table 02-00-00.1 • 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 02-00-00.2 • Accessory Drive Specifications

Accessory	Drive Ratio	Direction of Rotation
Starter	16.556:1	Counter-Clockwise
Alternator (not included)	3.250:1	Clockwise
Tachometer	0.500:1	Clockwise
Magneto	1.000:1	Clockwise
Vacuum Pump (not included)	1.300:1	Counter-Clockwise
Propeller Governor (not included)	0.866:1	Clockwise
Fuel Pump (if furnished)	0.500:1	Plunger Operated

Table 02-00-00.3 • Manufacturer's Physical Specifications

Model	Height (In)	Width (In)	Length (In)	Weight (Lb)
O-360-Axxx	24.6	33.4	32.8	288
O-360-Bxxx	24.6	33.4	32.8	291
O-360-Cxxx	24.6	33.4	32.8	291
O-360-Dxxx	24.6	33.4	32.8	294
O-360-Exxx	24.6	33.4	32.8	295
IO-360-Axxx	24.0	33.4	32.8	290
IO-360-Bxxx	24.0	33.4	32.8	293
IO-360-Cxxx	24.0	33.4	32.8	293
IO-360-Dxxx	24.0	33.4	32.8	296
IO-360-Exxx	24.0	33.4	32.8	297

Table 02-00-00.4 • Approved Engine Accessories

Model	Left Magneto	Right Magneto	Fuel System	Fuel Pump (if furnished)	Starter	Spark Plug Harness	Alternator (if furnished)
O-360	Unison 4371	Unison 4371	Precision MA-4-5	Aero Acc. AF15472	SkyTec 149-12LS	Unison M4001	Kelly Aerospace ALY8520LS
IO-360	Unison 4371	Unison 4371	Precision RSA-5	Aero Acc. AF15473	SkyTec 149-12LS	Unison M4001	Kelly Aerospace ALY8520LS

Table 02-00-00.5 • Illustrated Views of the Engine

Engine View	Figure Number	Location
O-360 Engine Front View	Figure 02-00-00.2	p. 7
O-360 Engine Left Side View	Figure 02-00-00.3	p. 8
O-360 Engine Top View	Figure 02-00-00.4	p. 9
O-360 Engine Rear View	Figure 02-00-00.5	p. 10
IO-360 Engine Front View	Figure 02-00-00.6	p. 11
IO-360 Engine Left Side View	Figure 02-00-00.7	p. 12
IO-360 Engine Top View	Figure 02-00-00.8	p. 13
IO-360 Engine Rear View	Figure 02-00-00.9	p. 14
Ignition Wiring Diagram	Figure 02-00-00.10	p. 15
Oil System Schematic	Figure 02-00-00.11	p. 16

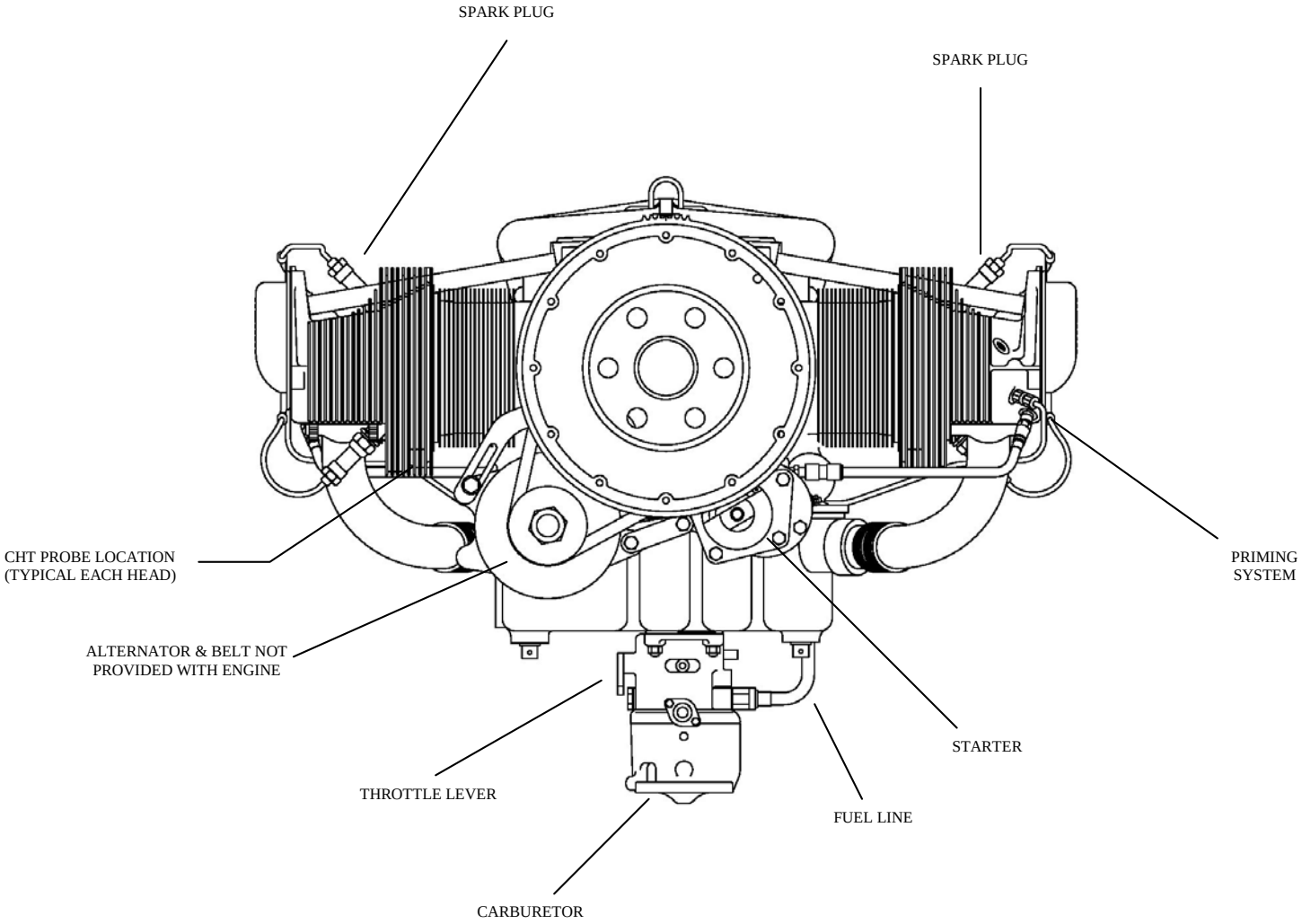

Figure 02-00-00.2 • O-360 Engine Front View

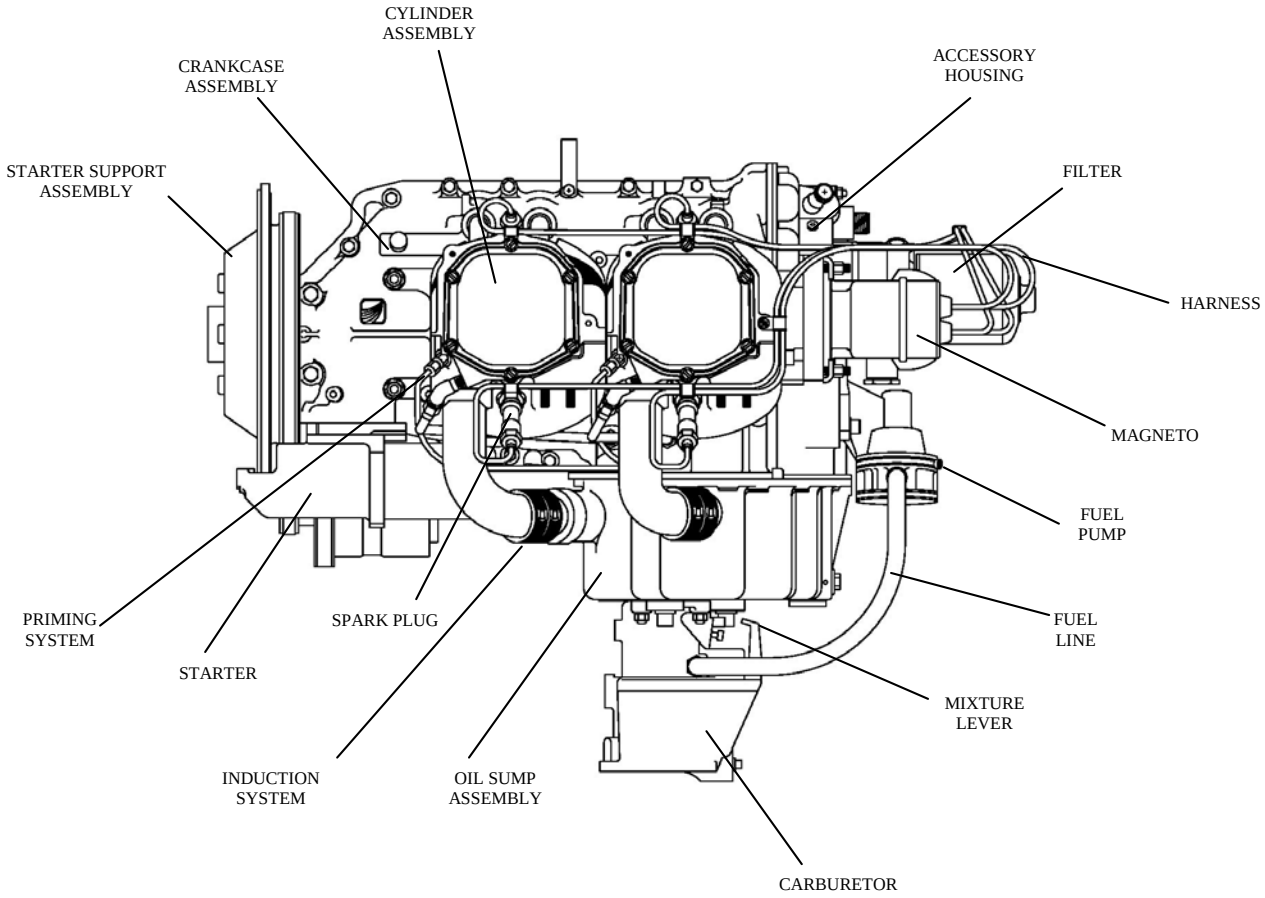

Figure 02-00-00.3 • O-360 Engine Side View

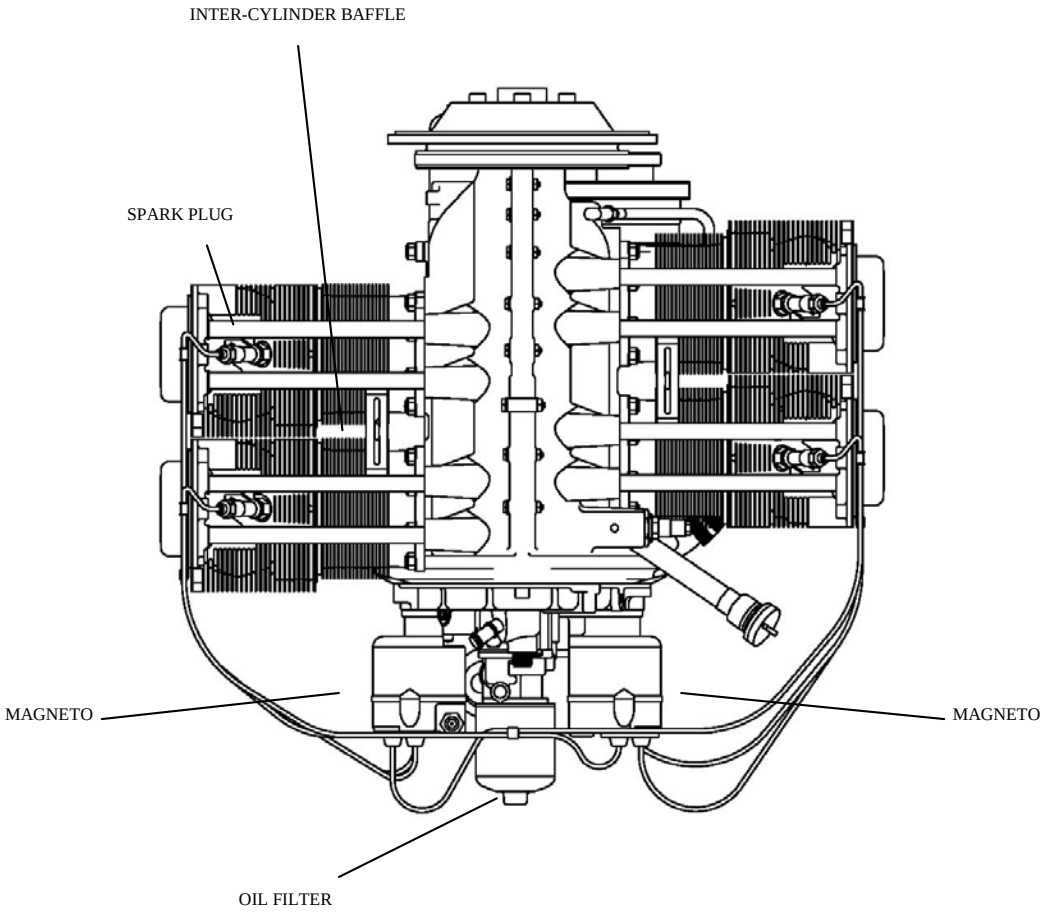

Figure 02-00-00.4 • O-360 Engine Top View

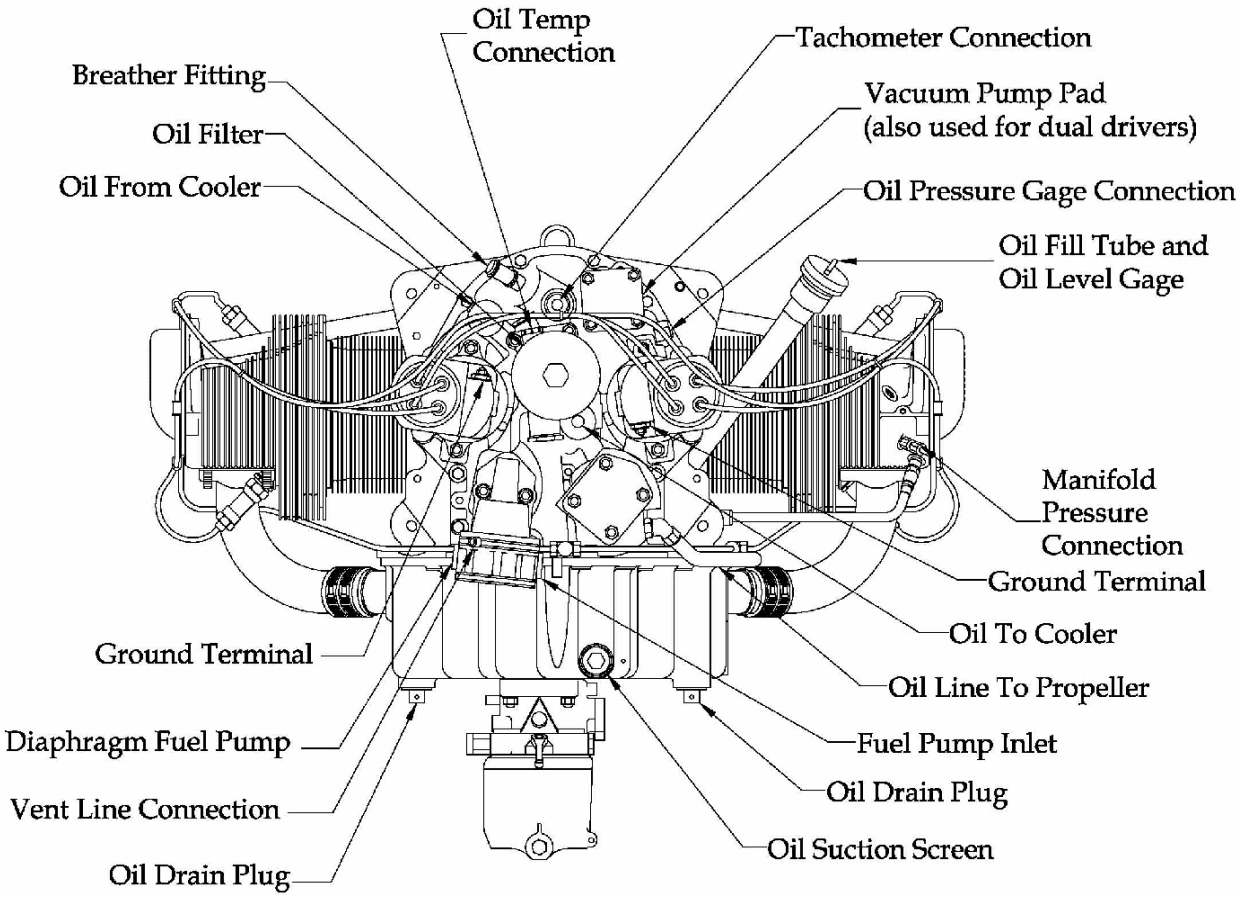

Figure 02-00-00.5 • O-360 Engine Rear View

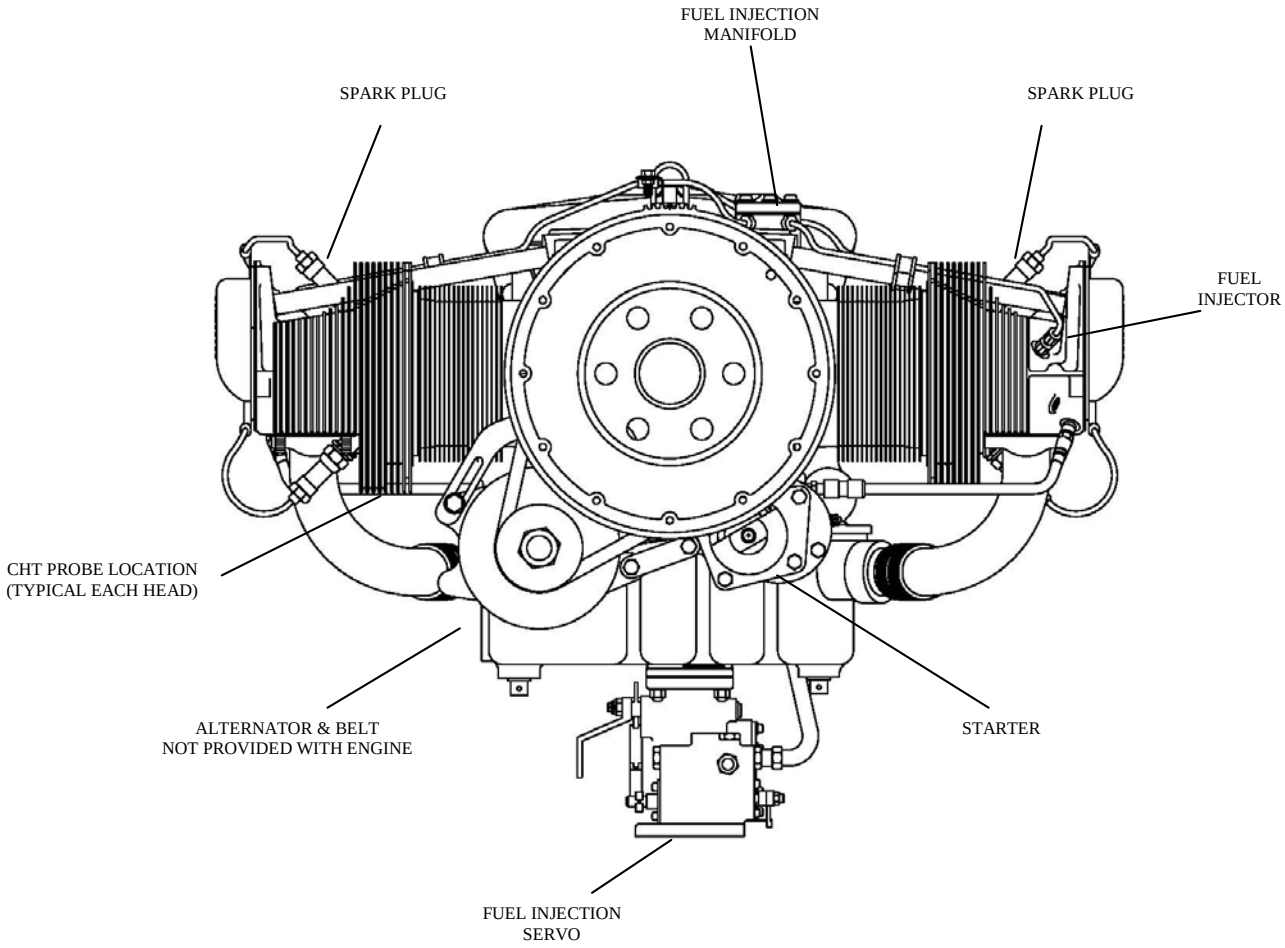

Figure 02-00-00.6 • IO-360 Engine Front View

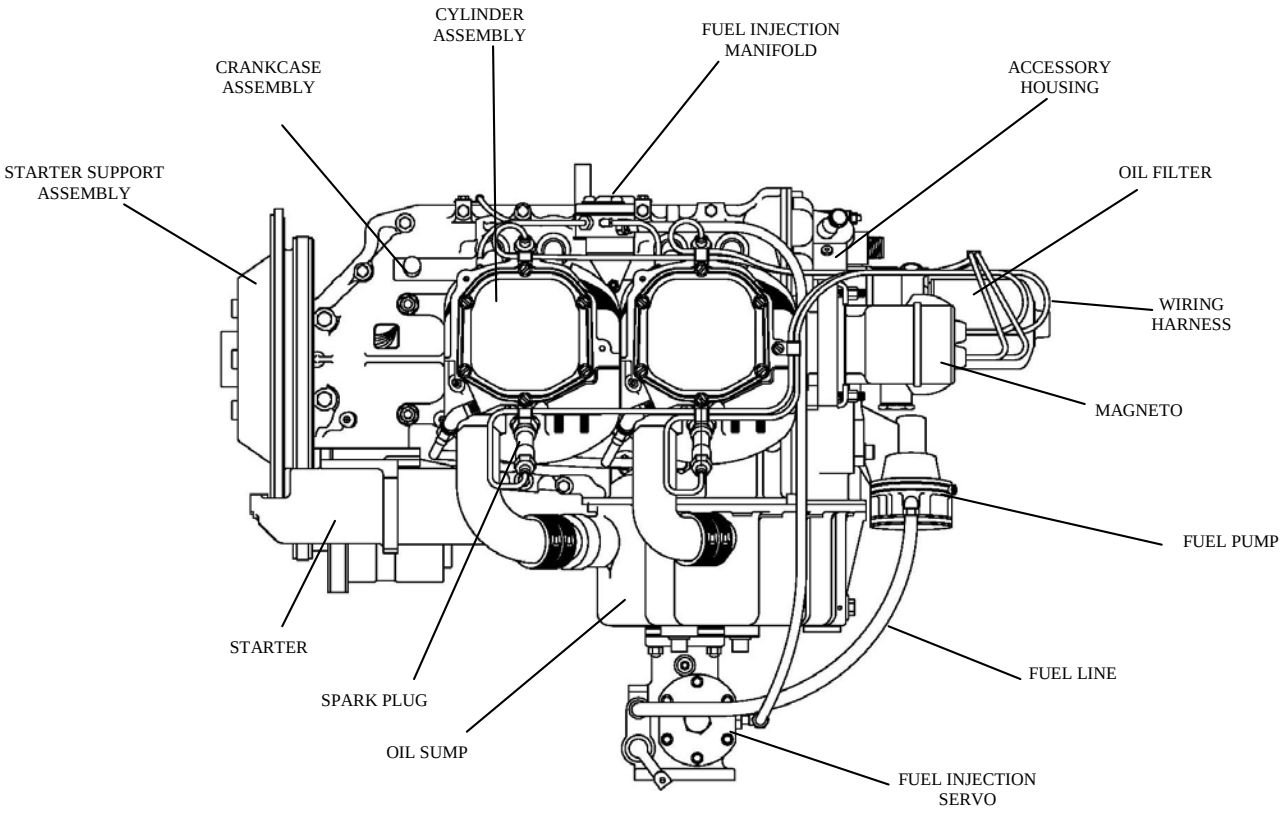

Figure 02-00-00.7 • IO-360 Engine Left Side View

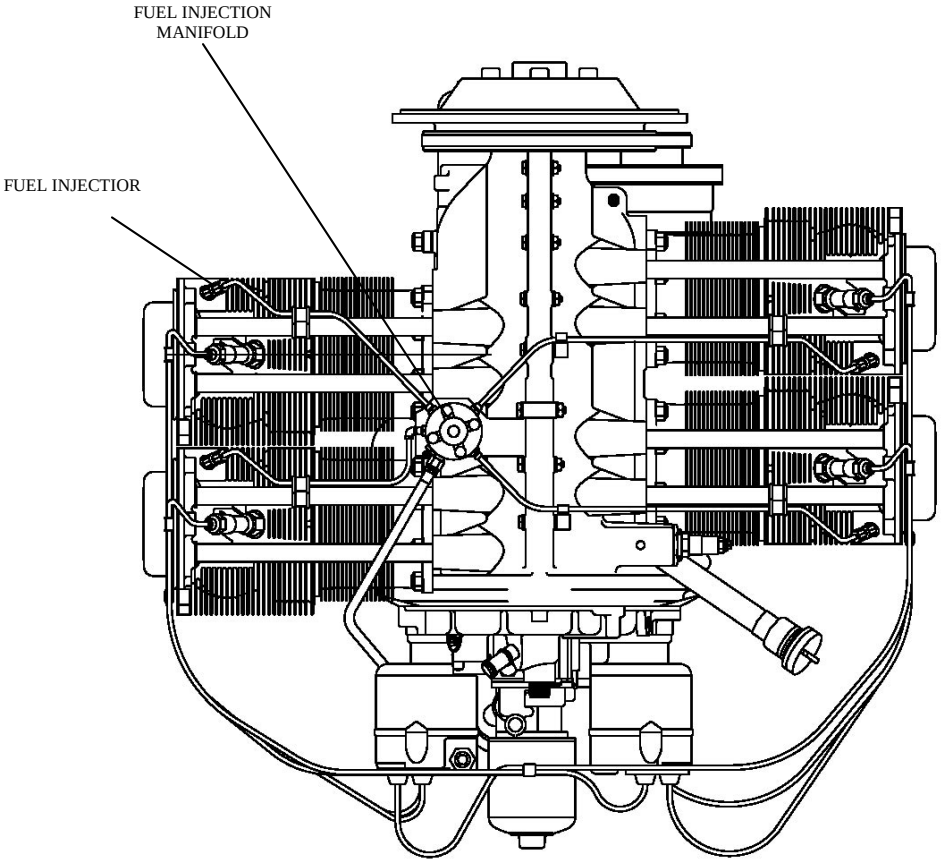

Figure 02-00-00.8 • IO-360 Engine Top View

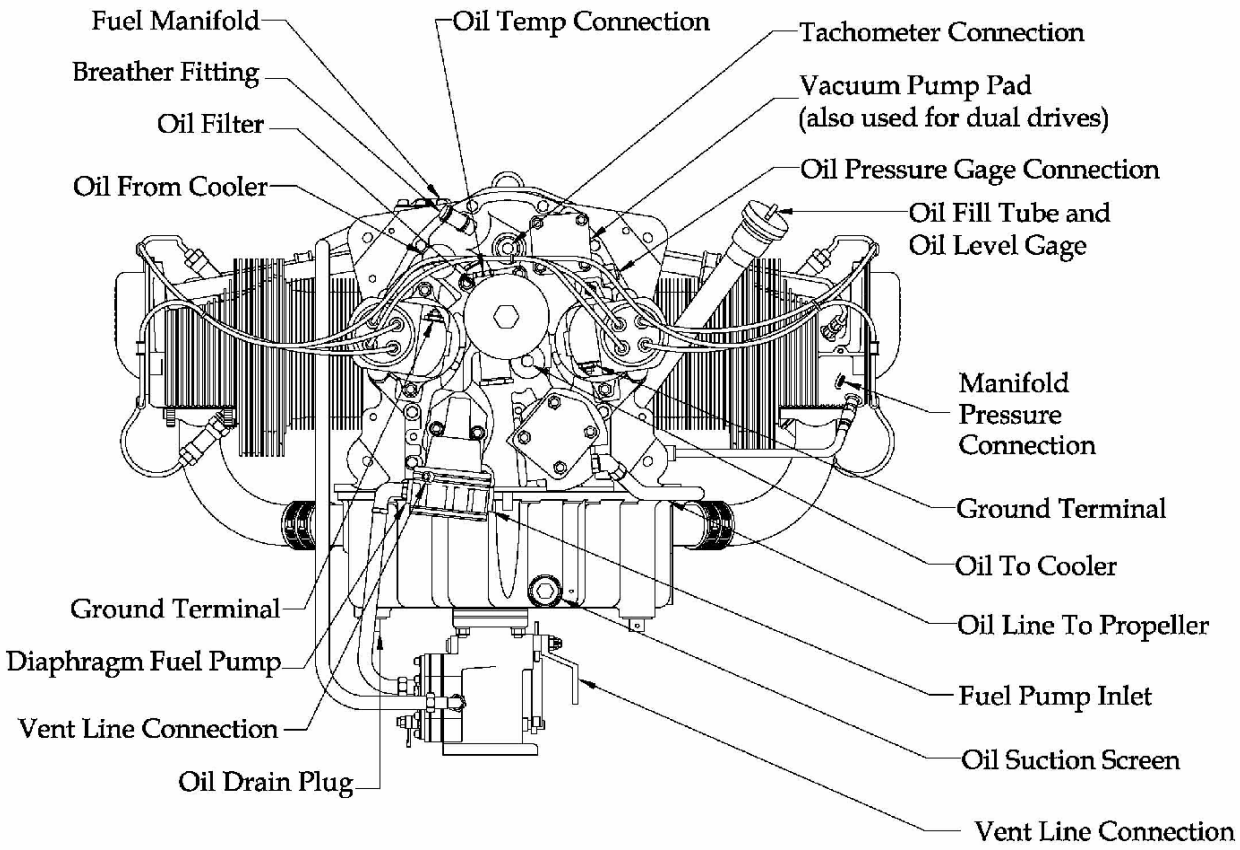

Figure 02-00-00.9 • IO-360 Engine Rear View

Firing Order
Clockwise Rotation 1-3-2-4
Ignition Wiring Diagram

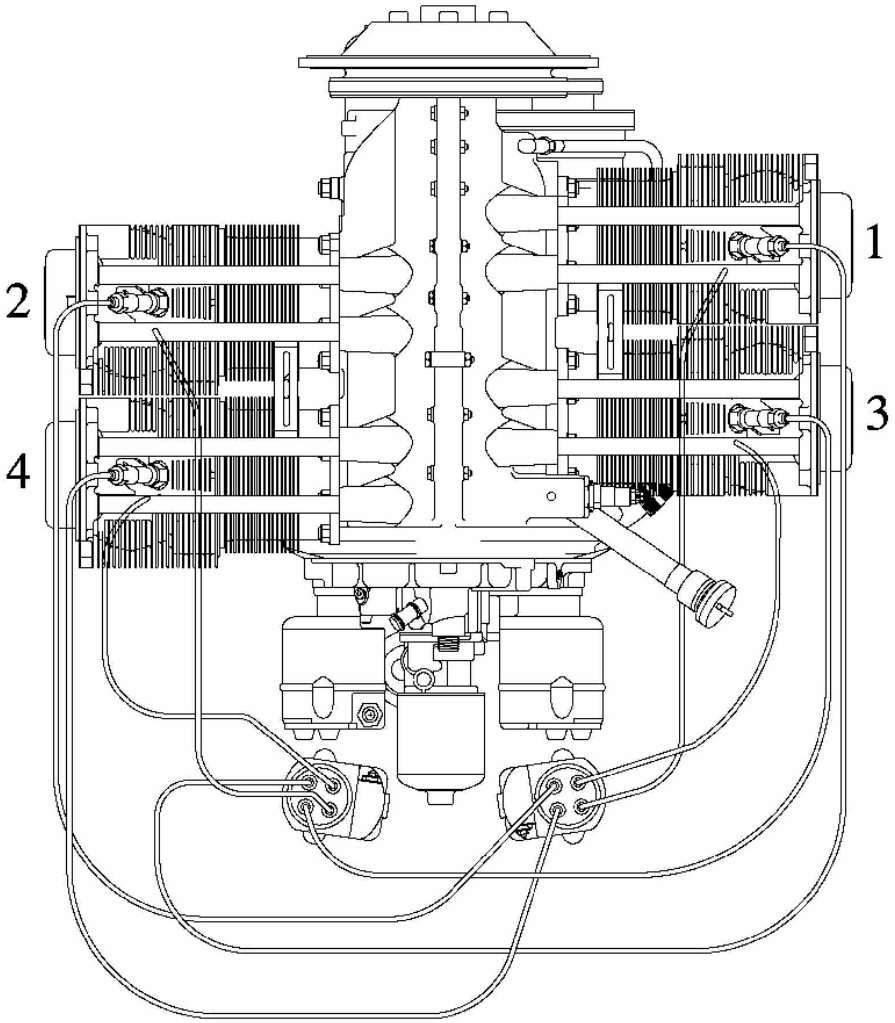

Figure 02-00-00.10 • Ignition Wiring Diagram

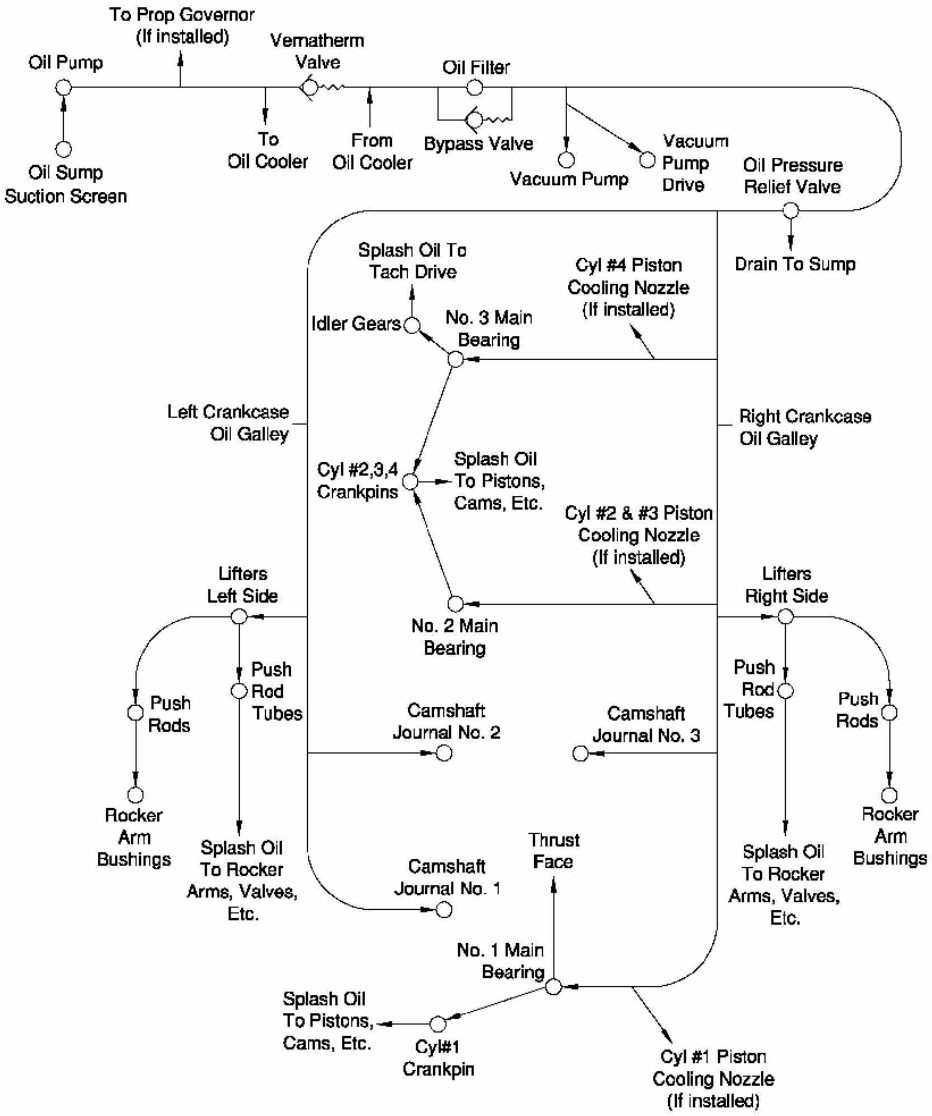

Figure 02-00-00.11 • Oil System Schematic

Features and Operating Mechanisms

Crankshaft - The crankshaft is made from high quality, aerospace grade steel. All bearing journal surfaces are nitrided. There are 3 kinds of crankshafts: thin-wall, thick-wall, and solid front mains which can be identified by looking at the center of the front of the crankshaft or prop oil cavity. The thin-wall and thick-wall crankshafts are each available as fixed-pitch or constant-speed. Fixed-pitch versions have a plug installed in the inner diameter of the front main, or prop oil, cavity which prevents escape of oil out the front, since there isn't a prop governor or constant-speed prop for the oil pressure to act upon.

Connecting Rods - The connecting rods are made from aerospace grade, high quality steel. 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 pushrods and valve rockers.

Crankcase - The crankcase is made from aerospace grade, stabilized structural aluminum alloy. 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 cast heads are made from a special aluminum alloy. All barrels are made from forgings produced to aerospace 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.

Electrical System – Engines may be furnished with an alternator, if provided for in the model specification. If an alternator is furnished, installation brackets, hardware and belt are provided. Alternators are available in either 12 or 24 volt systems and a range of amperages.

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AIRWORTHINESS LIMITATIONS

The Airworthiness Limitations Section is FAA 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.

Mandatory Replacement Time
Subject to additional information contained in FAA 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.

Mandatory Inspection Intervals
Subject to additional information contained in FAA 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 other than 100 and 500 hour inspections of magnetos as required by Unison Slick Service Bulletin SB2-80C.

Other Mandatory Intervals or Procedures
Subject to additional information contained in FAA 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.

Distribution of Changes to Airworthiness Limitations
Changes to this Airworthiness Limitations Chapter constitute changes to the type design of the O-360 and IO-360 engine series and require FAA approval pursuant to Federal Aviation Regulations. Such changes will be published in FAA 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.superiorairparts.com

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TESTING AND FAULT ISOLATION

General

This section provides the Fault Isolation procedures. Review all probable causes given. The engine electrical diagram and engine oil system schematic are provided as an additional aid in determining probable cause. Testing is limited to continuity checks of the ignition wiring harness.

- Special tools and equipment are listed in Table 72-00-03.1.
- The Fault Isolation procedures are listed in Table 72-00-03.2.
- The engine ignition diagram is provided in Figure 02-00-00.10.
- The engine oil system is provided in Figure 02-00-00-11.

Table 72-00-03.1 • Special Tools and Equipment

Item	Vendor
Electrical Tester	Commercially Available

Table 72-00-03.2 • Abnormal Operating Procedures

Symptom	Table
Engine will not start	72-00-03.3
Rough Idling	72-00-03.4
Engine Not Able to Develop Full Power	72-00-03.5
Rough Engine Operation	72-00-03.6
Low Power and Engine Runs Rough	72-00-03.7
Low Oil Pressure On Engine Gage	72-00-03.8
High Oil Temperature	72-00-03.9
Excessive Oil Consumption	72-00-03.10

Troubleshooting

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: 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.

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.

NOTE: The Fault Isolation sequence is in order of approximate ease of checking, not necessarily in order of probability.

Table 72-00-03.3 • 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.

Table 72-00-03.4 • 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

Table 72-00-03.5 • 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.
Internal Timing	Check rocker arm motion as engine is rotated on nose stand.

Table 72-00-03.6 • Rough Engine Operation	
Probable Cause	**Correction**
Broken engine mount	Replace or repair mount.
Mounting bushings worn	Install new mounting bushings.
Unstable compression	Check compression.

Table 72-00-03.7 • 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.

Table 72-00-03.8 • 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 Table 72-00-03.9, “High Oil Temperature”.
Defective pressure gage.	Replace defective gage.
Stoppage in oil pump intake passage	Check line for obstruction. Clean suction strainer.

Table 72-00-03.9 • 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.

Table 72-00-03.10 • 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 of this manual.
Oil siphoned from engine in flight	Insure that oil filler cap is tight and that o-ring is in good condition. Insure that breather hose exit is cut and located to avoid creating a vacuum in the breather hose.

SPECIAL PROCEDURES

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.

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

Special Tools and Equipment
- Standard aviation shop tools are required.
- Engine test stand.
- The aircraft can be a suitable test stand for running-in cylinders.

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.

Prior to Break-In Start-Up
- Engine oil sump should be filled with 100% straight weight mineral oil. Use MIL-L-6082, specific grade depending on ambient temperature. Refer to chapter 72-00-13 for fluid requirements.
- Engine must be pre-oiled and oil pressure obtained prior to start-up.
- To pre-oil an engine, do the following:
  1. Attach pressure-oiling equipment to one end of the main gallery and force oil through the galley at 35 psi until oil flows from the opposite galley with the plug removed from the front end of the opposite galley.
  2. Engine baffles and seals must be in good condition and properly installed.
  3. 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.

Break-In Ground Run
- Flight propeller may be used if test club is not available.
- Head aircraft into the wind.
- Start engine and observe oil pressure. Oil pressure should be indicated within 30 seconds. If this does not occur, shut down engine and determine cause.
- Run engine just long enough to confirm all components are properly adjusted and secured. There must be no fuel and/or oil leaks.
- Install cowling.
- Operate engine at 1000 -1200 RPM until oil has reached minimum operating temperature 120 °F.
- Check magneto drop at normal RPM.
- If engine is equipped with a controllable pitch propeller, cycle only to a 100 RPM drop.
- Shut down engine and check for fuel and/or oil leaks and repair any discrepancies.
- At no time should cylinder head temperature be allowed to exceed recommended maximum cruise limit of 430°F.

Break-In Flight Operation
- Perform normal pre-flight and run-up in accordance with the Installation and Operation Manual, SVIOM01 (remember: cycle controllable pitch prop to only a 100 RPM drop). Keep ground runs to a minimum.
- 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".

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

- Maintain shallow climb. Use caution to not overheat the cylinders. Should overheating occur, reduce power and adjust mixture appropriately.
- Monitor RPM, oil pressure, oil temperature and cylinder temperature.
- During the first hour of operation, maintain level flight at 75% power. Vary the power setting every 15 minutes during the second hour between 65-75%.
- Avoid long descents at cruise RPM and low manifold pressure (could cause ring flutter).
- 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.
- At no time should cylinder head temperature be allowed to exceed recommended maximum cruise limit 430°F.
- After landing, check again for any fuel and/or oil leaks, or other discrepancies, and repair as required.

Post Break-In Procedures

- After break-in, drain all mineral oil. Examine this oil for foreign matter or metal particle content.
- Fill with ashless dispersant of the appropriate grade for the expected normal operating conditions and ambient temperature.

ENGINE REMOVAL

General
This section contains engine removal procedures.

Equipment and Materials to accomplish removal procedures are listed in Table 72-00-05.1.

NOTE: NOTE: Standard aviation shop tools are required.

Table 72-00-05.1
Equipment and Materials List

Item	Vendor
Engine Stand	Commercially Available
Engine Hoist	Commercially Available
Protective Covers for Open Lines or Ports	Commercially Available

Removal
- Remove the engine from the airframe as follows:

NOTE: Identify each item as the item is disconnected from the engine to aid in reinstallation.

- Turn all cockpit switches and fuel selector valves to OFF.
- Remove aircraft cowling as required.
- Disconnect the battery ground cable.
- Disconnect the start cable.
- Remove engine baffles as required.
- Remove air intake ducting and heat ducting as required.
- Remove engine exhaust system as required.
- Disconnect and remove the “B” nuts from the spark plugs.
- Tag and disconnect the engine wiring bundles from all applicable components.
- Remove all clamps attaching engine wire bundles to engine components and route bundles clear of the engine.
- Drain the engine oil from the sump. Replace drain plug and tighten.
- Remove propeller in accordance with the airframe manufacturer’s instructions.
- Consult the airframe manufacturer for engine to airframe connections.

WARNING: PLACE A SUITABLE STAND UNDER THE AIRCRAFT TAILCONE IF NEEDED BEFORE REMOVING THE ENGINE. THE LOSS OF WEIGHT MAY CAUSE THE AIRCRAFT TAIL TO DROP.

- Attach a hoist to the engine lifting eye bracket and relieve the weight from the engine mounts. Only the lifting eye bracket installed on the backbone of the crankcase should be used to hoist the engine.

- Remove the engine mounts and engine as follows:
  1. Loosen and remove the engine mounts bolts in accordance with manufacturer’s instructions.
  2. Hoist the engine vertically out of the nacelle and clear of the aircraft.

NOTE: Hoist the engine slowly and make sure that all wires, lines, and hoses have been disconnected.

  3. Install the engine onto a transportation stand, dolly, or an engine shipping container base.

- Install protective covers/plugs on any remaining open fuel, oil/hydraulic lines, and electrical leads and exhaust ports.

Preservation
- If the engine is to be stored for longer than 30 days, refer to the Preservation and Storage section of this manual for procedures and materials.

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DISASSEMBLY

General
This section contains disassembly procedures. When necessary, disassembly illustrations are also provided. All item number references in the text are specific to this manual and the figures cited.

Disassembly Materials
The materials required for disassembly are listed in Table 72-00-06.1.

NOTE: Equivalent substitutes may be used.

Table 72-00-06.1 • Disassembly Materials

Description	Source
Penetrating Oil	Commercially Available

Parts for Discard
Parts to be discarded are listed in Table 72-00-06.2.

Table 72-00-06.2 • Discard Parts

Nomenclature
All Engine Oil, Air and Fuel Hoses
Gaskets, Oil Seals, and O-Rings
Bearing Inserts (Connecting Rod and Crankshaft)
Piston Rings and Piston Pins
Stressed Bolts and Fasteners
Intake and Exhaust Valves, Valve Guides and Valve Keepers
Crankshaft Gear Attaching Bolt
Connecting Rod Nuts and Bolts
All Lockwashers, Circlips, Retaining Rings, Locktabs and Locknuts
Counterweight Bushings in Crankshaft and Counterweights (if applicable)
Counterweight Washers (if applicable)
Vermatherm (Oil Temperature Bypass Valve)

Special Tools and Equipment
Special tools and equipment required for disassembly are listed in Table 72-00-06.3.

NOTE: Standard reciprocating engine aviation shop tools and equipment are used unless otherwise specified.

Table 72-00-06.3 • Special Tools and Equipment

Nomenclature	Source
Compressor, Piston Ring	Commercially Available
Expander, Piston Ring	Commercially Available
Puller, Slide Hammer-Medium	Commercially Available
Compressor, Valve Spring Bar	Commercially Available
Intercylinder Baffle Tool	Commercially Available
Puller, Valve Guide	Commercially Available
Puller Set, Oil Seal	Commercially Available
Stand, Vertical Nose Support	Commercially Available
Tool, Hydraulic Tappet Removal	Commercially Available

General Disassembly Procedures

- Place engine in horizontal position on a transfer cart.

WARNING: ENGINE OIL IS HAZARDOUS AND MAY CAUSE INJURY TO SKIN AND EYES. PUT ON PERSONNEL PROTECTIVE GEAR.

- Remove the oil drain plug and drain the oil from the engine, if not previously drained.
- Remove the starter ring gear support.
- Perform visual inspection during disassembly and immediately after disassembly. All individual parts should be laid out in an orderly manner as they are removed.
- All loose studs, cracked baffles, and loose or damaged fittings should be tagged to prevent being overlooked during regular inspection.
- Tag all components and parts as they are removed. Bag loose assemblies or attaching hardware.
- Prior to starting the component or parts disassembly phase, engine may be placed on a vertical nose support stand.

Disassembly

WARNING: FUEL IS TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. AVOID EYE AND SKIN CONTACT. USE 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: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

Removal of Carburetor and Priming System

(1) Remove engine fuel lines (30, Figure 72-00-09.37) and all attaching hardware.
   (a) Remove engine fuel priming system attaching hardware clamps, (25, 30, 45 Figure 72-00-09.36) screws (35) and nuts, (40). Disconnect tube (1, 5, 10, 15) coupling nuts at cylinder head and attaching tee tubes (20).
(2) Remove the carburetor on O-360 series engines as follows.
   (a) Remove nuts (1, Figure 72-00-09.37), lockwashers (2) and flat washers (3) from studs four places.
   (b) Remove carburetor (7) from studs and discard gasket (4).
   (c) Remove elbow (5) and discard o-ring (6).

Fuel injection system removal

(1) Remove engine fuel injection manifold tubing clamps (70, 75 Figure 72-00-09.39), nuts (85), and screws (80).
(2) Disconnect injector tubing (55, 60), eight places at fittings (40), elbow (25), and injector nozzle assembly (90). Remove nozzle assemblies (90) four places.
(3) Remove fuel manifold bracket (1) retaining nuts, washers, (5) and bolts (10). Remove manifold (15) retaining bolts (25) and washer (20).
(4) Disconnect and remove fuel hoses (30, 35, Figure 72-00-09.38). Remove nuts, (25) lockwashers (20), and flat washers (15) from studs. Remove injector servo assembly (10) and remove gasket and spacer (5).

Magneto and harness removal

(1) Unscrew ignition wiring harness leads (5, 10, Figure 02-00-00.10) from the top and bottom spark plugs (50). Remove harness attaching caps (5), two places, from the magneto. Remove spark plugs (50) from cylinder.
(2) Remove magneto (15, Figure 72-00-09.40) attaching nut (30), washer (25), and clamp (20). Remove the magneto (15) and discard gasket (10). Remove the adapter (5) and gasket (1). Remove cotter pin (40), nut, and washer. Remove magneto gear (35) and install nut back on threads to prevent damage to drive shaft threads.

Oil level gage housing Removal

(1) Unscrew the oil gage (10, Figure 72-00-09.28) and remove the oil gage housing (5). Discard seals (15, 20).

Fuel pump removal (as required)

(1) Remove fuel pump screws (15, Figure 72-00-09.32) and washers (10). Remove fuel pump (5) and gasket (1). Remove elbows (25, 30) and discard o-rings (20).

Oil filter and Adapter removal

(1) Unscrew the oil filter (40, Figure 72-00-09.35). Remove the vernatherm (temperature control valve) (35). Remove screws (30), washers (15, 20), and nut (25) that secure the oil filter adapter (10) to the accessory housing. Discard gasket (5). Remove cooler bypass plug (55), and discard gasket (50).

Vacuum pump or cover removal

(1) Remove the vacuum pump (or cover) attaching nuts (40, Figure 72-00-09.31), lockwashers (35) and flat washers (30). Remove pump (or cover (20) as appropriate) and discard gasket (15). Remove adapter assembly (25). Discard gasket (10) and remove vacuum gear (1) and thrust washer (5) from housing. Remove oil seal (55) and discard.

Propeller governor removal (as required)

(1) Remove the propeller governor oil line. Remove any clamps. Remove elbows (10, 15) and any attaching hardware, as required, to allow hose removal, discard o-ring (20).
(2) Remove the cover nuts (30) as required, (Figure 72-00-09.33), lockwashers (25), and flat washers (20). Remove cover (65) and discard gasket (60). Remove retaining ring (55) and thrust washer (5). Remove adapter nuts (30), lockwashers (25), and flat washers (20). Remove propeller governor adapter (15). Discard gasket (10). Tag and save thrust washer (5). Remove gear shaft (1) from housing.

Accessory Housing Assembly Removal

(1) Remove the accessory housing assembly by removing the bolts (15, Figure 72-00-09.23), lockwashers (10), and flat washers (5). Remove bolt (20), washer (10), and nut (25) two places. Remove accessory housing (40) and gasket (35). Remove fuel pump plunger (1, Figure 72-00-09.24).
    (a) Remove nuts (90) and washers (85) to remove oil pump housing assembly (80). Remove oil pump drive shaft (115) and impeller gears (105, 110).

Idler gears and shaft removal

(1) Remove idler gears (15,20, Figure 72-00-09.20). Remove idler shaft mount screws (5) and nut (10). Remove idler shafts (1) from crankcase.

Starter and alternator attaching hardware removal

(1) Remove starter mount bolt (15, Figure 72-00-09.42), nuts (20), lockwashers (10), and flat washers (5). Remove starter (1) from crankcase.
   (a) Remove alternator mount bolt (10, Figure 72-00-09.43) and washer (5) to loosen drive belt. Remove cotter pin (45), slotted nut (40), support bolt (25), and shims (35). Remove cotter pin (45), slotted nut (40), shims (35), and support bolt (30). Remove bolts (20, 90) and flat washers (15, 85) from strut bracket (80). Remove strut support (80) and remove alternator.
   (b) Remove alternator bracket (55) by removing bolts (60) and lock plate (50). Remove bolt (75), flat washer (70), and adjusting link (65). Visually inspect hardware and bag for reuse if not damaged.

Oil sump and induction disassembly

(1) Remove screws (25, Figure 72-00-09.29), lockwashers (20), and flat washers (15) from intake pipe flange (10). Discard gaskets (1).
(2) Remove clamps (35), intake hoses (30), and intake tubes (5) from oil sump assembly.
(3) Remove oil screen plug (85, Figure 72-00-09.27), discard gasket (80), and remove oil suction screen (75). Inspect for debris.
(4) Remove bolts (15,20), flat washers (25, 30), lockwashers (25), and nuts (35) from sump assembly flange. Discard gasket (11) and remove intake connection pipes (12) from sump assembly.

Cylinder drain tubes removal

(1) Loosen hose clamps (85, Figure 72-00-09.17) on hose (80) at drain nipple (75). Slide away from drain nipple (75). Loosen gland nut at cylinder head fitting and remove tube assembly (90) from cylinder.

Intercylinder cooling baffle removal

(1) Remove the intercylinder cooling baffles (1, Figure 72-00-09.26) using intercylinder baffle tool. Turn the baffle retaining hook (10) so that it disengages the retainer (5). Remove the baffle (1) and hook (10) from between the cylinders.

Cylinder removal

(1) Remove the valve cover screws (130, Figure 72-00-09.15) and cover (125) and discard gasket (120). Rotate the crankshaft to place the piston of the No. 1 cylinder at top center of the compression stroke.

NOTE: With the piston in this position both valves will be closed and the piston extended away from the crankcase to avoid damage when the cylinder is removed.

(2) Remove the valve rocker shaft caps (20), the valve rocker shaft (15), valve rocker arms (5), and the exhaust valve stem cap (115) from cylinder assembly. Remove the pushrod (1) by grasping the rod end and pulling it through the rod tube (40). Remove nut (60), spring (55), and lockplate (50). Pull rod tube through cylinder head and discard tube seals (35, 45).
   (a) Remove cylinder assembly by removing nuts from cylinder base. Remove cylinder by pulling straight away from crankcase. As the cylinder is being pulled away, hold the piston to prevent damaged. Discard cylinder base seal.

CAUTION: THE CONNECTING ROD MUST BE SUPPORTED TO PREVENT DAMAGE TO THE ROD AND CRANKCASE. SUPPORT EACH

CONNECTING ROD WITH HOLD DOWN PLATES TOOL OR RUBBER BANDS (OR DISCARDED CYLINDER BASE SEALS) LOOPED AROUND THE CYLINDER BASE STUD.

(3) Remove the piston pin (35, Figure 72-00-09.6) using a piston pin drive tool. Drive pin (35) from piston to remove piston (30) from the connecting rod (5).

NOTE: Removal of the remaining cylinders and pistons may be done in any sequence, but less turning of the crankshaft is involved if the cylinders are removed in firing order 1-3-2-4.

(4) Compress valve springs (90, 95, Figure 72-00-09.15) with spring compressor tool, while supporting cylinder, far enough to remove the valve cylinder keys (105, 110).

NOTE: If the valve keys are stuck in the spring seat, a light blow with a leather mallet on top of the compressor tool will release keys.

CAUTION: DO NOT DRIVE THE VALVES THROUGH THE GUIDES.

(a) Remove upper valve spring seats (95, 100), inner and outer springs (85, 90), and lower valve spring seats (75, 80) from rocker box. Keep parts for each valve (65, 70) separate. Hold valves by the stems to keep them from dropping out of the cylinder and remove cylinder from the holding block. Reach inside and remove valves. If valves are difficult to remove, push valves back in and clean carbon from stems.

CAUTION: BE CAREFUL NOT TO SCRATCH OR SCORE PISTONS WHEN REMOVING THE RINGS.

(b) Using the piston ring expander tool, remove the rings (40, 45, Figure 72-00-09.6) from all pistons. Remove the rings in order starting with the top ring and work down.

(5) Remove and disassemble the hydraulic lifter assembly.

CAUTION: MAINTAIN THE PARTS OF EACH TAPPET ASSEMBLY TOGETHER DURING ALL OVERHAUL OPERATIONS. ALL COMPONENT PARTS ARE TO BE REASSEMBLED WITH THEIR ORIGINAL MATING PARTS AND EACH ASSEMBLY REINSERTED IN ITS ORIGINAL LOCATION.

(a) Using hydraulic tappet tool, remove the pushrod socket (30, Figure 72-00-09.15) by placing heavy grease on ball end of the "T". By inserting the ball end in the tappet and withdrawing, the socket will adhere to the grease.
(b) Using the hollow end of the tool, push it over the plunger and withdraw the plunger. If the tool is not available, remove the pushrod socket with fingers or by using needle nose pliers. Insert a piece of wire bent at a right angle into the plunger between the plunger and the lifter body. Turn 90 degrees to engage a coil of spring and draw out the plunger assembly.

Crankcase Disassembly

(1) Remove nuts (25, 45, 70, 85, Figure 72-00-09.11 and 72-00-09.12), bolts (5, 30, 55, 90, 95), and washers (15, 20, 35, 40, 60, 65, 80). Draw or pull the thru-bolts (1) from the crankcase using cylinder base nuts and washers and/or spacers.
(2) Separate crankcase using care not to allow camshaft to fall to floor. Caution should be used to keep the right case thru-studs from becoming misaligned when separating the crankcase halves (60, Figure 72.00-09.5).

NOTE: Carefully pull crankshaft nose seal from crankcase forward on crankshaft to aid in crankcase half separation.

(3) Remove the bearing inserts (5, 10, Figure 72-00-09.2), lifter bodies (20), and camshaft. Remove and discard o-ring seals (10, 75).

NOTE: Place each lifter body in its proper location in a cleaning basket. The lifter bodies must be assembled in their original locations if reused.

(4) Remove all threaded plugs and discard oil seals.

Crankshaft Disassembly

(1) With the crankshaft firmly supported at the front and rear main bearing journals (or secured on a nose stand), remove rod nuts (15, Figure 72-00-09.6). Remove the rods (5) by tapping on the rod bolts (10) with a soft hammer. Discard the connecting rod bearing (1), bolts (10), and nuts (15).

NOTE: Maintain each cap and rod as an assembly. Rods and caps are not interchangeable.

(2) To remove the crankshaft gear (5, Figure 72-00-09.3), flatten the lockplate (10) and remove screw (15). Tap the gear lightly with a soft mallet or brass drift. Remove the crankshaft oil seal and discard.

CLEANING

General
Cleanliness of the aircraft engine is crucial to its optimum performance. This section provides information on materials, tools, and guidelines for cleaning.

After the initial visual inspection of internal engine parts, it is necessary to thoroughly clean the engine components for detailed inspection. Since this visual inspection is made during and after disassembly, the components should be cleaned afterwards and tagged to facilitate further non-destructive inspection methods. This identification procedure will also help prevent these components from being overlooked.

It is important to remember to visually inspect an engine prior to cleaning. Residue from the engine's operation can provide information as to hidden defects or other dangerous conditions.

Tools and Materials
For tools required during cleaning, refer to Table 72-00-07.1. For consumable materials required during cleaning, refer to Table 72-00-07.2.

Table 72-00-07.1
Equipment Required for Cleaning

Item	Vendor
Brush (soft and stiff bristles)	Commercially Available
Immersing tank	Commercially Available
Scraper (wood)	Commercially Available
Grit blaster	Commercially Available

NOTE: Equivalent substitutes may be used.

Cleaning Instructions
Two (2) processes are used in cleaning engine parts; degreasing to remove dirt and sludge (soft carbon) and the removal of hard carbon by decarbonizing, brushing or scraping and grit blasting.

CAUTION: DO NOT USE SAND OR METALLIC ABRASIVES WITH THE GRIT BLASTING EQUIPMENT.

Degreasing
Degreasing is accomplished by immersing or spraying the part in solution of white furnace oil (38-40 specific gravity) or another suitable solvent such as Varsol or Perm-A-Chlor.

Table 72-00-07.2
Materials Required for Cleaning

Item	Vendor
Cleaning solvent or degreaser such as white furnace oil, Varsol, or Perm-A-Chlor	Commercially Available
Decarbonizing solutions such as Gunk, Penetrol, Carbrax, Super-Chemco, or Gerlach #70	Commercially Available
Isopropyl Alcohol	Commercially Available
Aerosol electrical contact cleaner	Commercially Available
Lubricating Oil (SAE 20)	Commercially Available
Corrosion preservative oil	Commercially Available
Abrasive cloth (crocus cloth)	Commercially Available

NOTE: Residue from the solvent washing must be captured and contained to prevent contamination of the surrounding environment.

WARNING: USE THE CORRECT PERSONAL PROTECTION. SOME CHEMICAL SOLUTIONS CAN CAUSE SKIN, EYE AND LUNG DAMAGE. FOLLOW THE MANUFACTURER'S INSTRUCTIONS FOR EACH CLEANING SOLUTION.

CAUTION: IF ANY WATER-MIXED DEGREASING SOLUTIONS CONTAINING CAUSTIC COMPOUNDS OR SOAP ARE USED, EXTREME CARE MUST BE EXERCISED. THESE COMPOUNDS IN

ADDITION TO BEING POTENTIALLY DANGEROUS TO ALUMINUM AND MAGNESIUM, MAY BECOME IMPREGNATED IN THE PORES OF THE METAL AND CAUSE OIL FOAMING WHEN THE ENGINE IS RETURNED TO SERVICE. WHEN USING THESE WATER-MIXED SOLUTIONS ALWAYS THOROUGHLY RINSE THE PART IN CLEAN BOILING WATER. REGARDLESS OF METHOD OR SOLUTION USED ALWAYS COAT AND SPRAY ALL PARTS WITH LUBRICATING OIL IMMEDIATELY AFTER CLEANING IN ORDER TO PREVENT CORROSION.

CAUTION: USE THE CORRECT PERSONAL PROTECTION. HEATED PARTS WILL CAUSE BURNS.

Decarbonizing

Decarbonizing is usually accomplished by immersion of the part in a decarbonizing solution (usually heated). Decarbonization solutions such as Gunk, Penetrol, Carbrax, Super-Chemco, Gerlach No. 70 or any suitable solution. Refer to the above caution for water-soluble decarbonizers. Remove hard carbon deposits after degreasing by brushing, scraping or grit blasting. After cleaning, rinse the parts in petroleum solvent, dry, and remove loose particles by blowing the particles out with compressed air. Use a shop air supply with an appropriate water trap.

Decarbonizing solutions will usually remove most of the enamel from machined surfaces. All remaining enamel should be removed by grit blasting particularly in the narrow areas between cylinder cooling fins.

Valve seats may be left unprotected during decarbonizing processes. This will facilitate the reconditioning of the valve seat in later procedures.

CAUTION: EXTREME CAUTION SHOULD BE EXERCISED WHEN USING A DECARBONIZING SOLUTION. IT IS RECOMMENDED THAT THE USE OF HEATED SOLUTIONS BE AVOIDED UNLESS THE OPERATOR IS THOROUGHLY FAMILIAR WITH THE PARTICULAR SOLUTION BEING USED. IN ADDITION THE OPERATOR IS STRONGLY ADVISED AGAINST IMMERSING STEEL AND MAGNESIUM PARTS IN THE SAME DECARBONIZING TANK, BECAUSE THIS PRACTICE OFTEN RESULTS IN DAMAGE TO THE MAGNESIUM PARTS FROM CORROSION.

CAUTION: DO NOT DAMAGE MACHINED SURFACES. MASK ALL MACHINE SURFACES PLUG ALL DRILLED OIL PASSAGES TO PREVENT DAMAGE OR ENTRY OF FOREIGN MATTER.

CAUTION: WHEN YOU USE COMPRESSED AIR TO CLEAN OR DRY PARTS, MAKE SURE THAT THE PRESSURE IS NOT MORE THAN 20 PSI. DO NOT DIRECT THE AIRSTREAM AT PERSONNEL OR LIGHT OBJECTS. PUT ON GOGGLES OR A FACE SHIELD TO PROTECT YOUR EYES. THIS WILL HELP PREVENT INJURIES TO PERSONNEL OR DAMAGE TO THE EQUIPMENT. IF YOU GET AN EYE INJURY, SEEK MEDICAL ATTENTION

CAUTION: DO NOT USE WIRE BRISTLE BRUSHES OR METAL SCRAPERS ON ANY BEARING, MACHINED OR CONTACT SURFACES.

CAUTION: DO NOT USE GRIT BLASTING ON THE PISTON RING GROOVES. USE A WOODEN SCRAPER.

Scratch and Corrosion Removal

Remove corroded or pitted surfaces on the fillets at the edges of crankshaft main and crankpin journal surfaces, and thrust bearing races by polishing with crocus cloth or other mild abrasive material. Refer to the Fits and Clearances section of this manual for limits.

Shallow or small scratches, minor abrasions, or pitting on gears or screwed fittings may be dressed out with a fine abrasive (crocus) cloth, small file, or polishing stone. Refer to the Fits and Clearances section of this manual for limits.

Accessory Mounts

Clean mounting pads and studs by wiping with a clean cloth moistened with solvent. Use care to remove sludge and debris from around the bases of the studs.

NOTE: Use care to not force debris into drilled areas, passages, ports, or threaded receptacles.

WARNING: SOLVENT IS TOXIC. USE IN WELL-VENTILATED AREA. PREVENT EYE AND SKIN CONTACT AND DO NOT BREATHE VAPORS. 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.

Fuel Injector and Primer Nozzles

Remove the nozzle. Submerge in a cleaning solvent such as Stoddard Solvent or MEK or equivalent. Allow soaking for several hours. Remove from solvent and dry with dry and clean compressed air. Ultra-sound cleaning methods may also be used.

WARNING: SOLVENT IS TOXIC. USE IN WELL-VENTILATED AREA. PREVENT EYE AND SKIN CONTACT AND DO NOT BREATHE VAPORS. 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: WHEN YOU USE COMPRESSED AIR TO CLEAN OR DRY PARTS, MAKE SURE THAT THE PRESSURE IS NOT MORE THAN 30 PSI. DO NOT DIRECT THE AIRSTREAM AT PERSONNEL OR LIGHT OBJECTS. PUT ON GOGGLES OR A FACE SHIELD TO PROTECT YOUR EYES. IF YOU GET AN EYE INJURY, GET MEDICAL ATTENTION.

CAUTION: DO NOT USE A SHARP TOOL TO CLEAN OR DISASSEMBLE FUEL OR AIR BLEED NOZZLES.

NOTE: Under normal conditions, the shield and screen are NOT removed from the nozzle assembly. If removal is necessary, both must be thoroughly cleaned prior to reassembly. The shield must have a tight fit on the body.

Screens and Filters

A. Fuel system filters
   (1) Fuel screens may be soaked and rinsed in clean solvent and dried with compressed air.
B. Oil system filters
   (1) Oil screens may be soaked and rinsed in clean solvent and dried with compressed air.
   (2) Disposable external oil filter elements are not cleaned.
C. Air induction system filters
   (1) Foam air filters may be rinsed in clean solvent then washed with mild detergent and water and reinstalled.

Paper air filter elements are not cleaned

WARNING: SOLVENT IS TOXIC. USE IN WELL-VENTILATED AREA. PREVENT EYE AND SKIN CONTACT AND DO NOT BREATHE VAPORS. 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: WHEN YOU USE COMPRESSED AIR TO CLEAN OR DRY PARTS, MAKE SURE THAT THE PRESSURE IS NOT MORE THAN 30 PSI. DO NOT DIRECT THE AIRSTREAM AT PERSONNEL OR LIGHT OBJECTS. PUT ON GOGGLES OR A FACE SHIELD TO PROTECT YOUR EYES. IF YOU GET AN EYE INJURY, GET MEDICAL ATTENTION.

Accessories

Refer to the various manufacturers' manuals for information regarding the cleaning of these components.

Preservation and Corrosion Prevention

A. Upon conclusion of visual inspection and all cleaning operations, rinse parts with petroleum solvent. Dry and remove any loose particles by air blast. Apply a liberal coating of preservative oil to all surfaces.

B. For parts that will be repainted, do the following:
   (1) Be sure that the part is thoroughly degreased, clean, and dry.
   (2) Prime and paint in accordance with Repair section.

INSPECTION AND CHECK

General

The inspection of engine parts consists of three (3) categories: visual, structural, and dimensional. Visual and structural inspections deal primarily with structural defects. The dimensional checks are concerned with the size, shape, and fit of a given part. Upon successful completion of inspection, coat all steel parts with preservative oil.

Visual inspections should precede all other inspections. No cleaning operation should be permitted until a complete initial visual inspection is made of the part in question. Residue from the engine's operation can provide additional information as to hidden defects or other dangerous conditions. Refer to the Cleaning section of this manual.

Structural inspections will include checking flatness, out-of-roundness, and passageway clearance. They may also include magnetic particle and dye penetrant procedures as well as eddy-current, ultra-sonic, or other non-destructive testing methods.

For dimensional inspections, refer to the tables set forth in the Fits and Clearances section of this manual.

For repairs required prior to a final inspection or dimensional check of a part, refer to the Repairs section of this manual.

The use of a recording form is recommended during the inspection procedures. The form should be prepared so that all inspection and subsequent repair and reassembly procedures can be noted as they are completed. This usage will also help prevent the omission of components during the inspections and will provide a place to record findings and comments resulting from the inspections.

Materials and Tools

Materials required for inspection are listed Table 72-00-08.1. Special tools and equipment required for inspection are listed Table 72-00-08.2.

Table 72-00-08.1
Inspection Materials

Item	Source
Magnetic base oil	Commercially Available
Preservative oil	Commercially Available
Dye penetrant and developer	Commercially Available
Acetone	Commercially Available
Mineral Spirits	Commercially Available
SAE #10 lubricating oil (check fuel nozzle flow)	Commercially Available

NOTE: Equivalent substitutes may be used.

Table 72-00-08.2
Special Tools and Equipment

Item	Source
Calipers and micrometers: ID and OD	Commercially Available
10X Magnifying Glass	Commercially Available
Machinist's Ruler	Commercially Available
Small Flashlight	Commercially Available
Vee Blocks	Commercially Available
Dial Indicator	Commercially Available
Spring Tension Tester	Commercially Available
Magnetic Particle Inspection Equipment	Commercially Available

NOTE: Equivalent substitutes may be used.

General Inspection Procedures
All journal surfaces must be checked for galling, scores, misalignment, and out-of-round condition. Pins and shafts must be inspected for straightness.

Examine gears for evidence of pitting and excessive wear. This evidence is of special importance when found on the involute of the gear teeth. Deep pit marks in this area are reason to reject the part. Bearing surfaces of all gears may have minor abrasions dressed out with fine abrasive cloth but should be free from deep scratches.

Excessively worn or mutilated threads should be rejected. Small defects (such as slight nicks or burrs) may be dressed out with a small file, fine abrasive cloth (crocus cloth), or oil stone. If distortion, galling, or mutilation resulting from over tightening is discovered, the part must be replaced.

Inspection of highly stressed areas for corrosion is necessary. These areas are susceptible to pitting and can cause failure of the part. The following are components requiring particular attention with respect to this issue: the fillets at the edges of crankshaft main and crankpin journal surfaces, and thrust bearing races. If pitting is discovered in these areas and cannot be removed by polishing with crocus cloth or other fine abrasive, the part must be replaced. For polishing procedures, see the Repairs section of this manual.

Inspect all threaded inserts, fasteners, studs, fittings, plugs, etc., for condition of threads.

General Non-Destructive Testing
All parts must be thoroughly clean and dry prior to the start of the test and again upon completion of the test procedures. Refer to Cleaning section of this manual. It is important to carefully consider the results of the test to provide accurate interpretation.

All Ferro-magnetic steel parts should be inspected using a magnetic particle inspection method, such as MIL-STD-1949, performed by appropriately qualified personnel. This inspection is especially effective when used on highly stressed parts such as keyways, gear teeth, splines, roots of threads, small holes, and fillets.

NOTE: Perform the magnetic particle inspection strictly in accordance with the manufacturer's guidelines. Failure to do so can result in erroneous readings and the reuse of critical components with hidden damage that may cause engine failure.

NOTE: Care must be taken to prevent overheating or burning of the part as a result of the applied electricity during this test.

Tests using the dye penetrant method must be thoroughly cleaned of all penetrant and developer residue upon completion of the test. Any oils or other fluids used for other non-destructive procedures must be thoroughly cleaned from the part upon completion of the test.

NOTE: Upon completion of any cleaning procedure, be sure to coat all steel parts with preservative oil. Do not handle cleaned parts any more than necessary prior to their reassembly into the engine as this handling reintroduces dirt and corrosive substances to the parts.

Accessory Housing
Initially inspect accessory housing as illustrated in Figure 72-00-08.2. Remove all accessories (magnetos, pumps, valves, etc.) for separate inspection.

• Obvious excessive damage	Reject

Visually inspect accessory housing.

(1) Inspect accessory housing flange and drive pad surfaces.

• Deep scratches	Reject
• Minor scratches	Blend/hand polish per Repair No.2

(2) Inspect accessory case threaded and drilled areas and passages.

• Worn or mutilated, distorted, galled	Reject
• Slight nicks or burrs	Blend/hand polish per Repair No.1
• Obstructions or plugs	See Cleaning section of this manual

Crankcase Assembly
Perform initial inspection of crankcase assembly per Figure 72-00-08.3.

• Obvious excessive damage or wear	Reject

(1) Inspect all crankcase bearing bores and journals, saddle supports, support webs, tang slots, and flange surfaces.

• Deep scratches	Reject
• Fretting, heavy wear, flat spots	Reject
• Minor scratches	Blend/hand polish per Repair No.2
• Misalignment of mating surfaces	Reject
• Out of round conditions on journals	Reject

(2) Inspect crankcase threaded studs and drilled holes and passages.

• Worn, mutilated, distorted, or galled	Reject/See Repair No. 1
• Slight nicks or burrs	Blend/hand polish per Repair No.1

NOTE: Surfaces may be checked visually and by feel for roughness, flaking, and pitting of races and for scoring on the outside of the bearing races. Shafts, pins, etc., may be checked using vee blocks and dial indicators.

NOTE: Aluminum surfaces can withstand considerable scratching and light scoring without harming the engine integrity or performance provided these problems fall within the limits set forth in the Fits and Clearances section of this manual.

NOTE: Fretting on the saddle supports in the crankcase has a frosted appearance and tiny pit holes. This usually indicates a change in the size of the bearing saddles that can be sufficient to cause an excessively tight crankshaft bearing fit.

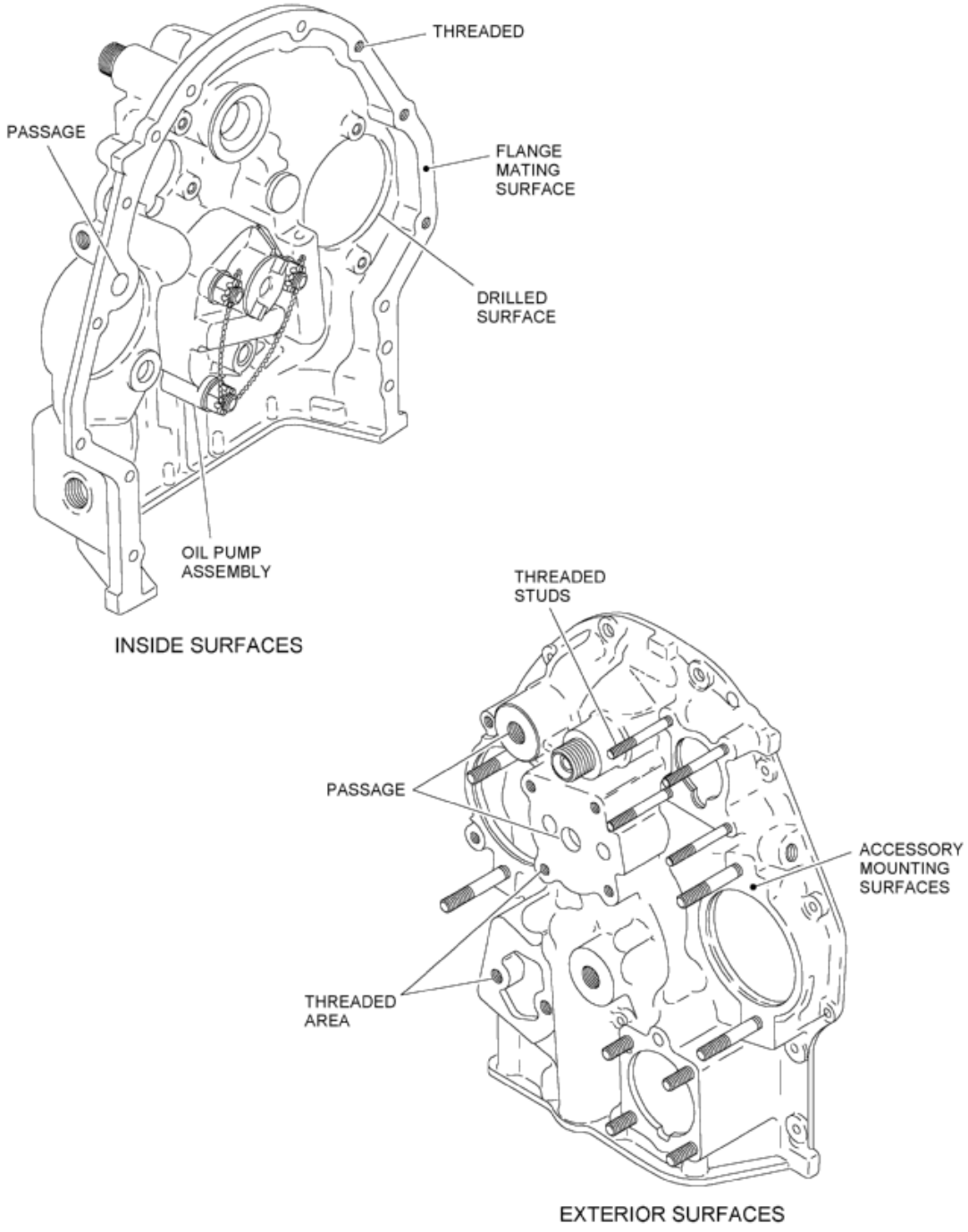

Figure 72-00-08.2 • Accessory Housing

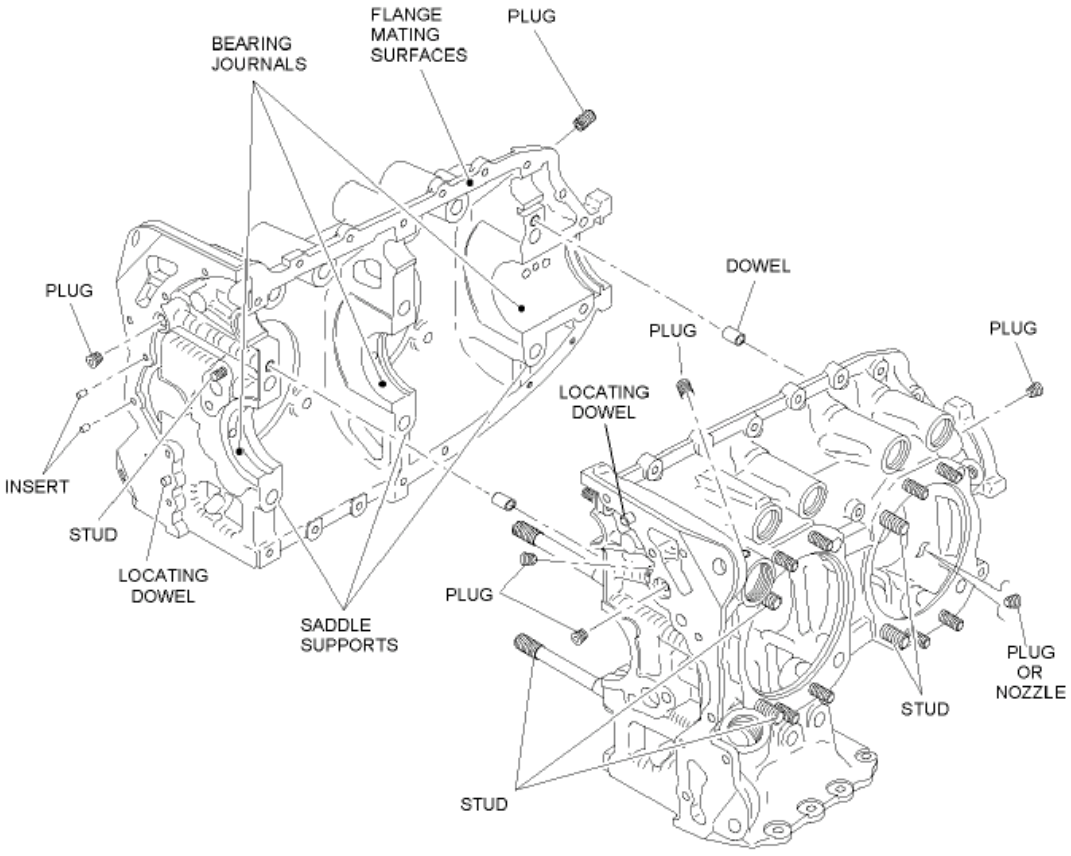

Figure 72-00-08.3 • Crankcase Bearing and Flange Surfaces

Cylinder Head

Initially inspect cylinder head. Refer to Figure 72-00-08.4.

- Obvious excessive damage to cylinder head — Reject

Visually inspect cylinder head.

(1) Inspect cylinder head valve seats.
- Loose, scored, or pitted valve seats — Reject

(2) Inspect cylinder for loose or damaged studs.
- Loose or damaged studs — Reject

NOTE: Loose or damaged studs must be replaced with oversized studs using 0.003, 0.007, or 0.012 inch.

(3) Inspect cylinder head spark plug helical coil inserts.
- Loose or damaged inserts — Reject

NOTE: Loose or damaged helical coil inserts must be replaced with oversized insert. See Repair No. 1.

(4) Inspect cylinder rocker box covers, intake and exhaust ports.
- Nicked, scored or dented mounting pads — Blend/hand polish per Repair No.2

(5) Inspect cylinder head cooling fins for cracks.
- Fin adjacent to the exhaust port flange — See Repair No.10
- Physically damaged, broken, or bent fins — See Repair No.10

Cylinder Head Dimensional Inspections

Inspect the rocker shaft bushings.
- Check the ID of the rocker shaft bushings a minimum of two (2) positions, 90 degrees apart. Several check locations are preferred. — Refer to Fits and Clearances

Cylinder Barrel Inspections

Visually inspect cylinder barrel for general condition. Refer to Figure 72-00-08.4.
- Cracks. — Reject

Visually inspect cylinder barrel cooling fins.
- Notches and nicks — Blend with hand grinder or file. See Repair No. 10

Visually inspect cylinder barrel skirt.
- Bent, cracked, or broken — Reject

Visually inspect cylinder barrel mounting flange.
- Nicks — Blend with file or crocus cloth. See Repair No. 2

Visually inspect cylinder barrel interior.
- Minor scoring or corrosion — Repair by honing. See Repair No. 9
- Deep scoring or pitting — Reject

Visually inspect cylinder barrel interior.
- Glazing or possible barrel wear — Repair by honing. See Repair No. 9

Cylinder Barrel Dimensional Inspections
Visually inspect cylinder barrel dimensions. Refer to Figure 72-00-08.4.

• Fit between piston skirt and cylinder	Refer to Fits and Clearances
• Maximum taper of cylinder walls	Refer to Fits and Clearances
• Maximum out of roundness	Refer to Fits and Clearances
• Bore diameter	Refer to Fits and Clearances

NOTE: All cylinder barrel diameter measurements must be taken at a two (2) locations, 90 degrees apart at the plane specifically being measured.

Cylinder Assembly Inspection
Perform a fluorescent dye penetrant inspection of the cylinder head.

• Cracks	Reject

Piston Inspections
Visually inspect piston general condition. Refer to Figures 72-00-08.5 and 72-00-08.6.

• Inspect the top of the piston for excessive pitting, cavities or surface distortion.	Reject
• Inspect the piston lands, piston pin holes, and bosses for excessive wear or damage.	Reject
• Inspect the piston ring in grooves clearances in excess of limits.	Refer to Fits and Clearances

Piston Dimensional Inspections
Inspect pistons for correct dimensions. Refer to Figure 72-00-08.5.

• Side clearance between piston and ring	Refer to Fits and Clearances

NOTE: These pistons are ground with a slight taper from the skirt to the head. The exception is the lands between the top compression and oil control rings, which are ground parallel. The clearance on wedge type compression rings must be measured with ring flush to outside edge of piston as shown in Figure 72-00-08.6 in order to obtain a true check of the side clearance.

• Inside diameter of piston pin hole	Refer to Fits and Clearances

NOTE: No pitting or corrosion is permitted in this area.

• Clearance between piston skirt and cylinder and piston diameter at top and bottom	Refer to Fits and Clearances

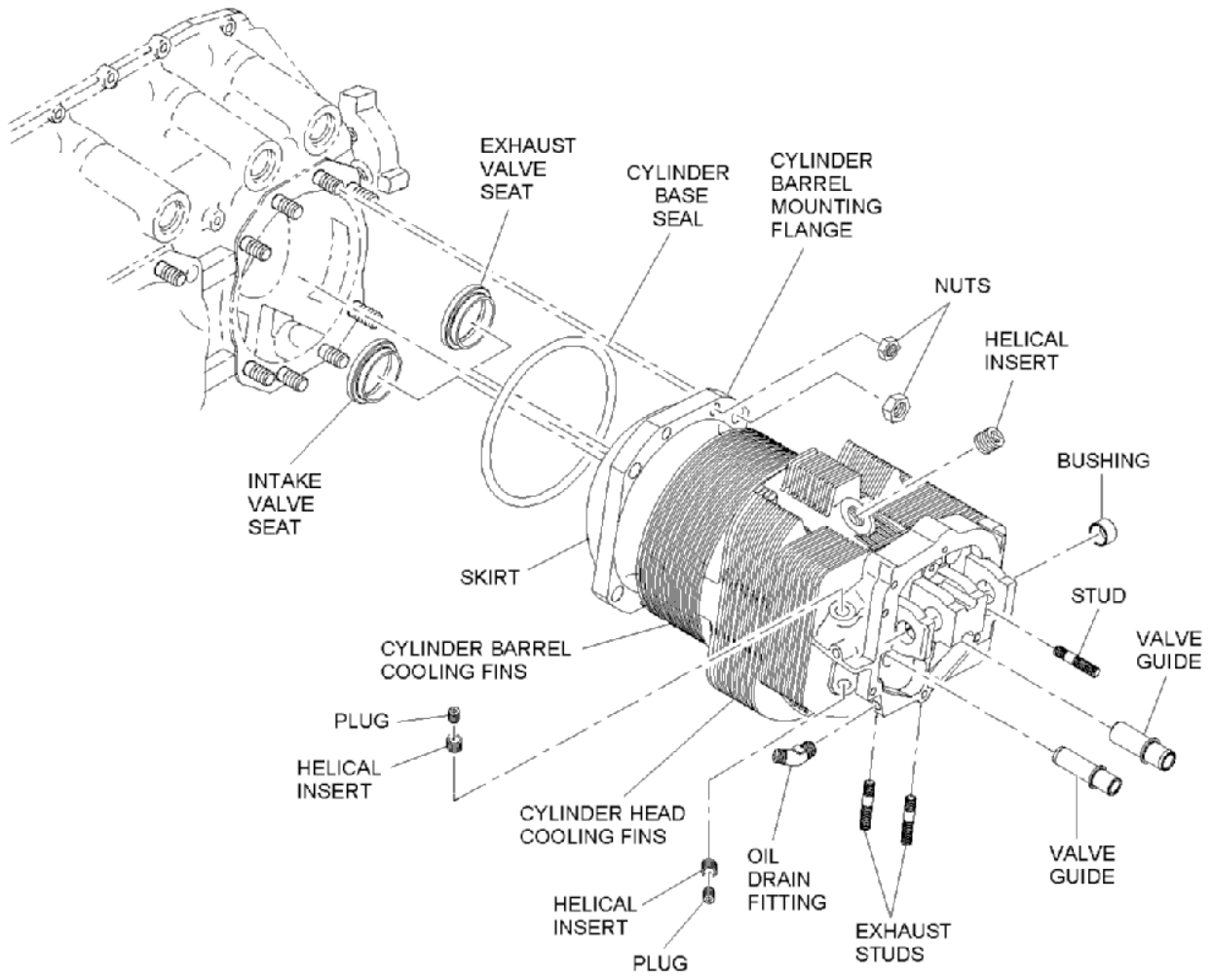

Figure 72-00-08.4 • Cylinder Assembly

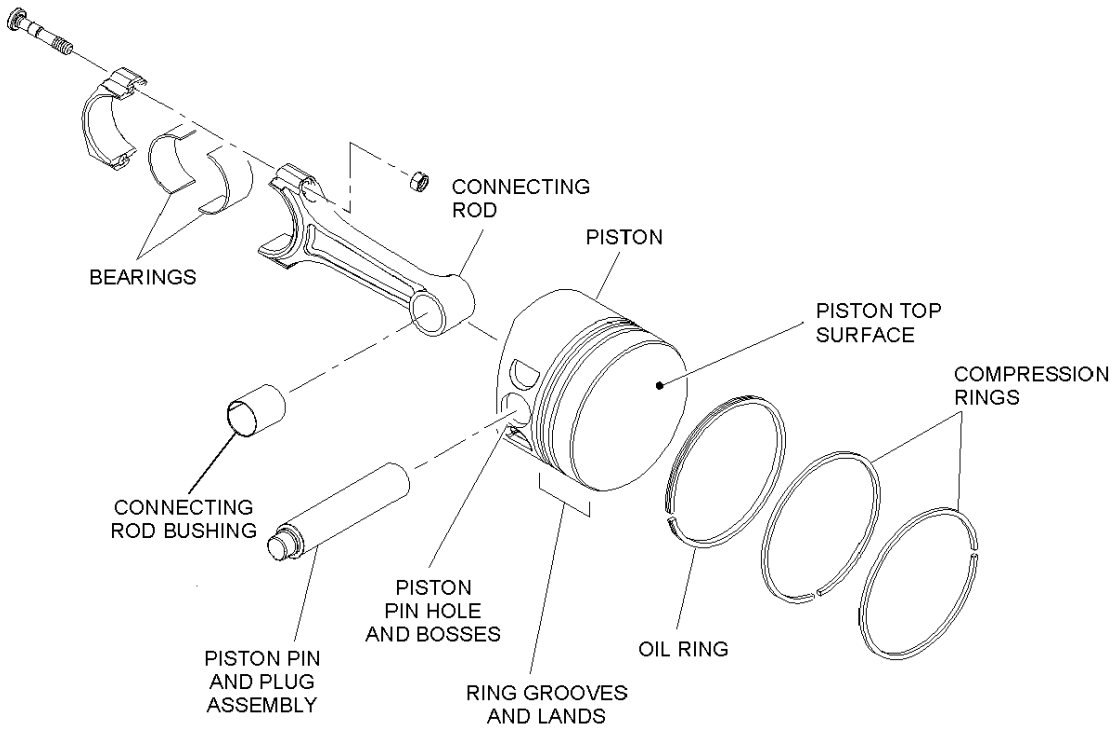

Figure 72-00-08.5 • Piston Assembly

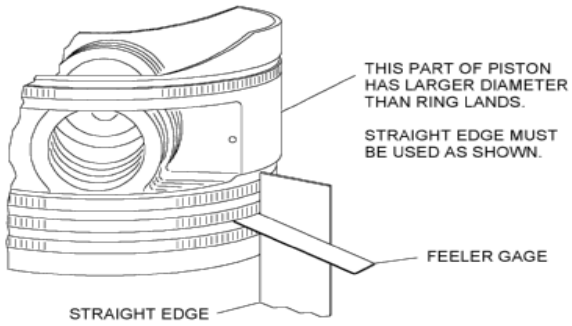

Figure 72-00-08.6 • Piston Rings and Lands

Valve Rockers

Inspect valve rocker for damage. Refer to Figure 72-00-08.7.

• Check for damaged, badly worn, pitted or scored tips and rod sockets.	Reject
• Check rocker bushing ID at two (2) locations 90° apart. Refer to Fits and Clearances.	Replace bushing per Repair No. 13

Pushrod Inspection

Inspect pushrods for wear, fit, and alignment. Refer to Figure 72-00-08.8.

• Inspect for excessive wear or damage.	Reject if in excess
• Rod must be straight within 0.010 inch	Reject if in excess

Valve Springs Inspection

Check valve springs using a spring tester. Refer to Figure 72-00-08.7.

• Reference spring load and deflection limits in Fits and Clearances section of this manual.	Replace if weak

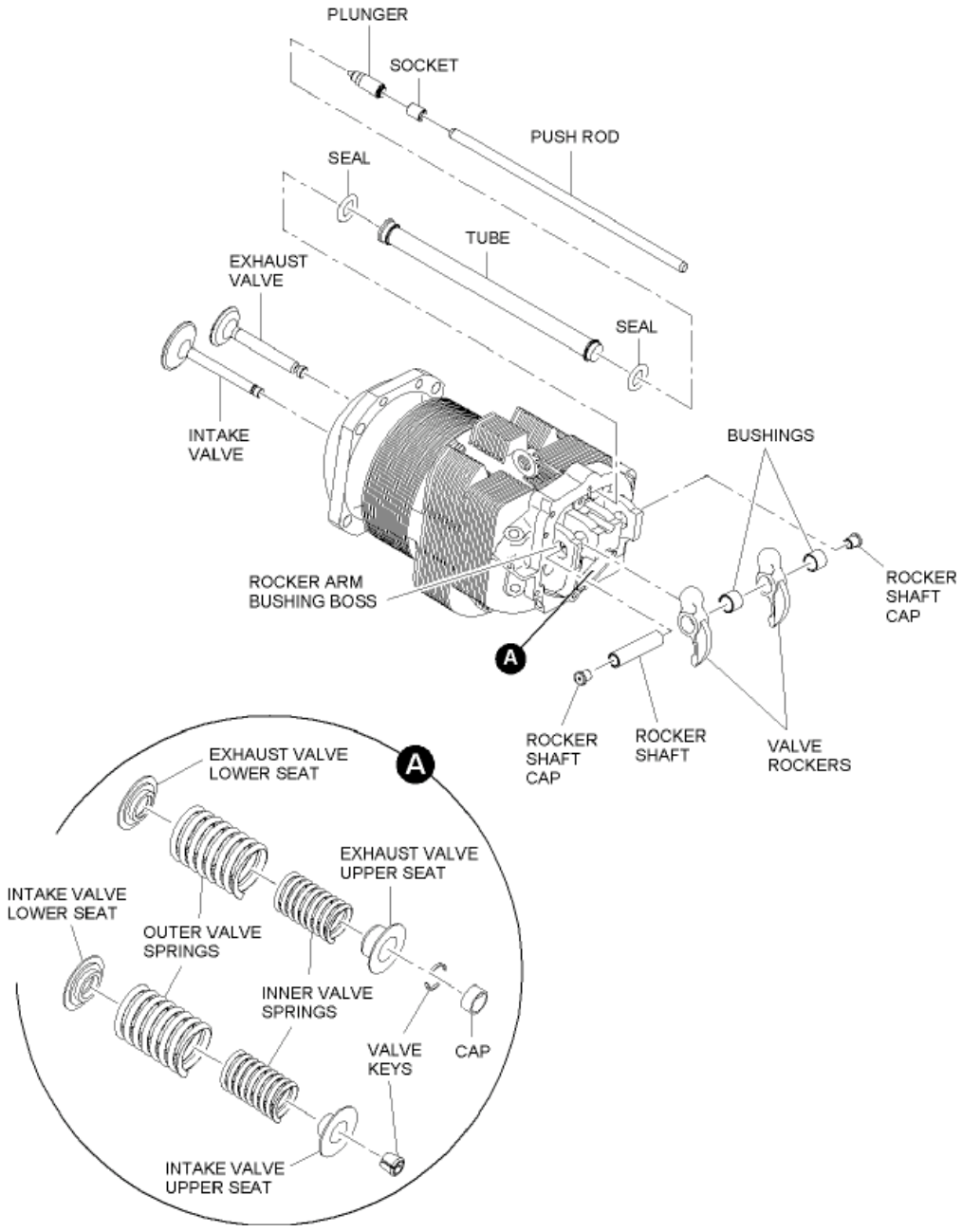

Figure 72-00-08.7 • Valve Train

Crankshaft

NOTE: A magnetic particle inspection should be performed whenever the crankshaft is removed from the engine.

Visually inspect the shaft.

• Scoring, galling, pitting, corrosion, cracks	Reject

Visually inspect the bearing surfaces.

• Scoring, scratching, etching	Reject

Dimensionally inspect the bearing surfaces.

• Refer to Fits and Clearances of this manual	Reject if beyond acceptable limits

Visually inspect the ID of the forward end of the shaft.

• Deterioration of the cadmium plating	See Repair No. 7

Measure the run-out of the crankshaft center main bearings and flange by supporting the crankshaft on a flat surface in vee blocks on the front and rear main bearing.

• Measure run-out of the crankshaft center main bearing	Reject if run-out exceeds limits of the Fits and Clearances.
• Measure run-out of crankshaft prop flange	Reject if run-out exceeds limits of the Fits and Clearances

Crankshaft Counterbore Face Inspection

Inspection of the counterbored gear mounting flange surface.

• Fretting, galling, scoring, pitting	Reject
• Check threads in gear retaining hole for nicks or burrs Check for hole depth by measuring with a gear retaining bolt threaded all the way in. Compare the exposed length of the bolt with the thickness of the gear and lockplate.	See Repair No. 8
• Inspect dowel for damage, out of roundness. Refer to Repair No. 4.	Replace
• Inspect pilot diameter of the counterbore for size and damage. The diameter should not exceed 2.1262 inches at any place. Refer to Repair No. 4.	Repair

CAUTION: IF THE DOWEL MUST BE REMOVED, BE CAREFUL NOT TO DAMAGE THE CRANKSHAFT HOLE. DRILL A 1/8 INCH DIAMETER HOLE THROUGH THE CENTER OF THE DOWEL. FILL THE HOLE WITH OIL AND INSERT A PIECE OF 1/8 INCH DIAMETER DRILL ROD IN THE HOLE. STRIKE THE END OF THE DRILL ROD WITH A SHARP BLOW. THE RESULTING HYDRAULIC PRESSURE SHOULD FORCE THE DOWEL OUT.

NOTE: If the crankshaft requires repairs other than those specified above, measure the crankshaft counterbore face. If the crankshaft measures more than the minimum dimension shown, the surface may be reworked to the dimensions shown (do not plate the surface). The surface must be true within 0.001 inch T.I.R. The surface finish must be held to 45 to 90 microns.

Camshaft Inspection

Visual inspection.

• Entire shaft for fretting, galling, scoring, pitting, cracks, pitting, or other damage	Reject
• Cam lobes for indications of distress, surface irregularity, or feathering along the edges.	Reject

NOTE: If the hydraulic lifter bodies have been rejected for spalling, inspect the corresponding cam lobe(s).

Dimensional inspection.

NOTE: Refer to Fits and Clearances section of this manual.

• Runout at center bearing in excess of 0.001 T.I.R.	Reject
• Difference between camshaft bearing journals and crankcase bore 0.002 minimum to 0.004 in. maximum	Reject if outside

Connecting Rods Inspection

Visual inspection.

• Inspect bore in large end of connecting rod.	Replace or repair if tolerances are outside the limits
• Inspect bushing bore in small end of connecting rod.	Replace bushing per Repair No 11
• Check connecting rod parallelism. Refer to Fits and Clearances. Refer to Figure 72-00-08.13	Replace rod if tolerances are outside the limits
• Check connecting rod squareness. Refer to Fits and Clearances. Refer to Figure 72-00-08.15.	Replace if tolerances are outside the limits

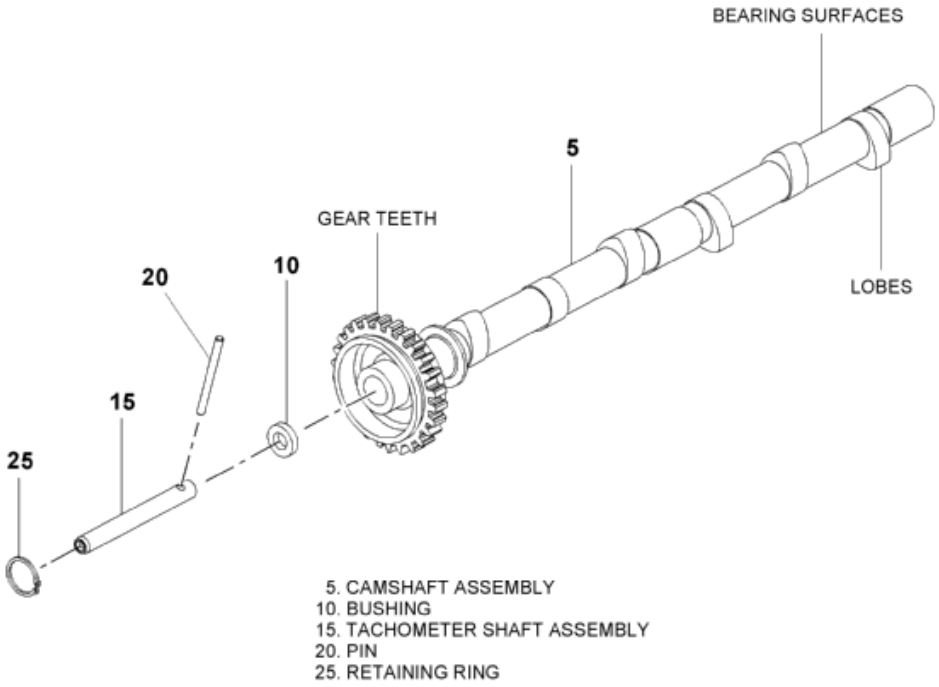

Figure 72-00-08.8 • Camshaft Assembly

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ENGINE ASSEMBLY

General
This section has the procedures and illustrations necessary to assemble the Vantage O-360 and IO-360 series engine.

Fits, Clearances and Torque Values
Fits, clearances and torque values to be established during repair or assembly are listed in the applicable paragraph so that the unit can be assembled without reference to another section of the manual.

NOTE: Limits followed by a letter "T" indicate "tight", i.e., interference fit. An example is the valve guide in the cylinder head. Where no "T" exists, the fit is a clearance dimension.

Materials Required for Assembly
Materials required for assembly are listed in Table 72-00-09.1 below.

NOTE: Equivalent substitutes may be used for listed items.

Table 72-00-09.1 • Assembly Materials

Material	Source
Acetone or Methyl Ethyl Ketone (MEK)	Commercially Available
Assembly Grease – Lubriplate™ No. 105	Commercially Available
Cleaning Solvent	Commercially Available
Copper Based Anti-seize, Fel-Pro™ C5-A	Commercially Available
Fuelube™	Commercially Available
Loctite™ 241, P/N 27183	Commercially Available
Loctite™ No. 2 Gasket Sealant P/N 30514	Commercially Available
Oil, Aviation Grade (Mineral, Non-detergent)	Commercially Available
Permatex™, P/N 27100	Commercially Available
Pre-Lube Mixture – approx. 15% STP™ and 85% Aviation Mineral Oil	Mixed Locally
RTV™ 102 Silicon Sealant	Commercially Available
Safety Wire (0.032 in.) Type 304 Stainless, P/N MS20995 C32	Commercially Available
Safety Wire (0.041 in.) Type 304 Stainless, P/N MS20995 C41	Commercially Available
Silk Thread #50 (100% Silk)	Commercially Available
STP™ High Viscosity Oil Treatment	Commercially Available
Titeseal™ No. 2 Gasket and Joint Compound P/N T2-01	Commercially Available

Special Tools and Equipment
Special tools and equipment required for assembly are listed in Table 72-00-09.2 below.

NOTE: Equivalent substitutes may be used for listed items.

NOTE: Standard reciprocating engine aviation shop tools and equipment are used, unless otherwise specified.

NOTE: Unless otherwise specified, all gaskets are installed dry.

Table 72-00-09. 2 • Special Tools and Equipment

Description	Source
Compressor, Valve Spring & Bar	Commercially Available
Piston Ring Expander	Commercially Available
Puller Set, Oil Seal	Commercially Available
Puller, Slide Hammer – Medium	Commercially Available
Puller, Valve Guide	Commercially Available
Socket, Connecting Rod Nut	Commercially Available
Stand, Engine	Commercially Available
Tool, Crankcase Separating	Commercially Available
Tool, Intercylinder Baffle	Commercially Available
Cylinder Base Wrenches, 3/4” and 9/16”	Commercially Available
Piston Ring Grinder	Commercially Available
Piston Ring Compressor	Commercially Available
Nose Seal Installation Tool	Commercially Available
Snap Ring Pliers	Commercially Available

Engine Assembly

WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

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NOTE: Unless otherwise specified, all torque loads listed for nuts, bolts, and screws are for use with pre-lube oil.

Crankcase Inspection and Preparation for Assembly.

(1) Place crankcase halves on workbench. Check for handling damage. Inspect for slight nicks and burrs surface finish, split lines, bearing and cam bores, mating surfaces, and tappet bores.
(2) Inspect studs for thread damage, bent condition.
(3) Inspect tang slots for deformation. Install center and aft main bearings in case halves.
(4) Check front main bearing retention dowel installation for correct height of 0.070-0.090 in. Refer to Figure 72-00-09.1.

WARNING: WHEN YOU USE COMPRESSED AIR TO CLEAN OR DRY PARTS, MAKE SURE THAT THE PRESSURE IS NOT MORE THAN 30 PSI. DO NOT DIRECT THE AIRSTREAM AT PERSONNEL OR LIGHT OBJECTS. PUT ON GOGGLES OR A FACE SHIELD TO PROTECT YOUR EYES. IF YOU GET AN EYE INJURY, GET MEDICAL ATTENTION.

(5) Inspect oil galleys in each crankcase half to ensure they are clean and that

they properly intersect. Compressed air may be used.

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(6) Apply a light coat of pre-lube oil to main bearings (5, Figure 72-00-09.2). Install crankshaft (25, Figure 72-00-09.3) in right crankcase half.
(7) Using a feeler gage, check thrust and slinger clearances. Clearances must be within limits per Fits and Clearances section of this manual. Rotate crankshaft 360 degrees to ensure adequate cheek to case clearance and record. Refer to Figure 72-00-09.4.
(8) Repeat steps 6 and 7 in the left crankcase half and record clearances.
(9) Lightly lubricate camshaft bore journals and temporarily install the camshaft and rotate in each crankcase half. Using feeler gage measure and record end clearance in each half. Clearances must be within limits per Fits and Clearances section of this manual.
(10) Check threaded areas of crankcase halves. Install external pipe plugs using Titeseal™ thread sealant. Torque plug (40, Figure 72-00-09.5) to 40 in-lbs.
(11) Install piston cooling nozzle, if furnished, using Locktite™ (95, Figure 72-00-09.5) torque nozzle to 100 in-lbs.

NOTE: Plug(s) MS27769-1 may be used in place of piston nozzle(s) as required by the engine model. Torque plug(s) to 40 in-lbs.

Crankshaft Inspection and Preparation for Assembly

(1) Visually inspect crankshaft for handling damage. Check bearing, slinger and thrust face surfaces.
(2) Measure and record main journal dimensions with micrometer. Dimensions must be within limits per Fits and Clearances section of this manual.
(3) Measure and record rod journal dimensions with micrometer. Dimensions must be within limits per Fits and Clearances section of this manual.

Crankshaft Front Oil seal Installation

1. Remove spring from new front oil seal (15, Figure 72-00-09.2). Apply pre-lube oil mixture to the crankshaft propeller flange and I.D. of oil seal. Install oil seal with flat side out to prop flange. Use tool to carefully stretch seal over flange.
2. Re-install the spring in seal (15) groove.
3. Clean oil from the prop flange.
4. Apply oil to crankshaft and front oil seal (15) at their fit locations.
5. If required, apply pre-lube and install the propeller flange bushings (50, 55, 60, Figure 72-00-09.3). Pull through with puller tool. Refer to Figure 72-00-09.3 for bushing positions.
6. Install and secure the crankshaft to a vertical support stand.

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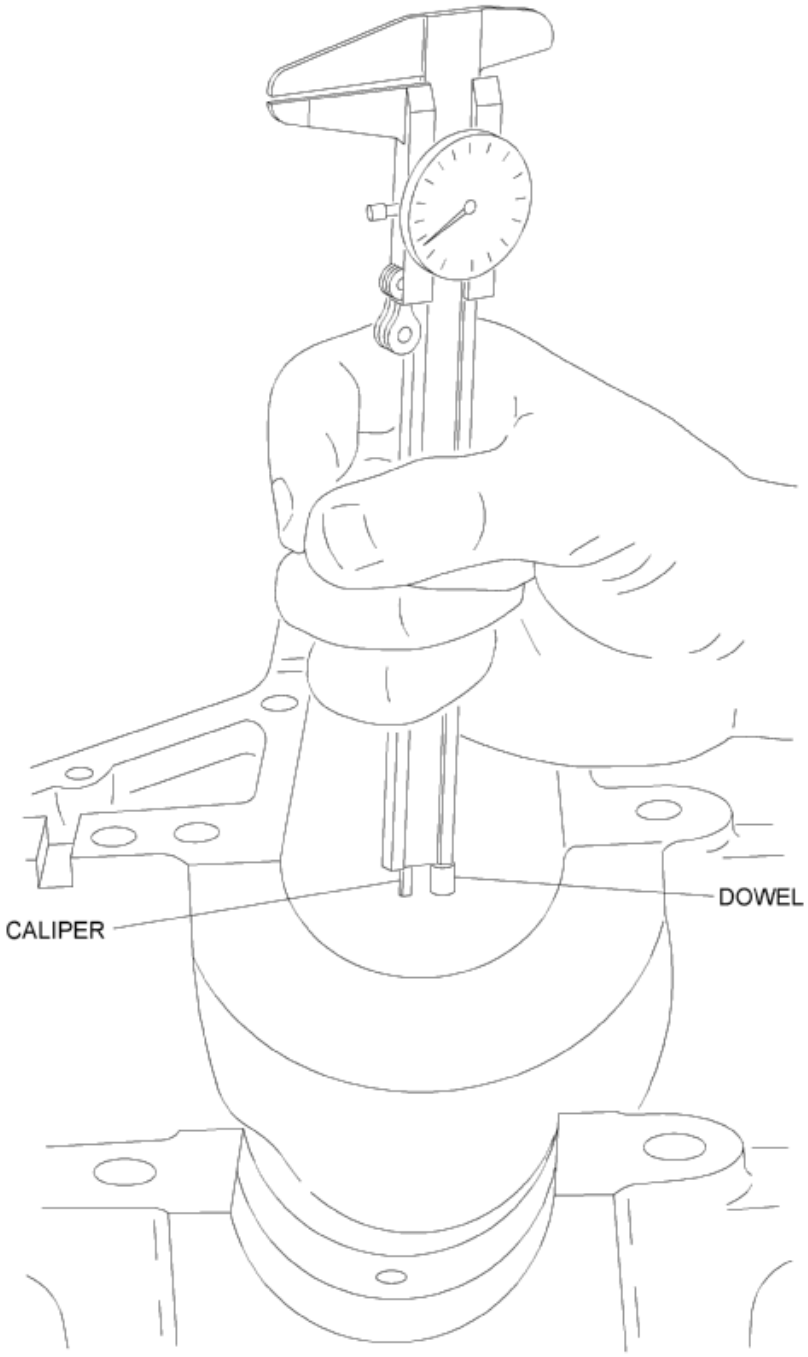
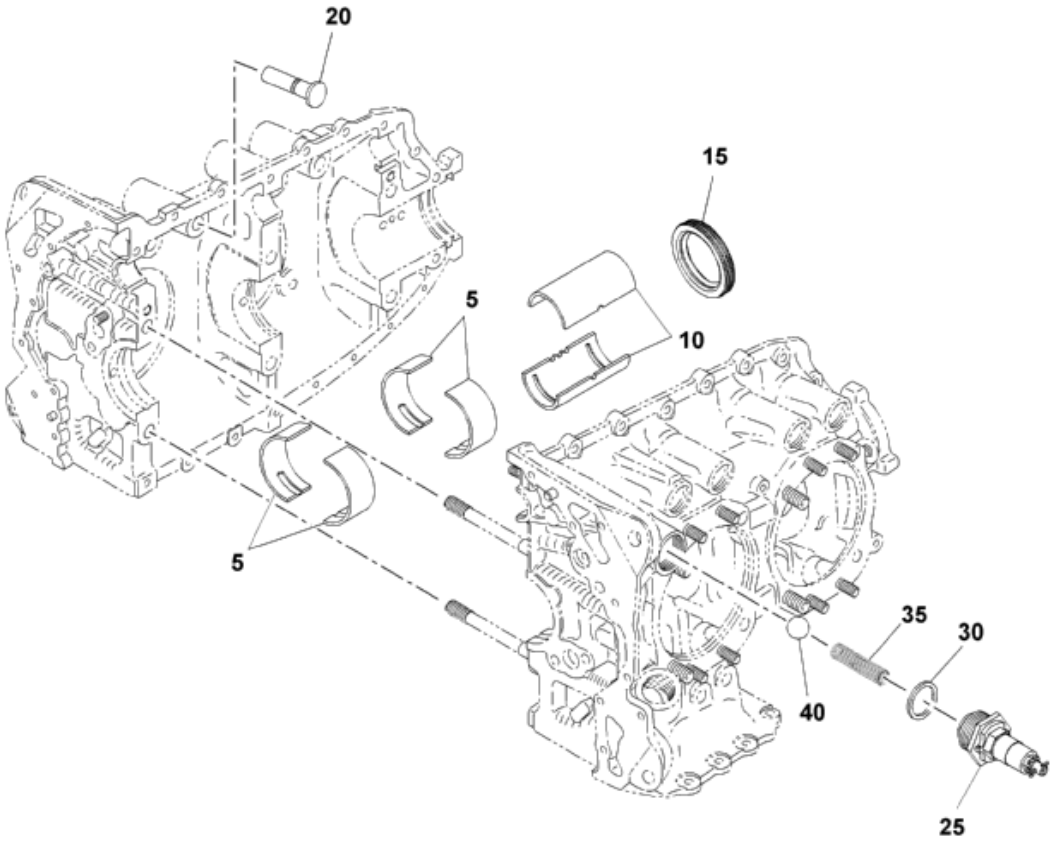
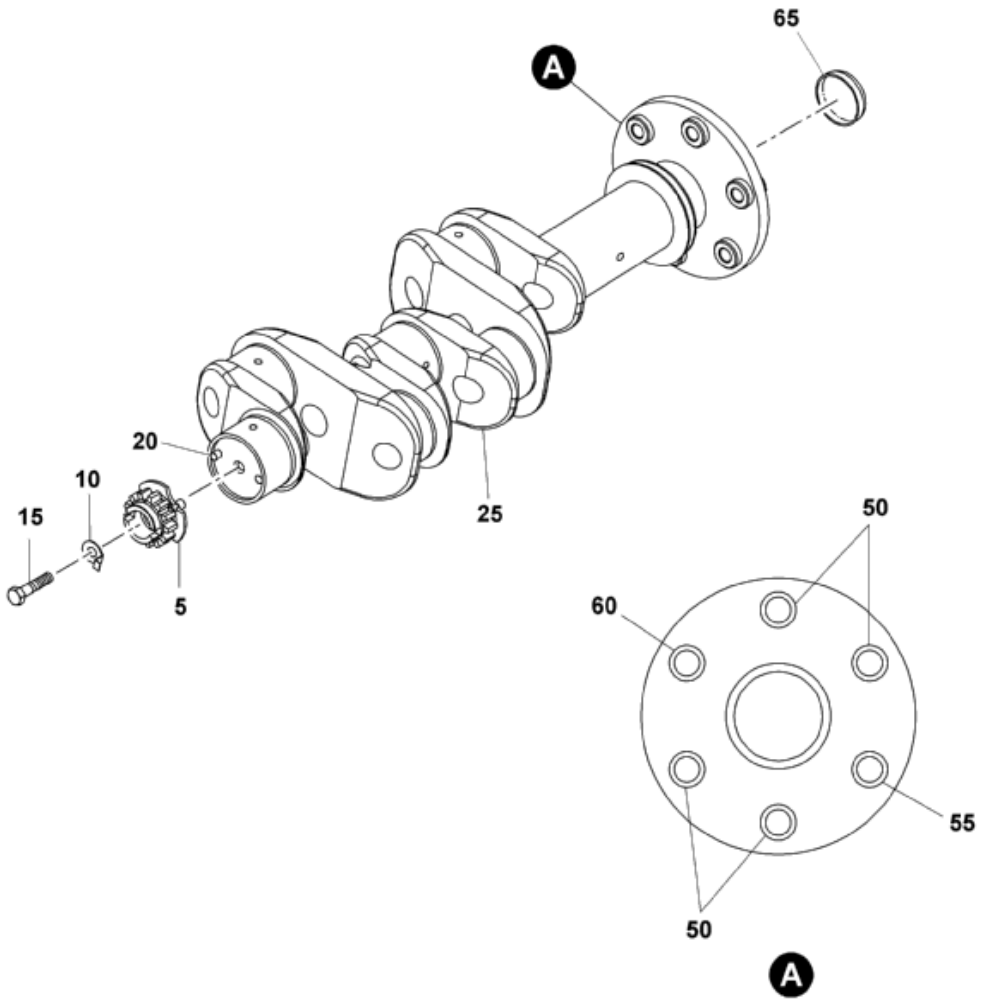


Figure 72-00-09.1 • Crankcase Bearing Retention Dowel



5. MAIN BEARINGS
10. FRONT MAIN BEARINGS
15. SEAL - OIL FRONT
20. LIFTER BODY
25. VALVE ASSY - OIL RELIEF
30. GASKET - COPPER
35. SPRING
40. BALL

Figure 72-00-09.2 • Crankshaft Bearing and Oil Pressure Relief Valve



5. GEAR - CRANKSHAFT
10. LOCKPLATE
15. SCREW
20. DOWEL - STEPPED
25. CRANKSHAFT ASSY
50. BUSHING - LONG
55. BUSHING - INDEXED
60. BUSHING - SHORT
65. PLUG - EXPANSION

Figure 72-00-09.3 • Crankshaft Assembly

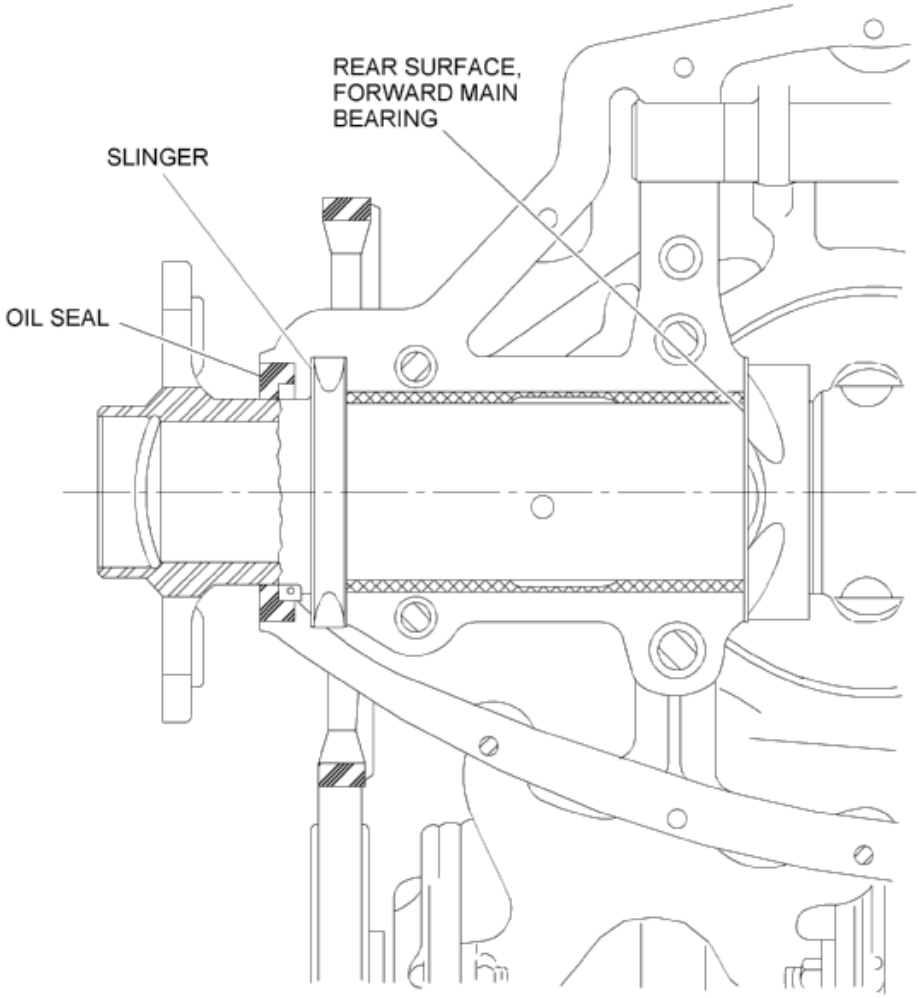
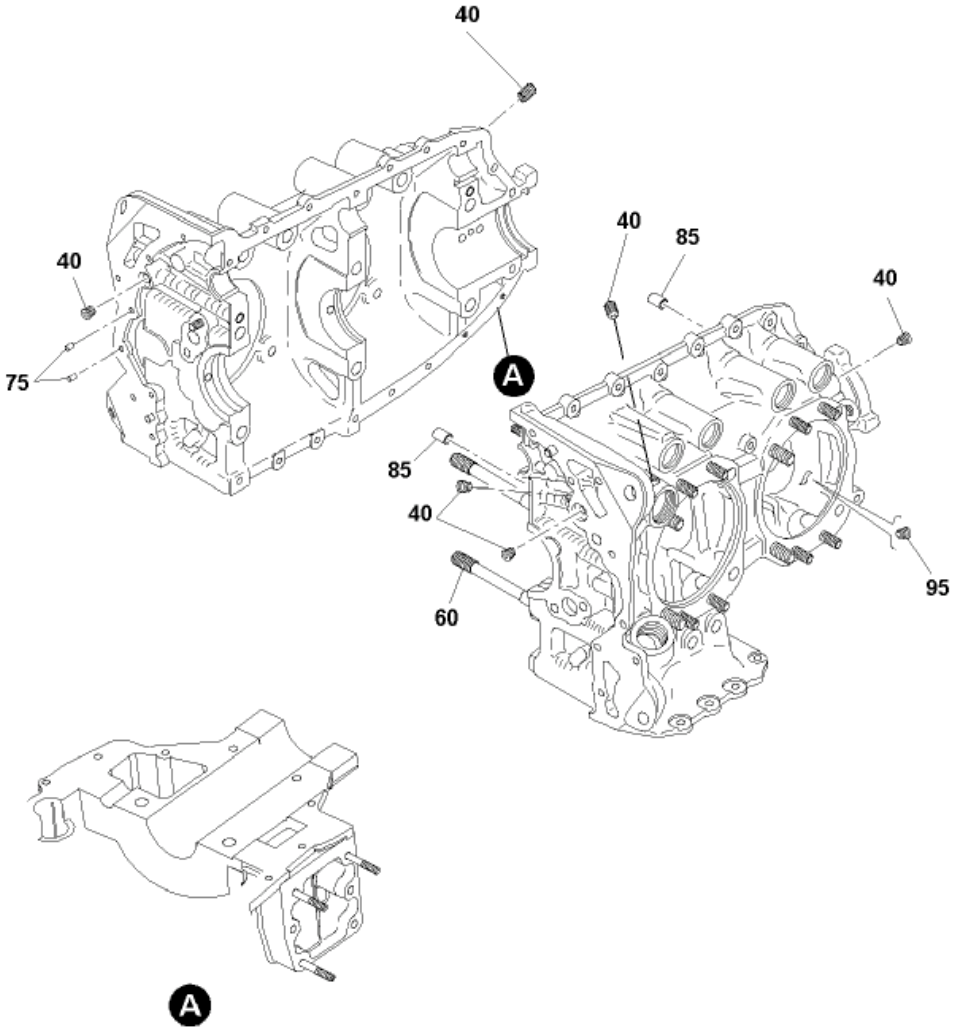


Figure 72-00-09.4 • Crankshaft Thrust and Slinger Clearance



40. PLUG
60. STUD
75. INSERT
85. DOWEL
95. PLUG OR PISTON COOLING NOZZLE (AS REQUIRED)

Figure 72-00-09.5 • Crankcase Assembly

Connecting Rod Assembly Inspection

(1) Visually inspect the rod assembly (5, Figure 72-00-09.6) for handling damage, defects, and corrosion.
(2) Inspect the bore finish. This must be smooth and free of burrs.
(3) Verify correct rod part number.
(4) Verify the serial number match for each rod and cap assembly.
(5) Verify and record each rod assembly weight.

NOTE: Difference in rod assembly weights must not exceed 2 grams in opposing pairs.

(6) Check each piston pin (35) in each rod (5) for fit. The pins must slide freely through the rod.

Subassembly of Connecting Rods to Crankshaft

(1) Visually inspect the rod bolts and nuts (10, 15 Figure 72-00-09.6). Lightly lubricate bolt shanks and threads with pre-lube oil.
(2) Verify bearing part number and size for crankshaft and model application.
(3) Install the connecting rod bearing shell (1) in each rod and cap (5).
(4) Apply pre-lube oil to the bearing shell (1).
(5) Apply pre-lube oil to the rod bearing journals of crankshaft.
(6) Insert 2 rod bolts through each rod cap. Begin with the lowest serial number rod cap and install it to the crankshaft with its matching rod (5) at the #1 (most forward) rod location.
    (a) Install with serial numbers in same plane and down towards oil sump. Refer to Figure 72-00-09.7.
    (b) Install the nuts with flat side to connecting rod. Refer to Figure 72-00-09.7. Tighten moderately to check fit prior to torque.
(7) Tighten each rod nut to bolt (10,15, Figure 72-00-09.6) evenly to 480 in-lb. torque.
(8) Rotate each connecting rod (5) after torque to check for smooth and free rotation.
(9) Measure and record connecting rod to crankshaft side clearance. Clearance must be within limits per Fits and Clearances section of this manual.

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Installation of Crank Gear to Crankshaft

(1) Inspect the crank gear (5, Figure 72-00-09.3), bolt (15), and lockplate (10) for defects.
(2) Lightly lubricate with pre-lube crank bolt threads and install the gear (5) to crankshaft with bolt (15) and new lockplate (10). Ensure that the gear (5) fits evenly in crank recess, aligns with dowel, and sits flat when torqued. Tapping the gear with a soft aluminum or brass drift will help ensure the seal is properly seated. Torque crankshaft gear bolt (15) to 204 in-lb. Attempt to insert a pointed 0.001 in. feeler gage or piece of shim stock between the gear and the crankshaft at each of the three scallops. There is no allowable clearance between crankshaft and gear. Bend lockplate (10) tab up to secure bolt head.

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Assembly of Case and Crankshaft Assembly

(1) With crankcase halves lying on bench with interior sides up, ensure that center and rear main bearings (5, Figure 72-00-09.2) are installed and lubricated with pre-lube.
(2) Lubricate tappet bore holes and tappet bodies (20) (shank) and install bodies in case.
(3) Apply cam pre-lube liberally to tappet (20) faces and camshaft lobes. (5, Figure 72-00-09.8). A moly-graphite grease is recommended.
(4) Place camshaft (5) on bench beside case halves.
(5) Clean mating surfaces of both case halves including nose seal area with fast dry solvent.
(6) Clean nose seal OD with fast dry solvent.
(7) Place front main (10, Figure 72-00-09.2) bearing temporarily in place in the left crankcase half making sure the bearing is properly seated on the 2 locator dowels.

NOTE: The front main bearing (10), unlike the center and rear main bearings, splits on the horizontal centerline of the engine.

(8) Use a felt marker to trace on the front bearings halves at the intersection between the crankcase parting flanges and the bearing. Make a vertical reference mark on both the bearing half and each case half at a convenient point along the line of intersection. This locates the bearing both radially and axially. Make two parallel marks across both bearing shells at their intersection for alignment reference. Refer to Figure 72-00-09.9.

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(9) Remove front main bearings. Lubricate bearing surfaces liberally with pre-lube oil and fit to crankshaft aligning the two parallel marks. Refer to Figure 72-00-09.10.
(10) Install two 3/8 in. bolts with their corresponding flat washers through the right case half and install 2 O-rings (10, Figure 72-00-09.11).
(11) Install 2 O-rings (75) on rear through studs of right case half.
(12) Lubricate crankshaft main bearing journals and cam bores with pre-lube oil.
(13) Lay out crankcase assembly hardware per Figure 72-00-09.11 and 72-00-09.12 together with appropriate hand tools.

- STOP -

PERFORM IN-PROCESS QUALITY INSPECTION #1. REFER TO APPENDIX A.

(14) Assure that case mating surfaces are clean and dry.

WARNING: ADHESIVE SEALANT IS TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. AVOID EYE AND SKIN CONTACT. USE 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.

(15) Apply an even, thin coat of approved sealant to the backbone and breastbone surfaces of the left case half only and to the front nose seal bore (both case halves) as well as the nose seal OD.
(16) When using RTV 102 the coating must not be too thick. A thin translucent coating is sufficient. Wipe off any excess on the inside and outside edges. Refer to Figure 72-00-09.13. Because this sealant will dry quickly when applied this thinly, it is important to proceed quickly until case halves are together and snug. A helper is required during this assembly process.

(17) Lay a single line of silk thread on the RTV sealant at the centerline of the sealing surface and loop the inside of each bolt hole. The tail of the thread should extend beyond the mating surface approximately 0.25 in. to the accessory gasket surface at the rear, the nose seal surface at the front and the sump gasket surface at the bottom. Refer to Figure 72-00-09.13.

(18) A helper places the left case half up to the crank assembly with the connecting rods protruding through their appropriate cylinder holes and allows the assembler to align the front main bearing inserts with the dowels in the crankcase. The helper uses light pressure against case half as the assembler adjusts front main bearing until it snaps in place.

NOTE: Using a tool to gently lift up on bearing while holding case half-tight to crankshaft will aid in determining if bearing is properly seated. When properly seated, the bearing and case will move slightly up and down together as the front of the bearing is pried up and down.

(19) With the left case half and bearing properly seated, the helper places a tool inserted through the #4 connecting rod piston pin hole. The case is rotated to wedge the tool against the case half. Firm pressure is maintained on crankcase. Refer to Figure 72-00-09.14.

NOTE: It is imperative that the helper maintains constant pressure on the left case half throughout the assembly process until case halves are snugged together. Enough case assembly hardware must be installed to not allow the front main bearing to shift from the locating dowels.

(20) Check thread and nose seal (15, Figure 72-00-09.2) for proper placement.

(21) Install camshaft in left case half and have helper hold in place.

(22) Mate the right case half to the left case half by carefully aligning rear through studs and front 3/8 in. nose bolts.

NOTE: NOTE: Care should be taken not to push out the 3/8 in. nose bolts (5, Figure 72-00-09.11) causing the o-rings (10) to fall out.

(23) Ensure that nose seal is properly in place.

(24) Install backbone bolts (30), breastbone bolts (90, 95), and nose bolts (5) with appropriate hardware. Snug all uniformly. Check for free case to crank rotation.

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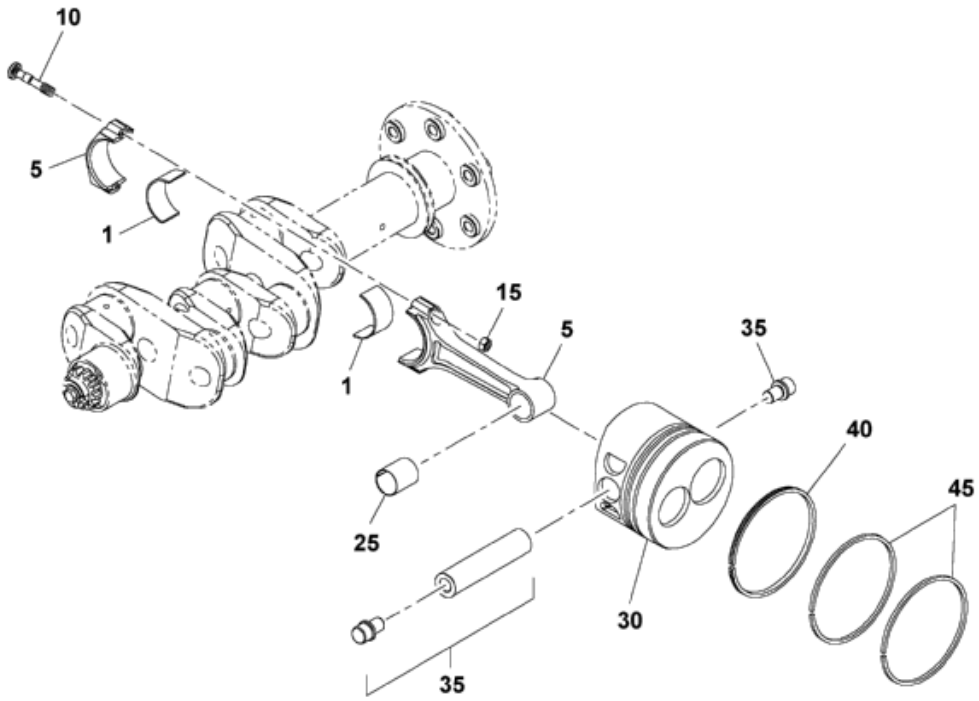
(25) Lightly lubricate shank and threads of the ½ in. Dia. through bolts (1, Figure 72-00-09.12), with pre-lube oil. Install using a soft faced (dead blow) hammer as far as possible. Finish installation with sufficiently sized ball-peen hammer or equivalent using a nut or threaded cap to protect the threads and thru-bolt end. Thru bolts are properly installed when an equal number of threads protrude from each case half.



1. BEARING
5. ROD ASSY
10. BOLT - ROD
15. NUT - ROD
25. BUSHING
30. PISTON
35. PIN AND PLUG ASSY
40. RING - OIL CONTROL
45. RING - COMPRESSION

Figure 72-00-09.6 • Connecting Rod and Piston Assembly

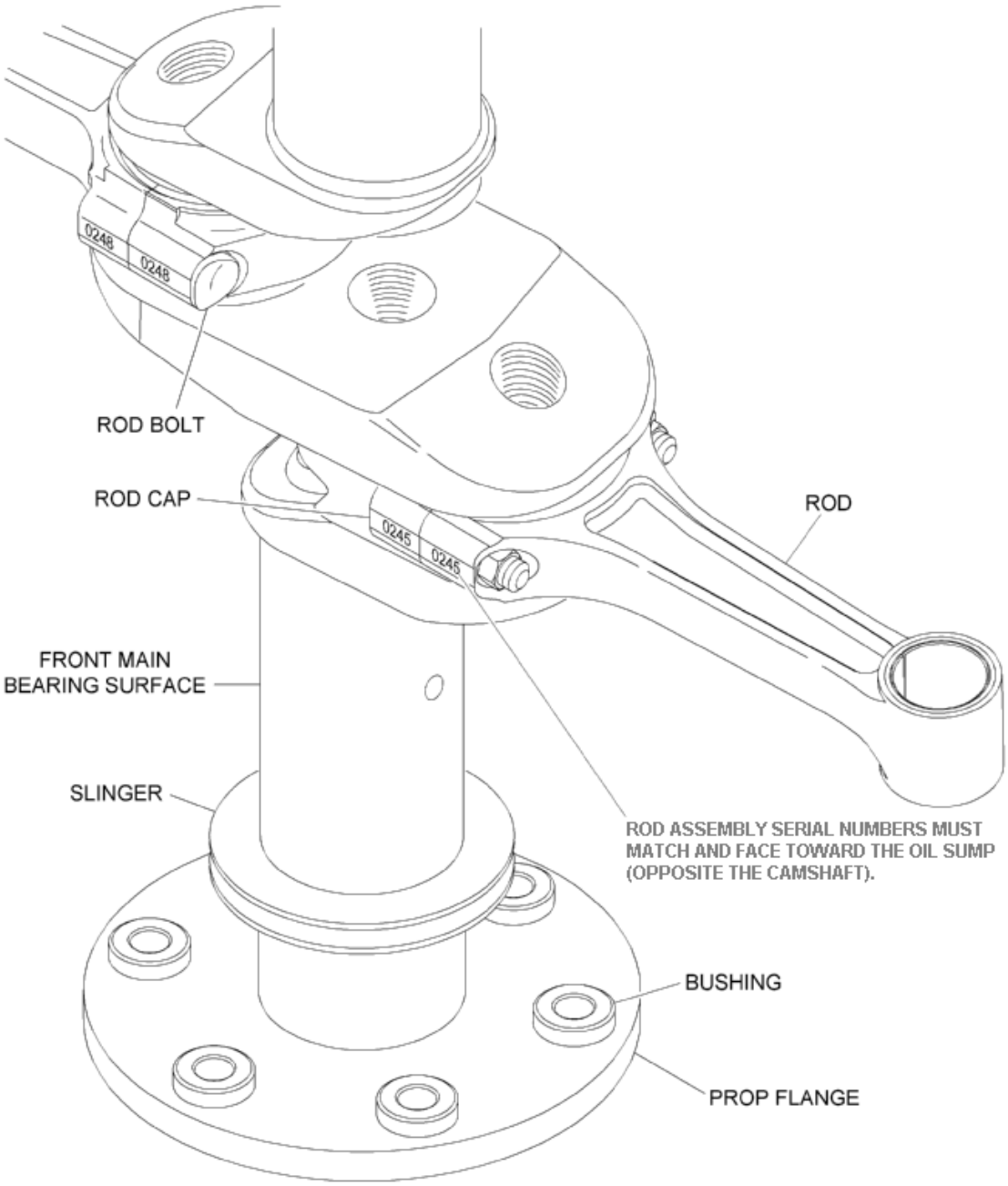
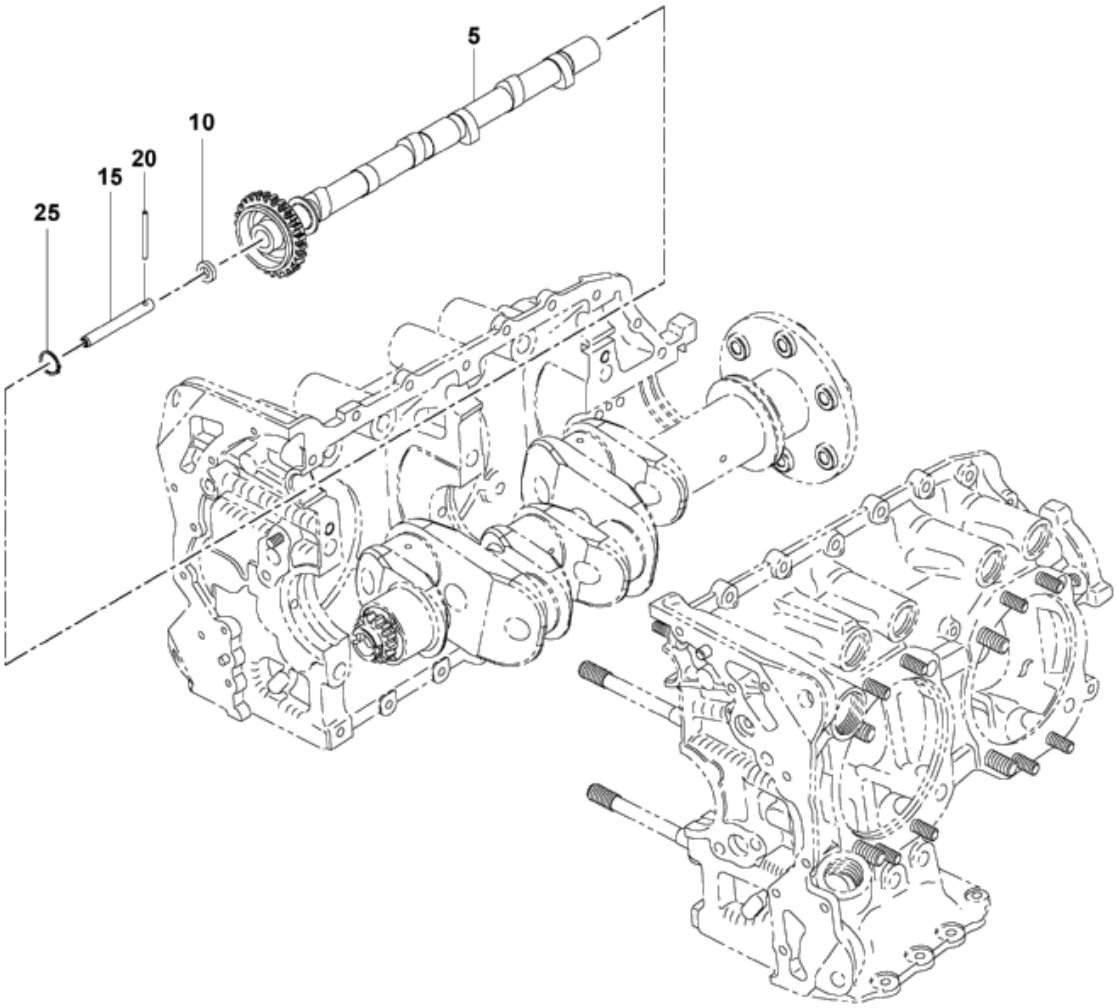


Figure 72-00-09.7 • Connecting Rod Installation



5. CAMSHAFT ASSEMBLY
10. BUSHING
15. TACHOMETER SHAFT ASSEMBLY
20. PIN
25. RETAINING RING

Figure 72-00-09.8 • Camshaft Assembly

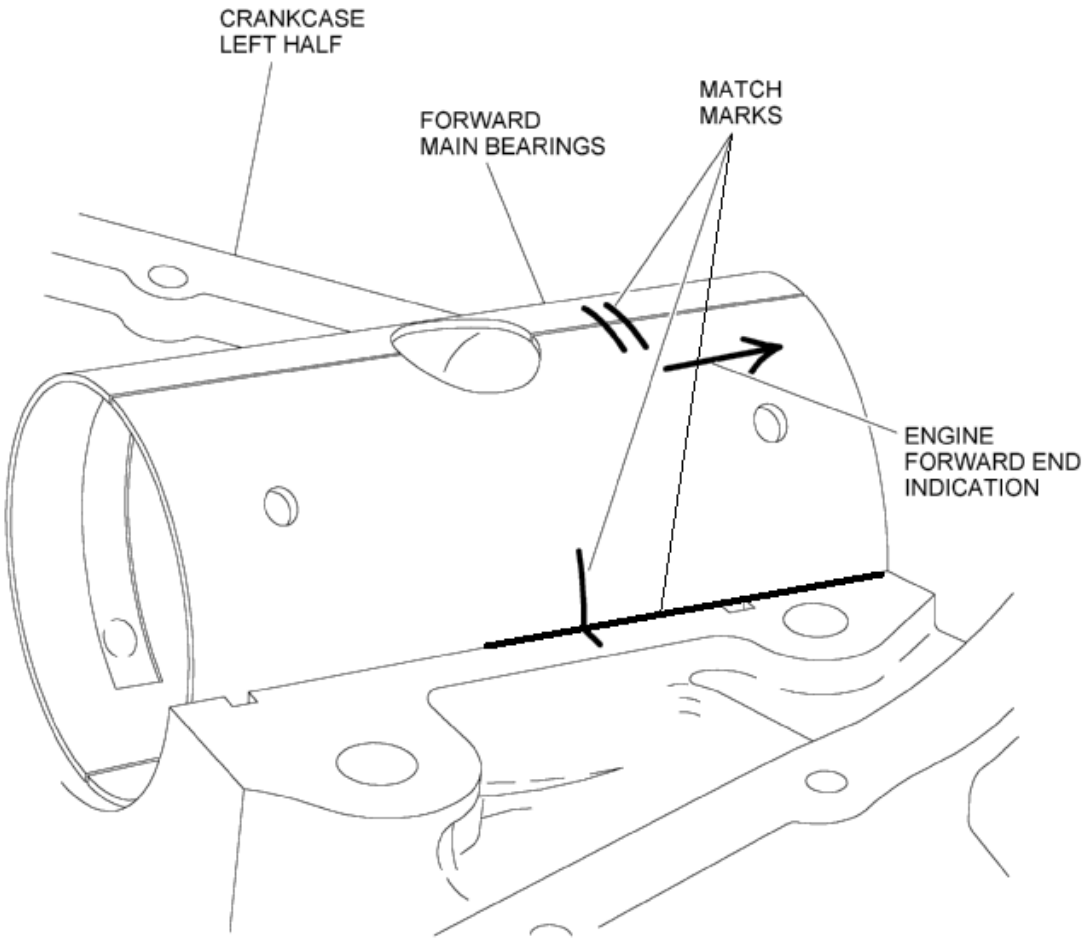


Figure 72-00-09.9 • Main Bearing Reference Marks

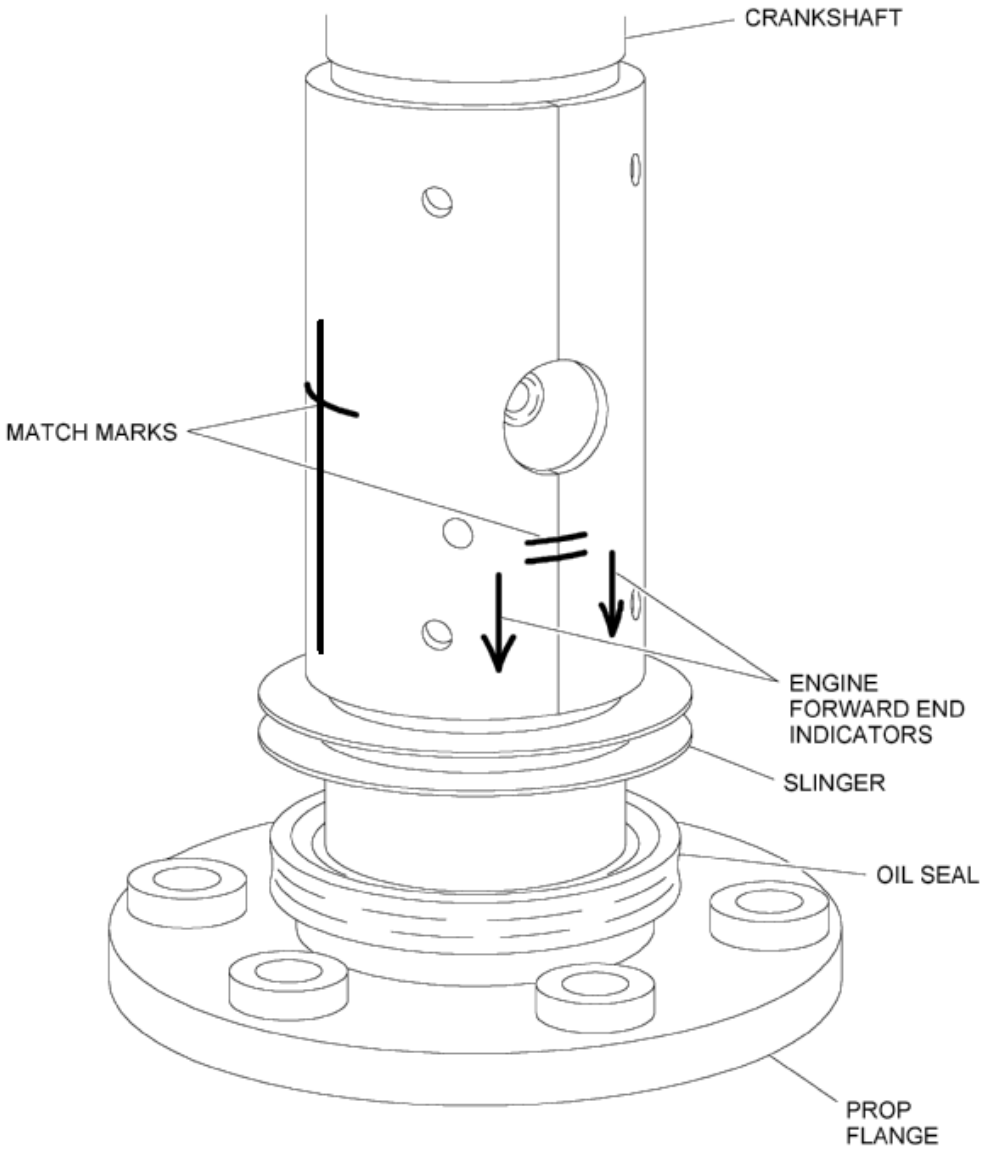
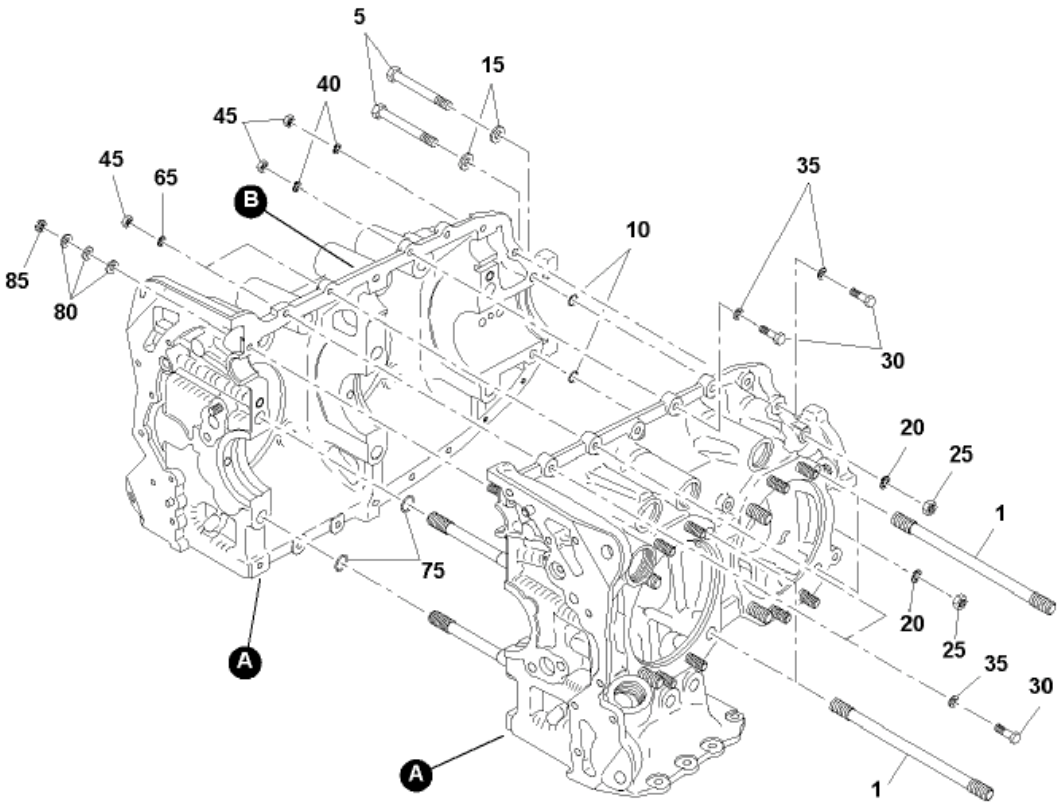


Figure 72-00-09.10 • Main Bearing Installation



1. STUD (1/2-20 X 10-11/16)
5. BOLT (3/8-24 X 3-37/64)
10. SEAL - OIL RING
15. WASHER - FLAT (3/8 INCH)
20. WASHER - LOCK (3/8 INCH)
25. NUT - PLAIN (3/8-24)
30. BOLT (1/4-20 X 1-1/2)
35. WASHER - FLAT (1/4 INCH)
40. WASHER - LOCK (1/4 INCH)
45.NUT - PLAIN (1/4-20)
50. STRAP - LIFTING
55. BOLT (1/4-20 X 2")
60. WASHER - FLAT (1/4 INCH)
65. WASHER - LOCK (1/4 INCH)
70. NUT - PLAIN (1/4-20)
75. SEAL - OIL
80. WASHER - PLAIN (3/8 INCH)
85. NUT - SLOTTED (3/8-24)
90. BOLT (1/2-20 X 1-1/8)
95. BOLT (1/4 INCH)
100. NUT - SLOTTED (1/4-20)

Figure 72-00-09.11 • Crankcase Attaching Hardware

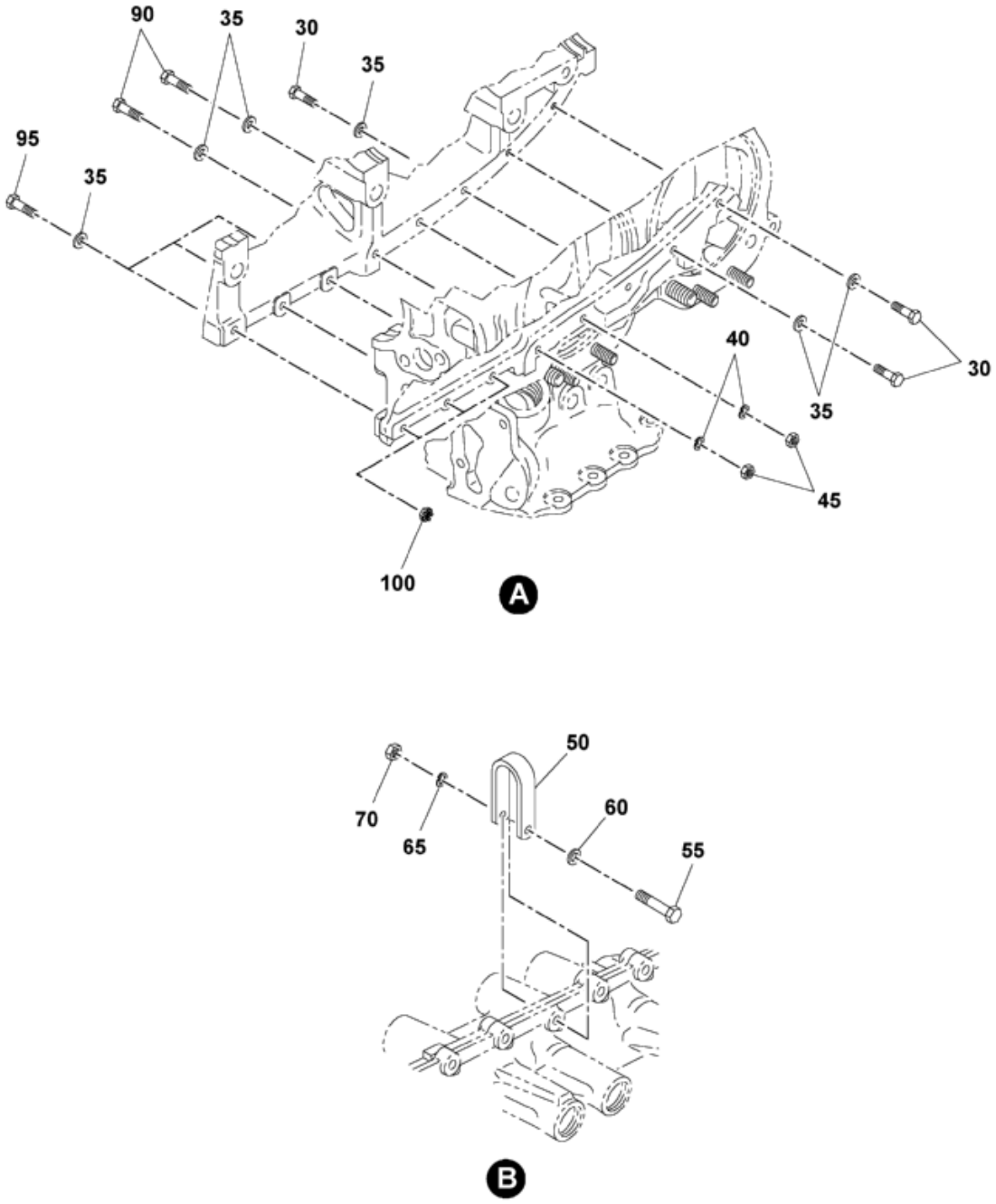


Figure 72-00-09.12 • Crankcase Attaching Hardware (cont'd.)

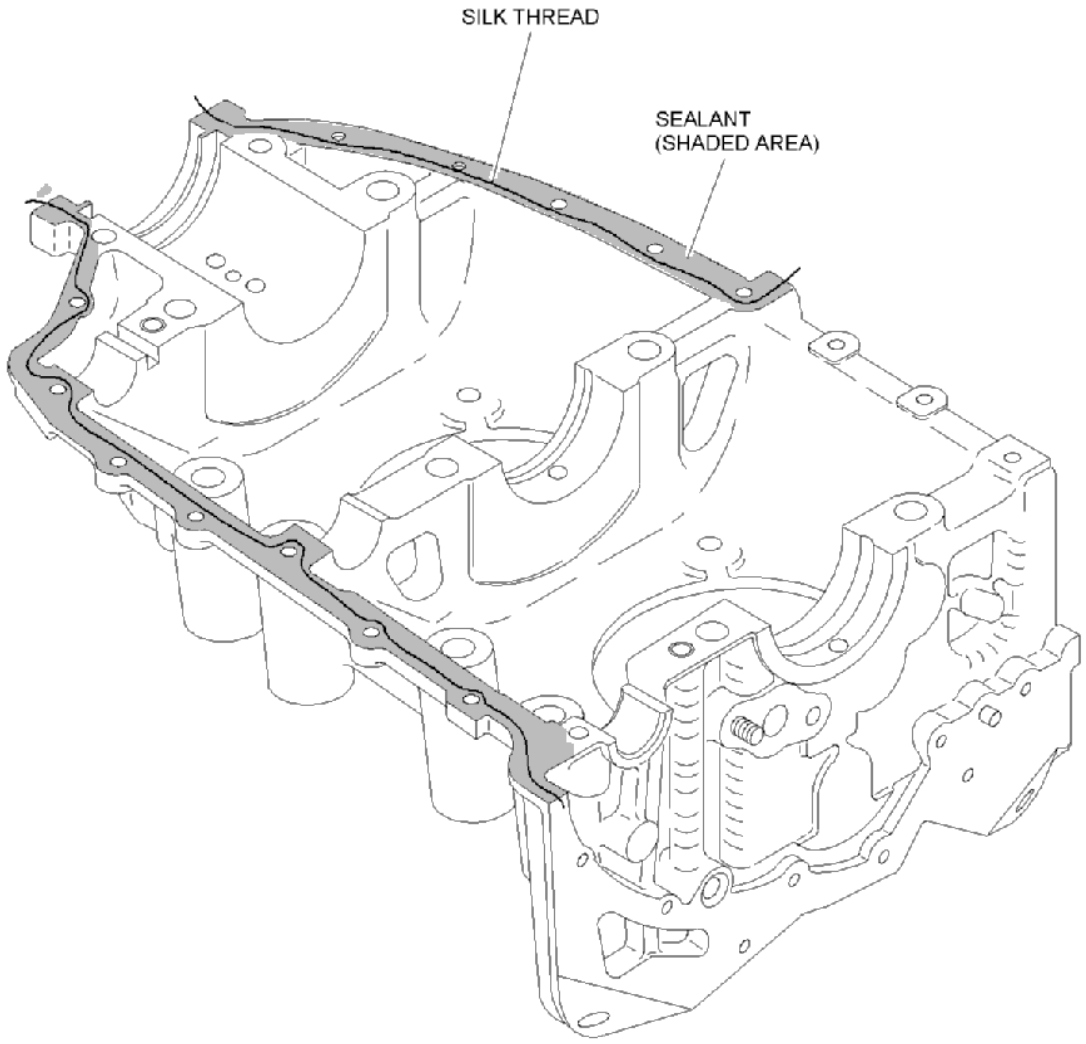


Figure 72-00-09.13 • Sealant Compound and Silk Thread Application

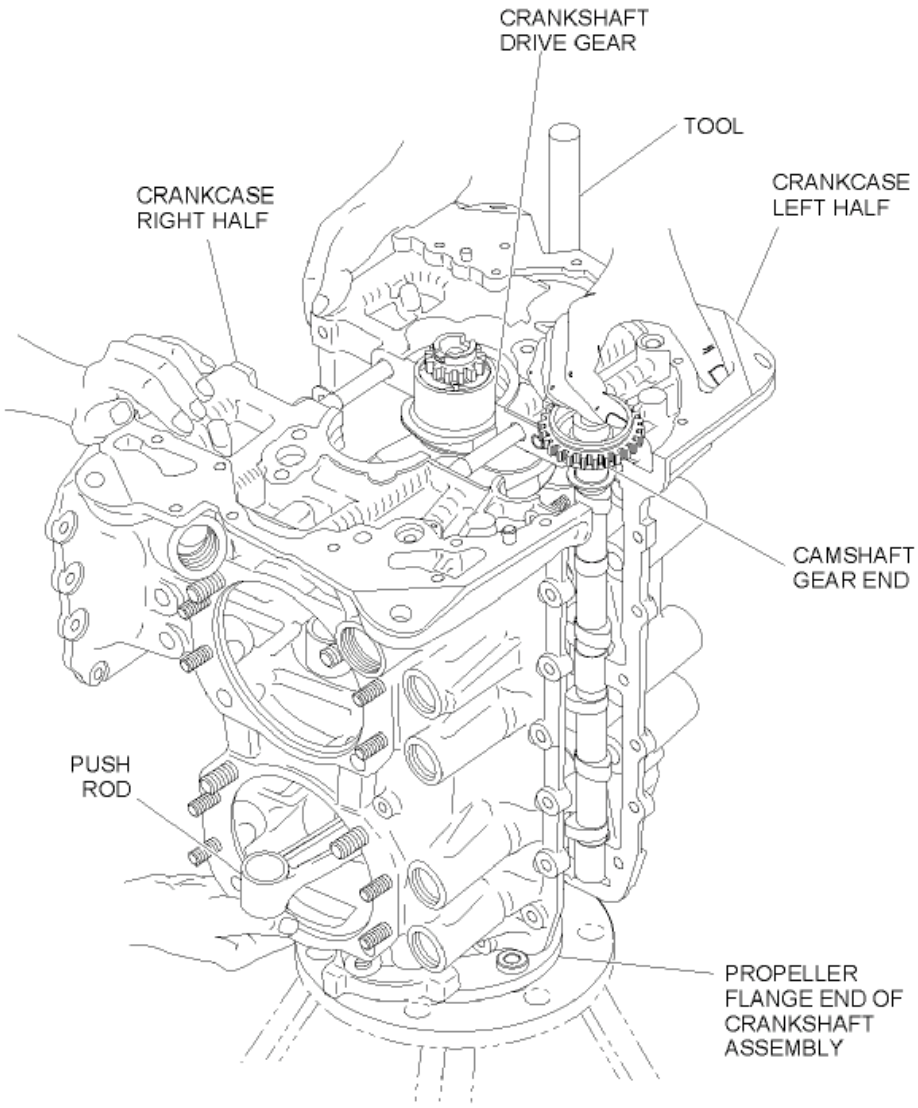


Figure 72-00-09.14 • Crankcase Halves Assembly

Cylinder Assembly Inspection

(1) Verify cylinder part number and serial number.
(2) Visually inspect general condition of cylinder for handling or shipping damage.
(3) Verify the valve, spring, and key (65, 70, 85, 90, 105, 110, Figure 72-00-09.15) installations.
(4) Visually check threaded holes for thread integrity and helical coil insert if required. Ensure the absence of foreign matter.

WARNING: SOLVENT IS TOXIC. USE IN WELL-VENTILATED AREA. PREVENT EYE AND SKIN CONTACT AND DO NOT BREATHE VAPORS 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) Wipe cylinder bores clean with lint-free rag saturated with fast dry solvent.
(6) Inspect piston (30, Figure 72-00-09.6) part number and weight.

NOTE: Piston weight differences should not exceed 2 grams in opposing pairs.

(7) Clean piston pins (35) with fast dry solvent and check fit to each piston.

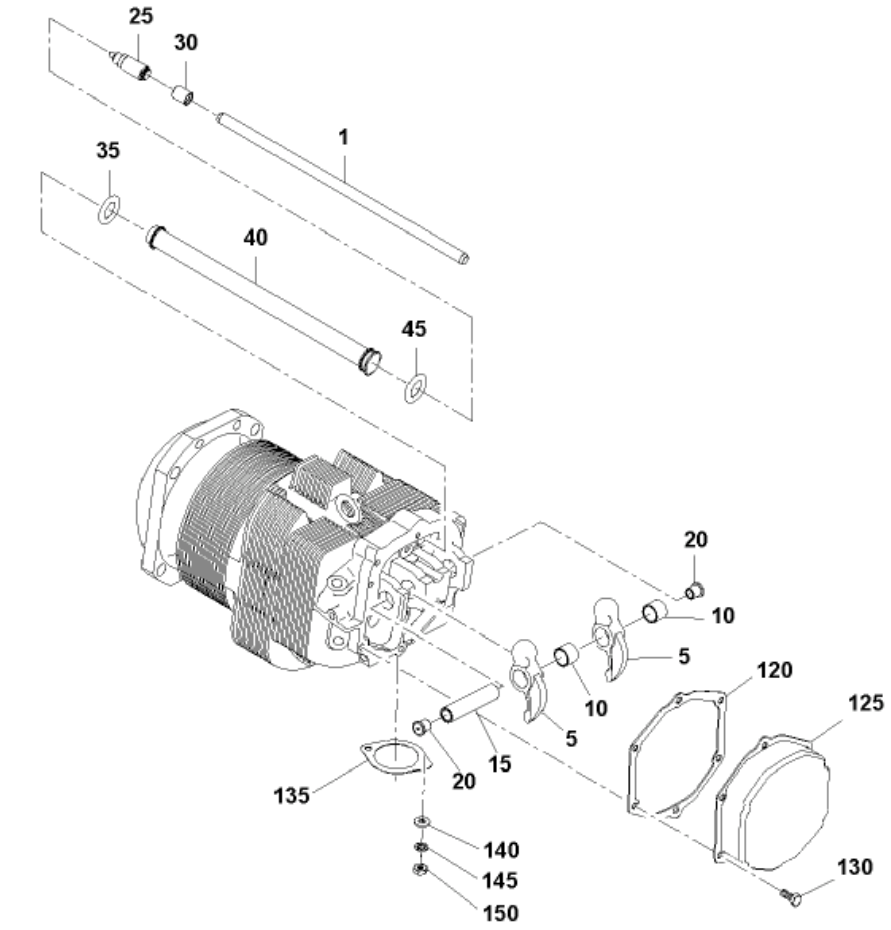
NOTE: Piston pins are a push fit with light lubrication. Refer to Figure 72-00-09.16.

(8) Verify piston ring (40, 45) part numbers.
(9) Check ring gaps of compression rings (45, Figure 72-00-09.6) and oil control ring (40) with feeler gauge. End gap at 1”-4” from flange and gap at top of piston stroke must be within limits per Fits and Clearances section of this manual.
(10) Insert piston rings, one at a time in their respective grooves.
(11) Using a ring expander, install rings to piston with the lower ring first, then middle and top.

NOTE: Numbers on the ring face indicate top of the piston or up.

(12) Check side clearance of each ring. Piston compression ring (45) in top groove is 0.0025 to 0.0055 in. Piston compression ring (45) in 2nd groove is 0.000. to 0.0040 in. Piston oil control ring (40) in 3rd groove is 0.0020 to 0.0040 in.

NOTE: Side clearance is checked with ring in its respective groove and flush with outside edge of piston.



1. PUSH ROD
5. ROCKER ARMS
10. BUSHING
15. ROCKER ARM SHAFT
20. CAP - ROCKER SHAFT
25. PLUNGER ASSY
30. PUSH ROD SOCKET
35. SEAL - TUBE BOTTOM
40. SHROUD TUBE
45. SEAL - TUBE TOP
120. GASKET - VALVE COVER
125. VALVE COVER
130. SCREW
135. GASKET - EXHAUST
140. WASHER - FLAT
145. WASHER - LOCK
150. NUT - PLAIN

Figure 72-00-09.15 • Cylinder Valve Train and Spring Assembly

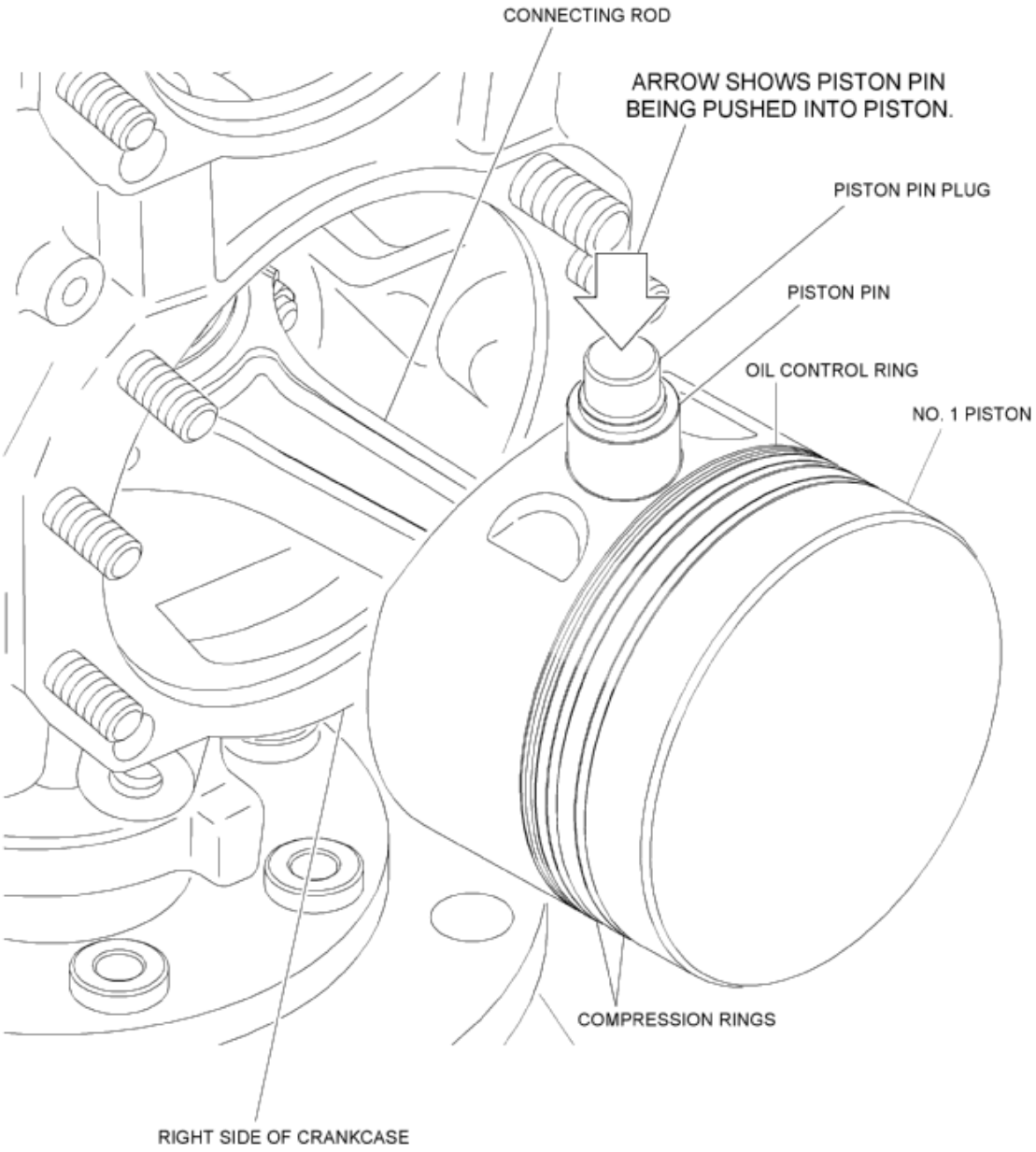


Figure 72-00-09.16 • Piston Assembly to Connecting Rod

Cylinder Assembly Installation to Engine

(1) Lubricate the rings and ring grooves on the piston with straight weight, non-detergent (mineral) aviation grade oil.
(2) Stagger the ring gaps as follows: Top ring gap is at approximately the 10 o'clock position, 2nd ring gap is at approximately 2 o'clock; and the oil control ring gap is at approximately 11 o'clock.

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NOTE: Oil control expander spring is installed in piston groove underneath the oil control ring and with its split line 180° from the ring gap.

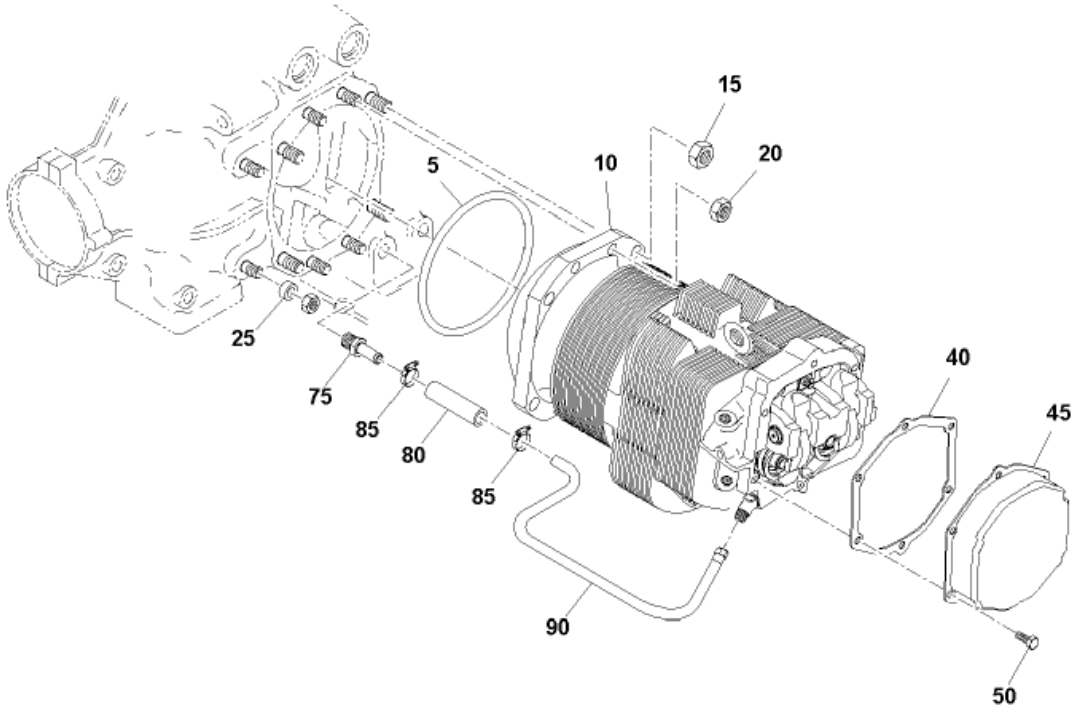
(3) Lubricate the cylinder bores, piston pins and piston pin bushing in connecting rod with straight weight, non-detergent (mineral) aviation grade oil.
(4) Lubricate the cylinder base o-ring (5, Figure 72-00-09.17) with oil and install over the cylinder base.
(5) Lightly lubricate cylinder deck studs and through bolts with pre-lube oil.
(6) Rotate the engine so that the #1 connecting rod is at the top of the stroke. Install the #1 piston to the #1 connecting rod with the piston pin. Refer to Figure 72-00-09.16.

NOTE: Ensure that piston is installed with ring gaps towards the top of the engine.

(7) Slide the ring compressor tool over the piston and rings far enough to allow the cylinder bore to fit over the piston top.
(8) Install cylinder #1: Position the top of cylinder facing the top of the engine over the piston. Push on until the ring compressor is pushed off the piston skirt and can be removed at notch over the connecting rod. Continue to slide the cylinder over the cylinder base studs until flush with the case deck. Refer to Figure 72-00-09.18.
(9) Secure the cylinder assembly with the cylinder base nuts (15, 20, Figure 72-00-09.17) as required and tighten to snug.
(10) Continue process with cylinders #2, then #3, and #4 in that order. Rotate the case and crank so that the connecting rod of the cylinder to be installed is at top dead center.
(11) Torque the large cylinder hold down nuts (15, Figure 72-00-09.17) to 600 in-lbs. Torque the small hold down nuts (20) to 300 in-lbs. Do this in the sequence shown in Figure 72-00-09.19.
(12) Torque all crankcase assembly hardware in accordance with Fits and Clearances Table 72-00-11.2. Do this in the sequence shown in Figure 72-00-09.19.

WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

(13) Torque slotted 0.38 in. nut (85) to 300 in-lbs. Install safety wire (0.041 in.) at accessory location by cam gear.
(14) Torque the three, drilled-shank, 0.25 in. belly bolts (95) and slotted nuts (100) to 55-60 in-lbs. Install safety wire (0.032 in.).



5. SEAL - CYLINDER BASE
10. CYLINDER ASSEMBLY
15. NUT - PLAIN (1/2 X 20)
20. NUT - PLAIN (3/8 X 24)
25. SPACER
40. GASKET
45. COVER
50. SCREW
75. NIPPLE - DRAIN
80. HOSE
85. CLAMPS
90. TUBE ASSEMBLY

Figure 72-00-09.17 • Cylinder Assembly and Head Oil Drain Line

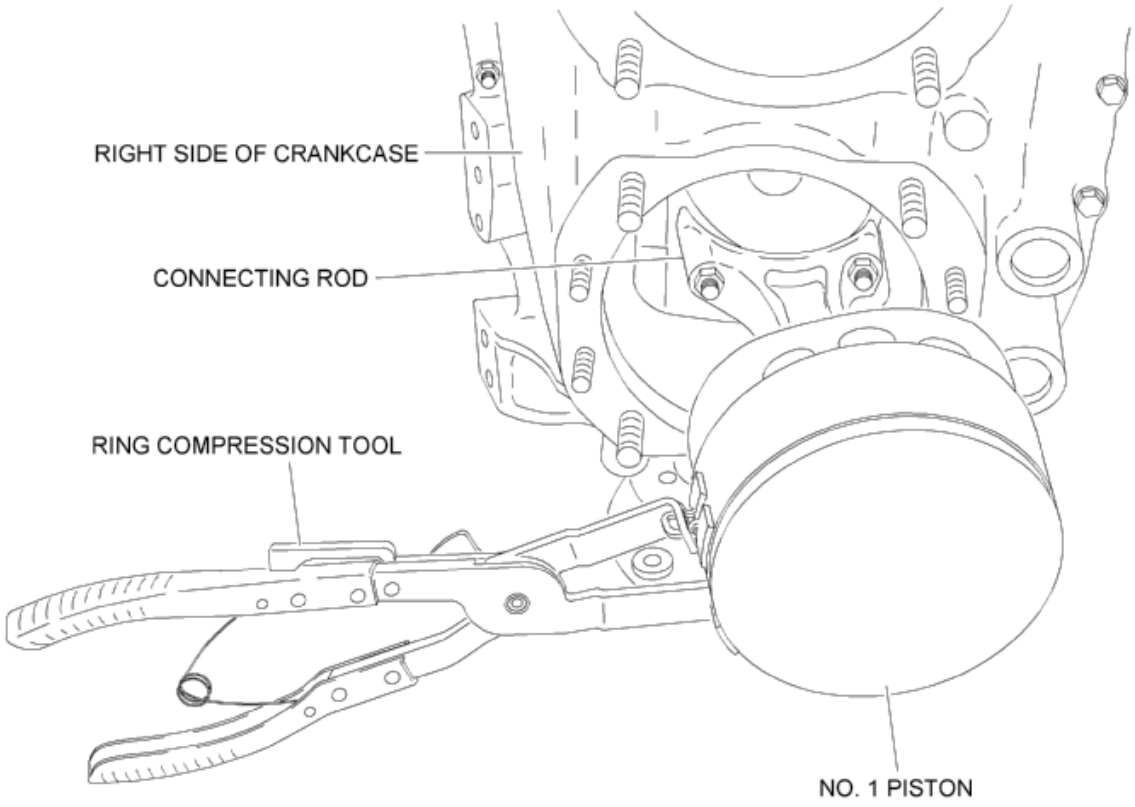


Figure 72-00-09.18 • Piston Assembly with Ring Compressor Tool

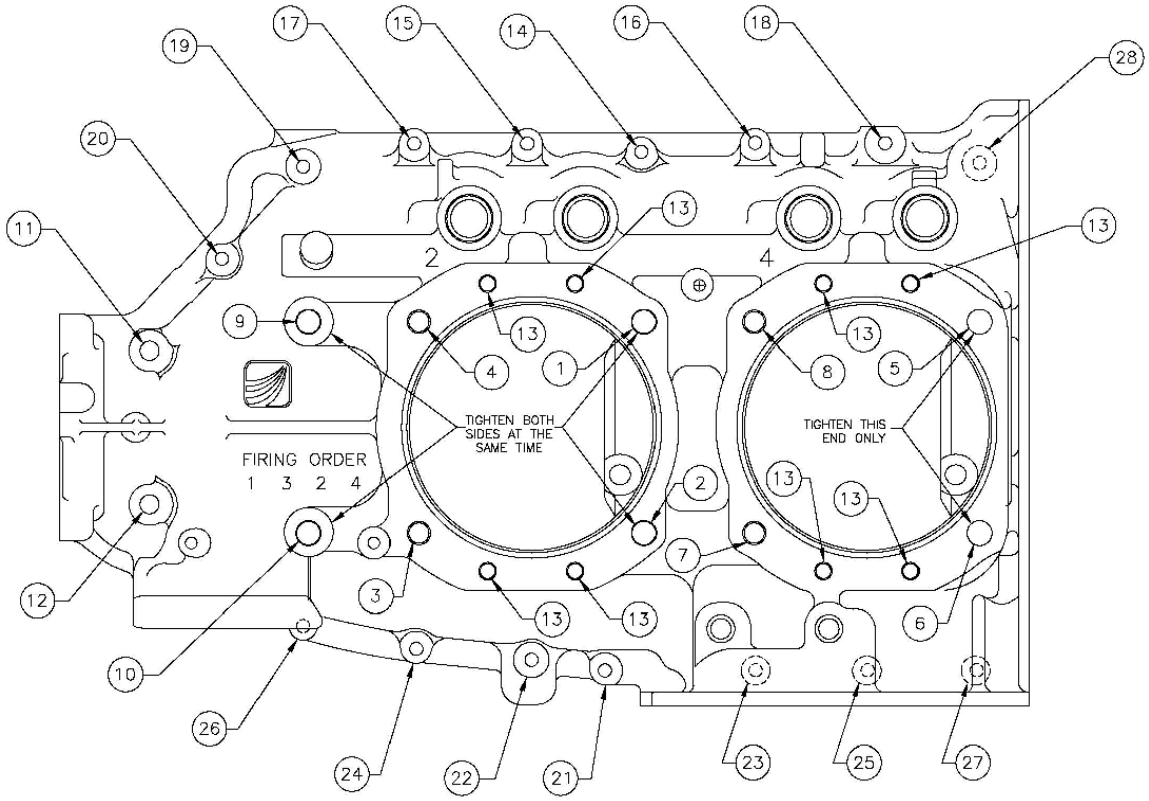


Figure 72-00-09.19 • Cylinder Base Nuts Sequence of Tightening (Left Side Shown)

Installation of Idler Shafts and Gears and Internal Gear Timing

(1) Install 2 each idler shafts (1, Figure 72-00-09.20) with 3 bolts (5) and one nut (10). Torque the bolts (5) and nut (10) in accordance with the torque specifications per the Fits and Clearances section of this manual. Safety the nuts and bolts with 0.032 in. safety wire to idler shaft flange holes. Refer to Figure 72-00-09.21.

WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

(2) Inspect idler gears and for handling damage, burrs, and general condition.

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(3) Apply pre-lube oil to idler shafts (1) and gear bushing (25).
(4) Highlight with a marker the timing marks on the camshaft, crank gear, and fuel pump drive idler gear (15).
(5) Place the left-hand idler gear (fuel pump drive idler gear) over the left idler shaft aligning its timing marks with the corresponding timing marks on cam and crank. Rotate cam and crank as needed to align with marks on the idler gear. See Figure 72-00-09.22.
(6) Install the right hand idler gear (20) on the right side idler shaft.

NOTE: It is not necessary to align timing marks on this gear.

(7) Check gear backlash of both idler gears with feeler gauge or dial indicator. Backlash limits must be within limits specified in Fits and Clearances section of this manual.
(8) Install tachometer shaft assembly (15, Figure 72-00-09.8) with retaining ring (25) in camshaft (5) at gear end.

- STOP -

PERFORM IN-PROCESS QUALITY INSPECTION #2. REFER TO APPENDIX A.

Cleaning, Inspection, and Installation of Hydraulic Plunger and Cup Assembly

(1) Visually inspect and clean hydraulic plunger assemblies (25, Figure 72-00-09.15) with fast dry solvent.

WARNING: SOLVENT IS TOXIC. USE IN WELL-VENTILATED AREA. PREVENT EYE AND SKIN CONTACT AND DO NOT BREATHE VAPORS. 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.

(2) Depress hydraulic plunger piston with thumb to ensure proper spring action.
  (a) If unit does not compress, use blunt end of a 3/32 in. diameter rod to dislodge check ball allowing trapped air, oil, or solvent to escape.
  (b) Remove rod and try depressing piston again.

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(3) Apply a light coat of pre-lube oil to the OD of each plunger.
(4) Insert plunger, small tube end first, into tappet body in crankcase. Refer to Figure 72-00-09.15.
(5) Insert tappet cup or socket (30) into tappet body on top of plunger assembly.

Put the cup side out (flat side against plunger). Refer to Figure 72-00-09.15.

Installation of Pushrod Tubes, Pushrods, and Rocker Arms

(1) Visually inspect the pushrod tubes (40, Figure 72-00-09.15) for handling damage, dents, or burrs. Check I.D. of each tube for debris.

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(2) Apply a light coat of Fuelube™ or equivalent to 8 O-ring seals (45) and 8 bottom tube seals (35). Install O-rings to pushrod tube (40) at top groove locations.
(3) Insert pushrod tubes through holes at the top of each cylinder then install bottom seal (35). Seat each tube into its crankcase lifter hole using a rotary or twisting motion. Ensure that o-ring seal and bottom seal are properly seated.
(4) Install spring clip (50) over stud in cylinder and over the edge of each pushrod tube.
(5) Secure spring clip with lock plate (55) and 0.25 in. nut (60).
(6) Torque nut (60) to 50-70 in-lbs. Bend lock tab with screwdriver or pliers to secure nut.
(7) Inspect pushrods for bends or damage.
  (a) Blow clean, dry air through each pushrod (1).
  (b) Visually inspect I.D. of each pushrod to verify each is clear, clean, and open.

WARNING: WHEN YOU USE COMPRESSED AIR TO CLEAN OR DRY PARTS, MAKE SURE THAT THE PRESSURE IS NOT MORE THAN 30 PSI. DO NOT DIRECT THE AIRSTREAM AT PERSONNEL OR LIGHT OBJECTS. PUT ON GOGGLES OR A FACE SHIELD TO PROTECT YOUR EYES. IF YOU GET AN EYE INJURY, GET MEDICAL ATTENTION.

(8) Install pushrods in pushrod tubes.

NOTE: There are different lengths of pushrods available for this engine model to aid in adjusting the dry tappet clearance. Use the appropriate length to achieve proper clearance of 0.028 to 0.080 in..

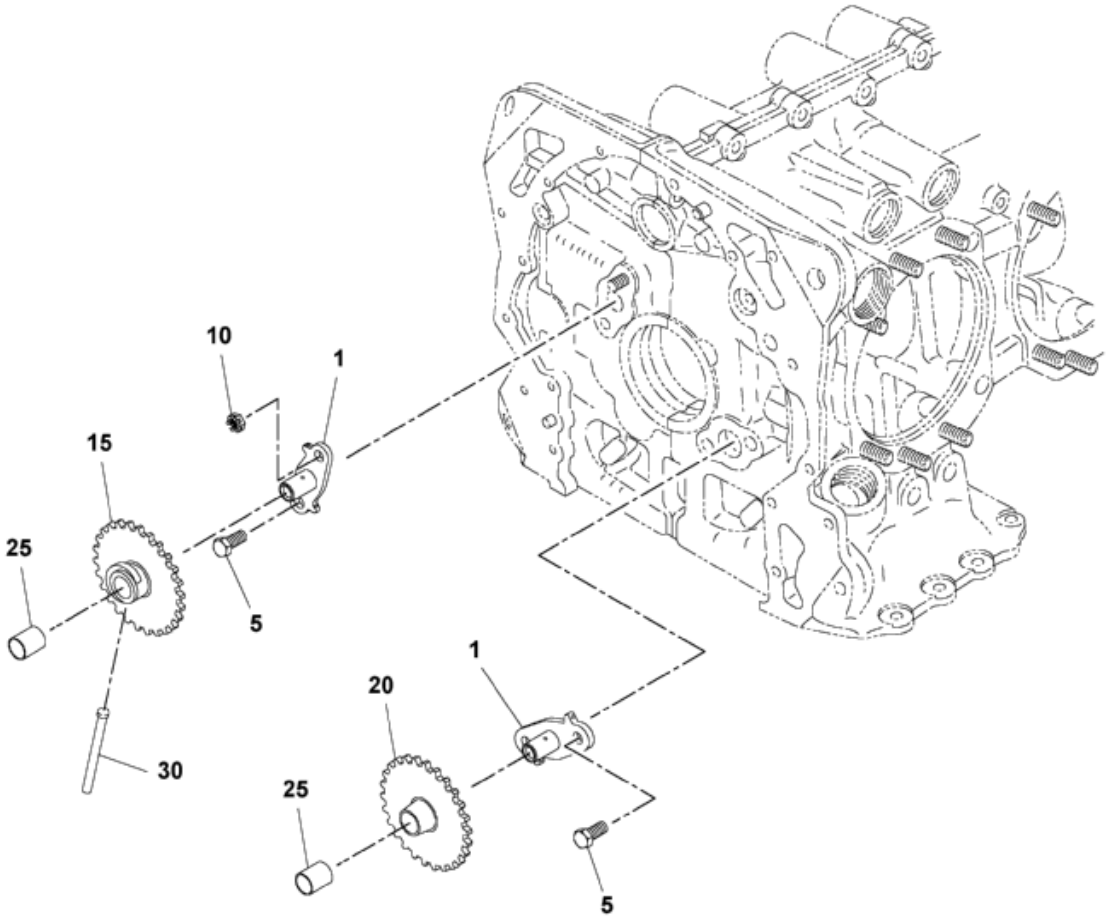
(9) Install exhaust valve rotator cap (115) on valve stem of each exhaust valve (65).

NOTE: A drop of pre-lube or spot of grease on the inside of each rotator cap will help retain it in place until the rocker arms are installed.

(10) Inspect rocker arms (5) for general condition.
  (a) Ensure bushing (10) is properly installed.
  (b) Check rocker shaft (15) in bushing for correct fit.
  (c) Lubricate the rocker arm socket and oil feed hole to ensure clear passage.
(11) Rotate the engine until cylinder #1 is at top dead center (TDC).
(12) Apply a light film of pre-lube oil to the rocker shafts. Install rocker arms and shafts in the #1 cylinder head.
(13) Check dry tappet clearance. Clearance must be within limits per Fits and Clearances section of this manual.
  (a) Repeat for all remaining cylinders.
  (b) Install the rocker shaft caps (thrust buttons) (20) in each end of the rocker shaft (15) immediately before installing rocker cover.

NOTE: Change the pushrod length as required to achieve proper clearance.

NOTE: A light coat of grease applied to the thrust buttons will aid in retaining them in position until the rocker covers (45, Figure 72-00-09.17) are installed.



1. SHAFT - IDLER
5. SCREW
10. NUT - SLOTTED
15. GEAR - IDLER
20. GEAR - IDLER
25. BUSHING
30. PLUNGER - FUEL PUMP

Figure 72-00-09.20 • Idler Gear and Tachometer Shaft Assemblies

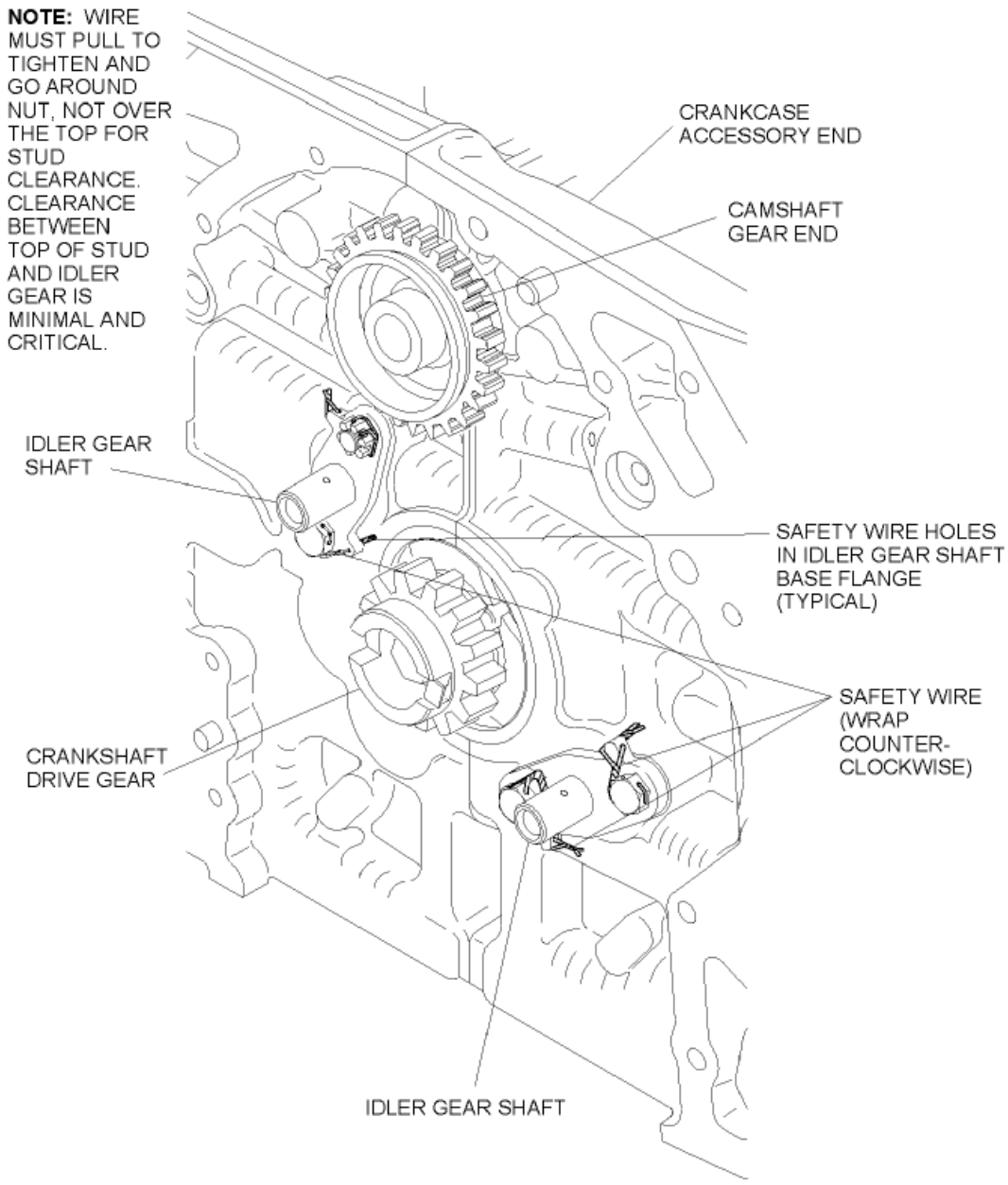


Figure 72-00-09.21 • Idler Gear and Tachometer Shaft Assemblies (cont'd.)

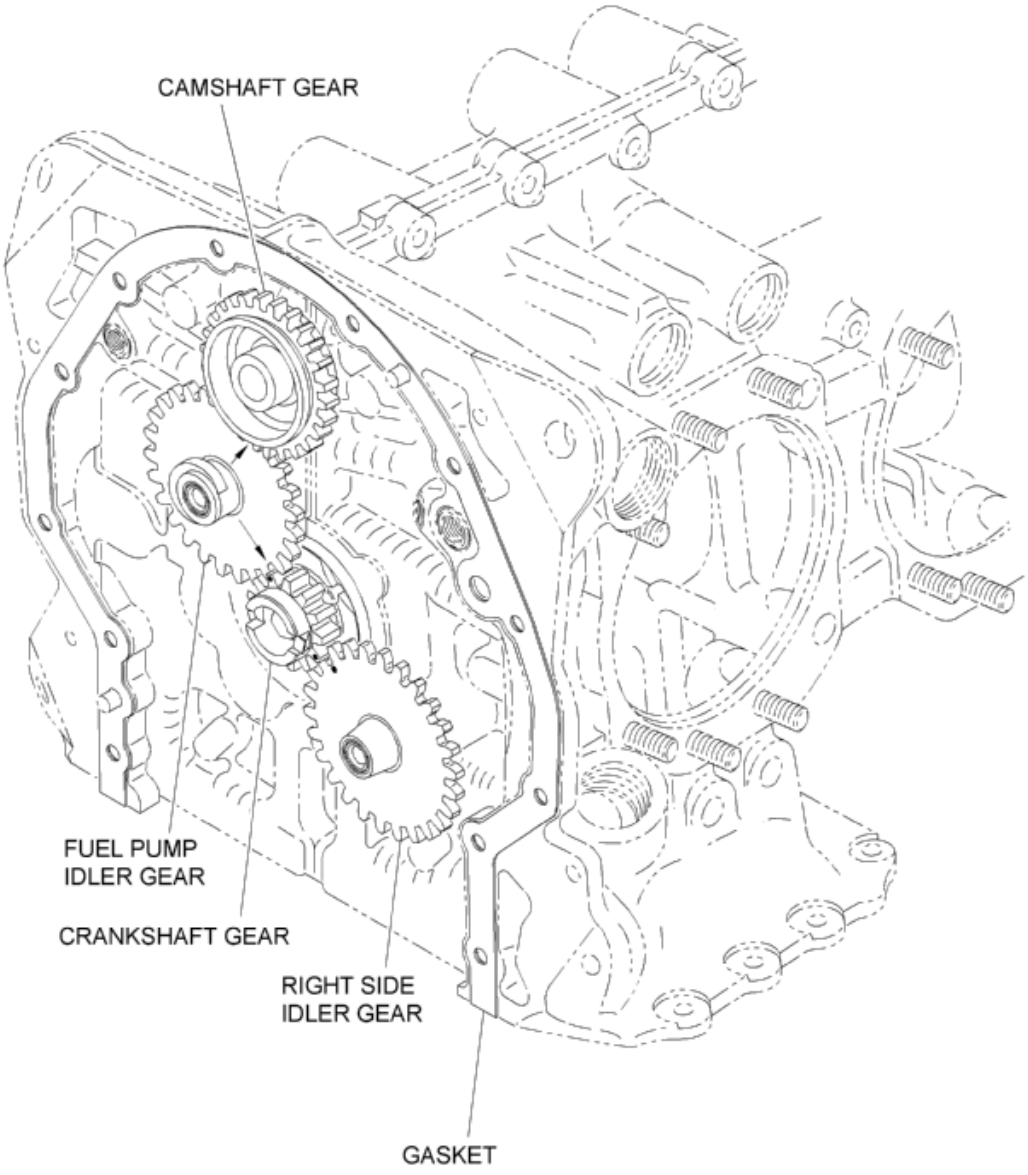


Figure 72-00-09.22 • Accessory Drive Gear Arrangement

Accessory Housing Inspection and Subassembly

(1) Inspect the accessory housing (1, Figure 72-00-09.23) for damage. Check the studs, threaded holes, and mating surfaces for damage or debris.
(2) Install new tachometer drive seal (30).
(3) Install the fitting (45, Figure 72-00-09.23) and/or oil pressure fitting removed for cleaning. Tighten per torque specifications in Fits and Clearances section of this manual.
(4) Install plug (55) and crush gasket (50) per Figure 72-00-09.35 and tighten per torque specifications in Fits and Clearances section of this manual.
(5) Inspect the oil pump housing (85) for damage. Verify plug (100) installation.
(6) Inspect the oil pump gears (105, 110) and oil pump drive shaft (115) for damage.
(7) Install the oil pump gears (105, 110) and drive shaft (115) into oil pump housing. Inspect gear backlash and housing clearance per specifications in Fits and Clearances section of this manual.

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(8) Apply pre-lube oil liberally to gears and shaft in housing.
(9) Install the oil pump assembly (80) over studs in accessory housing.
(10) Install the flat washers (85) and slotted nuts (90) to the studs. Tighten the installation hardware to snug.
(11) Rotate the oil pump drive shaft (115) to ensure smooth fit. The gears must rotate smoothly.

NOTE: It may be necessary to twist or move the oil pump housing slightly to achieve a smooth rotation of the oil pump assembly gears.

WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

(12) Tighten the slotted nuts (90) per torque specifications in the Fits and Clearances section of this manual. Install safety wire (0.032 in.). Refer to Figure 72-00-09.24.
(13) Lubricate and install the fuel pump plunger (1, Figure 72-00-09.24) in the accessory housing.

- STOP -

PERFORM IN-PROCESS QUALITY INSPECTION #3. REFER TO APPENDIX A.

Assembly of Accessory Housing to Engine

(1) Apply pre-lube oil to the tach shaft (15, Figure 72-00-09.8) as well as to the gear teeth of cam, crank and idler gears.

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(2) Ensure the mating surfaces of the crankcase and accessory housing are clean, flat, and free from burrs or scoring.
(3) Verify the dowels are installed in the proper location in the crankcase.
(4) Install the accessory housing gasket (35, Figure 72-00-09.23) to the crankcase over the dowels.

(5) Install the accessory housing assembly (1) over the tach shaft taking care to align oil pump drive with the crankshaft gear.
   (a) Lightly tap the accessory housing in place over the dowels with a soft face or dead blow hammer as required.
(6) Secure the accessory housing with washer (5), lock washer (10), and bolt (15) 10 places. Secure with the bolt (20), washer (5) and lock washer (10) 2 places. Tighten per the torque specifications in the Fits and Clearances section of this manual.
(7) Trim the protruding gasket ends flush with the sump mating surfaces. See Figure 72-00-09.25.

Installation of the Rocker Cover and Baffles

(1) Install the rocker box covers with the gaskets (120,125, Figure 72-00-09.15) and screws (130).
(2) Torque the rocker cover screws (130) in accordance with torque specifications per the Fits and Clearances section of this manual.
(3) Install the inner cylinder baffles with the hooks and retainers. See Figure 72-00-09.26.

Inspection of the Sump and Subassembly

(1) Inspect the sump (5, Figure 72-00-09.27) for general condition, handling damage, stud damage, mating surface condition, and security of the roll swaged intake pipe extensions (70).

WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

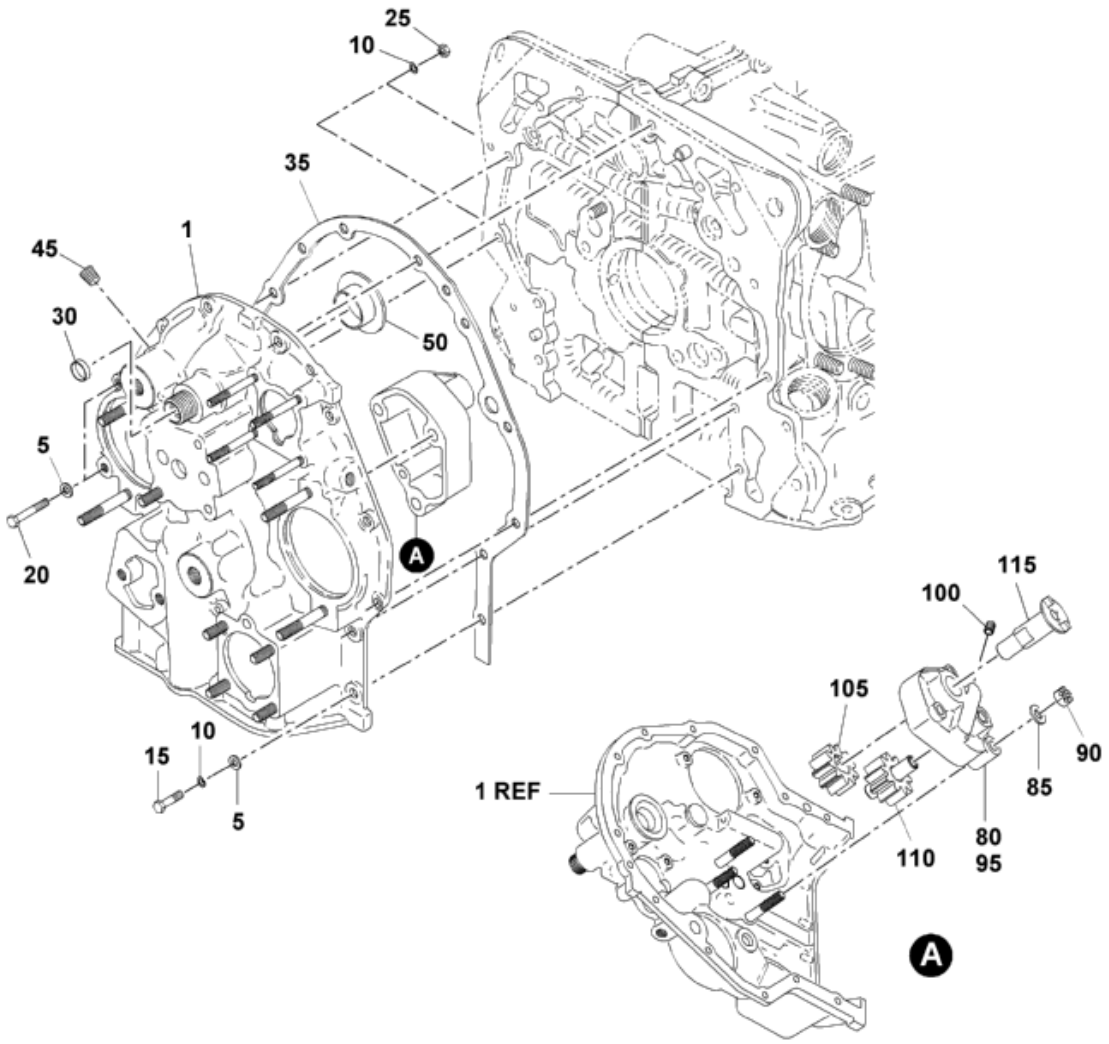
(2) Install the oil suction screen (75) with its gasket (80) and plug (85). Ensure the gasket seam faces the sump (5). Tighten the plug (85) until the plug body contacts the gasket (80) then turn an additional approx.135 degrees. Install safety wire (0.032 in.) on the plug (85).
(3) Install the sump gasket over sump studs.
(4) Install the sump with bolt (15), lock washers (30), washers (25), and nuts (35) 14 places. Install the bolts (20), lock washers (30), washers (25), and nuts (35) 2 places. Install the lock washers (30), washers (25), and nuts (35) on the sump studs 4 places. Torque the bolts (15, 20) and nuts (35) to 96-108 in-lbs. Refer to Figure 72-00-09.27.

Installation of the Oil Pressure Relief Valve Assembly

(1) Apply pre-lube oil in the crankcase at the oil pressure relief valve location.
(2) Insert the ball (40, Figure 72-00-09.2) into the hole in the crankcase.
(3) Install the spring (35) into the oil pressure relief valve housing (25).
(4) Install the gasket (30) to the relief valve housing (25).
(5) Apply pre-lube oil to the threads of the oil pressure relief valve housing and install the housing in the crankcase.
(6) Tighten the relief valve assembly (25, Figure 72-00-09.2) until the valve body contacts gasket (30) then turn an additional approx. 90°. Install safety wire (0.032 in.) from the relief valve assembly (25) to the hole provided in the crankcase.

Oil Level Gage and Housing

(1) Install the oil level gage housing (5, Figure 72-00-09.28) with the gasket into the crankcase. Tighten the assembly to 300 in-lbs.. Install safety wire (0.032 in.) between the oil level gage housing (5) and crankcase.
(2) Install the oil level gage (10) with its O-ring seal (15) into the housing.



1. HOUSING ASSEMBLY - ACCESSORY
5. WASHER - FLAT
10. WASHER - LOCK
15. BOLT
20. BOLT
25. NUT - HEX
30. SEAL
35. GASKET
45. SET SCREW - PLUG
50. SHIELD - OIL BREATHER
80. HOUSING ASSEMBLY - OIL PUMP
85. WASHER - FLAT
90. NUT - SLOTTED
95. HOUSING
105. GEAR - IMPELLER
110. GEAR - IMPELLER
115. SHAFT - OIL PUMP DRIVE

Figure 72-00-09.23 • Accessory Housing

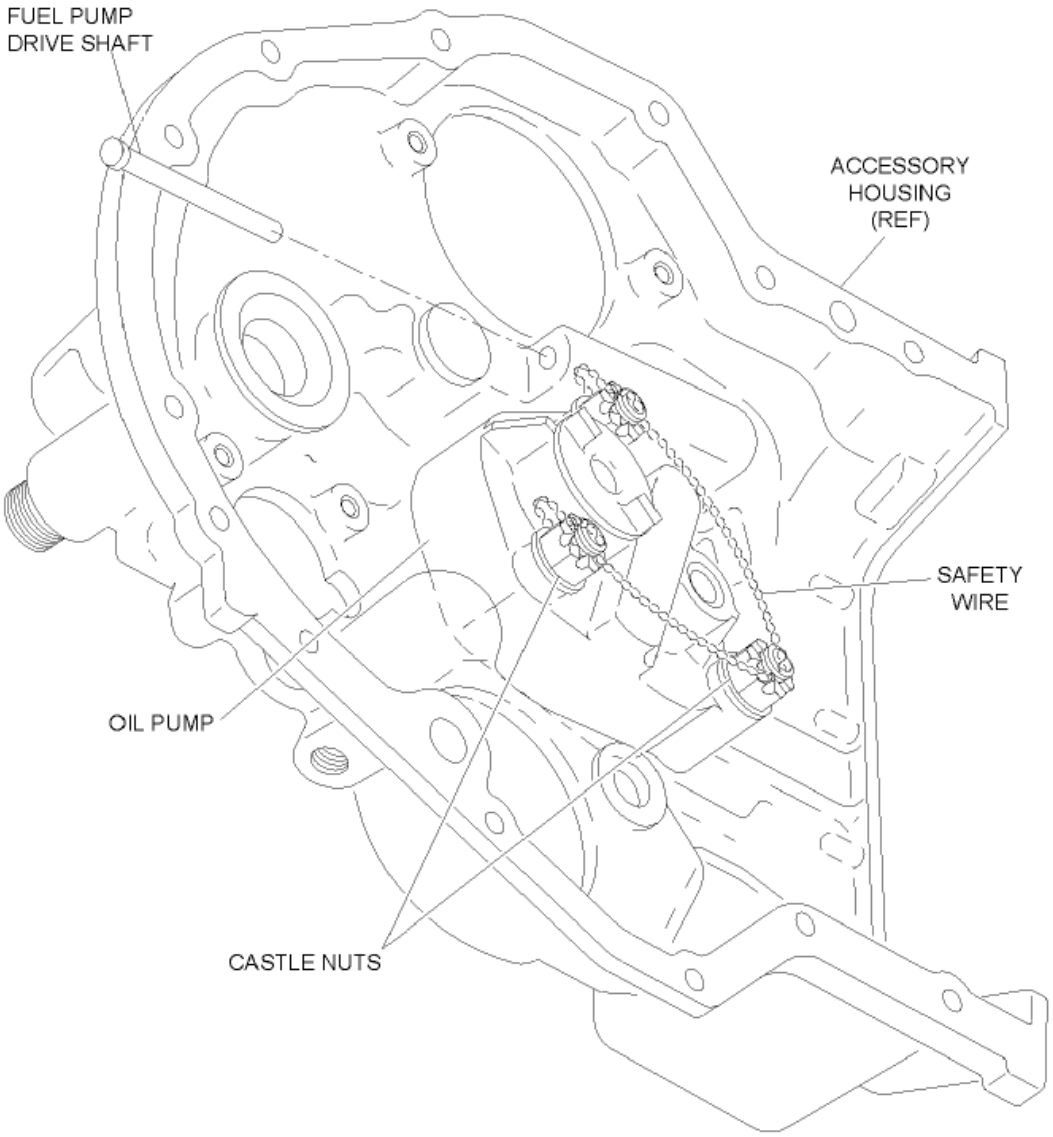


Figure 72-00-09.24 • Oil Pump Assembly

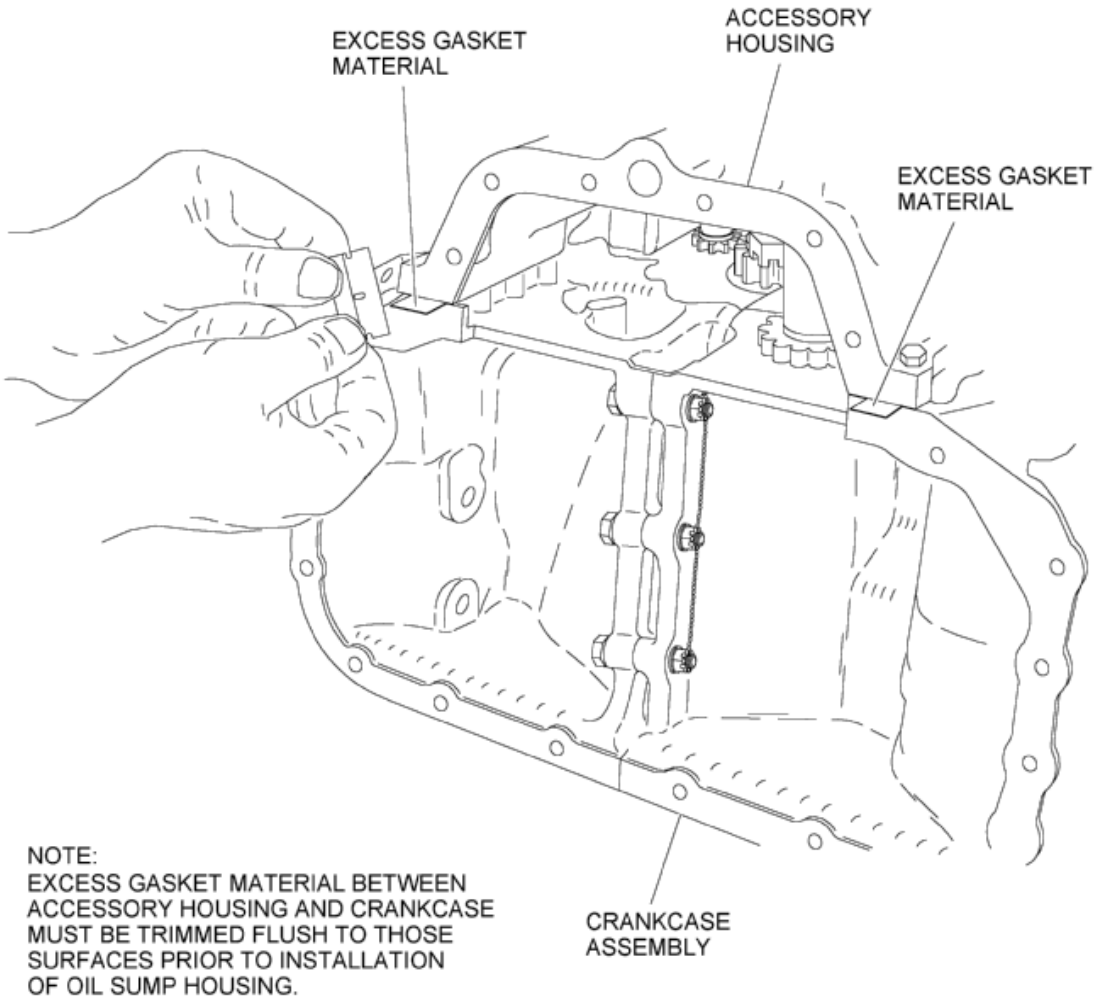
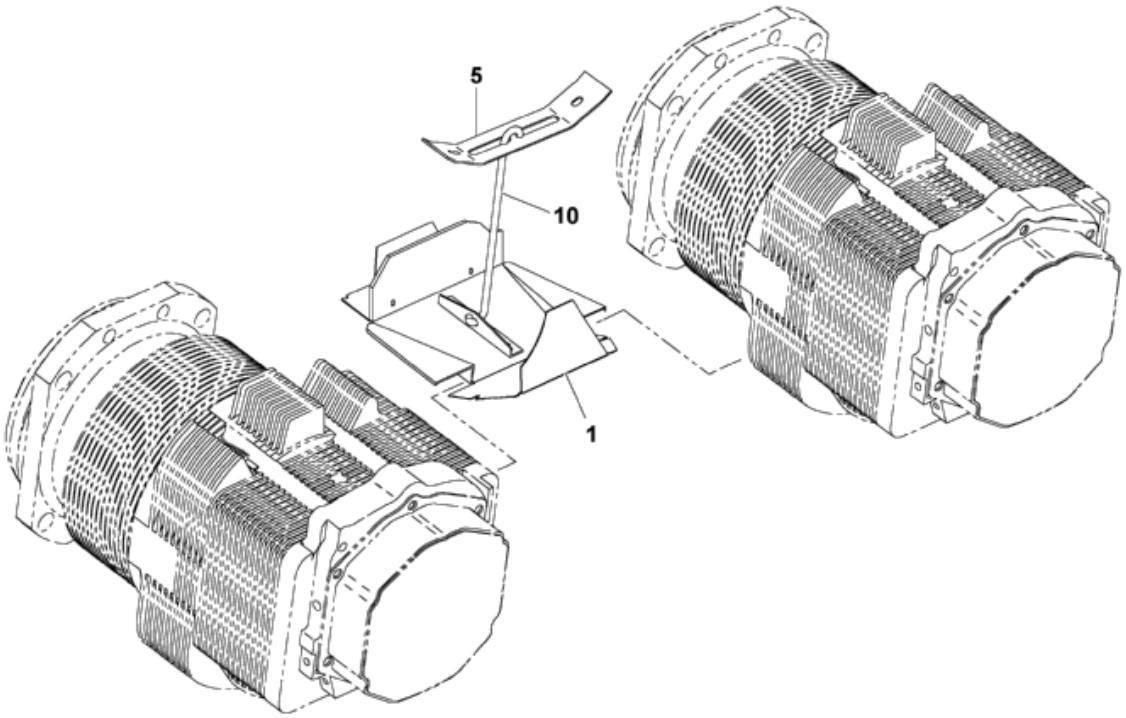


Figure 72-00-09.25 • Accessory Housing Gasket Trimming

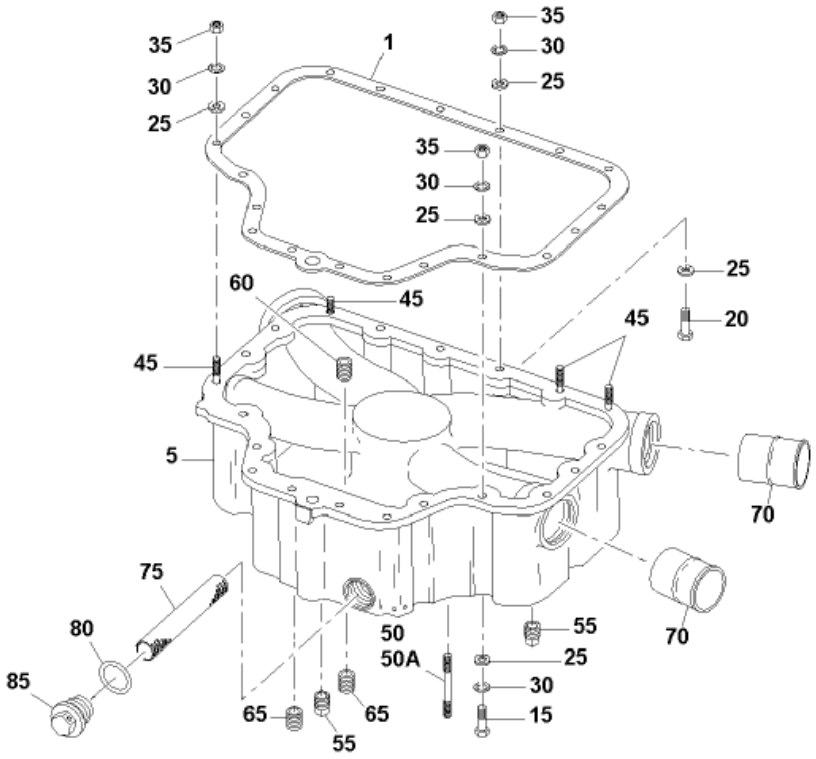
Installation of Intake Pipes

(1) Slide the intake flange (10, Figure 72-00-09.29) onto the intake elbow (5). Allow the flanged end of the elbow to seat in the recessed flat side of the intake flange.
(2) Install the rubber hose coupler (30) onto other end of the elbow along with 2 clamps (35).
(3) Place the bolts (25) with the appropriate lock washer (20) and flat washer (15) through the holes in the intake flange. Install the gasket (1) over the bolts. Refer to Figure 72-00-09.29.
(4) Attach the elbow assembly to the engine with the hose connection to sump and the flange coupling to the intake port of the cylinder head. Refer to Figure 72-00-09.30.
(5) Slide the hose coupler over the intake extension in the sump. Center the hose coupler over the joint and tighten the bolts (25) into the cylinder head until snug.
(6) Ensure that the flange end of the intake elbow fits completely in the recess in the aluminum hold down flange (10). This must lay flat against the cylinder port. Torque the bolts (25) 96 to 108 in-lbs.
(7) Position the clamps (35) over the hose coupler (20) to secure each side of the connection. Tighten to 10 in-lbs.



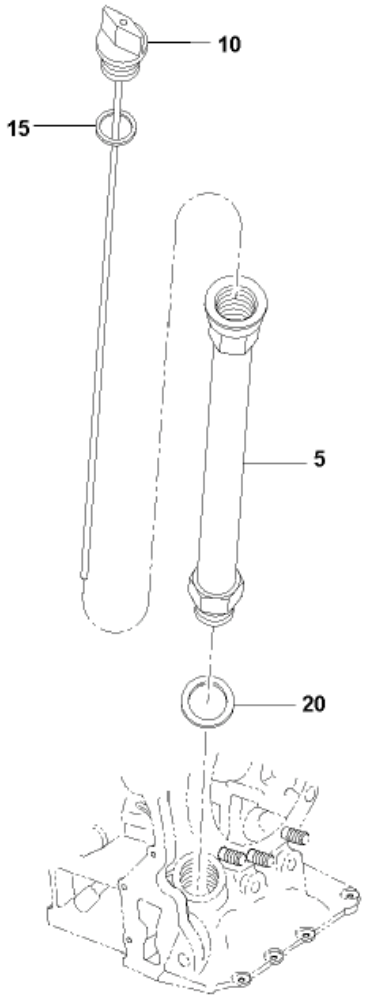
1. BAFFLE ASSEMBLY
5. RETAINER
10. HOOK - RETAINER

Figure 72-00-09.26 • Inner Cylinder Cooling Baffle



1. GASKET
5. OIL SUMP ASSEMBLY
15. BOLT
20. BOLT
25. WASHER - PLAIN
30. WASHER - LOCK
35. NUT - PLAIN
45. STUD
50. STUD
50A. STUD
55. PLUG
60. PLUG
65. PLUG
70. PIPE - INTAKE
75. SCREEN
80. GASKET
85. PLUG

Figure 72-00-09.27 • Oil Sump and Induction System



5. OIL GAGE TUBE
10. OIL GAGE
15. SEAL - GAGE
20. SEAL - TUBE

Figure 72-00-09.28 • Oil Level Gage

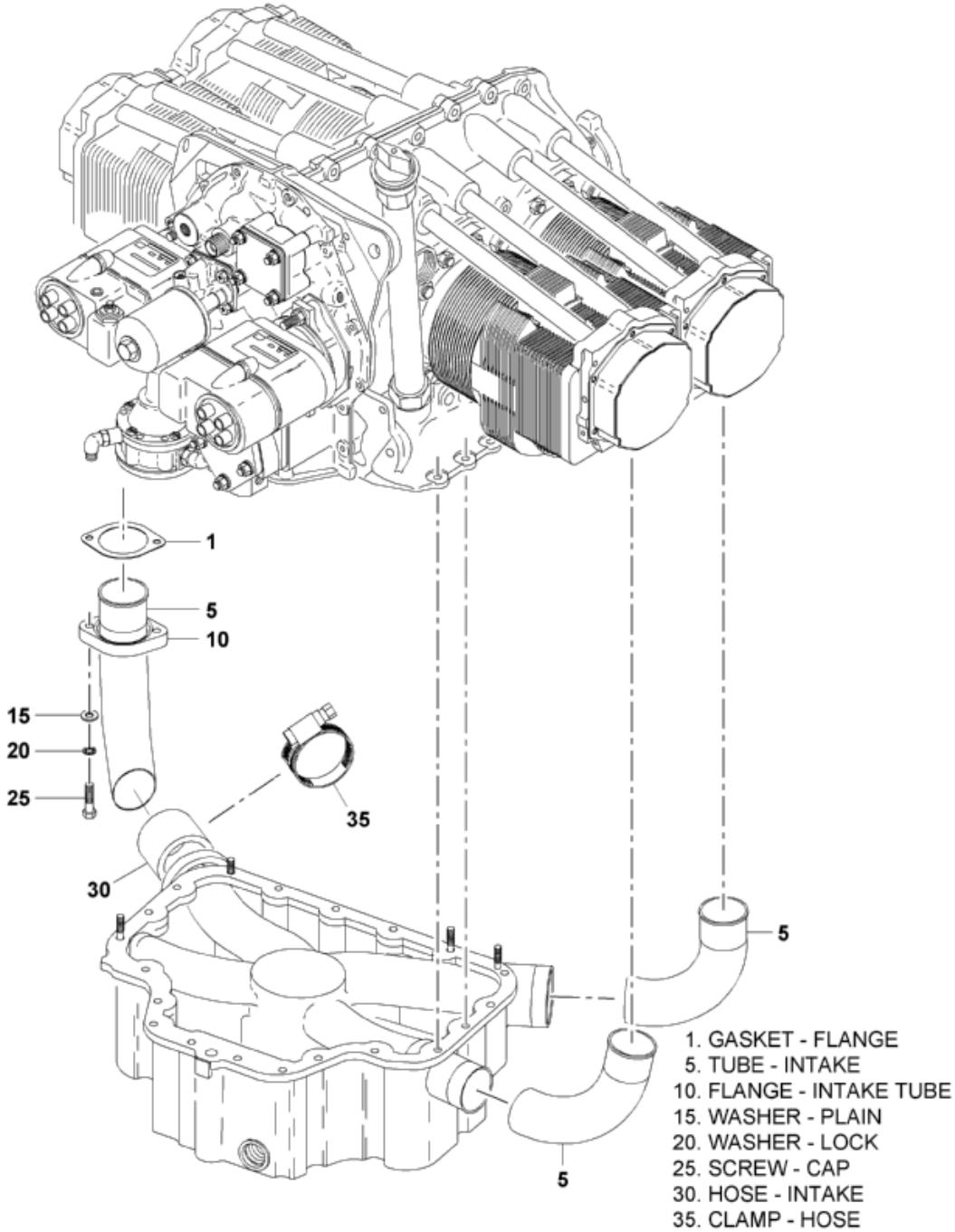


Figure 72-00-09.29 • Induction System

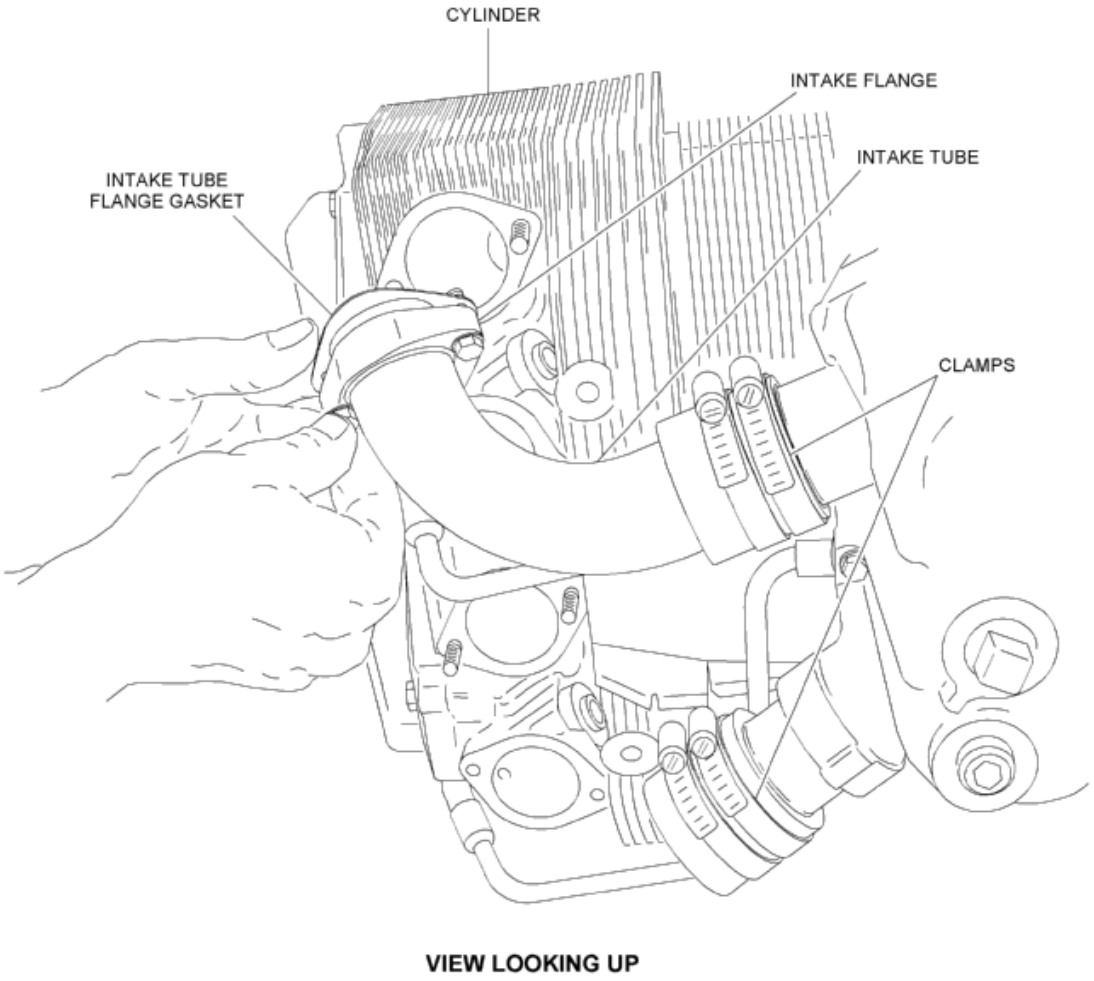


Figure 72-00-09.30 • Intake Tube Assembly

Installation of Cylinder Drain Tubes

(1) Secure the cylinder drain tubes (90) to their corresponding cylinders. Do this by installing the drain back hose (80) to the case nipple (75) and the drain tube using the clamps (85). Fasten the B-nut end of the drain tube to 45º fitting in cylinder head. Torque the 2 clamps (85) to 10 in-lbs. Torque the drain tubes (90) B-nuts to 35 in-lbs. Refer to Figure 72-00-09.17.

NOTE: Ensure that the cylinder drain fitting is tight and pointed in the correct position for the drain tube (90) installation. The tube should not touch the intake pipe, cylinder, or inner cylinder baffle.

Installation of Vacuum Pump Adapter

(1) Install new oil seal (55, Figure 72-00-09.31) in the vacuum pump adapter (25).
   (a) Lightly lubricate the seal OD with Fuelube™ or equivalent. Press into the adapter, flat side up, until it bottoms out.

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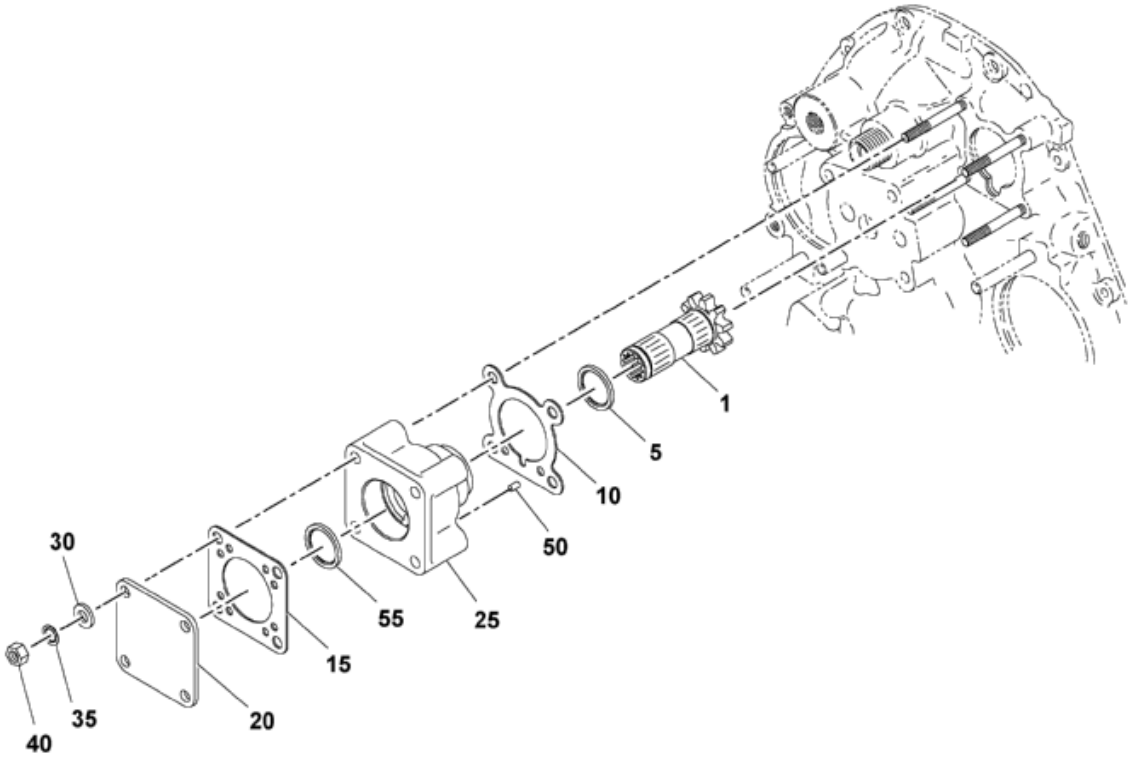
(2) Apply pre-lube oil and thrust washer to the shaft gear (1) and install the gear in the housing. Rotate the gear upon installation to ease it through the seal and to ensure it turns smoothly.
(3) Install the gasket (10) over the studs in the accessory housing. Align holes in gasket to correspond with holes in the housing. Refer to Figure 72-00-09.31.
(4) Install the vacuum pump adapter (25) and the gear assembly (1) over the studs in the accessory housing. Align the holes and dowel pin. Ensure that the drive gear teeth mesh with the idler gear teeth.
(5) Check the gear endplay and backlash. Values must be within limits per Fits and Clearances section of this manual.
(6) Install the gasket (15), and cover plate (20) with the washer (30), lockwasher (35), and nuts (40). Torque the nuts (40) to 96 – 108 in-lbs.

Installation of Accessories

(1) Install the engine accessories per instructions given later in this section.

- STOP -

PERFORM IN-PROCESS QUALITY INSPECTION #4. REFER TO APPENDIX A.



1. GEAR ASSY
5. WASHER - THRUST
10. GASKET - ACCESSORY DRIVE
15. GASKET - VACUUM PUMP
20. COVER
25. ADAPTER
30. WASHER
35. WASHER - LOCK
40. NUT - PLAIN
50. PIN
55. OIL SEAL

Figure 72-00-09.31 • Vacuum Pump Drive

Engine Accessory Assembly Installation

NOTE: Unless otherwise specified, all torque loads listed for nuts, bolts, and screws are for use with pre-lube oil.

Installation of Fuel Pump (if furnished)

(1) Verify new fuel pump part number.

WARNING: LUBRICANTS ARE TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. BEFORE YOU USE, READ THE MATERIAL SAFETY DATA SHEET (MSDS) FROM THE MANUFACTURER OR SUPPLIER. USE IN A WELL-VENTILATED AREA FREE FROM SPARKS. WEAR 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.

(2) Apply pre-lube oil to threads of 90º elbow (25, Figure 72-00-09.32) and o-ring (20). Install into fuel pump (5) outlet port. Position elbow (25) to point straight back and torque lock nut to 110 in-lbs.
(3) Apply pre-lube oil to the threads of the 45º elbow (30) and o-ring (20). Install into the fuel pump (50) inlet port. Position the elbow (30) to point up and torque the lock nut to 110 in-lbs.
(4) Rotate the engine to provide least amount of fuel pump plunger extension.
(5) Apply grease to the fuel pump arm and plunger where they will make contact on the wear surfaces.
(6) Install the fuel pump (5) with the gasket (1), drilled sockethead screws(15), and flat washers (10).

WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

(7) Torque the screws (15) to 250 in-lbs. Install safety wire (0.032 in.).

Installation of Propeller Governor Adapter Assembly

(1) This instruction applies to engine models requiring a prop governor installation.
(2) Lubricate the governor shaft gear (1, Figure 72-00-09.33) and the bore in the adapter (15) with pre-lube oil. Install the shaft gear in the adapter.

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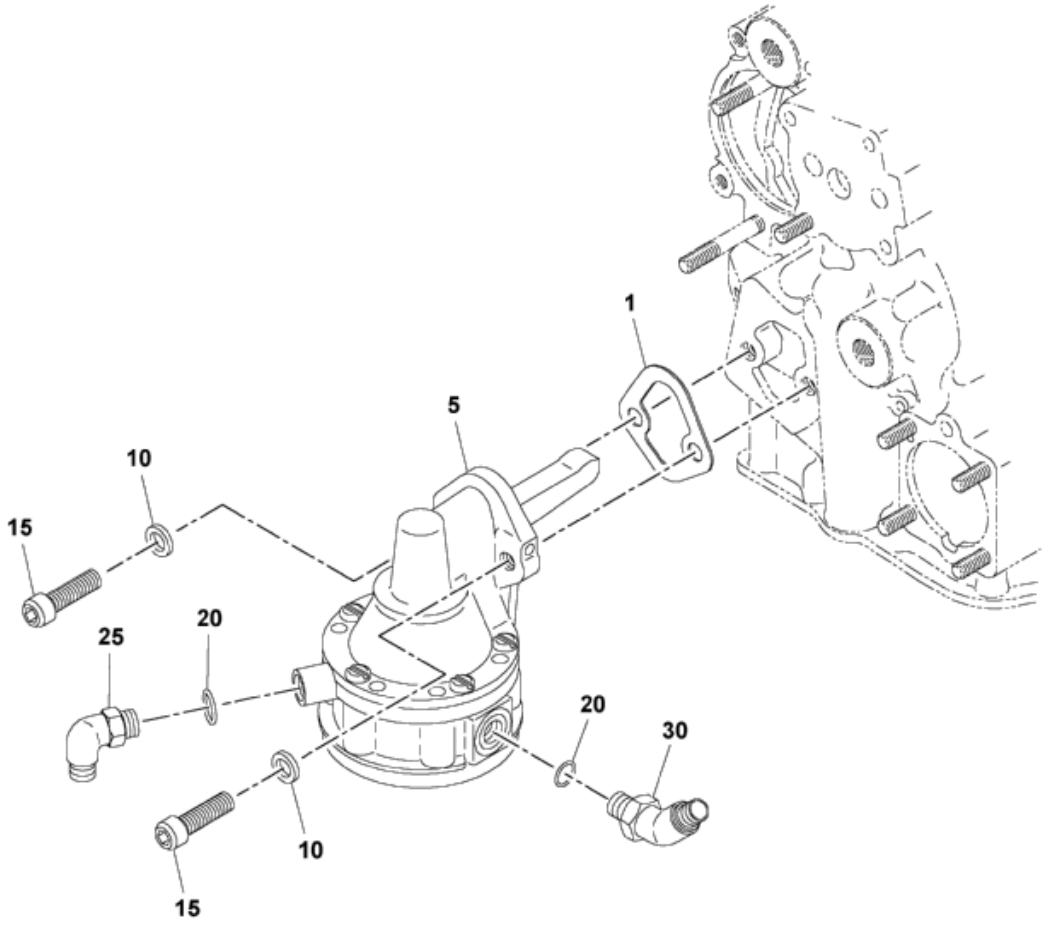
(3) Place the thrust washer (5) on the shaft gear. Secure the shaft gear in the adapter with snap ring (55). Refer to Figure 72-00-09.33.
(4) Ensure free spin of the gear in the adapter and check the end clearance. Allowable end clearance is 0.002 to 0.024 in.
(5) Install the adapter assembly to the accessory housing with the gasket (10), washer (20), lock washer (25), and nut (30) per Figure 72-00-09.33. Torque the nuts (30) to 200 in-lbs.
(6) Check the gear lash to the idler gear. Clearances are 0.004 to 0.015 in.
(7) Lightly lubricate the threads of the 45º elbow (15, Figure 72-00-09.34) and its o-ring (20) with pre-lube oil and install in the propeller governor adapter.



1. GASKET
5. PUMP - FUEL
10. WASHER - FLAT
15. SCREW
20. O-RING
25. ELBOW - 90°
30. ELBOW - 45°

Figure 72-00-09.32 • Fuel Pump

WARNING: ADHESIVE SEALANT IS TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. AVOID EYE AND SKIN CONTACT. USE 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.

(8) Apply TiteSeal™ thread sealant or equivalent to the threads of 90º elbow fitting (10) and install in the right crankcase half, forward of No.1 cylinder. Refer to Figure 72-00-09.34.
(9) Position fittings per Figure 72-00-09.34 and install the propeller governor oil hose (1). Torque the oil hose (1) nuts to 35 in-lbs.

Installation of Propeller Governor Cover Plate

(1) This instruction applies to all engine models not requiring a prop governor.
(2) For the engine models where no propeller governor is used, install cover (65, Figure 72-00-09.33), gasket (60), washer (30), and lockwasher (25). Torque the 5/16 in. nuts (30) to 200 in-lbs.

Installation of Oil Filter Adapter (if furnished)

(1) Install the Vernatherm valve (45) with the aluminum gasket and torque to 300 in-lbs. Install safety wire (0.032 in.) from the Vernatherm to the adapter.
(2) Install the oil filter adapter (10, Figure 72-00-09.35) to the accessory housing with the gasket (5), washers (15), lock washers (20), 1 nut (25), and 3 screws (30). Torque to 96-108 in-lbs.

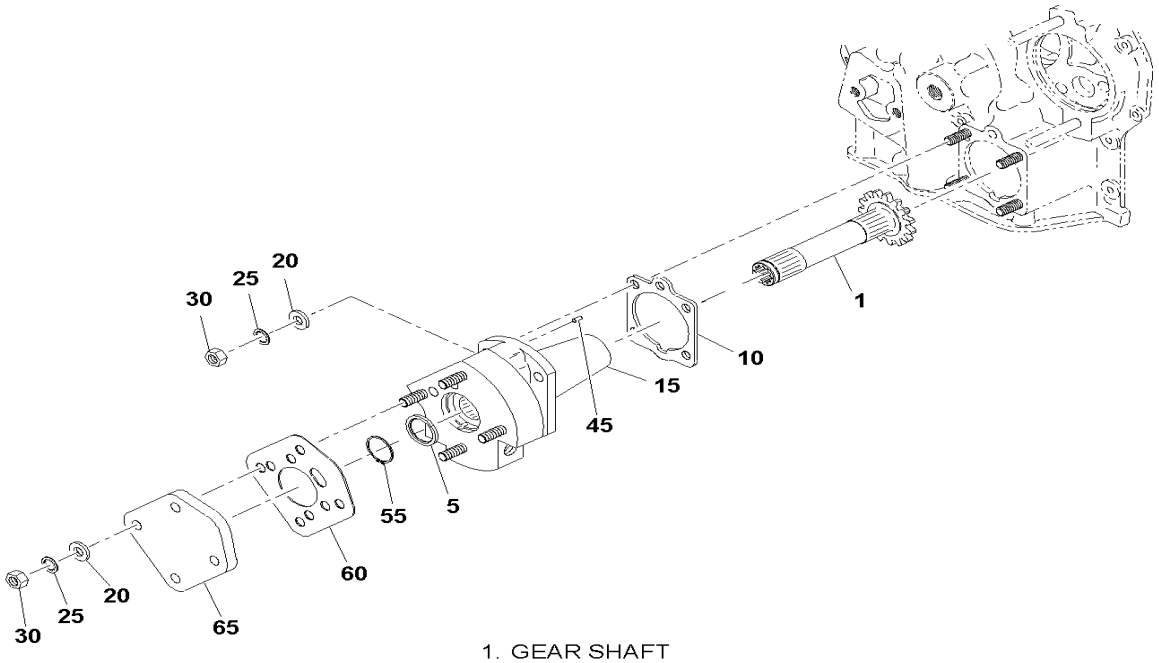
WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

Installation of Spin-On Oil Filter

(1) Apply light coat of Dow Corning #4 lubricant or equivalent to the rubber seal at base of the oil filter (40, 72-00-09.35) and lightly lubricate the filter threads then install to the adapter (10) and torque to 192-216 in-lbs. Reference SVIMM01, Maintenance Manual. Install safety wire (0.032 in.) from the oil filter to the adapter.

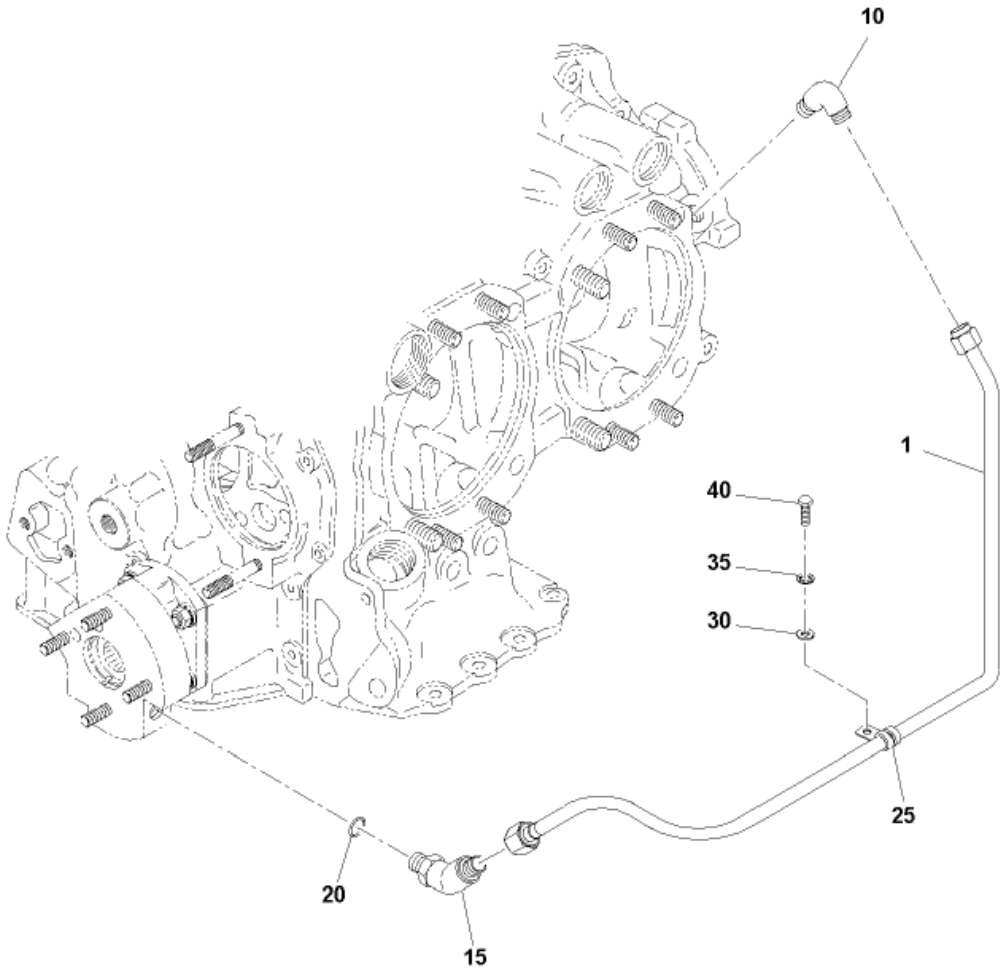
WARNING: PUT ON SAFETY GOGGLES WHEN INSTALLING OR REMOVING SAFETY WIRE.

WARNING: LUBRICANTS ARE TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. BEFORE YOU USE, READ THE MATERIAL SAFETY DATA SHEET (MSDS) FROM THE MANUFACTURER OR SUPPLIER. USE IN A WELL-VENTILATED AREA FREE FROM SPARKS. WEAR 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.



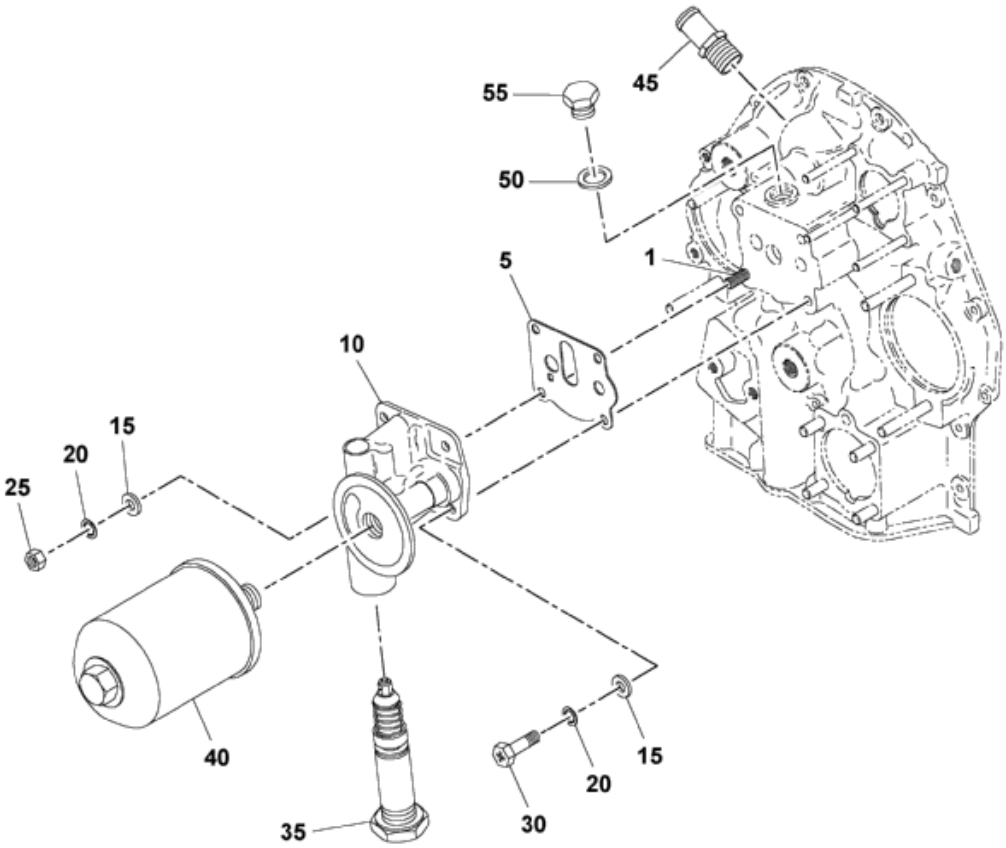
1. GEAR SHAFT
5. WASHER - THRUST
10. GASKET - ACCESSORY DRIVE
15. ADAPTER ASSY
20. WASHER - FLAT
25. WASHER - LOCK
30. NUT - PLAIN
45. PIN - SPRING
55. RING - RETAINING
60. GASKET
65. COVER

Figure 72-00-09.33 • Propeller Governor Adapter



1. HOSE
10. ELBOW - 90°
15. ELBOW - 45°
20. O-RING
25. CLAMP
30. WASHER - FLAT
35. WASHER - LOCK
40. BOLT

Figure 72-00-09.34 • Propeller Governor Oil Line



1. STUD (1/4-20 X 1-1/4)
5. GASKET - ADAPTER
10. ADAPTER - OIL FILTER
15. WASHER - FLAT (1/4 INCH)
20. WASHER - LOCK (1/4 INCH)
25. NUT - PLAIN (1/4 INCH)
30. SCREW (1/4-20 X 31/32)
35. VALVE CONTROL ASSY - VERNATHERM
40. OIL FILTER - SPIN ON
45. FITTING - CRANKCASE BREATHER
50. GASKET - COPPER
55. PLUG - OIL COOLER BYPASS

Figure 72-00-09.35 • Oil Filter Assembly

Installation of Carburetor and Primer System

NOTE: This section applies to carbureted engine models only.

(1) Verify the correct part number of the carburetor.
(2) Install the carburetor (5, Figure 72-00-09.37), gasket (1), washers (10), lockwashers (15), and nuts (20) per Figure 72-00-09.37. Torque the nuts (20) to 200 in-lbs.
(3) Apply anti-seize to the threads of the primer nozzles (1, Figure 72-00-09.36).
(4) Install the primer nozzles in cylinder numbers 1, 2, and 4 (lower ports, Fig. 72-00-09.36). Torque the nozzles (1) to 60 in-lbs.
(5) Install the primer lines (5, 10, 15, 20) to the nozzles and "T" junctions. Clamp to the induction elbows and sump flange.

Installation of Fuel Injection System

NOTE: This section applies to fuel injected engines only.

(1) Verify the correct part number of the fuel injection unit (servo), flow divider, and nozzles.
(2) Install the servo to the sump with gaskets (1, Figure 72-00-09.38), spacer (5), washer (15), lock washers (20), and nuts (25). Torque the attaching nuts (25) to 200 in-lbs.
(3) Install the fuel injector fittings, appropriate pipe plugs and nipples per Figure 72-00-09.39 into the flow divider. Use anti-seize on the male threads and torque as follows:
    - Plug (30) to 40 in-lbs.
    - Elbow (35) to 40 in-lbs.
    - Fitting (40) to 40 in-lbs.
    - Nipple (50) to 60 in-lbs.
    - Nipple (45) to 60 in-lbs.
(4) Install the flow divider bracket (1) to the flow divider with screws (25) and lock washers (20). Torque the screws to 49 in-lbs.
(5) Install the flow divider and bracket assembly to the engine backbone (top) per Figure 72-00-09.39 and torque the attaching hardware to 96-108 in-lbs.

NOTE: Remove and reinstall the appropriate backbone hardware to accommodate bracket

(6) Install the bolt (10) with lock washer (5).
(7) Apply anti-seize to the fuel injectors (90). Install in the cylinders. Torque the injectors to 60 in-lbs.
(8) Install the fuel lines (55) between the fuel injectors (90) and the flow divider (15). Tighten to 25 in-lbs. Install clamps.
(9) Install the fuel hose (30, Figure 72-00-09.38) between the fuel pump and fuel servo. Install the fuel hose (35, Figure 72-00-09.38) between the fuel servo and flow divider. Torque the hose (30, 35) B-nuts to 45 in-lbs.

Magneto and Harness Installation

(1) Verify the correct magneto part numbers.
(2) Assemble the magnetos as follows:
    (a) Install the drive gear (35, Figure 72-00-09.40) to the magneto (15) by removing the gear retaining nut, washer, and cotter pin (40) from the magneto.
    (b) Install the drive gear (35) with the washer and nut. Torque the nut to 120-320 in-lbs. Secure with cotter pin (40).
(3) Repeat for the 2nd magneto's assembly.
(4) Install the magneto gasket (1) and spacer (5), as appropriate, to the accessory housing at each magneto location.
(5) Remove the harness cover cap from each magneto as required. Retain screws for harness installation.
(6) Determine direction of rotation. Refer to magneto data plate.
(7) Insert the alignment pin in appropriate hole "R" or "L" in magneto, as determined by the direction of rotation, and slowly rotate the magneto drive shaft "backwards" until the alignment pin drops into position (to the first shoulder), locking the shaft.

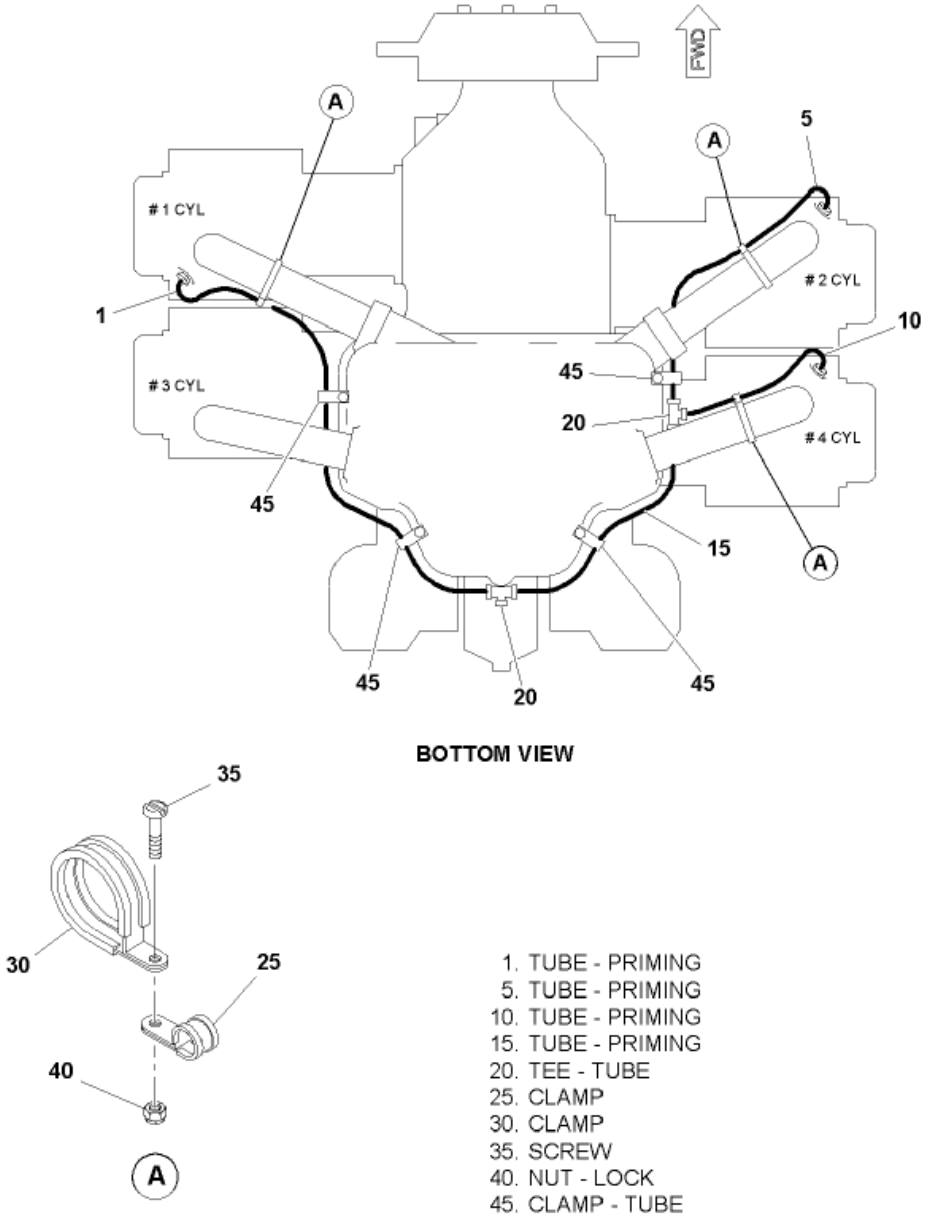
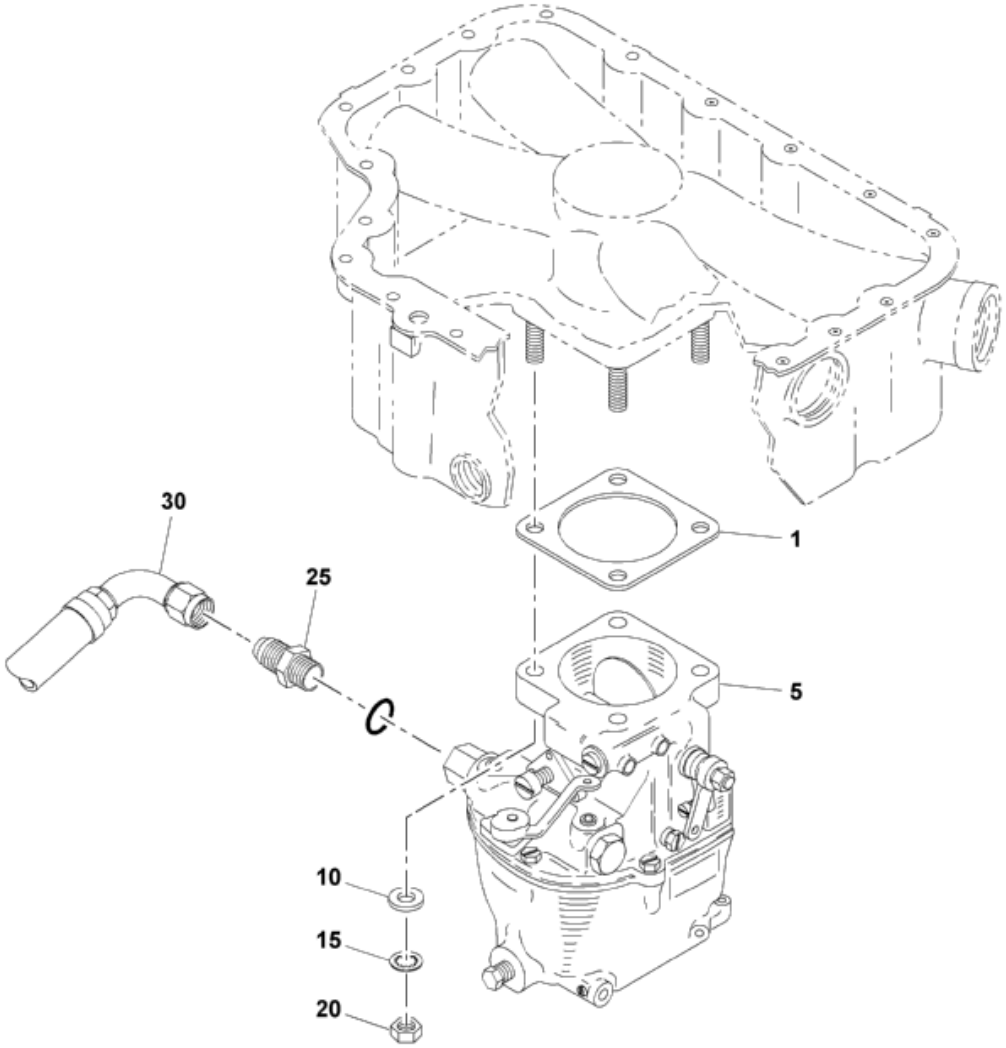
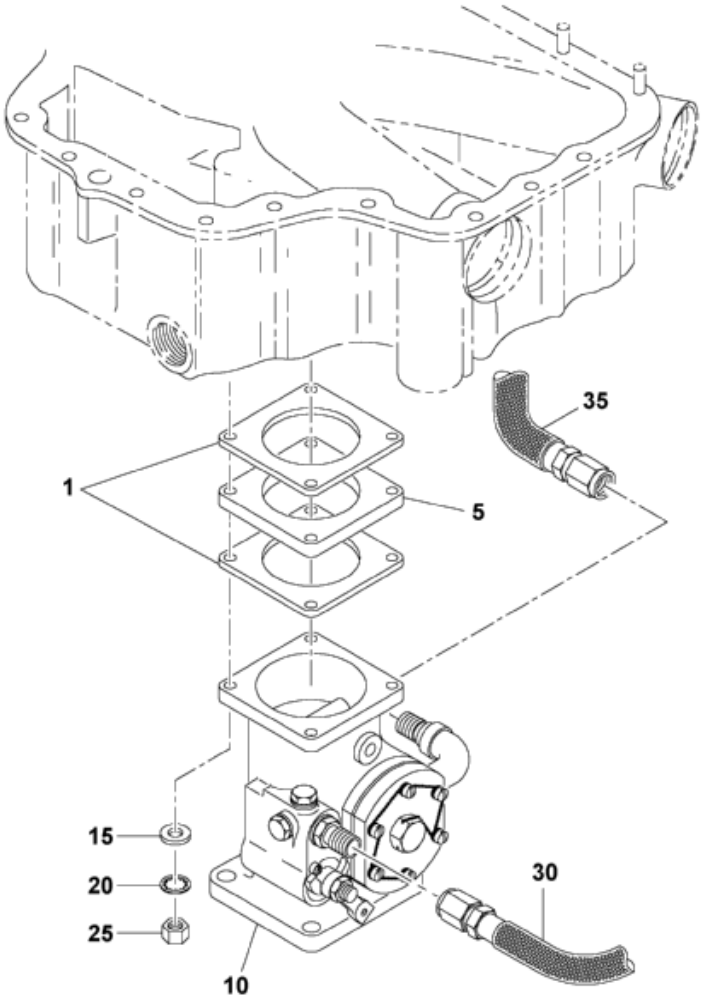


Figure 72-00-09.36 • Fuel Priming System



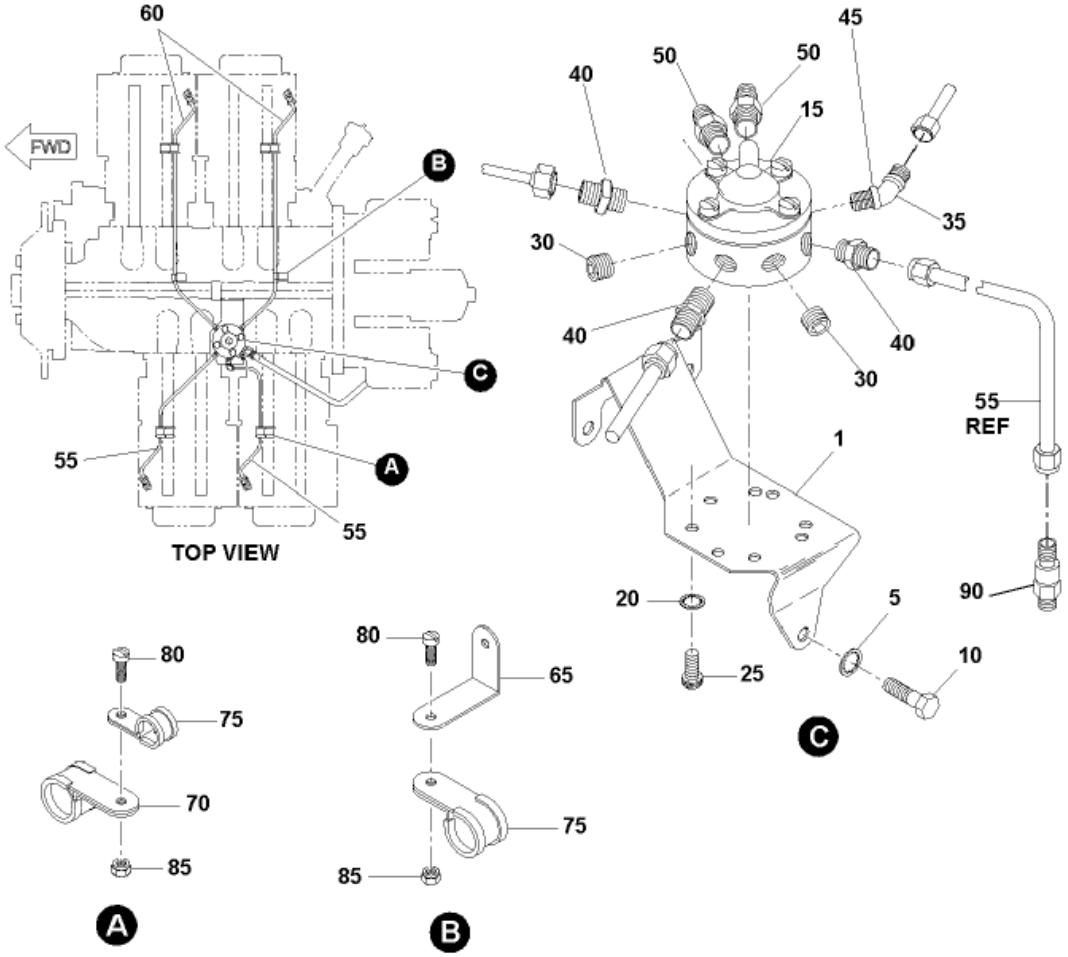
1. GASKET
5. CARBURETOR
10. WASHER - PLAIN
15. WASHER - LOCK
20. NUT - PLAIN
25. FITTING
30. HOSE ASSEMBLY - FUEL

Figure 72-00-09.37 • Carburetor Installation



1. GASKET
5. SPACER
10. THROTTLE BODY - FUEL INJECTION SERVO
15. WASHER - FLAT
20. WASHER - LOCK
25. NUT - PLAIN
30. HOSE ASSY
35. HOSE ASSY

Figure 72-00-09.38 • Fuel Injection Servo Installation



1. BRACKET - MANIFOLD
5. WASHER - LOCK
10. BOLT
15. DIVIDER - FLOW
20. WASHER - LOCK
25. SCREW
30. PLUG
35. ELBOW - TUBE
40. FITTING
45. FITTING - 45
50. NIPPLE
55. TUBING - INJECTOR
60. TUBING - INJECTOR
65. BRACKET
70. CLAMP
75. CLAMP
80. SCREW
85. NUT - LOCK
90. NOZZLE ASSEMBLY

Figure 72-00-09.39 • Fuel Injection Manifold Installation

NOTE: While rotating the magneto shaft backwards with alignment pin in hole, if the shaft stops turning due to internal interference against the alignment pin prior to pin seating, pull pin out just far enough to allow the shaft to continue to rotate. Re-insert the pin and continue rotation until the pin seats as previously described. This procedure locates the magneto at the No.1 cylinder firing position.

(8) Repeat for the 2nd magneto's alignment.
(9) Bring the engine to the compression stroke on the No. 1 cylinder.
(10) Rotate engine to approx. 25º before top dead center using a timing indicator installed in a spark plug hole of the No. 1 cylinder or equivalent method.

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(11) Apply pre-lube oil to the idler gear teeth and magneto drive gear teeth (35) and apply light coat of Dow Corning™ #4 or Fuelube™ to the magneto gasket (10). Install each magneto with the clamp (20), lock washers (25), and nut (30). Tighten moderately.

NOTE: Magnetos must be able to move for final timing. This will be accomplished later with the engine horizontal, disconnected from nose stand, and with the ring gear and starter installed.

WARNING: DO NOT ROTATE ENGINE OR CRANKSHAFT BEFORE REMOVAL OF TIMING LOCATOR PINS.

(12) Remove the timing locator pins from the magnetos (15) and install the harness. Ensure correct harness locations. Align the harness cover caps properly. Secure with the screws removed from the cap removal.

Starter Installation

(1) Verify the starter part number.
(2) Install the starter IAW the starter manufacturer's installation instructions. Tighten the bolt and nuts to 200 in-lbs.

Alternator Installation (if furnished)

(1) Verify the alternator part number is correct.
(2) Install pulley, as required, to alternator IAW manufacturer's installation instructions.
(3) Attach mounting bracket (55, Figure 72-00-09.43) to engine with bolts (60) and lock plate (50) and tighten until snug (finger tight).
(4) Attach alternator to mounting bracket (55) using drilled shank bolts (25, 30) with shim washers (35) and hardware as required for alternator pulley/belt alignment to starter ring gear assembly.
(5) Attach strut support (80) to alternator bracket in forward location using bolt (25).
(6) Install adjusting link (65) to crankcase and alternator with drilled head bolts (75, 10). Use single washer (70) at the crankcase attach point and two (2) washers (5) at slotted alternator attach point for strength.

NOTE: Leave all attach hardware snug or finger tight as required to allow for alignment and belt tension adjustment.

(7) Install alternator belt (not shown) to starter ring gear assembly and install starter ring gear assembly to crankshaft flange. Reference SVMM01, Maintenance Manual. A "slave" bolt may be used to temporarily hold starter

ring gear assembly in place if propeller and spinner are to be installed later.

(8) Install new belt to alternator pulley and adjust alternator and/or brackets to achieve proper alignment.

(9) Adjust belt tension to allow a midspan deflection of 0.31" with a 14lb load.

NOTE: An alternate method of checking belt tension is to measure the torque required to slip the belt at the small alternator pulley. A new belt is properly tensioned when 12 ft-lb ±1 is required to cause it to slip.

(10) Torque and safety the 3/8-24 slotted nuts (40) to 360 in-lb.

(11) Torque and safety all other attaching hardware in accordance with values listed in the Fits and Clearances section of this manual.

Engine Removal

(1) Remove the engine from nose stand and place horizontal on transfer cart.

Final Magneto Timing and Adjustment

NOTE: Magneto assembly to the engine is outlined in the accessory installation instructions of this section.

(1) Install the ring gear to the crankshaft propeller flange and retain with one slave bolt.

(2) Rotate the crankshaft, using ring gear, to compression stroke of number one cylinder.

NOTE: It may be necessary to rotate the crankshaft just beyond top dead center to allow the magneto impulse couplings to release. Upon release of the couplings, rotate the crankshaft back in the opposite direction, to correct timing degree mark.

(3) Align the correct timing mark on the ring gear with the mark on the starter housing. See Figure 72-00-09.41.

(4) Attach the timing indicator leads of the magneto synchronizer (timing box) to the magneto P-lead connections and ground lead to an appropriate ground.

(5) Rotate or adjust the magnetos until each magneto synchronizer lights indicate that the magneto points are just opening.

(6) Snug the magneto nut (30, Figure 72-00-09.40) and rotate the crankshaft back a few degrees before the correct timing. Slowly rotate the crankshaft in the direction of rotation until the timing lights simultaneously indicate the magneto points are just opening.

(7) Repeat the process above for minor adjustments as needed to achieve the correct timing.

(8) Torque the magneto nut (30) to 200 in-lbs.

(9) Remove the timing indicator leads of the magneto synchronizer from the magneto P-lead connections and ground lead.

(10) Install the spark plugs into the top and bottom spark plug ports of each cylinder. Torque to 420 in-lbs. Reference SVMM01, Maintenance Manual.

(11) Attach the harness leads. Refer to wiring diagram Figure 02-00-00.10. Secure to each spark plug.

(12) Install the clamps provided with the harness kit to prevent wire chafing.

NOTE: Assembly steps 10, 11 and 12 above may be replaced by assembly of dehydrator plugs if the engine will be stored prior to engine test. In this event, spark plug leads should be neatly coiled and stowed with the clamps for later assembly.

Storage After Assembly

If not immediately proceeding to engine testing section, preserve the engine for storage per instructions in the Preservation and Storage section of this manual.

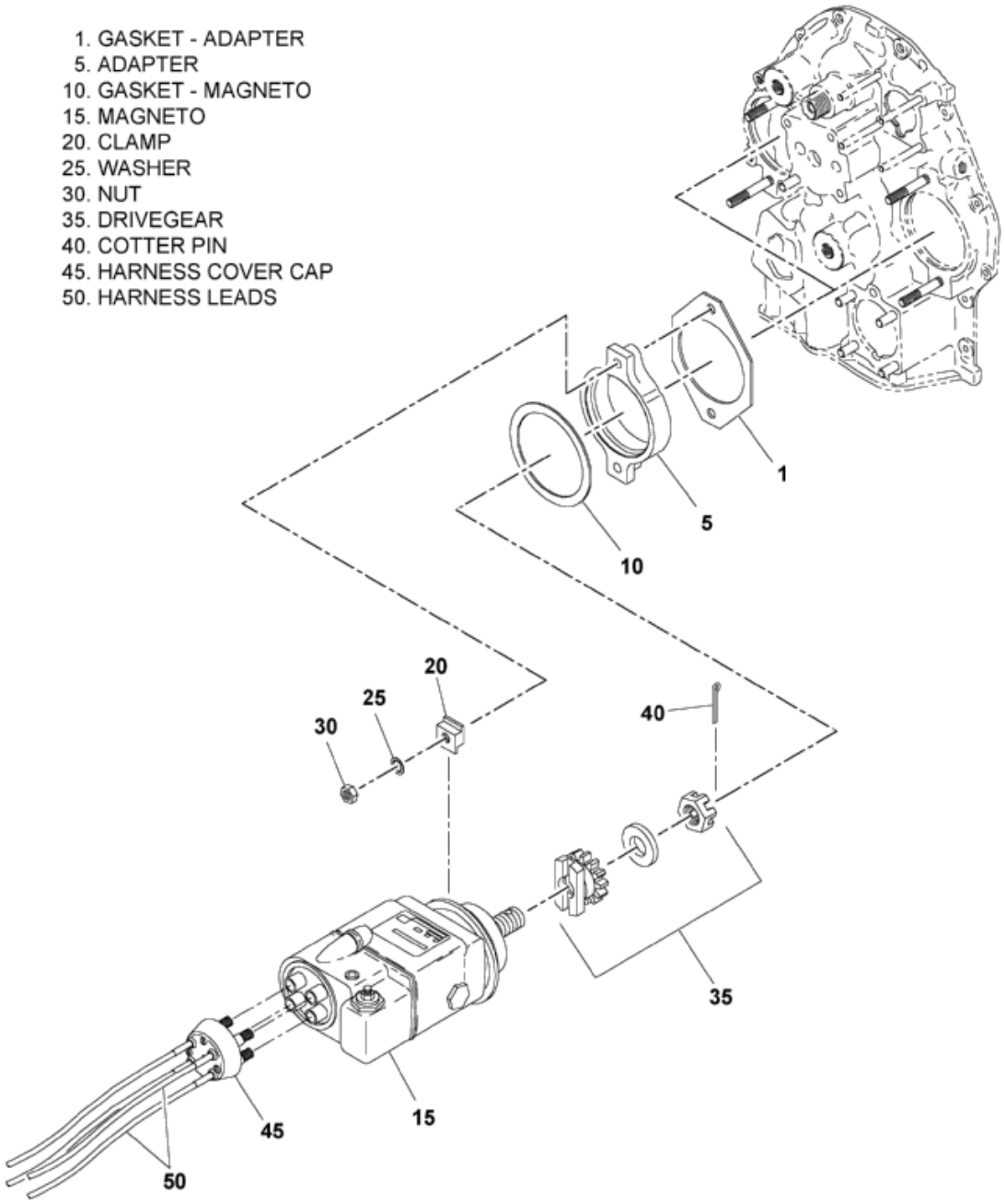


Figure 72-00-09.40 • Magneto and Adapter Installation

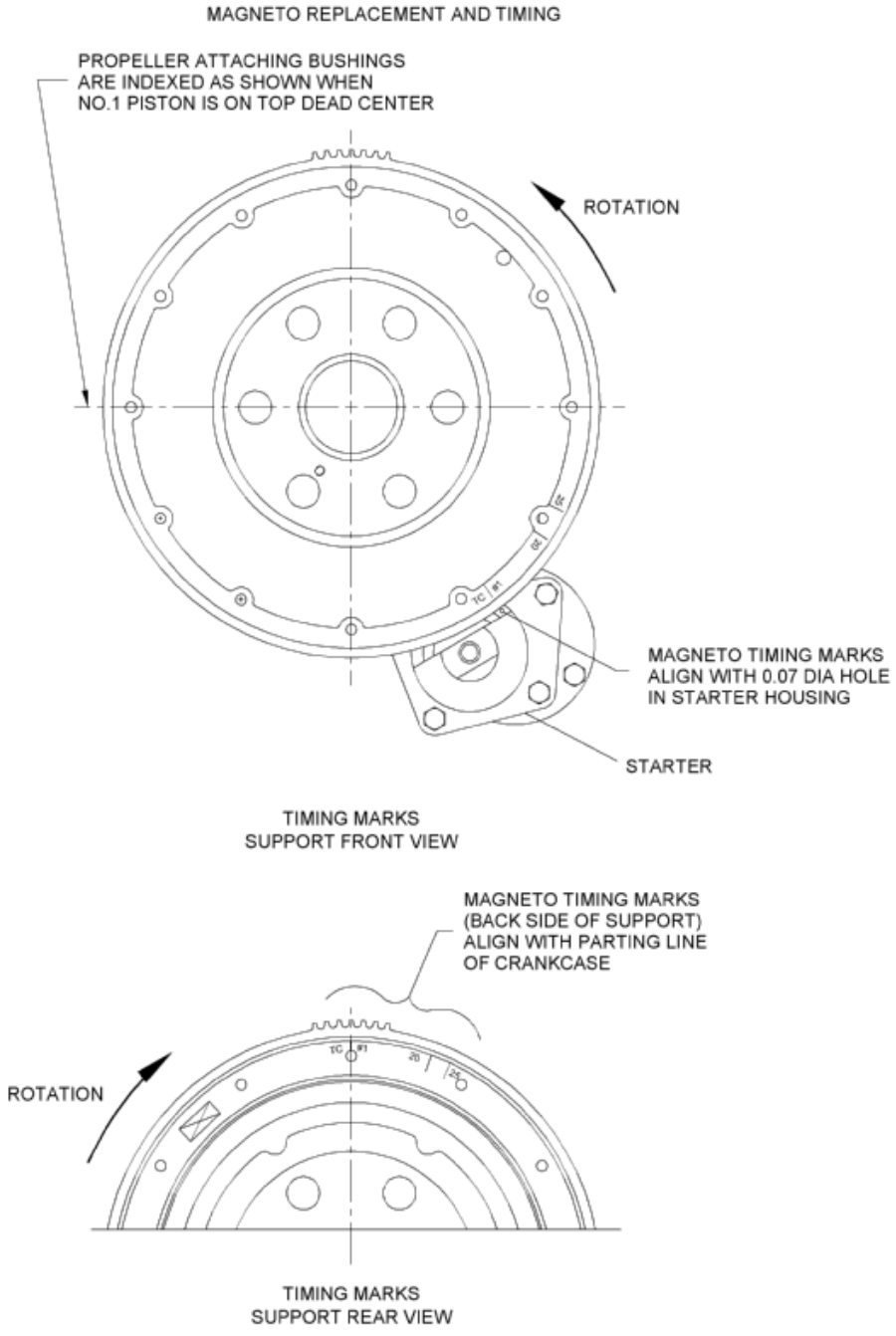
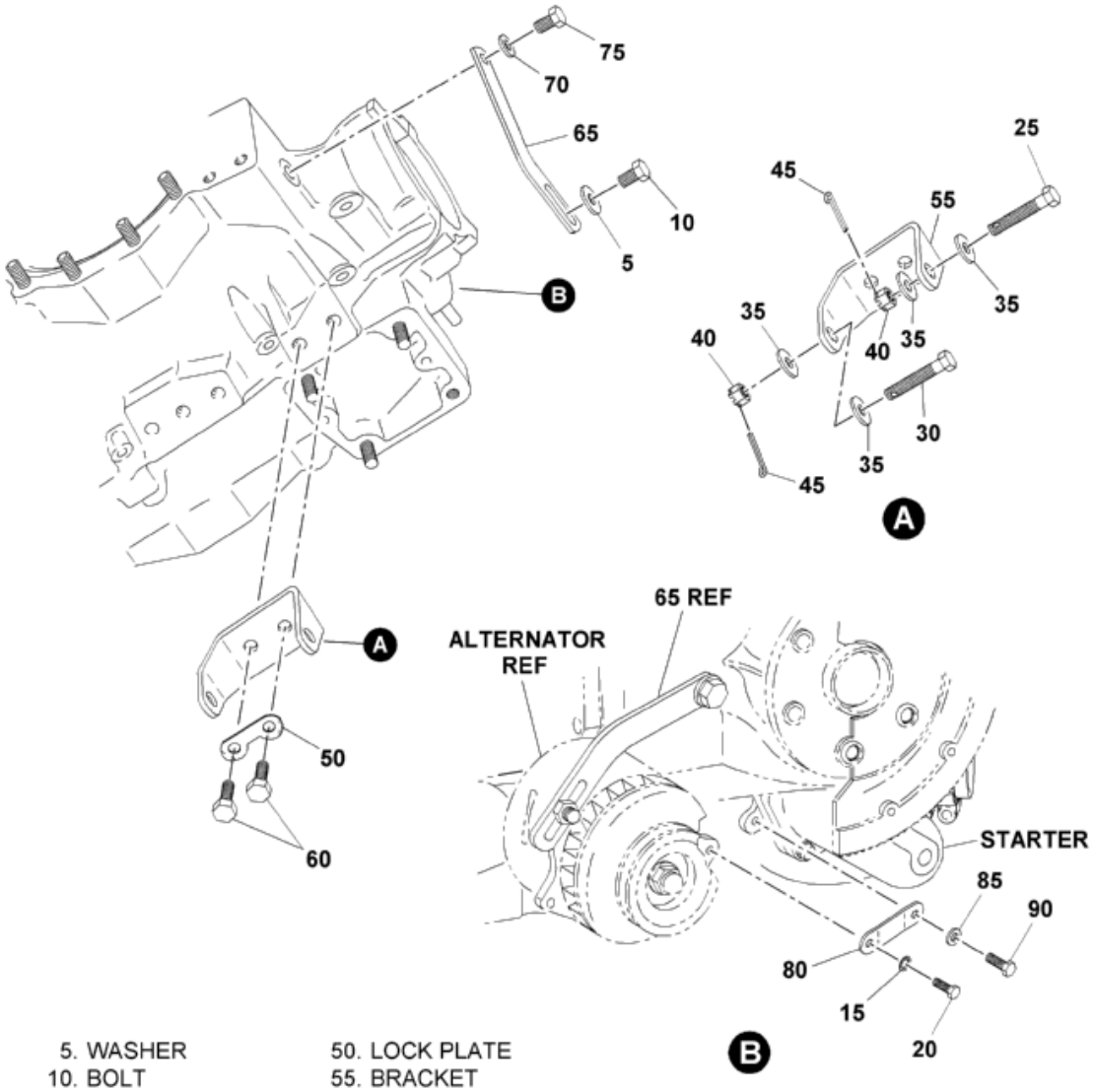


Figure 72-00-09.41 • Starter Ring Gear Alignment



5. WASHER
10. BOLT
15. WASHER
20. BOLT
25. BOLT
30. BOLT
35. SHIMS
40. NUTS
45. COTTER PINS
50. LOCK PLATE
55. BRACKET
60. BOLT
65. ADJUSTING LINK
70. WASHER
75. BOLT
80. STRUT SUPPORT
85. WASHER
90. BOLT

Figure 72-00-09.43 • Alternator Installation

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ENGINE INSTALLATION

General
This section consists of installation procedures.

- Equipment and Materials to accomplish installation procedures are listed in Table 72-00-10.1.
- Model specific illustrations and data may be found in the Model Specification Data attached to the Installation and Operation Manual (SVIOM01) for the appropriate engine model.

Table 72-00-10.1 • Equipment and Materials List

Item	Vendor
Engine Hoist	Commercially Available
Aircraft engine oil	Commercially Available
Accessory drive pad gaskets as required	Commercially Available

NOTE: Standard aviation shop tools are required.

Preparing Engine for Service
- If the engine has been preserved, perform the following steps:
  1. Remove the shipping plugs installed in the upper spark plug holes and inspect the cylinder bores for rust or contamination.
  2. 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.
  3. Drain preservation oil from engine.
- Engines that have been subjected to a cold environment for long periods of time should be placed into at least a 70°F atmosphere for 24 hours or more before attempting to drain the preservative oil. If this cannot be done, heat the engine with heating lamps before attempting to drain the engine.
- Remove exhaust port protective plugs. Service the lubrication system with mineral (non-detergent) oil.
- Remove the shipping plate from the propeller governor pad as required for governor installation. Lubricate the governor shaft splines with engine oil, install a new gasket and then install the propeller governor control.
- Align the spline of 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.
- Attach with plain washers and new lock washer. Torque the nuts to 200 in-lb.
- 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 any airframe manufacturers' required cooling baffles, hoses, fittings, brackets and ground straps in accordance with airframe manufacturer's instructions.

Installation of Engine
- Install engine per airframe manufacturer's instructions. Use only the lifting eye bracket installed on the backbone of the crankcase 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.

CAUTION: FAILURE TO PURGE THE AIRCRAFT FUEL TANKS AND LINES CAN CAUSE ERRATIC FUEL SYSTEM OPERATION AND DAMAGE TO ITS COMPONENTS.

- The aircraft fuel tanks and lines must be purged to remove all contamination prior to installation in the main fuel inlet line to the fuel pump or engine.
- Install the approved propeller in accordance with the manufacturer's instructions.

WARNING: 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.

FITS AND CLEARANCES

General
These limits provide dimensions, clearances and interference fits necessary to repair and overhaul Superior Vantage O-360 and IO-360 series engines. Service limits for used parts are provided where they have been established. If no service limits are provided, new limits must be maintained.

Service Limits
- Dimensional Limits are provided in Table 72-00-11.1.
- Backlash and Clearances Limits are provided in Table 72-00-11.3.
- Torque Limits are provided in Table 72-00-11.2.
- Spring Limits are provided in Table 72-00-11.4.
- Crush Type Gasket Tightening Angles are provided in Table 72-00-11.5.

NOTE: Limits followed by the letter "T" indicate a "tight", i.e., an interference fit. An example is the fit of the valve guide in the cylinder head. Where no "T" exists, the fit is a clearance dimension.

Table 72-00-11.1 • Dimensional Limits

Description of Limit	Minimum (in.)	Maximum (in.)
Piston		
Piston in Cylinder (Bottom of Skirt Clear)	0.0065	0.0095
Piston Weight Difference (Opposing Pairs)	-	.4 oz.
Piston Rings		
Piston Ring in Groove Side Clearance (Top Compression)	0.0025	0.0055
Piston Ring in Groove Side Clearance (2nd Compression)	0.0000	0.0040
Piston Ring in Groove Side Clearance (3rd Oil)	0.0020	0.0040
End Gap (Top Compression)	0.0450	0.0550
End Gap (2nd Compression)	0.0450	0.0550
End Gap (Oil Control)	0.0150	0.0300
NOTE: Measure end gaps 1.0" to 4.0" from bottom of barrel. Minimum ring gap at top of stroke is 0.0075" (measure compression ring gaps approx. 6.5" from bottom of barrel and oil ring gap approx. 6" from bottom of barrel).		
Piston Pin		
Piston Pin and Plug in Cylinder (End Clear)	0.0250	0.057
Piston Pin in Piston (Diameter)	0.0003	0.0014
Piston Pin in Connecting Rod Bushing	0.0008	0.0021
Connecting Rod		
Bearing to Crankpin	0.0008	0.0038
Connecting Rod to Crankshaft (Side Clear)	0.0040	0.0100
Connecting Rod Weight Difference (Opposing Pairs)	-	1 oz.
Connecting Rod Crankpin Bore to Piston Pin Bore Twist	-	.001 in. per in.
Connecting Rod Crankpin Bore to Piston Pin Bore Convergence	-	.001 in. per in.

Continued on Next Page

Table 72-00-11.1 • Dimensional Limits (continued)

Description of Limit	Minimum (in.)	Maximum (in.)
Crankshaft Main Bearings		
Crankshaft in Front Bearing (End Clear)	0.0090	0.0160
Crankshaft in Front Bearing (Diameter)	0.0015	0.0045
Crankshaft in Front Bearing (Diameter)	0.0015	0.0045
Crankshaft Oil Slinger	0.0020	0.0070
Crankshaft Rod Journal Diameter	2.1240	2.1250
Crankshaft Run-Out (to Center Main)	-	0.0050 T.I.R.
Crankshaft Main Bearing Journal Diameter	2.3750	2.3760
Crankshaft Flange O.D. Run-out	-	0.0050 T.I.R.
Crankshaft Flange Pilot Diameter (to Front and Rear Mains)	-	0.0020 T.I.R.
Camshaft Journal		
Camshaft Center Bearing Journal Run-Out	-	0.0010 T.I.R.
Journals in Crankcase	0.0020	0.0040
Rear Journal in Crankcase (End Clearance)	0.0020	0.0090
Valve Tappet in Crankcase	0.0010	0.0033
Rocker Shaft		
Rocker Shaft in Rocker Bearings	0.0007	0.0017
Rocker Shaft in Cylinder Head	0.0001	0.0013
Valves in Guides		
Exhaust Valve in Guide	0.0040	0.0060
Intake Valve in Guide	0.0010	0.0028
Oil Seal in Propeller Governor Adapter	0.0010T	0.0030T
Valve Rocker (Side Clearance)	0.0050	0.0130
Dry Tappet Clearance	0.0280	0.0800
Oil Pump Housing I.D. and Oil Pump Gear O.D.	0.0020	0.0060
Oil Pump Gear Shaft in Accessory Case	0.0015	0.00300
Crankshaft Gear in Crankshaft Pilot	0.0005T	0.0010L
Oil Seal in Accessory Tachometer Housing	0.0010T	0.0030T
Fuel Pump Pushrod in Accessory Case	0.0015	0.0030
Tachometer Drive Shaft in Accessory Case	0.0015	0.0035

Table 72-00-11.2 • Torque Limits

Description of Limit	Torque (in-Lb)
Spark Plug	420
Plug and Fitting (1/2-14 NPT)	160
Plug and Fitting (1/16-27 NPT)	40
Plug and Fitting (1/8-27 NPT)	40
Plug and Fitting (1/4-18 NPT)	85
Plug and Fitting (3/8-18 NPT)	110
Nut ¼" (Nut and Capsrew)	96-108
Slotted Nut ¼" (Nut and Capscrew)	55-60
Nut 5/16" (Nut and Capscrews)	200
Slotted Nut 5/16" (Idler Shaft)	150
Nut ½-20 Cylinder to Crankcase	600
Nut 3/8-24 Cylinder to Crankcase	300
Nut 3/8-24 Crankcase to Crankcase	300
3/8-24 Nut Connecting Rod Bolts	480
Slotted Nut 3/8-24 (Drilled Stud Over Camshaft)	300
5/16 Crankshaft Gear Bolt	204
¼-20 Pushrod Shroud Retaining Nut	50-70
¼-20 Rocker Cover Screws	50
Oil Spray Nozzles (1/16-27 NPT)	100
Oil Gage Tube (1-1/8-27 NPT)	300
Drain Back Tube Nut	35
Drain Back Hose Clamp	10
Intake Hose Clamps	45
Fuel Pump and Prop Governor Hose Nuts	35
Fuel Injector Hose Nuts	30
Fuel and Prop Governor Elbow Locknuts	30
Spin-on Oil Filter	192-216
Fuel Pump Socket Head Bolts (3/8-16)	225-250
Vernatherm Valve	300
Injector and Primer Nozzle	60
Nut and Capscrews (10-24, 10-32)	49
Primer and Injector Tubing Nuts	25
Cylinder Hold Down Studs – 3/8-16	100
Cylinder Hold Down Studs – 1/2-13	250
Other Studs, Minimum Driving Torque	
¼-20	15
5/16-18	25
3/8-16	50

Table 72-00-11.3 • Backlash and End Clearance Limits

Description of Limit	Minimum (in.)	Maximum (in.)
Crankshaft Gear to Idler Gear	0.004	0.015
Magneto Drive Gears to Idler Gears	0.004	0.015
Camshaft Gear to Idler Gear	0.004	0.015
Vacuum Pump Gear to Camshaft Gear	0.004	0.015
Oil Pump Gears	0.010	0.030
Propeller Governor Gear to Idler Gear	0.004	0.015
Idler Gears (End Clear)	0.005	0.040
Propeller Governor Gear (End Clear)	0.002	0.024
Vacuum Pump Gear (End Clear)	0.010	0.057

Table 72-00-11.4 • Valve Spring Dimensional Limits

Description of Limit	Wire Dia. (in.)	Compressed Height (in.)	Compression Force (Lb)	
			Min	Max
Spring Valve, Inner	0.135	1.17	59	67
Spring Valve, Outer	0.177	1.30	111	122

Table 72-00-11.5 • Crush Type Gasket Tightening Angles

Description of Limit	Angle (approx.)
Oil Suction Screen Gasket	135º
Pressure Relief Valve Gasket	90º
Oil Cooler Bypass Plug Gasket	135º

NOTE: Install Crush Gasket with seam toward aluminum case. Tighten thread until cap or valve body contacts gasket. Turn additional angle shown above. Lock wire in place.

PRESERVATION AND STORAGE

General

There is no practical procedure that will ensure corrosion prevention on installed aircraft engines. Geographical locations, season and usage all influence the degree of corrosion. 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. Primary wear concerns are cylinders, piston rings, camshaft and lifters.

WARNING: HOT OIL MAY CAUSE BURNS TO EYES AND SKIN. PUT ON SPLASH GOGGLES AND 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.

WARNING: ENGINE OIL IS HAZARDOUS AND MAY CAUSE INJURY TO SKIN AND EYES. PUT ON PERSONNEL PROTECTIVE GEAR.

Table 72-00-12.1 • Storage Materials

NOMENCLATURE	VENDOR
Preservative Oil MIL-C-6529 Type II, or equivalent	Commercially Available
Preservative Oil MIL-L-46002, Grade 1, or equivalent	Commercially Available
Cortec VpCI-326 Preservative Oil Concentrate, or equivalent	Cortec Corp. 4119 White Bear Pkwy St. Paul, MN 55510 612-429-1100
Preservative Oil Mil-C-16173 Grade 2, or equivalent	Commercially Available
Dehydrator plugs, AN4062-1 or MS27215-2	Commercially Available
Covers, as required	Commercially Available
Moisture Resistant Caps	Commercially Available
Moisture Resistant Tape	Commercially Available

The following instructions are general and apply to both temporary and indefinite storage.

- If engine contains engine oil, 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 preservative oil or equivalent, or a mixture of 1 part Cortec VpCI-326 to 10 parts regular single grade engine oil. This oil is not to be used as a lubricant.
- On aircraft: Perform a ground run-up. Perform a pre-flight inspection and correct any discrepancies. Fly the aircraft for approximately one hour or until 180°F oil temperature is reached. Do not exceed 400°F cylinder head temperature.
- On test cell: Perform run-up to warm engine to a minimum of 180°F oil temperature. Do not exceed 400°F cylinder head temperature. Run at these conditions for a minimum of 15 minutes

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

- **DISCONNECT ALL SPARK PLUG LEADS.**
- **VERIFY MAGNETO SWITCHES ARE CONNECTED TO MAGNETOS AND THAT THEY ARE IN THE "OFF" POSITION AND THE "P" LEADS ARE GROUNDED.**
- **THROTTLE POSITION "CLOSED."**
- **MIXTURE CONTROL "IDLE-CUT OFF."**
- **SET BRAKES AND BLOCK AIRCRAFT WHEELS. ENSURE THAT AIRCRAFT TIE DOWNS ARE INSTALLED AND VERIFY THAT THE CABIN DOOR LATCH IS OPEN.**
- **DO NOT STAND WITHIN THE ARC OF THE PROPELLER BLADES WHILE TURNING THE PROPELLER**

- After operation, verify all spark plug leads are removed and remove the top spark plugs. Protect the ignition lead ends with AN-4060 protectors or equivalent. Using a common garden sprayer or equivalent, spray approximately 2-3 ounces of atomized preservative oil MIL-P-46002 Grade I, or Cortec VpCI-326, 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.

- Remove carburetor or fuel injection servo, drain all fuel from system and lines and cap lines. Insert desiccant bag in intake port. Attach a red "Remove Before Flight" streamer to each bag of desiccant and seal the openings.

- Preserve carburetor or fuel injection servo IAW manufacturer's storage instructions.

Follow the appropriate section below for temporary or indefinite preservation and storage.

Temporary Storage

After following the above steps, and while the engine is still warm, prepare the engine for short-term (90 days or less) storage or shipment in the following manner.

- 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.
- Install dehydrator plugs in top spark plug holes. Make sure each plug is blue in color when installed. Install caps in bottom spark plug holes
- Seal all engine openings exposed to the atmosphere using suitable plugs and covers.
- On aircraft, tag each propeller or, if propeller is not installed, on the propeller flange, with the following notation on the tag, : "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.

Indefinite Storage
After following the step in the general section above, and while the engine is still warm, prepare the engine for long-term storage in the following manner.

- Do not 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.
- Install dehydrator plugs in top spark plug holes. Make sure each plug is blue in color when installed. Install caps in bottom spark plug holes
- Install desiccant bags in exhaust ports. Attach a red "Remove Before Flight" streamer to each bag of desiccant in the exhaust ports and seal the openings.
- Seal all engine openings exposed to the atmosphere using suitable plugs and covers.
- Preserve crankshaft propeller flange with Mil-C-16173 Grade 2, or equivalent, preservative oil.
- On aircraft, tag each propeller or, if propeller is not installed, on the propeller flange, with the following notation on the tag, : "Do Not Turn Propeller – Engine Preserved – (Preservation Date)"
- 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.
- The cylinder bores of all engines prepared for indefinite storage must be re-sprayed with corrosion preventive oil mixture every 90 days.

Returning an Engine to Service After Storage
- Remove all seals and all desiccant bags.
- Remove cylinder dehydrators and plugs from upper and lower spark plug holes.

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

- **DO NOT STAND WITHIN THE ARC OF THE PROPELLER BLADES WHILE TURNING THE PROPELLER.**
- **VERIFY ALL SPARK PLUG LEADS ARE DISCONNECTED.**
- **VERIFY MAGNETO SWITCHES ARE CONNECTED TO MAGNETOS AND THAT THEY ARE IN THE "OFF" POSITION AND "P" LEADS ARE GROUNDED.**
- **THROTTLE POSITION "CLOSED."**
- **MIXTURE CONTROL "IDLE-CUT OFF."**
- **SET BRAKES AND BLOCK AIRCRAFT WHEELS. ENSURE THAT AIRCRAFT**
- **TIE DOWNS ARE INSTALLED AND VERIFY THAT THE CABIN DOOR LATCH IS OPEN.**

- Rotate propeller by hand for several revolutions to remove preservative oil.
- Remove oil sump drain plug and drain the corrosion preventive oil 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 maintenance instructions.
- Service and install spark plugs and ignition leads and carburetor or fuel injection servo IAW the manufacturer's instructions.
- Service engine and aircraft in accordance with the manufacturer's instructions.
- Thoroughly clean the aircraft and engine. Perform visual inspection.
- Correct any discrepancies.
- Conduct a normal engine start.
- Perform a test flight in accordance with "Operation Instructions" of the Installation and Operation Manual.
- Correct any discrepancies.
- Perform a test flight in accordance with airframe manufacturer's instructions.
- Correct any discrepancies prior to returning aircraft to service.
- Change oil and filter after 25 hours of operation.

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REPAIR

General

The following sections contain major repair procedures required to return the Superior Vantage O-360 AND IO-360 series engine to serviceable condition. Replace all parts that do not meet requirements after repair. A list of repairs is provided in Table 72-00-13.1.

- Materials required for repair are listed in Table 72-00-13.2.
- Equipment used for repair is listed in Table 72-00-13.3.
- Codes used for repair are listed in Table 72-00-13.4
- Symbols used for repair are listed in Table 72-00-13.5

Repair Procedures

Perform repair procedures as listed in Table 72-00-13.1 when components do not meet requirements specified in the Inspection and Check section of this manual.

Table 72-00-13.1 • List of Repairs

Repair Procedure	Title	Description
72-00-15.1	Threaded area repair and stud replacement	Repairs threaded areas and replaces studs and threaded inserts.
72-00-15.2	Nick and scratch repair	Blends nicks, scratches in mounting/mating flanges and other flat surfaces.
72-00-15.3	Crankshaft or crankpin repair	Repairs crankshaft or crankpin bearing journals.
72-00-15.4	Crankshaft counterbored gear mounting surface	Repairs the gear mounting surface.
72-00-15.5	Painted parts	Paints parts stripped during degreasing or inspection procedures.
72-00-15.6	Crankshaft oil seal surface	Reconditions the oil seal area at the prop flange surface.
72-00-15.7	Crankshaft flange	Allows grinding of the flange area to reduce distortion.
72-00-15.8	Crankshaft forward counterbore	Polishes and re-plates pilot diameter of crankshaft forward end.
72-00-15.9	Cylinder interior surface	Hones glazed interior surfaces of hardened cylinders.
72-00-15.10	Cylinder head cooling fins	Repairs nicks, chips, cracks
72-00-15.11	Valve, valve seat, and valve guide	Reseats, polishes, re-faces valves and adjoining parts.
72-00-15.12	Spark plug threaded insert	Replaces the spark plug threaded insert.
72-00-15.13	Rocker bushing replacement	Replaces the bushing in intake and exhaust rockers.
72-00-15.14	Connecting Rod bushing replacement	Replaces the bushing in small end of the connecting rod.

Table 72-00-13.2 • List of Materials

Material	Source
Dress wheel (polishing)	Commercially Available
Thread lubricant	Commercially Available
Locktite™	Commercially Available
Abrasive (crocus) cloth	Commercially Available
Zinc chromate primer (AMS 3110 or equivalent per MIL-P-8585)	Commercially Available
Sodium dichromate	Commercially Available
Enamel paint (AMS 3125C or equivalent per MIL-E-7729)	Commercially Available
Toluene (AMS 3180 or equivalent per TT-T-548)	Commercially Available
Alodine (Mil-C-5541 Class 1A or equivalent)	Commercially Available

Table 72-00-13.3 • List of Equipment	
Material	**Source**
Stud extractor	Commercially Available
Lathe	Commercially Available
Collet grip tool	Commercially Available
Spray gun (paint)	Commercially Available
Carborundum wheel (GA54-J5-V10 or equivalent)	Commercially Available
Hand file	Commercially Available
Reamer set	Commercially Available
Bushing puller kit	Commercially Available
Tap & die set	Commercially Available
Extraction tool for threaded inserts	Commercially Available
Insertion tool for threaded inserts	Commercially Available

Table 72-00-13.4 • List of Repair Codes	
Material	**Source**
M03MP	Main and crankpin journals 0.003 inch undersize
M03M	Main bearing journals 0.003 inch undersize
M03P	Crankpin bearing journals 0.003 inch undersize

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REPAIR NO. 1
THREADED AREA REPAIR AND STUD REPLACEMENT

Repair and Replacement

(1) Repair defective threaded areas on studs with a suitable die or tap. Small nicks can be removed satisfactorily with files or small, edged stones.

(2) Replace defective studs with a collet grip tool, or other appropriate tool.

(a) If stud is broken and tool cannot be used, drill a hole into the stud to use a pilot bushing. A stud extractor may then be utilized to remove the stud.

(b) After defective stud is removed, check hole threads for damage. Repair or reject as required. Also check thread size to determine replacement stud thread size.

(c) Use compressed air to clean out shavings prior to installation of new stud.

WARNING: WHEN YOU USE COMPRESSED AIR TO CLEAN OR DRY PARTS, MAKE SURE THAT THE PRESSURE IS NOT MORE THAN 30 PSI. DO NOT DIRECT THE AIRSTREAM AT PERSONNEL OR LIGHT OBJECTS. PUT ON GOGGLES OR A FACE SHIELD TO PROTECT YOUR EYES. IF YOU GET AN EYE INJURY, GET MEDICAL ATTENTION.

WARNING: LUBRICANTS ARE TOXIC AND FLAMMABLE. DO NOT BREATHE VAPORS. BEFORE YOU USE, READ THE MATERIAL SAFETY DATA SHEET (MSDS) FROM THE MANUFACTURER OR SUPPLIER. USE IN A WELL VENTILATED AREA FREE FROM SPARKS. WEAR 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.

(d) Coat threads of new stud with lubricant or Loctite™ and drive stud to correct depth with suitable stud driver. Torque IAW Fits and Clearances section of this manual.

Preservation

Coat threads of repaired threaded areas or studs with lubricant or preservative oil.

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REPAIR NO. 2
NICK AND SCRATCH REPAIR

Repairs

(1) Using hand file or abrasive (crocus) cloth, remove minor nicks and scratches on mating surfaces of accessory housing, crankcase and accessory assemblies, and mounting flanges or bodies of other components.

(2) If necessary, lap mating surfaces on a surface plate to remove abnormal damage.

(3) Clean to remove all abrasive dust and other debris. If lapping was performed, check the part with its mate to assure that the clearances are still within tolerances. Refer to Fits and Clearances section of this manual for limits.

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REPAIR NO. 3
CRANKSHAFT OR CRANKPIN REPAIR

Repairs

Measure crankshaft main and crankpin journals.

(1) Determine if the components in question are standard or undersize bearing journals. Determine this information prior to beginning any polishing or grinding operation.

(2) Measure the OD of the crankshaft main and rod bearing journals and compare results to the limits shown in the Fits and Clearances section of this manual. If dimensions do not fall within specified limits, the shaft must be brought to undersize.

(3) Check the crankshaft flange for a code symbol stamped as a suffix to the part number. Possible code symbols are: M03MP (main and crankpin journals 0.003 in. undersize); M03M (main bearing journals 0.003 in. undersize); M03P (crankpin bearing journals 0.003 in. undersize).

If the maximum service limits are exceeded, standard shafts may be polished to 0.003 in. undersize and fitted with 0.003 in. undersize bearing inserts.

CAUTION: DO NOT ALLOW LATHE SPEED TO EXCEED 150 RPM DURING ANY POLISHING OPERATION.

Polish crankshaft or crankpin journals as needed to reestablish proper fits and clearances. Refer to Fits and Clearances section of this manual for size limits.

WARNING: DO NOT DAMAGE THE NITRIDED SURFACES OF THE CRANKSHAFT.

WARNING: IF ONE SURFACE IS POLISHED TO UNDERSIZE, ALL CORRESPONDING SURFACES MUST BE POLISHED TO THE SAME SIZE.

WARNING: USE THE CORRECT PERSONAL PROTECTION. POLISHING WILL CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.

NOTE: Main bearing surfaces may be polished without affecting crankpin surfaces and likewise, the crankpin bearing surfaces may be polished without affecting the main bearing surfaces.

Inspection After Resurface Procedure

(1) Upon completion of the polishing procedure, thoroughly clean the part. Buff the surface to a high finish.

(2) After polishing operation, clean the part and perform a complete magnetic particle inspection of the shaft or pin. If any cracks or checks are found, the part must be rejected.

(3) Coat the clean surfaces of approved parts with preservative oil and store until ready for reassembly.

WARNING: USE CORRECT PERSONAL PROTECTION. SOME CHEMICAL SOLUTIONS CAN CAUSE SKIN, EYE AND LUNG DAMAGE. FOLLOW THE MANUFACTURER'S INSTRUCTIONS FOR EACH CLEANING SOLUTION.

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REPAIR NO. 4
PAINTED PARTS

Painted Parts Repair

Some parts may have had paint removed from either normal operation or during the cleaning and inspection procedures. The new crankcase and other aluminum cast components have been alodined after machining and prior to any hardware installation per MIL-C-5541, Class 1A.

Parts requiring the use of paint for protection should be painted in accordance with the following recommendations using material from the list of approved materials. See Table 72-00-15.6.

All paint used in these procedures should be sprayed on. If it is necessary to brush the paint on, extreme care must be exercised to prevent excessive accumulation of paint in small corners or void areas of the crankcase.

NOTE: All machined bosses should be masked before painting. Do not paint areas under hold-down nuts or bolt heads where torque is required.

Table 72-00-15.6 • Consumable Materials for Paint Procedures

Material	Source
Resin-type enamel, AMS 3125C or equivalent MIL-E-7729 (such as Randolph Black #303)	Commercially Available
Toluene or equivalent AMS3180 (or equivalent Federal Spec. TT-T-548)	Commercially Available
Zinc chromate primer	Commercially Available

A. Aluminum and steel parts

(1) Clean and degrease all parts prior to paint procedures.

WARNING: SOLVENT IS TOXIC. USE IN WELL-VENTILATED AREA. PREVENT EYE AND SKIN CONTACT AND DO NOT BREATHE VAPORS. 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.

(2) Apply one coat zinc chromate primer, thinned with approximately 2 parts toluene, and allow to air dry.

NOTE: Parts from which the paint has not been removed may be repainted without the primer coat.

(3) Apply one coat of enamel and bake at 250°F for ½ hour. If allowed to air dry, an inferior finish will result.

WARNING: USE THE CORRECT PERSONAL PROTECTION. HEATED PARTS WILL CAUSE BURNS.

B. Cylinder Barrels

(1) Thoroughly clean all old paint from the cylinder. A vapor degreaser is well suited for this purpose.

(2) Superior Air Parts does not recommend painting of cylinder heads for optimum cooling. Only alodine is required for cylinder head surface protection.

(3) Mask off the cylinder head, plug flange bolt holes and cover cylinder bore.

NOTE: Masking materials may include tape, corks, plugs, foil, metal covers, etc.

(4) Spray a very light coat of zinc chromate primer (0.0005 in. maximum thickness) on the cylinder flange. A correct thickness of paint will appear green with a yellow tint and allow the metal to show

through. Paint that is too thick will appear zinc chromate yellow.

CAUTION: THICKNESS OF PRIMER MUST BE NO MORE THAN 0.0005 IN. USE EITHER A TINSLEY THICKNESS GAGE OR A MICROMETER TO MEASURE THE THICKNESS OF THE FLANGE BEFORE AND AFTER PAINTING. IF THE PRIMER IS TOO THICK IT MUST BE REMOVED AND THE BARREL REPAINTED.

(5) Mask off the flange area around nut seating surface. Paint the cylinder with an enamel resin or equivalent that has been properly thinned with toluene or equivalent.
(6) Use a cloth wet with thinner to clean paint from any surfaces where overspray paint may have adhered.
(7) Allow the cylinder to air dry for 15 minutes then bake in an oven until completely dry.

REPAIR NO. 5
CRANKSHAFT OIL SEAL SURFACE

Crankshaft Oil Seal Flange Recondition

(1) If the crankshaft oil seal surface on the shaft itself is damaged to the point that the oil seal might leak, use the following procedure to recondition this area.

WARNING: DO NOT DAMAGE THE NITRIDED SURFACES OF THE CRANKSHAFT.

(2) Use crocus cloth to polish the oil seal area of the shaft while the shaft is rotated counterclockwise (viewed from the front or flange end of the shaft). To prevent the occurrence of spiral marks, do not move the cloth while polishing. The surface roughness of the oil seal area should not exceed 8 microns. Clean the shaft so that all traces of debris are removed.

Preservation

Coat steel parts with preservative oil per MIL-L-6529.

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REPAIR NO. 6
CYLINDER INTERIOR SURFACE

Cylinder Interior Surface Reconditioning
The Superior Vantage O-360 AND IO-360 series engines utilize cylinders constructed of through-hardened steel. These do not include nitride-hardened or chrome plated interior surfaces.

WARNING: USE THE CORRECT PERSONAL PROTECTION. POLISHING AND GRINDING WILL CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.

CAUTION: DO NOT ALLOW THE HONING WHEEL TO RUN PAST THE BARREL MORE THAN 1/8 IN. INTO THE COMBUSTION CHAMBER.

1) Place the cylinder on a honing stand. If the cylinder exceeds allowable service limits in taper, diameter, or out-of-roundness, regrind to 0.010 oversize.
2) Recommended equipment information for honing is as follows:
   (a) Wheel:
      - Friable bond material – 2A; grain size – 54; grade – K; structure – 5 porous; vitrify bond treatment – V92; diameter – 3 ½ to 4 inches.

   (b) Wheel speed:
      - 3 ½ inch wheel: 5600 to 6000 surface feet per minute.
      - 4 inch wheel: 5350 to 5730 surface feet per minute.

   (c) Work speed: 250 RPM.
3) Oversize allowance is determined by adding 0.004 in. to the barrel diameter at the point of greatest wear. This must not exceed 0.002 in. per wall. Grind the barrel to the oversize above this amount.
4) Grind the surface of the steel barrel to 25-35 microinches. This can be obtained by grinding the barrel diameter to within 0.0005 to 0.001 in. of the desired ID with rough-in cuts.
5) Redress the wheel and make a finish pass. Allow the wheel to run over the work up to five more times to ensure a proper surface finish.

NOTE: The surface finish must be properly crosshatched along the entire length of the barrel. The crosshatch pattern must be 35°-37° from a line parallel with the cylinder base. Refer to Figure 72-00-13.3.

6) If oversizing must occur, the cylinder must be fitted with P010 (.010 in.) oversize pistons and piston rings. These must be used in opposing pairs to maintain the dynamic balance of the engine.

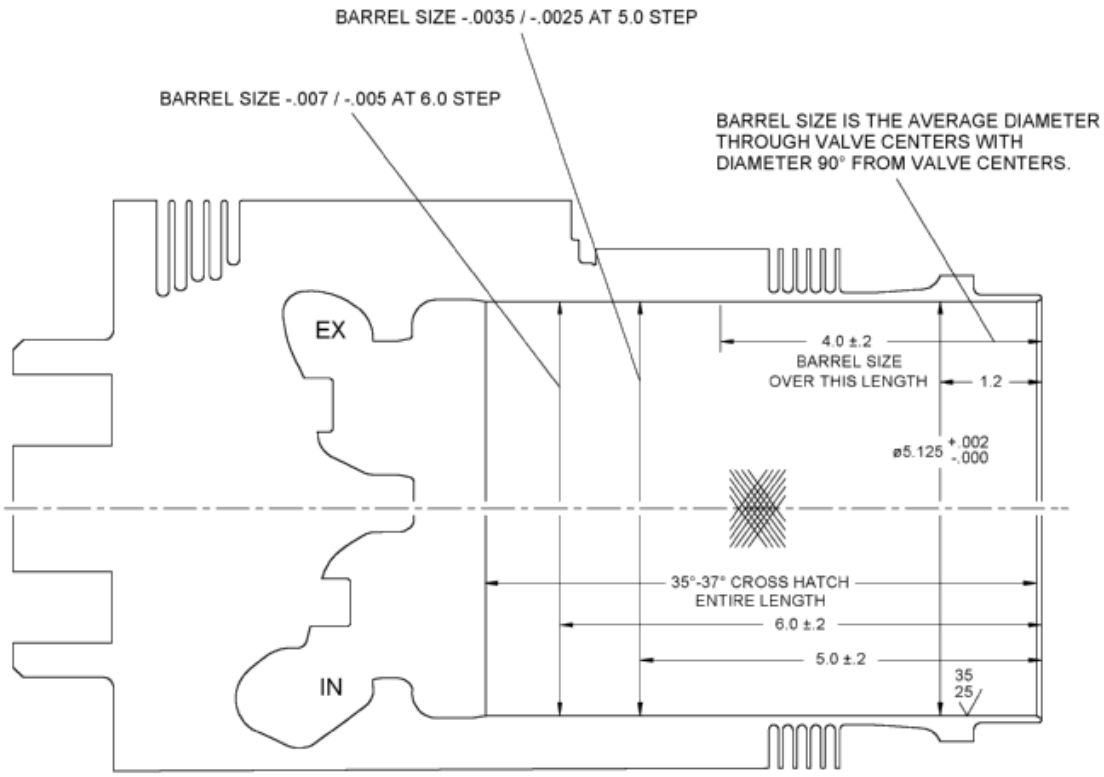


Figure 72-00-13.1 • Cylinder Interior Resurface Crosshatch

REPAIR NO. 7
CYLINDER HEAD COOLING FINS

Cylinder Head Cooling Fin Repair
The Superior Vantage O-360 AND IO-360 series engines utilize cylinders constructed of through-hardened steel and heads of cast aluminum. Only the fins on the aluminum head may be repaired. Cooling fins on the steel barrels may **NOT** be repaired by this process.

The cooling fins on these cylinders are finely balanced to provide appropriate cooling to the overall cylinder assembly.

CAUTION: REFER TO THE INSPECTION AND CHECK SECTION OF THIS MANUAL TO DETERMINE DAMAGE LIMITS FOR COOLING FINS ON ANY CYLINDER PRIOR TO REPAIRS.

Perform repairs as follows:

(1) For cracks in the fin, it is permissible to drill a 0.19 in diameter hole (a stop drill) at the end of the crack provided the crack is at least 0.25 in. from the root of the fin.

(2) For fins cracked almost all the way across, it is permissible to remove a portion of the fin as follows. Refer to Figure 72-00-15.4.
   (a) The maximum material removed is no more than ½ the total fin width.
   (b) No burrs or sharp edges remain.
   (c) The minimum filet at the root of the removed portion of the fin is 0.25 in. radius. Minimum corner at top of fin adjacent to the removed portion is 0.50 in. radius.

(3) For damaged, cracked, or broken fins, it is permissible to perform the following repairs:
   (a) A damaged area may be blended. The blended area for any one fin shall not exceed 0.38 in. square area or 0.38 in. depth.
   (b) There may be no more than two blended areas on one fin.
   (c) No more than four blended areas on the pushrod side of the cylinder head. No more than six blended fins on the side opposite the pushrod side of the cylinder head.

(4) It is recommended that a fluorescent penetrant inspection be performed upon completion of any of these repairs.
   (a) Pay special attention to the area on exhaust port side of the cylinder.
   (b) Pay special attention to the area around the lower spark plug counterbore.

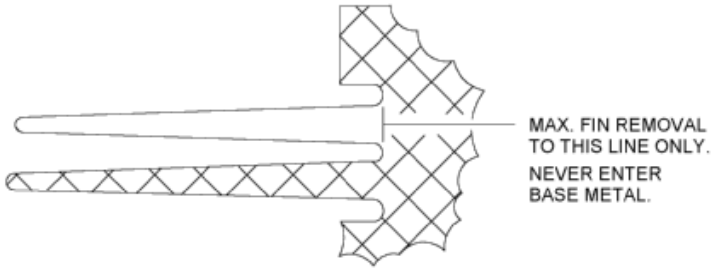


Figure 72-00-13.2 • Cooling Fin Removal Maximum

REPAIR NO. 8
VALVE, VALVE SEAT, AND VALVE GUIDE

General
Valves and valve guides must be replaced at overhaul. The surfaces of the valves and their seats can normally be resurfaced and reconditioned as a repair.

Valves must be removed from the cylinder and cleaned of all sludge and carbon build-up prior to repairs. Refer to the Cleaning section of this manual. Refer to the Inspection and Check section of this manual for appropriate inspection procedures and limits on damage and wear.

Valve seat grinding

(1) The ID of the valve guide is used as a pilot for all valve seat reconditioning operations.

WARNING: USE THE CORRECT PERSONAL PROTECTION. POLISHING AND GRINDING WILL CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.

(2) Grind valve seats with suitable grinding equipment to a 30° angle on intake valve seats and a 45° angle on exhaust valve seats. Grind valve seats to 16 RA max. (ref) concentric to guide bore within 0.002 in.
   (a) On intake valve seats, use a 15° grinding wheel to grind the top surfaces of the valve seat to produce the outer face diameter. Bring the face of the intake valve seats to the specified width (Dimension "B") by narrowing the throat with a 75° wheel. Refer to Figure 72-00-13.5.
   (b) On exhaust valve seats, use a 15° grinding wheel to grind the top surface of the valve seats to produce the outer face diameter. The width of the exhaust valve seats should conform to dimension "D". Refer to Figure 72-00-13.5.
   (c) If the seat wear has progressed to the extent that the entire face of the 15° narrowing wheel must be brought into contact with the seat in order to achieve the specified diameter, the seat must be replaced.

Valve seat replacement

(3) Valve seats that are damaged, worn, or loose must be replaced. Use the following procedure or an equivalent.

NOTE: The valve guide must be replaced at the same time as a valve seat is replaced. This ensures concentric grinding of the valve seat. See discussions later in this Repair for guide replacement procedures.

NOTE: For the purpose of removing valve seats, a tool may be fabricated from threaded bar stock, hardware and sponge material.

NOTE: The valve seats are an interference fit installation. The cylinder must be heated and the valve seat cooled. The resulting difference in size will allow the seat to be removed from the cylinder head.

WARNING: USE THE CORRECT PERSONAL PROTECTION. HEATED PARTS WILL CAUSE BURNS.

(4) Heat the cylinder to 575°F and secure to a fixture.
(5) Soak the removal tool sponge in cold (refrigerated) water. Insert the tool through the valve seat. The seat should shrink slightly and stick to the sponge. Pull the tool back out with the seat. Use care to not tilt the seat during this process.

NOTE: This procedure must be performed as quickly as possible.

(6) Measure the ID of the valve seat recess to determine which oversize seat must be installed. Refer to Tables 72-00-13.7 and 72-00-13.8.

WARNING: USE THE CORRECT PERSONAL PROTECTION. POLISHING AND GRINDING WILL CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.

(7) Use an appropriately sized cutter installed with its pilot and drive on a drill press. Cut the recess in the cylinder head to proper oversize. Remove no more metal than required to clean the major diameter of the seat recess.

NOTE: The cutter pilot shall engage the ID of the valve guide hole in the cylinder head.

(8) Place the new valve seat onto a replacement drift.

WARNING: USE THE CORRECT PERSONAL PROTECTION. HEATED PARTS WILL CAUSE BURNS.

(9) Heat the cylinder to 575°F and secure to a fixture. Place the new seat on a replacement drift. Drive the new seat into the recess by tapping the drift with a hammer.

(10) Grind the face of the new seat as described above in this Section.

Table 72-00-13.7 • Exhaust Valve Seat Standard and Oversize Dimensions

Exhaust Valve Seat Part Number	Standard and Oversize (In)	"A" Diameter (In)
SL72058A	STD	1.7387-1.7402
SL72058A P05	+0.005	1.7437-1.7452
SL72058A P10	+0.010	1.7487-1.7502
SL72058A P20	+0.020	1.7587-1.7602
SL72058A P30	+0.030	1.7687-1.7702

Table 72-00-13.8 • Intake Valve Seat Standard and Oversize Dimensions

Intake Valve Seat Part Number	Standard and Oversize (In)	"A" Diameter (In)
SL72057A	STD	2.0807-2.0822
SL72057A P05	+0.005	2.0857-2.0872
SL72057A P10	+0.010	2.0907-2.0922
SL72057A P20	+0.020	2.1007-2.1022
SL72057A P30	+0.030	2.1107-2.1122

Valve guide replacement

(1) Remove valve guides as follows:
  (a) Use a valve guide puller to the head of a ¾-16 bolt. Place the tool retainer over the valve guide inside the rocker box. Insert the ¾-16 bolt into the retainer and valve guide. From inside the cylinder, insert the 3/8-24 bolt into the end of the larger ¾ bolt. Tighten the 3/8 bolt until it is against the valve guide. Turn the nut in the rocker box clockwise until the valve guide is out of the cylinder head.

(2) Install valve guides as follows:
  (a) Prior to installation of a new valve guide, measure the guide hole to determine if an oversize guide must be used. Refer to Tables 72-00-13.9 and 72-00-13.10 and Figure 72-00-13.6. Use a hole plug gage and measure each valve guide hole. Determine if a standard size or oversize guide must be used. Refer to Tables 72-00-13.9 and 72-00-13.10.
  (b) Fasten the cylinder in place on a guide replacement tool. Set the tool

to the appropriate angle for the guide being installed.

(c) If an oversize guide must be installed, use an appropriate size reamer in a drill press. Ream the valve guide hole to the specified size. Measure the hole again and confirm proper size.

(d) Heat the cylinder to between 350°F-425°F for a minimum of 1 hour. Position the new guide onto the end of a valve guide installation drift and insert the guide in the hole in the cylinder head.

(e) Drive the guide into the hole with firm hammer blows on the end of the drift.

WARNING: USE THE CORRECT PERSONAL PROTECTION. USE OF A HAMMER CAN CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.

(f) Allow the cylinder to cool. Ream the valve guide with an appropriate ID reamer. Check the finished ID with a hole plug gage.

Table 72-00-13.9 • Exhaust Valve Guide Standard and Oversize Dimensions

Exhaust Valve Guide Part Number	Standard and Oversize (In)	"A" Diameter (In)
SL74230A	STD	0.6638-0.6633
SL74230A P05	+0.005	0.6688-0.6683
SL74230A P10	+0.010	0.6738-0.6733
SL74230A P20	+0.020	0.6838-0.6833
SL74230A P30	-0.030	0.6938-0.6933
SL74230A P40	+0.040	0.7038-0.7033

Table 72-00-13.10 • Intake Valve Guide Standard and Oversize Dimensions

Intake Valve Guide Part Number	Standard and Oversize (In)	"A" Diameter (In)
SL61681A	STD	0.5932-0.5940
SL61681A P05	+0.005	0.5982-0.5990
SL61681A P10	+0.010	0.6032-0.6040
SL61681A P20	+0.020	0.6132-0.6140
SL61681A P30	-0.030	0.6232-0.6240
SL61681A P40	+0.040	0.6332-0.6340

Intake valve face grinding

CAUTION: DO NOT ATTEMPT TO BEND OR STRAIGHTEN THE VALVE FACE OR STEM.

NOTE: Intake valves require replacement at overhaul.

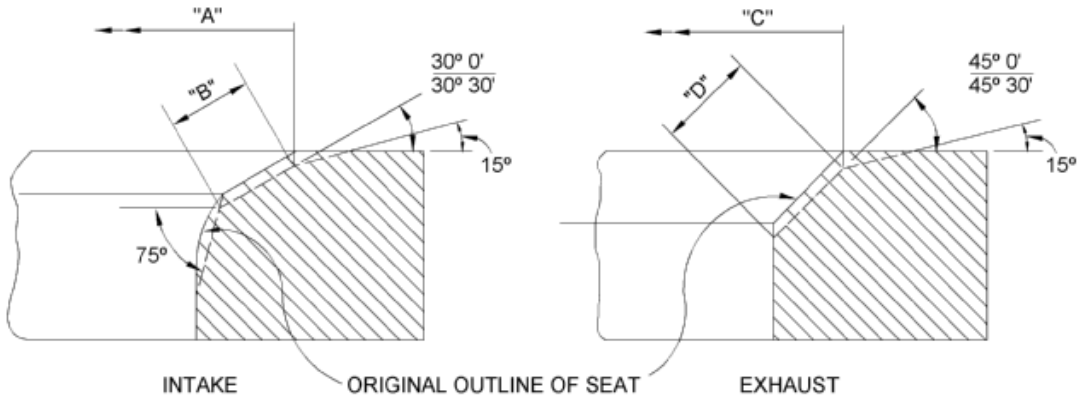
NOTE: Refer to Figure 72-00-13.7.

1) Intake valve faces that have minor pitting or warping may be refaced by grinding.

WARNING: USE THE CORRECT PERSONAL PROTECTION. POLISHING AND GRINDING WILL CAUSE LOOSE PARTICLES THAT CAN GET IN YOUR EYES.

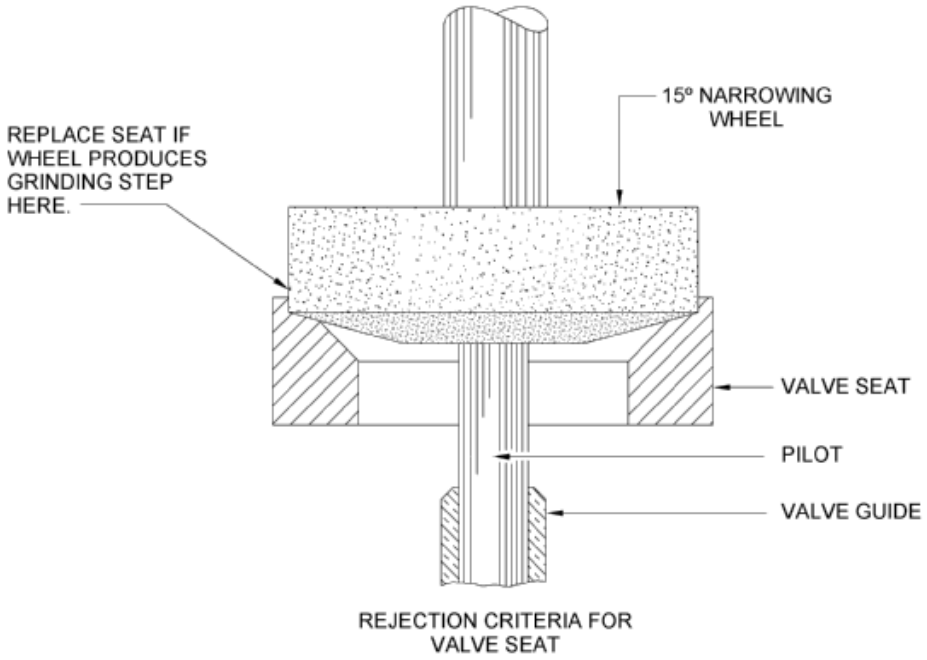
   (a) Set the valve refacing equipment to 30° for intake valves. Use a soft #80 grit wheel to grind only enough of the valve face to remove small pits.
   (b) Round off any burrs or sharp edges with a polishing stone while the valve is still turning in the refacing equipment.

2) After grinding and cleaning, the valve stem may be polished to remove superficial scratches.



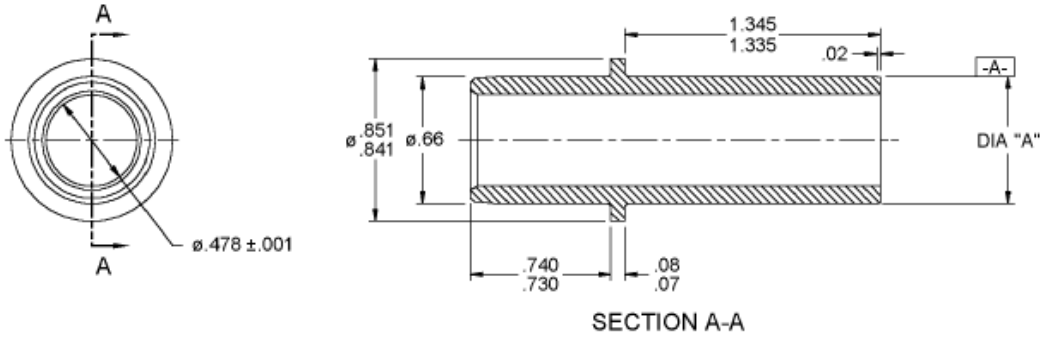
"A" (INTAKE)	"B" (INTAKE)	"C" (EXHAUST)	"D" (EXHAUST)
2.145 / 2.155	.076 / .117	1.740 / 1.750	.058 / .077

VALVE SEAT DIMENSIONS FOR RECONDITIONING

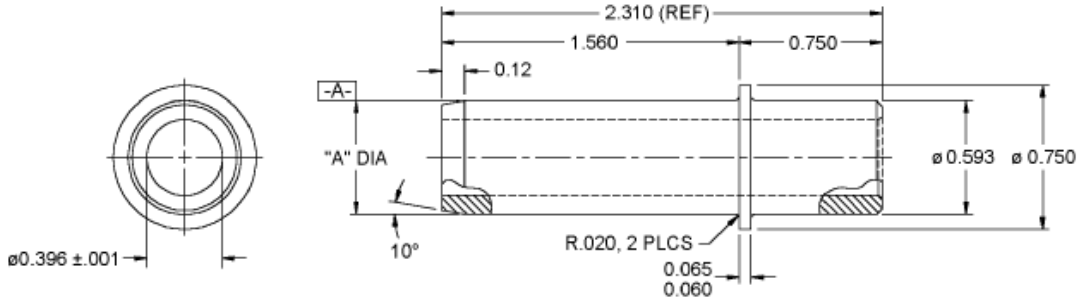


REJECTION CRITERIA FOR VALVE SEAT

Figure 72-00-13.3 • Valve Seat Dimensions



EXHAUST VALVE GUIDE



INTAKE VALVE GUIDE

Figure 72-00-13.4 • Valve Guide Dimensions

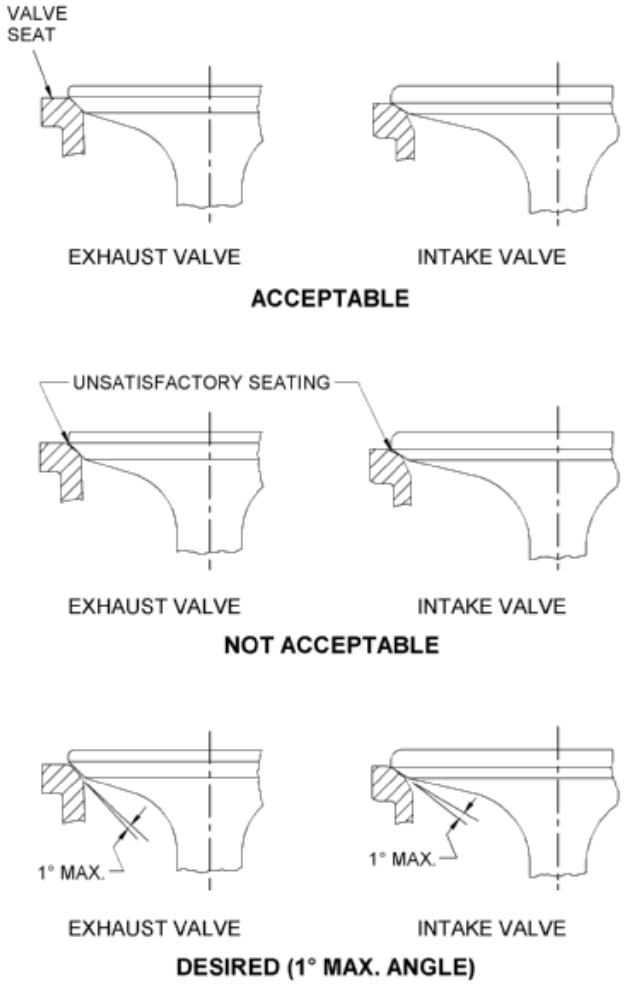


Figure 72-00-13.5 • Valve to Seat Fit Acceptable Criteria

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REPAIR NO. 9
SPARK PLUG THREADED INSERT

Spark Plug Threaded Insert Replacement

Spark plug threaded inserts that were rejected during inspection must be removed and replaced as described in this section. Use an extraction tool to remove the rejected insert as follows:

(1) Insert the tool in the spark plug hole so that the edges of the tool cut into the top thread of the insert.
(2) Rotate the tool counterclockwise to unscrew and remove the threaded insert from the hole.

Inspect the condition of the tapped hole after removal of the insert in accordance with the Inspection and Check section of this manual. Assemble the insertion tool with new insert as follows:

(1) Withdraw the mandrel portion of the tool beyond the recessed section of the sleeve. Place insert into the recess area.
(2) Allow the mandrel to advance to engage its slotted end with the tang of the insert.
(3) Rotate the mandrel clockwise and press slightly. This engages the insert in the threaded end of the sleeve.
(4) Continue to rotate the mandrel while holding the sleeve. This secures the insert firmly on the insertion tool.
(5) Wind the insert through the threaded portion of the tool sleeve to within one-half turn of the end of the coil.
(6) Keep the insert tight on the tool to prevent unwinding and facilitate the installation of the insert. Wind the insert so that the adjacent turns of the insert are in contact with each other. This eliminates the possibility of crossed threads.
(7) Screw the insert into the hole.
    (a) Be sure that the first coil of the insert picks up the first thread of the hole. As the tool is turned, the insert will advance into the hole.
    (b) When the face of the sleeve is approximately 0.13 in. from the face of the boss, the inserting tool should be held tightly by the handle. The sleeve must be rotated counterclockwise which will free the left half turn of the insert.
    (c) Slide the sleeve toward the top of the mandrel and check that the top of the insert projects above the boss.
    (d) Rotate the mandrel until the insert disappears from sight. Stop the turning action and remove the tool.
    (e) The top of the insert should be one half turn from the face of the boss and the tang end should not protrude into the combustion chamber.
(8) Set the insert as follows:
    (a) Break off the tang of the insert at the location of the notch.
    (b) Use an expander tool to secure the insert in the plug hole. Set the limit of expansion by fixing the stop nut on the expanding tool at the correct position.
    (c) Assemble a staking sleeve over the mandrel until the sleeve meets the boss. Stake the insert by striking the top of the sleeve a light blow with a hammer. This will create a slight chamfered edge around the edge of the tapped hole.
    (d) Remove the staking sleeve, release the adjusting screw, and remove the expanding mandrel from the insert.

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REPAIR NO. 10
ROCKER ARM BUSHING REPLACEMENT

Rocker Arm Bushing Replacement

Rocker bushings that were rejected during inspection must be removed and replaced as described in this section.

Use an arbor press and an extraction/insertion tool (piloted shoulder press tool) to remove the rejected bushing as follows:

(1) Support the rocker arm on the base of the arbor press such that the center bore of the rocker arm is directly supported and the bushing can be freely pressed from the rocker arm.

NOTE: Avoid supporting the rocker arm in such a way that bending loads are placed on the rocker arms in order to prevent damage to the rocker arms.

(2) Insert the tool in the rocker arm bushing so that the shoulder of the tool rests on the edge face of the bushing and is clear of the ID of the rocker bore
(3) Press out the rocker arm bushing.
(4) Clean rocker arm bore and oil holes thoroughly as described in the Cleaning section of this manual and inspect the condition of the rocker arm bore. Repair scratches as required per the Cleaning section of this manual.

Assemble a new rocker arm bushing using the arbor press and extraction/insertion tool described above as follows:

(1) Support the rocker arm on the base of the arbor press such that the center bore of the rocker is directly supported.

NOTE: Avoid supporting the rocker arm in such a way that bending loads are placed on the rocker arms in order to prevent damage to the rocker arm.

(2) Rotate to align the bushing so that the lubrication hole is aligned with the oil hole on the pushrod side of the rocker arm bore.
(3) Insert the tool in the rocker arm bushing so that the shoulder of the tool rests on the edge face of the bushing and is clear of the ID of the rocker arm bore
(4) Insert rocker arm bushing until the lubrication hole of the bushing is centered on the oil hole on the pushrod side of the rocker arm bore and the bushing is flush with the sides of the rocker arm.
(5) Ream or hone the bushing ID to size per the Fits and Clearances section of this manual.

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REPAIR NO. 11
CONNECTING ROD BUSHING REPLACEMENT

Connecting Rod Bushing Replacement
Connecting Rod bushings (small end) that were rejected during inspection must be removed and replaced as described in this section.

Use an arbor press and an extraction/insertion tool (piloted shoulder press tool) to remove the rejected bushing as follows:

(1) Support the connecting rod on the base of the arbor press such that the small end bushing bore of the connecting rod is directly supported and the bushing can be freely pressed from the connecting rod.

NOTE: Avoid supporting the connecting rod in such a way that bending loads are placed on the length of the connecting rod in order to prevent damage to the connecting rod.

(2) Insert the tool in the connecting rod small end bushing so that the shoulder of the tool rests on the edge face of the bushing and is clear of the ID of the connecting rod bore
(3) Press out connecting rod bushing.
(4) Clean connecting rod thoroughly as described in the Cleaning section of this manual and inspect the condition of the connecting rod bushing bore. Repair scratches as required per the Cleaning section of this manual.

Assemble a new connecting rod bushing using the arbor press and extraction/insertion tool described above as follows:

(1) Support the connecting rod on the base of the arbor press such that the connecting rod bushing bore is directly supported.

NOTE: Avoid supporting the connecting rod in such a way that bending loads are placed on the length of the connecting rod in order to prevent damage to the connecting rod.

(2) Insert the tool in the bushing so that the shoulder of the tool rests on the edge face of the bushing and is clear of the ID of the connecting rod bore
(3) Insert bushing until the bushing is centered within the bore of the connecting rod and bushing is flush with the sides of the connecting rod.
(4) Broach the bushing ID to size per the Fits and Clearances section of this manual.

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TESTING

General
This section defines the testing that each Superior Vantage O-360 AND IO-360 series engine shall undergo to determine its acceptability after assembly/overhaul. The Fault Isolation/Trouble Shooting section of this manual should be consulted as required. Review all probable causes given. The fault isolation sequence is in order of approximate ease of checking, not necessarily in order of probability.

NOTE: Refer to the Disassembly/Assembly sections of this manual for replacement of defective components.

Special Tools and Equipment
Standard aviation shop tools and equipment are required.

Engine Installation and Testing Procedures
Refer to appropriate Test Cell Installation Procedures. For Testing Procedures, refer to Superior Air Parts Engine Break-in Procedure, 72-00-04.

WARNING: 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.

WARNING: USE THE CORRECT PERSONAL PROTECTION EQUIPMENT TO AVOID INJURY. ENSURE AREA IS FREE OF MOVABLE OBJECTS THAT COULD IMPACT BY PROPELLER AIR BLAST.

Engine Storage After Testing
Refer to the Assembly Section of this manual for storage instructions.

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APPENDIX A
ASSEMBLY IN-PROCESS QUALITY INSPECTIONS

Inspection 1

A. Inspect and verify correctness of all parts and procedures prior to further assembly of crankcase halves to the crankshaft assembly.
B. This quality inspection shall include visual inspection of parts and written records (paperwork) in accordance with the assembly guidelines in this Overhaul Manual.
C. This inspection shall be accomplished during the engine assembly process as noted in the Assembly section of this manual.
D. Perform the inspections as follows:
   (3) Verify the case serial numbers match each case half.
   (4) Verify correct crankshaft part number.
   (5) Verify correct camshaft part number.
   (6) Verify the correct main bearing part number and ensure proper fit.
   (7) Verify that all pipe plugs and fittings are properly installed in the case halves.
   (8) Check the tappet body fit in lifter bore and ensure that all tappet bodies are installed.
   (9) Rotate the camshaft in each case half to verify smooth fit.
   (10) Verify that all mating surfaces are clean and absent of burrs and/or scoring.
   (11) Verify thrust bearing and slinger clearance of crankshaft. Verify the end clearance of camshaft. See Fits and Clearances section of this manual.
   (12) Inspect fit of connecting rods to crankshaft.
      (a) Verify the correct rod installation with rod serial numbers in the same plane and oriented toward oil sump.
      (b) Verify the correct rod nut assembly with the lip out.
      (c) Rotate or spin each rod on the crankshaft to verify smooth rotation.
      (d) Verify proper side clearance of each rod in accordance with the Fits and Clearances section of this manual.
      (e) Check the torque on each rod nut in accordance with the Fits and Clearances section of this manual.
   (13) Verify that nose bolts are installed with o-rings in the right case half.
   (14) Verify the presence of o-rings on rear through bolts in right case half.
   (15) Verify the crankshaft gear installation.
      (a) Ensure the gear is properly seated in the crankshaft recess in accordance with the Fits and Clearances section of this manual. Verify security of the lock tab.
   (16) Verify the nose seal installation.
      (a) Verify that the seal is installed with the flat side toward crankshaft prop flange.
      (b) Verify that the seal spring is correctly installed in the seal groove or lip.
   (17) Verify that the front main bearing on the crankshaft has the correct part number and check its alignment marks.

Inspection 2

A. Inspect and verify the correct installation of cylinders and assembly hardware, including proper torque and safety techniques. Verify the internal timing of the crankshaft gear, camshaft gear, and idler gear as well as proper clearances and gear lash.
B. This quality inspection shall include visual and physical inspection of parts and assemblies in accordance with the assembly guidelines in this Overhaul Manual.
C. This inspection shall be accomplished during the engine assembly process as noted in the Assembly section of this manual.
D. Perform the inspections as follows:

(1) Check the torque of cylinders and assembly hardware.
  (a) Check the torque on the cylinder base nuts in accordance with the Fits and Clearances section of this manual
  (b) Check the torque on all crankcase assembly hardware in accordance with the Fits and Clearances section of this manual.
(2) Verify correct safety techniques.
  (a) Verify the safety of the slotted nut and drilled stud at accessory location, under the camshaft gear.
  (b) Verify the safety of the drilled belly bolts/nuts at sump location.
  (c) Verify the safety of the idler shaft hardware.

NOTE: Ensure clearance between the idler shaft stud and idler gear.

(3) Verify that the timing marks align correctly between the crankshaft gear, camshaft gear, and idler gear with #1 cylinder on TDC (top dead center).
(4) Verify the gear lash of the idler gears with the crankshaft gear and camshaft gear. Refer to Fits and Clearances, Gear Backlash Table 72-00-12.3.
(5) Verify installation of the tachometer shaft, bushing and snap ring in the camshaft.

Inspection 3

A. Inspect and verify proper installation, safety, and clearances of the cylinder valve train and accessory housing subassembly prior to rocker cover and accessory housing installation.
B. This quality inspection shall include visual inspection of assembly and safety techniques. A physical check of clearances shall be performed as described in this list.
C. This inspection shall be accomplished during the engine assembly process as noted in the Assembly section of this manual.
D. Perform the inspections as follows:
  (1) Perform a valve train inspection as follows:
    (a) Inspect the pushrod tube seals for proper installation.
    (b) Verify security and installation of the nut and lock tab securing the spring clip to each pushrod tube.
    (c) Verify installation of the exhaust valve rotator cap on the valve stem of each exhaust valve.
    (d) Verify the dry tappet clearance for each rocker arm in accordance with the Fits and Clearances section of this manual.
    (e) Verify installation of the rocker shaft caps (thrust buttons) in each rocker shaft.
  (2) Perform inspection of the accessory housing as follows:
    (a) Visually inspect the housing for damage and general condition.
    (b) Verify proper installation of the plugs and fittings.
    (c) Verify proper installation of the tachometer shaft seal.
    (d) Verify safety of the oil pump housing.
    (e) Ensure smooth rotation of the oil pump drive shaft.
    (f) Verify correct installation of the fuel pump plunger as required.

Inspection 4

A. Inspect and verify proper installation of the accessory housing, rocker covers, inner cylinder baffles, sump, cylinder drain tubes, induction/intake system, accessory adapters, and accessories.
B. This quality inspection shall include visual and physical inspections of the complete engine assembly.
C. This inspection shall be accomplished after the engine assembly has been completed and prior to engine test.
D. Perform the inspections as follows:
  (1) Perform complete visual and physical inspections of the engine as follows:

(a) Inspect for loose or missing parts or components.
(b) Verify security of the accessory housing and accessory adapters to housing.
(c) Verify security of the accessories including magnetos, carburetor or fuel injector servo, starter, and alternator.
(d) Verify security of the cylinder drain tubes.
(e) Verify security of the rocker covers.
(f) Verify security of the sump.
(g) Verify security and installation of the inner cylinder baffles.
(h) Verify security of the intake elbows. Ensure that the flange of intake elbow fits completely in the recess of the aluminum flange at the cylinder port.
(i) Verify installation and safety of the oil pressure relief valve.
(j) Verify installation and safety of the oil level gage housing and the oil level gage.
(k) Verify safety of the fuel pump attachment hardware.
(l) Verify correct installation of the magneto harnesses.
(m) Check security and routing of the primer lines or fuel injection lines and fuel hoses as applicable.

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