ARROW™
ENGINE COMPANY

A-32 A-42 A-62

PARTS, OPERATION, & MAINTENANCE

AEPBVR260380 FEB17

A Tradition of Excellence Since 1955

ARROW ENGINE COMPANY™

Arrow Engine Company was founded in 1955 as Arrow Specialty Company by Jeff Davis in Tulsa, Oklahoma, beginning a tradition of providing premium service and exceptional products to the oil & gas industry, as well as other industrial markets throughout the world. Arrow is a market-leading provider of natural gas powered engines and parts, as well as gas compressors, gas production equipment, meter runs, engine electronics and chemical pumps. Today, Arrow continues its tradition of focusing on producing the most reliable equipment, parts and extraordinary customer service in the industry.

Arrow is a part of the Engineered Components segment formed by TriMas Corporation. TriMas Corporation is a diversified global designer, manufacturer and distributor of engineered and applied products that serve a variety of industrial, commercial and consumer end markets. TriMas provides its customers with highly-engineered products and services that reflect the company's commitment to market leadership, innovation and operational excellence. TriMas is organized into four reportable segments: Packaging, Aerospace, Energy and Engineered Components. With headquarters in Bloomfield Hills, Michigan, TriMas has approximately 4,000 employees at more than 50 facilities in 16 countries.

THANK YOU FOR SELECTING THE ARROW A-SERIES ENGINE!

MAIL WITHIN 10 DAYS

KEEP FOR YOUR RECORDS

A-SERIES (VR) ENGINE

STANDARD ARROW LIMITED WARRANTY VALIDATION CARD

ARROW ENGINE COMPANY warrants to the purchaser that any new engine manufactured by **ARROW** will be free of defects in both workmanship and materials for twelve (12) months from the date of initial startup or eighteen (18) months from the date of **ARROW** factory shipment, whichever occurs first.

Owner's Name _____

Address _____

City _____ State_____ Zip _____

Serial No _____ Date Purchased _____

Distributor's Name _____

Exact Engine Location _____

OE Model _____

Engine HP & RPM _____ Type of Fuel _____

FOR WARRANTY DETAILS SEE ARROW STANDARD LIMITED WARRANTY.
Send this card to **ARROW** within 10 days after purchase for warranty validation.

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A Tradition of Excellence
Since 1955

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BUSINESS REPLY MAIL
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POSTAGE WILL BE PAID BY ADDRESSEE

ARROW ENGINES

ARROW ENGINE COMPANY
2301 E INDEPENDENCE ST
TULSA OK 74110-9903

A Series Start-Up Report

Mail to: Attn: Warranty Dept.
Arrow Engine Co.
2301 E. Independence
Tulsa, OK 74110-4900
Fax: 918-699-2202

All applicable information must be filled in:

Site Name: _____ Contact Person: _____

Unit Number: _____ Phone No: _____

Contact Person E-mail Address: _____

Site Address: _____ Lease No: _____

City: _____ State: _____ Country: _____

Overhauled: _____
by: _____
_____
Owner: _____
_____
Address: _____

Engine Model: _____
S/N: _____ Spec: _____
Compression Ratio: _____ : 1
Name & Model of Driven Equipment: _____
_____
Application: _____
Duty Cycle:

Organization Performing start-up:
Organization: _____
Address: _____
_____
Date of Startup: _____
Technician Performing Start-Up:

Lube Oil & Filter:

Brand: _____
API: _____
Viscosity: _____
Oil Change Hours: _____

Cooling System Information

Type: _____
Water Hardness: _____
Treatment Used: _____
Maintained by: _____
_____
_____

Fuel Information

Type: _____
_____
BTU Content (LHV): _____
Filtration Type: _____
% of H_2S: _____
µg/l of CL: _____

Hot Alignment

Readings in .001" Increments

_____" _____" (A) _____" _____" _____" (P) _____"
_____" _____"

CRANKSHAFT END PLAY: _____"
Distance from center of shaft to the angular dial indicator: _____"

Valves Adjusted to: INT. _____" EXH. _____"

FUNCTION TEST NO LOAD OPERATION. ENGINE RAN FOR _____ Minutes.

RPM			IGN. TIMING	INT. MFLD.	GAS OVER	Safety Trip Points					Checked Oiling	
IDLE	HI IDLE	GOV	@GOV.RPM BTDC	VAC. AT IDLE	AIR RATIO	HI WATER	LOW OIL	O.S. GOV.	INT. MFLD.	FUEL SHUT OFF	ROCKER ARMS	TURBO
			°	"Hg	H_2O	°F ℃	PSI	RPM	°F ℃	PSI		

FUNCTION TEST LOADED OPERATION. ENGINE RAN FOR _____ Hours

RPM	WATER OUT TEMP	OIL TEMP OIL TEMP	OIL PRESS. OIL PRESS.	C. CASE PRESS.	EXH. BACK PRESS.	LOAD	IGN. TIMING @GOV. RPM BTDC	INT. MFLD VAC/PRESS	EXHAUST TEMP	FUEL PRESS. AT REG. IN	GAS OVER AI RATIO
	°F ℃	°F ℃	PSI	"H_2O	"H_2O	BHP KW	°	"Hg	°F ℃	PSI	H_2O

NOTE ANY OIL OR WATER LEAKS and any discrepancies which should be corrected. Explain any support system such as fuel, cooling, air induction, exhaust, or general insallation features which may be detrimental to engine performance or service life.

REMARKS: _____

DISCUSSED WARRANTY? _____ ADVISED WHERE TO OBTAIN PARTS AND SERVICE? _____

_____
CUSTOMER'S SIGNATURE (Required)
(Indicating Start-Up Performance to His/Her Satisfaction)

_____
SERVICEMAN'S SIGNATURE

_____
CERTIFIED SERVICEMAN'S SIGNATURE

EXPLANATION OF ABBREVIATIONS: "HG (Inches of Mercury), "H_2O (Inches of Water), F°(Degree Fahrenheit), C°(Degree Centigrade), RPM (Engine Crankshaft RPM), PSI (Pounds Per Square Inch Gage), O.S. (Over Speed), A=Angular, P=Parallel

SAFE OPERATING PROCEDURES

Arrow Stationary Engines

DO NOT operate this engine unless you have been instructed & trained in its safe use and operation.

Hard hat & safety glasses must be worn at all times while working on or around equipment.

Long and loose hair must be contained.

Protective footwear must be worn at all times.

Protective clothing must be worn at all times.

Hearing protection must be worn while working on or around equipment.

Rings and jewelry should not be worn while operating equipment.

PRE-OPERATIONAL SAFETY CHECKS

1. The equipment must be used in accordance with manufacturer's instructions.
2. Ensure the area is clean and clear of grease, oil, and objects that may be a slip or trip hazard.
3. Familiarize yourself with and check all engine operations and controls.
4. Check all safety devices are in good working condition.
5. Ensure work area is well ventilated and free from exhaust fumes before operating.
6. Ensure all flammable materials are correctly stored or disposed of before operating.
7. Faulty equipment must not be used. Immediately report suspect equipment.

OPERATIONAL SAFETY CHECKS

1. Engine must not be operated unless the person is qualified to operate the equipment.
2. Ensure work area around engine has been cleared of tools and debris before starting.
3. Be aware that during operation, parts of the engine or equipment are hot or rotating.
4. When performing any preventive maintenance or repairs on the engine or equipment ensure that the battery (if fitted) is disconnected, the fuel supply has been turned off and proper lock out/tag out procedures have been followed.

POTENTIAL HAZARDS

- Hot components
- Entanglement hazards – rotating parts
- Fuel supply – LPG/NG vapors
- Exhaust fumes
- Confined space – trapping, tripping hazards
- Crushing hazards
- Fire
- Shock hazard

Note: This SOP does not necessarily cover all possible hazards associated with the engine operation and should be used in conjunction with other PPE safety procedures.

A-32
A-42
A-62

PARTS, OPERATION, & MAINTENANCE

For A-Series
A-32 A-42 A-62 Engines

A32 A42 A62-POM-C-FEB17

2301 East Independence

Tulsa, Oklahoma 74110

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1 Safety Precautions

1.1 Safety Precautions

The safety precautions written in this manual are published for your information. Arrow Engine Company does not, by the publication of these precautions, imply or in any way represent that these published precautions are the sum of all dangers present near industrial engines. If you are operating industrial engines it is your responsibility to ensure that such operation is in full accordance with all applicable safety requirements and codes. All requirements of the United States Federal Occupational Safety and Health Administration Act must be met when Arrow engines are operated in areas that are under the jurisdiction of that United States department. Engines operated in countries other than the United States of America must be installed operated and serviced in accordance and compliance with any and all safety requirements of that country which may be applicable.

Details on safety rules and regulations in the United States, contact your local Occupational Safety and Health Administration (OSHA.)

1.2 Bodily Protections

Wear OSHA approved bodily sight hearing and respiratory system protections. Never wear loose clothing jewelry or loose, long hair around an engine.

1.3 Exhaust Gases

Engine exhaust products are toxic and may cause injury or death if inhaled. All engine installations must have an exhaust discharge pipe so that exhaust gases are delivered into the outside air. A closed building or shelter must be adequately vented to provide a steady supply of fresh air.

1.4 Engine Fuels

Engine fuels are highly combustible and may ignite or explode. DO NOT SMOKE anywhere near the engine. The natural gas fuel the engine uses is highly explosive and its lubricating oil is very flammable. Fuels must be conducted to the engine with proper piping free from leaks and designed to resist breakage from vibration.

1.5 Positive Fuel Shut Off

Some means of positive fuel shut off should be provided for emergency use. Pressurized fuels natural gas, liquefied petroleum gas etc. Should have another positive shut off valve preferably automatic other than those in carburetor or the gas pressure regulation equipment. It is the final responsibility of the engine owner to ensure that the installation is free from fuel or exhaust leakage and such installation meets all applicable codes.

1.6 Safety Guards

Engines must be provided with guards to protect people or structures from rotating or heated parts. It is the responsibility of the engine owner to specify or provide such protection.

1.7 Ignition Systems

Ignition systems can cause electrical shocks. Avoid contacting ignition units and wiring.

The spark plug will ignite any gas that has accumulated in that cylinder. The crankshaft and driven equipment may rotate possibly causing personal injury or damage to equipment. Gas that has accumulated in the exhaust system may also be ignited.

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1.8 Cooling System Pressure Caps and Connections

Do not remove the pressure caps while the engine is operating or while coolant is hot. The cooling system is under pressure and severe burns could result from the hot coolant spewing out when the cap is removed. Wait until the engine and coolant have cooled down before removing the radiator or surge tank caps. Always replace weak hoses lines and fittings.

1.9 Generator Sets

The voltage produced by a generator sets is dangerous. Severe, possibly fatal, shock may result from contact. Make sure the generator set is grounded before operation. Be extremely careful when the unit or surrounding area is damp or wet.

When servicing any part of the electrical system or making any connections, make sure the main power switch is OFF. Clean or service generator set only when engine is shut down.

In case of an accident from electrical shock shut down the generator set at once. If it cannot be shut down, free the victim from the live conductor. Avoid direct contact with the victim. Use a dry board, dry rope or any nonconducting implement to free the victim. If the victim is unconscious, apply artificial respiration and get medical help.

Do not operate the generator set with the ammeter circuit open. Voltage dangerous to both equipment and personnel can be generated in an open secondary circuit of a current transformer.

If the generator set is stopped by operation of safety devices, do not attempt to operate it until the cause has been eliminated.

When the generator set is shut down after operation, disconnect all line switches to all external power load and parallel circuits.

1.10 Engine and Equipment Repair and Service

Always stop the engine before cleaning servicing or repairing the engine or driven equipment. Place all controls in OFF position to prevent accidental restarting. If possible, lock all controls in the OFF position and take the key. Put a sign on the instrument panel warning that the engine is being serviced. Before restarting, make sure that all tools and other material are removed from the engine and equipment.

Proper service and repair are important to the safe, reliable operation of engines and related equipment. The procedures recommended by Arrow in this manual are effective methods for performing service and repair operations. Some of these procedures require the use of specially designed tools. These special tools should be used when and as recommended. Anyone who uses a service repair or installation procedure not recommended by Arrow Engine Company must first thoroughly insure that their safety will not be jeopardized by the service methods they select.

1.11 Housekeeping

Good housekeeping results in a clean, safe work area. An orderly work area with clean walkways and neatly arranged tools and equipment is a major factor in accident prevention.

Engine Fan Blades

1. Do not operate the engine with a fan which has been bent, mutilated, modified or in any way damaged.
2. Do not operate the engine if the fan contacts or strikes any engine accessory or the radiator shroud or core.
3. Do not rebalance the fan. Contact the fan supplier if rebalancing is required.
4. Ensure that all bolts attaching the fan are securely installed to a torque specified by the engine manufacturer.
5. Install the fan so the word front stamped on the fan faces the radiator.
6. Perform all required maintenance on the subassembly to which the fan is attached, water pump fan drive etc. See operator service manual.
7. Do not modify or substitute any parts of the engine without the approval of Arrow Engine Company. Take special care not to make modifications which will increase the operating speed of the fan.
8. Install the fan only if the engine has been approved for fan installation. Likewise, install a subassembly to which the fan is attached (water pump, fan drive, etc.) only if approved or specified for use on the engine.
9. If the fan or fan drive contains any plastic or rubber component, have the fan and drive inspected by a qualified mechanic after operation at or exposure to excessively high temperatures above 250°F (120°C) air temperature.
10. Replace the fan if indications of excessive corrosion or erosion appear in the fan.
11. For reversible or adjustable pitch fans, make sure the blades are correctly locked in the proper position prior to operation. Also inspect the fan prior to operation to ensure that ice and dirt have not accumulated on the fan to cause potential unbalance of the fan.
12. Be sure all fans, fan drives and belts are properly shielded.

1.12 Engine Storage Chemicals

Preservative oil contains a petroleum distillate which is harmful or fatal if swallowed. Avoid contact with skin. Vapor is harmful and causes irritation of eyes, nose, throat and skin. Use only with adequate ventilation. Avoid prolonged or repeated breathing of vapor. Avoid contact with eyes and clothing. Do not take internally. Keep container closed and away from heat. Always read and observe the CAUTION labels on the containers. Do not destroy the labels on the containers. Generally, heating of preservative compounds is confined to 200°F (93°C) or less. These temperatures are easily reached by placing the preservative container in heated water. If this is done, the container must be vented or opened to reduce the danger of explosion. Direct heating presents a dangerous and unnecessary fire hazard.

1.13 Fire Protection

Locate fire extinguishers so that they are easily accessible if a fire starts. Carefully maintain records of extinguisher inspection and recharging to ensure the fire extinguishing capabilities when required. Consult your fire extinguisher supplier or insurance engineer for recommendations on the type, size and quantity of fire extinguishers required. Select and post alternate routes of escape from any engine installation. Design installation to meet all applicable fire codes.

Use approved cleaning solvents in a well ventilated area. Avoid breathing fumes - some vapors

can be fatal. Keep away from open flames or sparks. Do not use gasoline, paint thinners or other highly volatile fluids for cleaning. Always read and observe the CAUTION labels on containers. Do not destroy the labels on he containers. Cleaning solvents can cause various types of skin irritations.

1.14 Welding Equipment

Disconnect battery and use proper grounding.

1.14.1 Grounding Precautions When Welding

When using an electric welder on an engine, clip the ground lead as close to the welding site as possible. Putting the ground lead too far from the welding site may result in arcing across the main bearings and fusing them to the crankshaft.

1.15 Lead Acid Batteries

Always disconnect the battery ground connection from batteries before performing any work on the engine or equipment. This will prevent sparks or burns when accidently shorting an electrical connection.

Never expose batteries to open flame or electric spark. Battery action generates a flammable explosive gas. Do not allow battery fluid to contact skin, eyes, fabrics or painted surfaces. Battery fluid is a sulfuric acid solution which could cause serious personal injury or property damage. Wear eye protection when working with batteries.

1.15.1 Precautions When Using Booster Batteries And Cables

Do not attempt to jump start an engine having a frozen battery. The battery may rupture or explode. Before starting examine all fill vents on the battery. If ice can be seen or if the electrolyte fluid cannot be seen do not attempt to start with jumper cables.

Batteries should be treated carefully when using jumper cables. The following procedures assist in reducing sparks and explosion hazards always present in both batteries when connecting charged batteries to discharged batteries.

Turn off all electrical loads. Remove vent caps and lay a damp cloth over open vent wells of each battery. The charged booster battery or batteries must have the same voltage capacity as the discharged battery or batteries.

The positive post is identified by a "+", pos, and red color and is larger in diameter than the negative post.

The negative post is identified by a "-", neg, and gray color.

1.15.2 Negative Grounded Battery or Batteries

First, connect one jumper cable from the positive post on the charged battery or batteries to the positive post on the discharged battery or batteries. If more than one battery is connected in series or parallel, connect the jumper cable to the positive post that has the cable leading to the starting motor.

Second, connect the other jumper cable from the negative post on the charged battery or batteries to a good ground on the engine.

When removing jumper cables always disconnect the ground jumper cable from the engine before disconnecting the other jumper cable.

1.16 Sodium Filled Valves

When handling sodium filled valves, always wear approved safety goggles, a hat or cap, long sleeves and gloves. If refacing of sodium filled valves, do not exert undue force at the grinding wheel as this could crack the hollow valve stem and allow the sodium to escape.

Do not handle broken sodium filled valves with bare hands. Sodium or sodium residue can cause severe burns. Sodium burns are of the same nature as caustic burns. Wash burns with large volumes of cold water then neutralize with vinegar. The affected parts should then be treated as a burn and medical attention sought.

If a broken valve should ignite, smother the flames in dry soda ash or dry sand. Water, carbon dioxide in any form or carbon tetrachloride should never be used on sodium fires since these materials react violently with hot sodium. The smoke and fumes are irritating, adequate ventilation should be provided and inhalation or contact with the smoke and fumes avoided.

Broken sodium filled valves may be stored prior to disposal in moisture free clean oil or kerosene. Unserviceable sodium filled valves must be disposed of in accordance with local state and or federal regulations as applicable.

CAUTION

The operator should familiarize him or herself with the manual before attempting to operate the engine.

A new engine will require a 50 hour run-in during which no overload operation is allowed.

When cold starting the engine, the speed should be increased slowly. Do not run the engine at a high speed suddenly nor let it idle for an extended period. Do not bring the engine to a dead stop after running it under a load - allow the engine to idle for 5 - 10 minutes.

If the ambient temperature is lower than freezing (32°F - 0°C) and no antifreeze is used in the coolant system, the engine should be stopped and the cooling system drained. If the engine is to resume running, the cooling system should be refilled with an antifreeze mixture.

Do not run the engine without the air filter.

Lubricating oil must be of the proper weight and clean.

Assembly and maintenance of the engine must be done by properly trained personnel

Check to assure that the coolant and lubricating oil are full before starting the engine.

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2 Specifications

2.1 A-32 Specifications

2.1.1 Specifications

Displacement	190 cubic inches	3.2 liters
Bore	4.134”	105 mm
Stroke	4.724”	120 mm
Speed Range	1,000-1,200 rpm	
Maximum Continuous Horsepower	24.5 Bhp @ 1,200 rpm	
Normal Oil Pressure	70 psi @ 1,200 rpm (average)	45 psi @ 1,000 rpm (minimum)
Oil Temperature (Full Load STD Day)	180°F	82.25°C
Normal Coolant Temperature (Full Load STD Day)	180°F 82.25°C	82.25°C
Dry Weight	1,234 lbs	560 kg
Number of Cylinders	3	
Flywheel Teeth	115	
Compression Ratio	9:1	
Firing Order	1, 3, 2	
Number of Main Bearings	4	
Engine Length	34 1/4” (cm)	
Engine Width	27 5/16”	69.37 cm
Engine Height	37 3/4”	95.88 cm
Crankcase capacity (Including Filter)	5.5 qts	12.77 L
Valve Clearance, Cold (Intake) (see page 37 for more details)	0.008”	0.2 mm
Valve clearance exhaust	0.012”	0.3 mm
Flywheel HSG	SAE-3	
Ignition timing	18°	
Fuel Pressure Requirements	See emissions requirements (Section 3.3)	

2.2 A-42 (VR260) Specifications

Displacement	253 cubic inches	4.2 liters
Bore	4.134″	105 mm
Stroke	4.724″	120 mm
Speed Range	1,000-1,800 rpm	
Maximum Continuous Horsepower	47 HP @ 1,800 rpm	
Normal Oil Pressure	70 psi @ 1,800 rpm (average)	45 psi @ 1,800 rpm (minimum)
Oil Temperature (Full Load STD Day)	180°F	(82.25°C)
Normal Coolant Temperature (Full Load STD Day)	180°F	(82.25°C)
Dry Weight	1,450 lbs.	(658 kg.)
Number of Cylinders	4	
Flywheel Teeth	115	
Compression Ratio	9:1	
Firing Order	1, 3, 4, 2	
Number of Main Bearings	5	
Engine Length	39 3/8″	100 cm
Engine Width	27 5/16″	69.37 cm
Engine Height	37 3/4″	95.88 cm
Crankcase capacity (Including Filter)	13.5 qts.	12.77 L
Valve Clearance, Cold (Intake) (see page 37 for more details)	0.008″	0.2 mm
Valve Clearance Cold (Exhaust) (see page 37 for more details)	0.012″	0.3 mm
Flywheel Housing	SAE 3	
Ignition timing	24°	
Fuel Pressure Requirements	4 to 8 in/H_2O	

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2.3 A-62 (VR380) Specifications

Displacement	380.8 cubic inches	6.24 liters
Bore	4.134″	105 mm
Stroke	4.724″	120 mm
Speed Range	1,000-1,800 rpm,	1,000-2,000 intermittent duty
Maximum Continuous Horsepower	80 Bhp @ 1,800 rpm	
Normal Oil Pressure	70 psi @ 1,800 rpm (average)	45 psi @ 1,800 rpm (minimum)
Oil Temperature (Full Load STD Day)	180°F	82.25°C
Normal Coolant Temperature (Full Load STD Day)	180°F	82.25°C
Dry Weight	1,851 lbs.	840 kg.
Number of Cylinders	6	
Flywheel Teeth	115	
Compression Ratio	9:1	
Firing Order	1,5,3,6,2,4	
Number of Main Bearings	7	
Engine Length	63 1/2″	161.3 cm
Engine Width	28 1/4″	71.75 cm
Engine Height	48″	121.9 cm
Crankcase capacity (Including Filter)	20 qts	19 liters
Valve Clearance, Cold (Intake) (see page 37 for more details)	0.008″	0.2 mm
Valve Clearance Cold (Exhaust) (see page 34 for more details)	0.012″	0.3 mm
Flywheel Housing	SAE 3	
Ignition timing	24°	
Fuel Pressure Requirements	4 to 8 in/H_2O	

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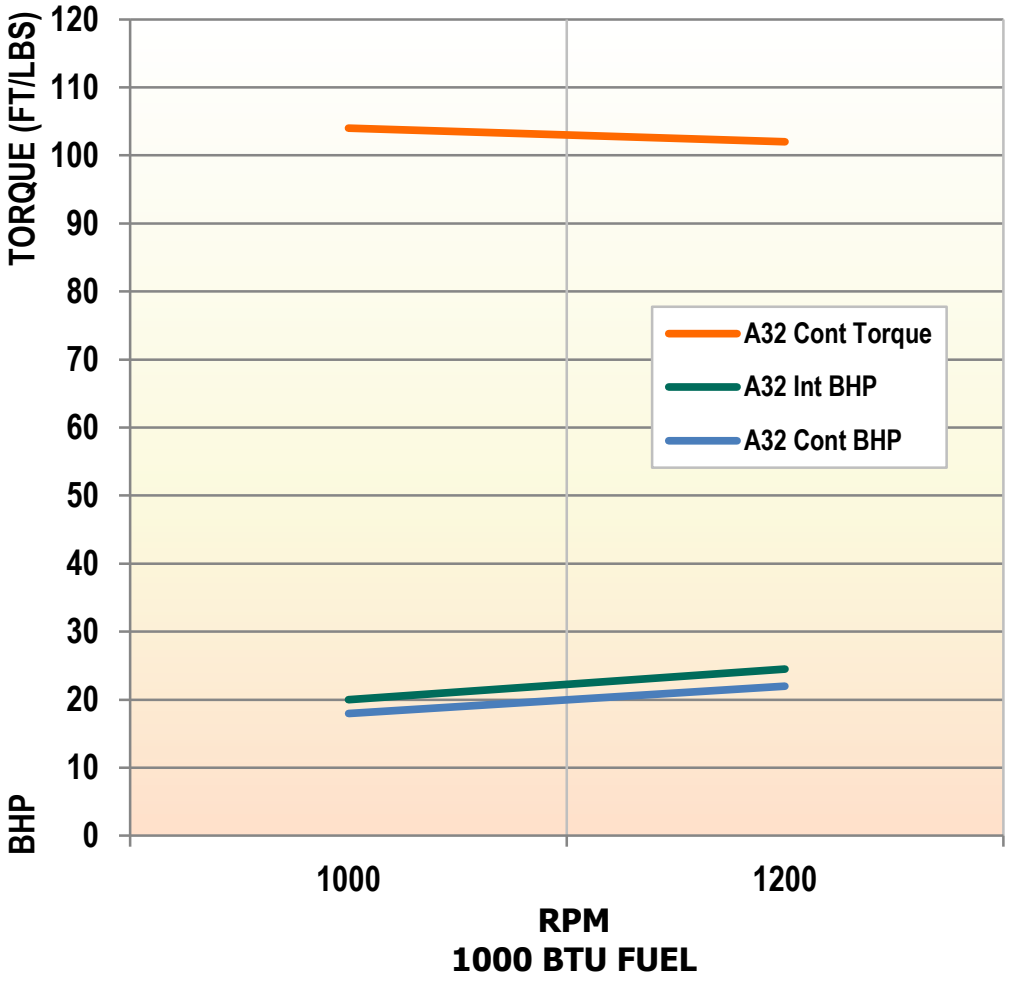
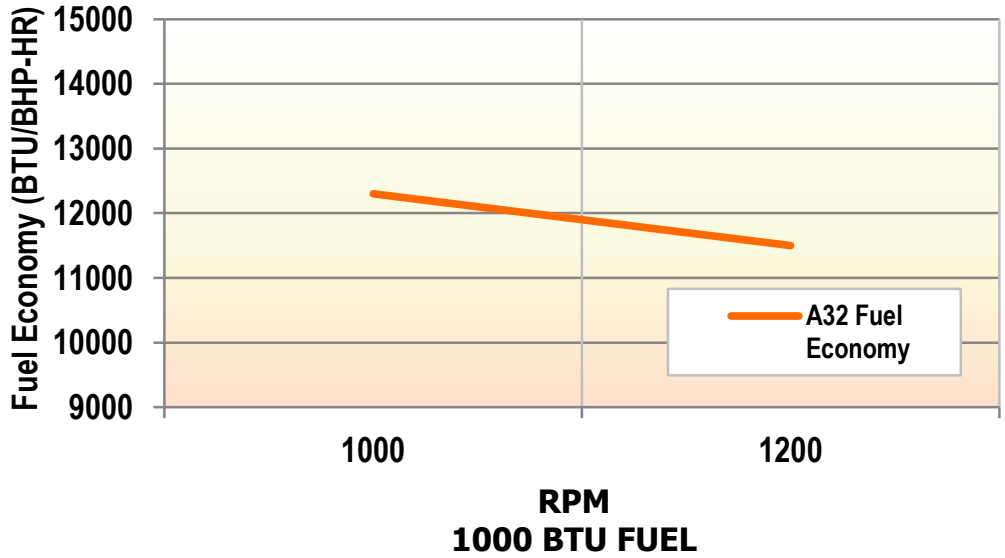
A-32 Power Ratings



A-32 Fuel Economy



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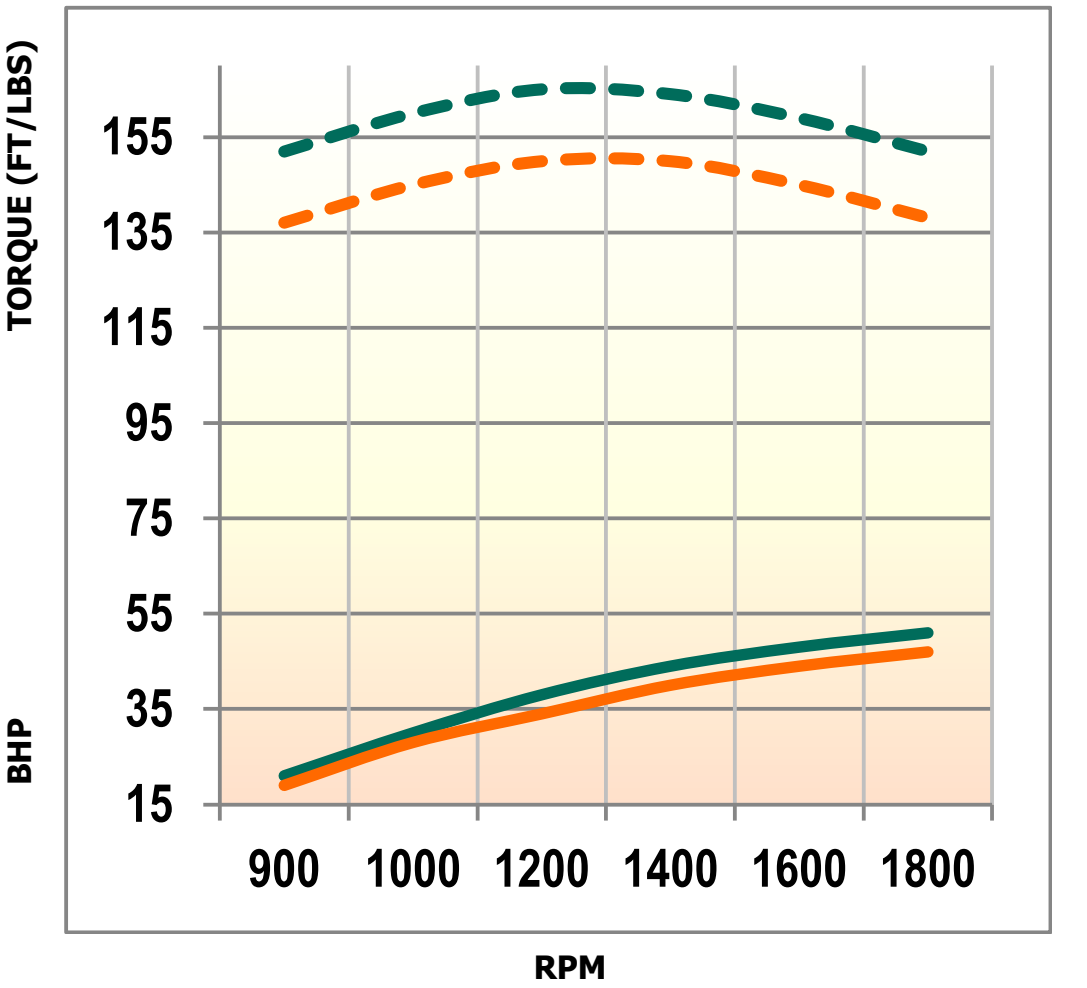
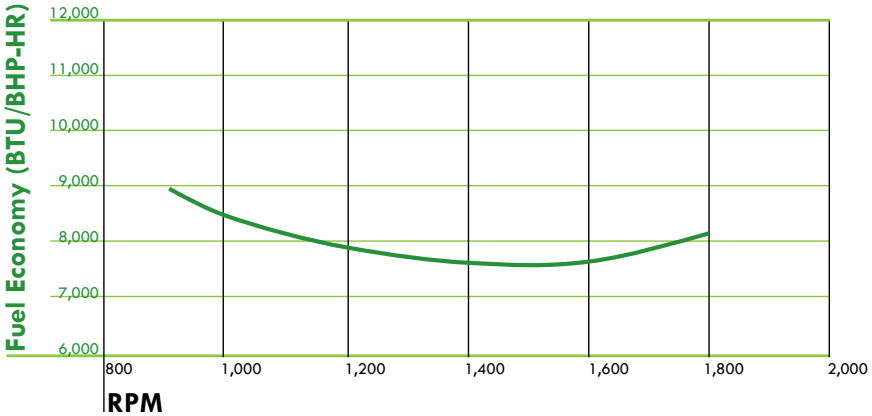
A-42 Power Ratings



A-42 Fuel Economy



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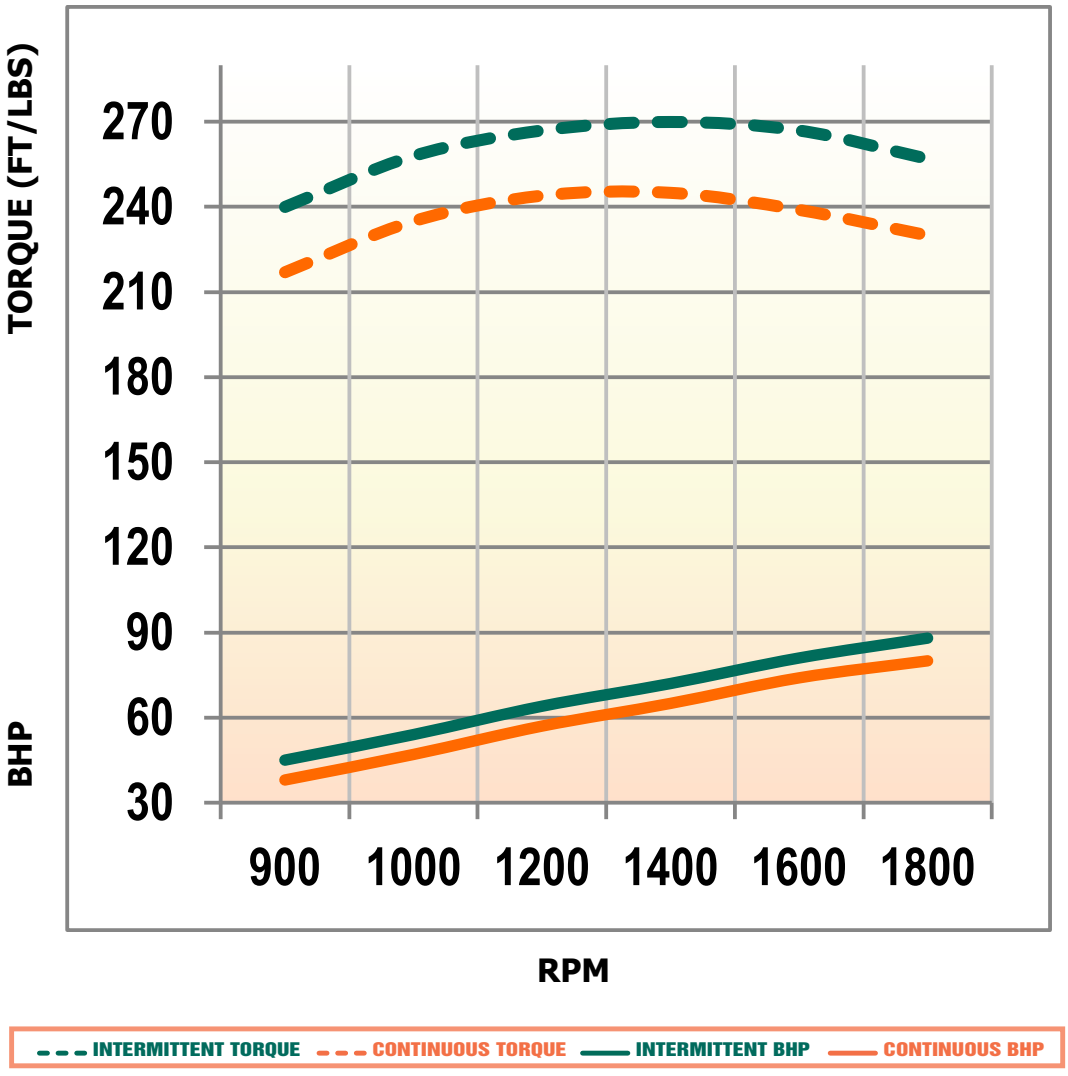
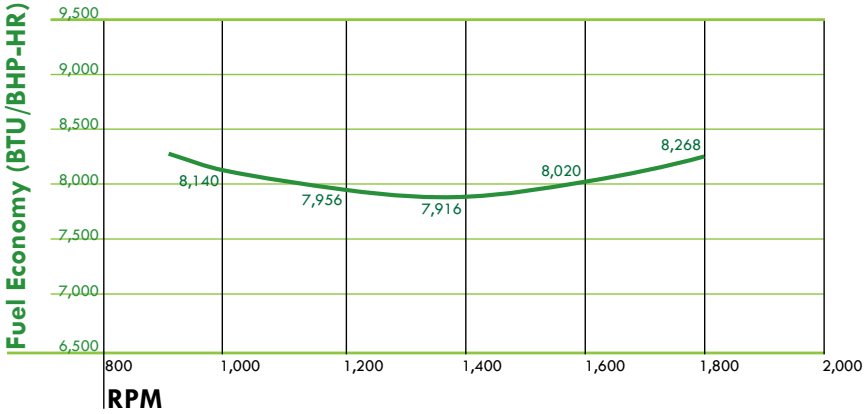
A-62 Power Ratings



A-62 Fuel Economy



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3 Emissions

3.1 Compliant vs. Certified Engines

As of July 1, 2008 Arrow Engines rated under 25 HP will be sold as "certified" which means they meet the emissions standards (40 CFR 1054 and 40 CFR 60) set forth by the EPA effective July 1, 2008.

Arrow engines that are "compliant" engines means they are NOT certified coming out from the factory. Being "compliant" means that with the proper air fuel ratio controller and catalyst the engines are able to meet the EPA emission standards required as of July 1, 2008.

3.2 Arrow Certified Engines

Owner and operators must retain the "Certificate of Conformity", follow Arrow or equivalent maintenance plan, and keep maintenance records in order to keep the engine in a "certified" manner.

Maintenance recommendations are listed on page 61 of this manual and should be considered a minimum. Owners and operators should maintain their engine(s) per Arrow or equivalent maintenance program that should be updated to account for specific site operating conditions.

Please consult Arrow Engine Company engineering department if adding any exhaust back pressure restriction to the system. Emission certifications is based on using the (standard) silencer.

Contact Arrow Engine Company engineering department if the engine is to be operated continuously below 25% load.

3.3 Emission Set Points

A-32 Emission Set Points	
RPM RANGE	1000 to 1200 RPM
MAX. HP RATING	1000 RPM @ 20 HP (14.91 kW) 1100 RPM @ 22 HP (16.41 kW) 1200 RPM @ 24 HP (17.90 kW)
GAS SUPPLY SETTINGS *(Pressure measured at fuel inlet to carburetor)*	1000 RPM @ 1" WC (2.54 cm) 1100 RPM @ 1" WC (2.54 cm) 1200 RPM @ 1" WC (2.54 cm)

* *Set fuel pressure @ 1.5" WC (2.54 cm) for loads < 50 %*

All emission settings in the above tables are based on 1000 BTU Pipeline Quality Natural Gas.

This manual is intended to give the installer of this certified engine all of the information that is necessary to properly install the engine and related components. Failure to follow these instructions when installing a certified engine violates federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act.

Use of the correct engine fuel supply pressure is essential. It is the responsibility of the installer to install a fuel pressure regulator upstream of the engine and to verify the correct fuel pressure specified by the manufacturer is supplied to the engine. After the fuel pressure has been set and verified it is the responsibility of the installer to protect the fuel pressure setting from any further adjustment or tampering.

Arrow cannot be held liable for any emissions noncompliance resulting from incorrect installation of this engine or failure to use the required settings.

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Emission Related Instructions (All measurements in inches of Water column).

Engine Model	1000 RPM	1050 RPM	1100 RPM	1150 RPM	1200 RPM
A-32					
2,000 FT ALTITUDE	-0.13	-0.24	-0.35	-0.39	-0.42
4,000 FT ALTITUDE	-0.42	-0.54	-0.65	-0.72	-0.78
6,000 FT ALTITUDE	-0.70	-0.83	-0.95	-1.05	-1.14
8,000 FT ALTITUDE	-0.93	-1.07	-1.20	-1.32	-1.44
10,000 FT ALTITUDE	-1.35	-1.43	-1.50	-1.65	-1.80

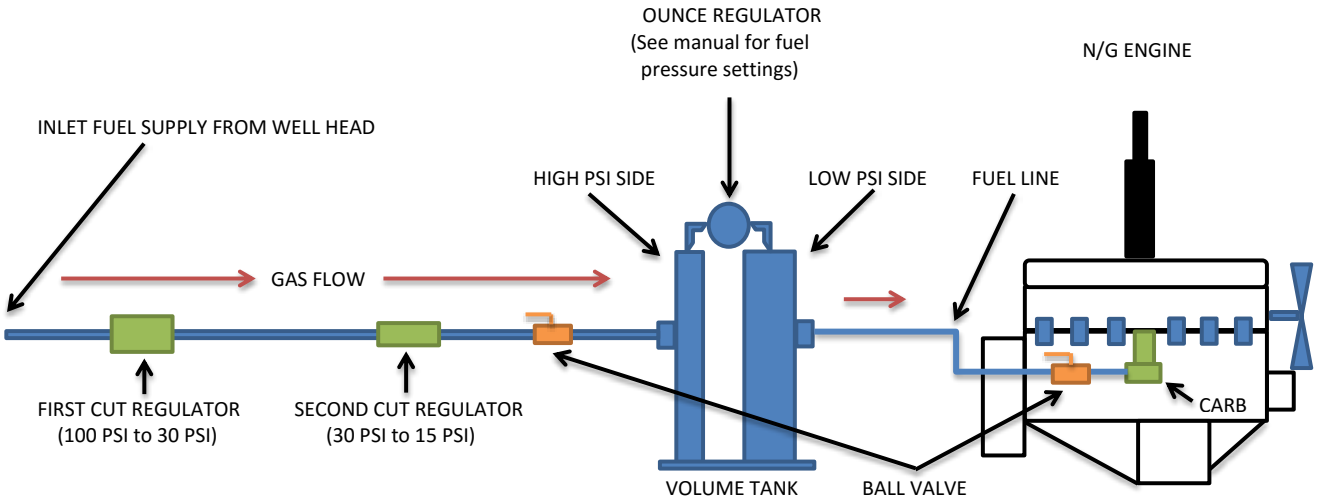
3.4 Fuel Supply Setup

1) Make sure your volume tank is of adequate size. If the volume bottle being used is not like the one pictured below and is a single cylinder design with no ounce regulator attached you must plumb the ounce regulator up stream of the volume bottle as the engine requires a high volume of low ounce fuel.

2) The fuel line to the carb must be 1" ID minimum and no longer than 6-8 ft. in length or as short as possible.

3) Once you have determined you have adequate fuel pressure the fuel adjustment can be made after start-up at the ounce regulator or at the power valve on the carburetor.

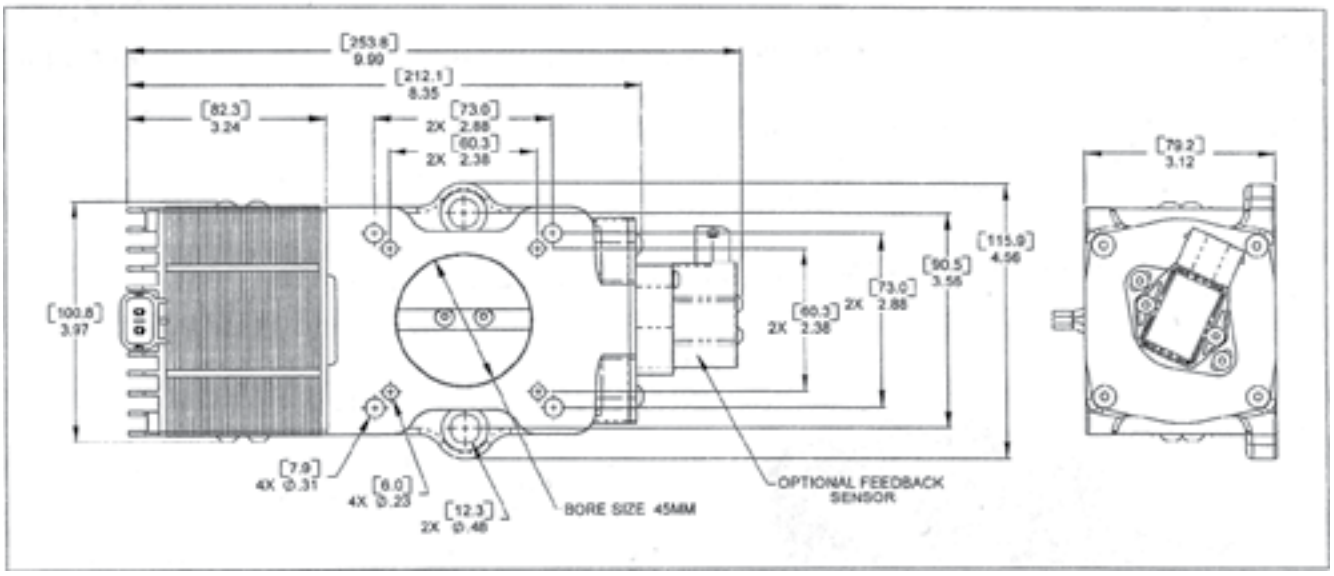
4) The personnel responsible for maintenance on the engine should after initial startup, determine the specific requirements for the application and establish a preventative maintenance program and scheduled check accordingly.



This diagram is for a typical setup. Refer to owners manual for your specific engine.

4 Engine Accessory Specifications

4.1 ATB Series Integral Throttle Body Actuator



Performance		
Maximum Throttle Plate Rotation	65°	±I degree
Power Input		
Operating Voltage	12 AMPS	24 VDC
Normal Operating Current	2 Amps 1 Amp	12 VDC 24 VDC
Maximum Current - Continuously Rated	6 Amps 3 Amps	12 VDC 24 VDC
Environmental		
Operating & Storage Temperature Range	-40° to +200° F	-40° to +95° C
Relative Humidity	SAE J1455	
Salt Spray	ASTM B 117-97	
All Surface Finishes (Fungus and Corrosion Resistant)		
Reliability		
Vibration	25 to 100 Hz	±4 g
Shock	20 g	11 msec
Testing	100 % Functionally Tested	
Rated Life	>40 million cycles	

4.2 Speed Control Units

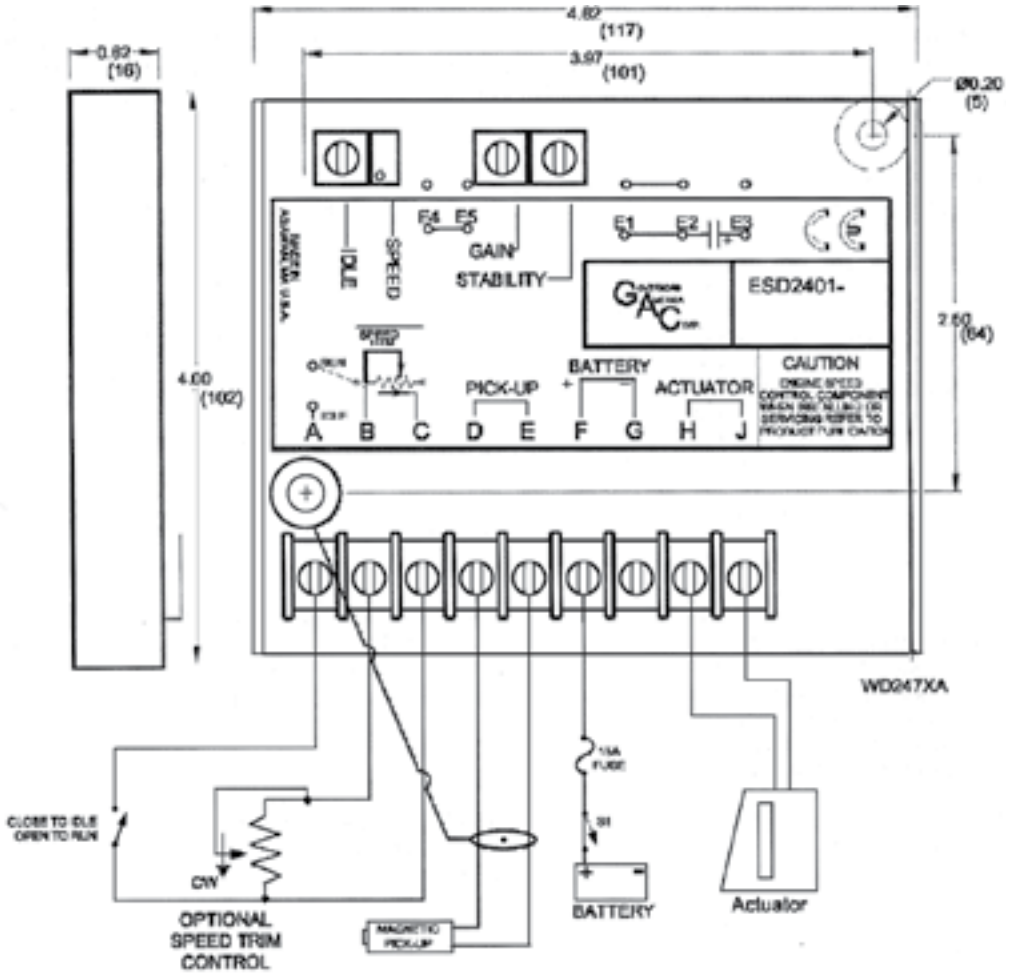
The speed control unit is located in an enclosed box on the side of the flywheel housing.

Basic electrical connections are illustrated in the above diagram. Actuator and battery connections to terminal F, G, H, and J are #16 AWG (1.3 mm sq.) or larger. Long cables require and increased wire size to minimize voltage drops. The battery positive (+) input, Terminal F, is fused for 15 amps, as illustrated.

Magnetic speed sensor wires connected to Terminals D and E are twisted or shielded for their entire length. The shield is insulated to insure no part of the shield may come in contact with the engine ground so that no stray speed signals are introduced into the speed control unit.

Number of Cylinders	1-8	
Power Required	12 VDC 24 VDC	1.0 Amp 0.5 Amp
Maximum Voltage Output	40 KV	
Spark Duration	300-600 microseconds	
Timing Adjustment	8 Position Switch	

4.3 ESD2400 Series Speed Control Unit



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Performance		
Isochronous Operation/Steady State Stability	± 0.25% or Better	
Speed Range/Governor	I kHz	7.5 KHz
Continuous Speed Drift with Temperature	±%I Maximum	
Speed Trim Range	±250 Hz Typical	
Idle Range	<±0-3% Typical	
Environmental		
Ambient Operating Temperature Range	-40°F to +180°F	-40°C to +85”C
Relative Humidity (Non-condensing)	Up to 100%	
All Surface Finishes (Fungus Proof & Corrosion Resistant)		
Input Power		
Supply (Transient and Reverse Voltage Protected)	-12; 8-20 Vdc	-24; 16-32 Vdc
Polarity Negative Ground (Case Isolated)		
Power Consumption (Continuous plus actuator current)	60 mA	
Maximum Actuator Current at 77°F (25°C)	10 Amps Continuous	
Speed Sensor Signal	0.50 VAC	50 VAC RMS
Reliability		
Vibration	5G	20-500 Hz
Testing (Functionally Tested)		
Physical		
Dimensions (See diagram page 13)		
Weight	12 oz	347 g
Mounting Any Position (Vertical Preferred)		

* *Reverse voltage is protected against by a parallel diode. A 15A fuse must be installed in the positive battery lead. See Diagram.*

4.4 ESD5100 Series Speed Control Unit

4.4.1 Installation

The ESD5100 Series speed control unit is rugged enough to be placed in a control cabinet or engine mounted enclosure with other dedicated control equipment. If water, mist, or condensation may come in contact with the controller, it should be mounted vertically. This will allow the fluid to drain away from the speed control unit. Extreme heat should be avoided.

Warning

An overspeed shut down device, independent of the governor system, should be provided to prevent loss of engine control, which may cause personal injury or equipment damage. Do not rely exclusively on the governor system electric actuator to prevent overspeed. A secondary shut off device, such as a fuel solenoid, must be used.

4.4.2 Wiring

Basic electrical connections are illustrated in section 4.6. Actuator and battery connections to Terminals A, B, E, and F should be #16 AWG (1.3 mm sq.) or larger. Long cables require an increased wire size to minimize voltage drops.

The battery positive (+) input, Terminal F, should be fused for 15 amps as illustrated. The ESD5100 series is suitable for 12 VDC and 24 VDC operation.

Magnetic speed sensor wires connected to Terminals C and D MUST BE TWISTED AND/OR SHIELDED for their entire length. The speed sensor cable shield should ideally be connected as shown in Diagram 2. The shield should be insulated to insure no other part of the shield comes in contact with engine ground, otherwise stray speed signals may be introduced into the speed control unit. With the engine stopped, adjust the gap between the magnetic speed sensor and the ring gear teeth. The gap should not be any smaller than 0.020 in. (0.45 mm). Usually, backing out the speed sensor 3/4 turn after touching the ring gear teeth will achieve a satisfactory air gap. The magnetic speed sensor voltage should be at least 1 VAC RMS during cranking.

4.4.3 Adjustments Before Starting Engine

Check to insure the GAIN and STABILITY adjustments, and if applied, the external SPEED TRIM CONTROL are set to mid position.

4.4.4 Start Engine

The speed control unit governed speed setting is factory set at approximately engine idle speed. (1000 Hz, speed sensor signal)

Crank the engine with DC power applied to the governor system. The actuator will energize to the maximum fuel position until the engine starts. The governor system should control the engine at a low idle speed. If the engine is unstable after starting, turn the GAIN and STABILITY adjustments counterclockwise until the engine is stable.

4.4.5 Governor Speed Setting

The governed speed set point is increased by clockwise rotation of the SPEED adjustment pot. Remote speed adjustment can be obtained with an optional 5K Speed Trim Control. (See section 4.6)

4.4.6 Governor Performance

Once the engine is at operating speed and at no load, the following governor performance adjustment can be made.

1. Rotate the GAIN adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further counterclockwise to insure stable performance (270° pot).

2. Rotate the STABILITY adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further to insure stable performance (270° pot).

3. Gain and stability adjustments may require minor changes after engine load is applied. Normally, adjustments made at no load achieve satisfactory performance. A strip chart recorder can be used to further optimize the adjustments.

If instability cannot be corrected or further performance improvements are required, refer to the SYSTEM TROUBLESHOOTING section. In this section, information can be found regarding troubleshooting procedures as well as instructions on adjusting the DIP switch positions of the ESD5131.

4.4.7 Idle Speed Setting

After the governor speed setting had been adjusted, place the optional external selector switch in the IDLE position. The idle speed set point is increased by clockwise of the IDLE adjustment control. When the engine is at idle speed, the speed control unit applies droop to the governor System to insure stable operation.

4.4.8 Speed Droop Operation

Droop is typically used for the paralleling of engine driven generators.

Place the optional external selector switch in the DROOP position. DROOP is increased by clockwise rotation of the DROOP adjustment control. When in droop operation, the engine speed will decrease as engine load increases. The percentage of droop is based on the actuator current change from engine no load to full load. A wide range droop is available with the internal control. Droop level requirements above 10% are unusual.

After the droop level has been adjusted, the rated engine speed setting may need to be reset. Check the engine speed and adjust that speed setting accordingly.

4.4.9 Accessory Input

The Auxiliary Terminal N accepts input signals from load sharing units, auto synchronizers, and other governor system accessories, GAC accessories are directly connected to this terminal.

It is recommended that this connection from accessories be shielded, as it is a sensitive input terminal. If the auto synchronizer is used alone, not in conjunction with a load-sharing module, a 3 M ohm resistor should be connected between Terminals N and P. This is required to match the voltage levels between the speed control unit and the synchronizer.

When an accessory is connected to Terminal N, the speed will decrease and the speed adjustment must be reset. When operating in the upper end of the control unit frequency range, a jumper wire or frequency trim control may be required between Terminals G and J. This increases the frequency range of the speed control to over 7000 Hz.

4.4.10 Accessory Supply

The +10 volt regulated supply, Terminal P, can be utilized to provide power to GAC governor system accessories. Up to 20 ma of current can be drawn from this supply. Ground reference is Terminal G.

4.4.11 Wide Range Remote Variable Speed Operation

Simple and effective remote variable speed can be obtained with the ESD5100 Series speed control unit.

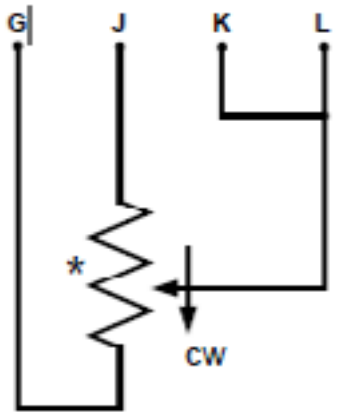
A single remote speed adjustment potentiometer can be used to adjust the engine speed continuously over a specific speed range. Select the desired speed range and corresponding potentiometer value. (Refer to section 4.4.12) If the exact range cannot be found, select the next higher range potentiometer. An additional fixed resistor may be placed across the potentiometer to obtain the exact desired range. Connect the speed range potentiometer (as shown in section 4.6).

To maintain engine stability at the minimum speed setting, a small amount of droop can be added using the DROOP adjustment. At the maximum speed setting the governor performance will be near isochronous, regardless of the droop adjustment setting.

Contact GAC for assistance if difficulty is experienced in obtaining the desired variable speed governing performance.

4.4.12 Potentiometer Wiring

Speed Range	Potentiometer Value
900 HZ	1K
2,400 HZ	5K
3,000 HZ	10K
3,500 HZ	25K
3,700 HZ	50K



* *Select proper potentiometer value from table.*

4.5 System Troubleshooting

4.5.1 Insufficient Magnetic Speed Signal

A strong magnetic speed sensor signal will eliminate the possibility of missed or extra pulses. The speed control unit will govern well with 0.5 volts RMS speed sensor signal. A speed sensor signal of 3 volts RMS or greater at governed speed is recommended. Measurement of the signal is made at Terminals C and D.

The amplitude of the speed sensor signal can be raised by reducing the gap between the speed sensor tip and the engine ring gear. The gap should not be any smaller than 0.020 in (0.45 mm). When the engine is stopped, back the speed sensor out by 3/4 turn after touching the ring gear tooth to achieve a satisfactory air gap.

4.5.2 Electromagnetic Compatibility (EMC)

EMI SUSCEPTIBILITY – The governor system can be adversely affected by large interfering signals that are conducted through the cabling or through direct radiation into the control circuits.

All GAC speed control sensors contain filters and shielding designed to protect the unit's sensitive circuits from moderate external interfering sources.

Although it is difficult to predict levels of interference, applications that include magnetos, solid sate ignition systems, radio transmitters, voltage regulators or battery chargers should be considered suspect as possible interfering sources.

If it is suspected that external fields, either those that are radiated or conducted, are or will affect the governor systems operation, it is recommended to use shielded cable for all external connections. Be sure that only one end of the shields, including the speed sensor shield, is connected to a single point on the case of the speed control unit. Mount the speed control to a grounded metal back plate or place it in a sealed metal box.

Radiation is when the interfering signal is radiated directly through space to the governing system. To isolate the governor system electronics from this type of interference source, a metal shield or a solid metal container is usually effective.

Conduction is when the interfering signal is conducted through the interconnecting wiring to the governor system electronics. Shielded cables and installing filters are common remedies.

In severe high-energy interference locations such as when the governor system is directly in the field of a powerful transmitting source, the shielding may require to be a special EMI class shielding. For these conditions, contact GAC application engineering for specific recommendations.

4.5.3 Instability

Instability in a closed loop speed control system can be categorized into two general types. PERIODIC appears to be sinusoidal and at a regular rate. NON-PERIODIC is a random wandering or an occasional deviation from a steady state band for no apparent reason.

The ESD5131 Sped Control Unit was derived from the standard GAC ESD5111 Speed Control Unit. All specifications, installation procedures, and adjustments, except those noted are identical.

The difference between the ESD5131 and the ESD5111 lies in the two DIP switches located under the upper access hole.

Switch 1 controls the "Lead Circuit" found in the ESD5111. The normal position is "ON." Move the switch to the "OFF" position if there is fast instability in the system.

Switch 2 controls an additional circuit added in the ESD5131 that is designed to eliminate fast erratic governor behavior, caused by very soft or worn couplings in the drive train between the engine and generator. The normal position is "OFF." Move to the "ON" position if fast erratic engine behavior due to a soft coupling is experienced.

The PERIODIC type can be further classified as fast or slow instability. Fast instability is a 3 Hz or faster irregularity of the speed and is usually a jitter. Slow periodic instability is below 3 Hz, can be very slow, and is sometimes violent.

If fast instability occurs, this is typically the governor responding to engine firings. Raising the engine speed increases the frequency of instability and vice versa. In this case, the removal of E6 to E7 jumper will reduce the speed control unit's sensitivity to high frequency signals. Readjust the GAIN and STABILITY 1 or optimum control. Should instability still be present, the removal of E1 to E2 jumper may help stabilize the engine. Post locations are illustrated in Diagram 2. Again, readjust the GAIN and STABILITY for optimum control. Interference from powerful electrical signals can also be the cause. Turn off the battery chargers or other electrical equipment to see if the system instability disappears.

Slow instability can have many causes. Adjustment of the GAIN and STABILITY usually cures most situations by matching the speed control unit dynamics. If this is unsuccessful, the dead time compensation can be modified. Add a capacitor from posts E2 to E3 (negative on E2). Post locations are illustrated in section 4.6. Start with 10 mfds, and increase until instability is eliminated. The control system can also be optimized for best performance by following this procedure.

If slow instability is unaffected by this procedure, evaluate the fuel system and engine performance. Check the fuel system linkage for binding, high friction, or poor linkage. Be sure to check linkage during engine operation. Also look at the engine fuel system. Irregularities with carburetion or fuel injection systems can change engine power with a constant throttle setting. This can result in speed deviations beyond the control of the governor system. Adding a small amount of droop can help stabilize the system for troubleshooting.

NON-PERIODIC instability should respond to the GAIN control. If increasing the gain reduces the instability, then the problem is probably with the engine. Higher gain allows the governor to respond faster and correct for disturbance. Look for engine misfiring, an erratic fuel system, or load changes on the engine generator set voltage regulator. If the throttle is slightly erratic, but performance is fast, removing the jumper from E6 to E7 will tend to steady the system.

If unsuccessful in solving instability, contact GAC for assistance.

4.5.4 System Inoperative

If the engine governing system does not function, the fault may be determined by performing the voltage tests described in Steps 1 through 4. Positive (+) and negative (-) refer to meter po-

larity. Should normal values be indicated during troubleshooting steps, and then the fault may be with the actuator or the wiring to the actuator. Tests are performed with battery power on and the engine off, except where noted. See actuator publication for testing procedure on the actuator.

STEP	TERMINALS	NORMAL READING	PROBABLE CAUSES OF ABNORMAL READING
1	F(+) & E(-)	Battery Supply Voltage (12 or 24 VDC)	1. DC battery power not connected. Check for blown fuse 2. Low battery voltage. 3. Wiring error
2	C & D	1.0 VAC RMS min. while cranking	1. Gap between speed sensor and gear teeth too great. Check gap. 2. Improper or defective wiring to the speed sensor. Resistance between D and C should be 30 to 1200 ohms. 3. Defective speed sensor.
3	P(+) & G(-)	10 VDC, Internal Supply	1. Short on Terminal P. (This will cause a defective unit.) 2. Defective speed control unit
4	F(+) & A(-)	1.0 - 2.0 VDC while cranking	1. SPEED adjustment set too low. 2. Short/open in actuator wiring. 3. Defective speed control. 4. Defective actuator. See Actuator Troubleshooting.

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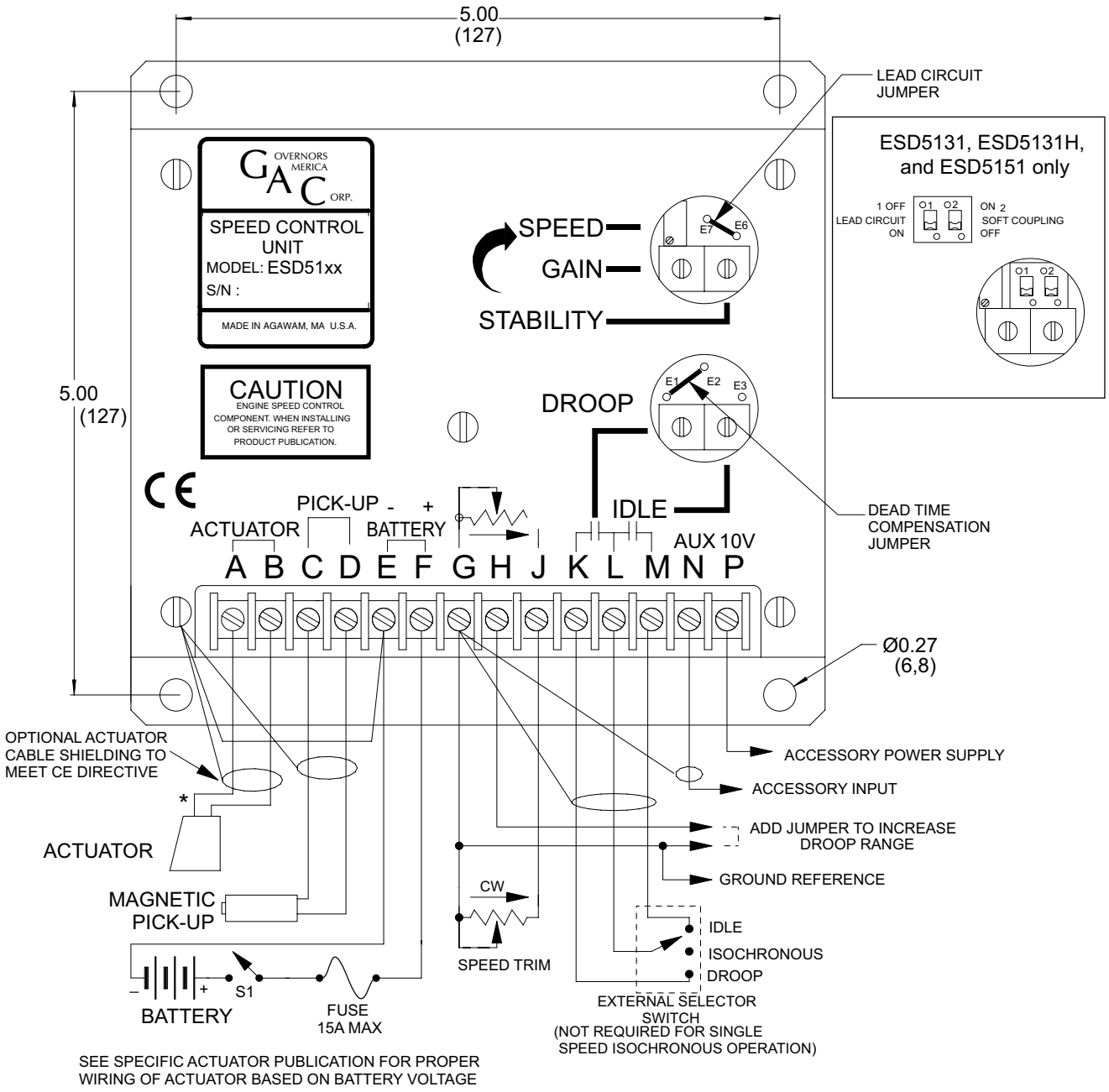
4.5.5 Unsatisfactory Performance

If the governing system functions poorly, perform the following tests.

SYMPTOM	TEST	PROBABLE FAULT
Engine overspeed	1. Do Not Crank. Apply DC power to the governor system.	1. Actuator goes to full fuel. Then disconnect speed sensor at Terminal C & D (5131). If actuator still at full fuel-speed control unit defective. If actuator at minimum fuel position, erroneous speed signal. Check speed sensor cable.
	2. Manually hold the engine at the desired running speed. Measure the DC voltage between Terminals A(-) & F(+) on the speed control unit.	1. If the voltage reading is 1.0 to 2.0 VDC, a) SPEED adjustment set above desired speed b) Defective speed control unit. 2. If the voltage reading is above 2.0 VDC, actuator or linkage binding. 3. Set point of overspeed shutdown device set too low. 4. If the voltage reading is below 1.0 VDC, defective speed control unit.
Overspeed shuts down engine after running speed is reached.		1. Speed adjustment set too high. 2. OVERSPEED set to close to running speed. 3. Actuator or linkage binding. 4. Speed control unit defective
Overspeed shuts down engine before running speed is reached.	1. Check impedance between Terminals C & D Should be 30 to 1200 ohms.	1. OVERSPEED set too low. Adjust 5-6 turns CW. 2. Erroneous speed sensor signal. Check wiring.
Actuator does not energize fully while cranking.	1. Measure the voltage at the battery while cranking.	1. If the voltage is less than 7V for a 12V system, or 14V for a 24V system, check or replace the battery.
	2. Momentarily connect Terminals A and F. The actuator should move to the full fuel position.	1. Actuator or battery wiring in error. 2. Actuator or linkage binding. 3. Defective actuator. 4. Fuse opens. Check for short in actuator or harness.
Engine remains below desired governed speed	1. Measure the actuator output, Terminals A & B, while running under governor control.	1. If voltage measurement is within 2 volts or more of the battery supply voltage level, then fuel control restricted from reaching full fuel position. Possibly due to mechanical governor, carburetor spring, or linkage interference. 2. Speed setting too low.

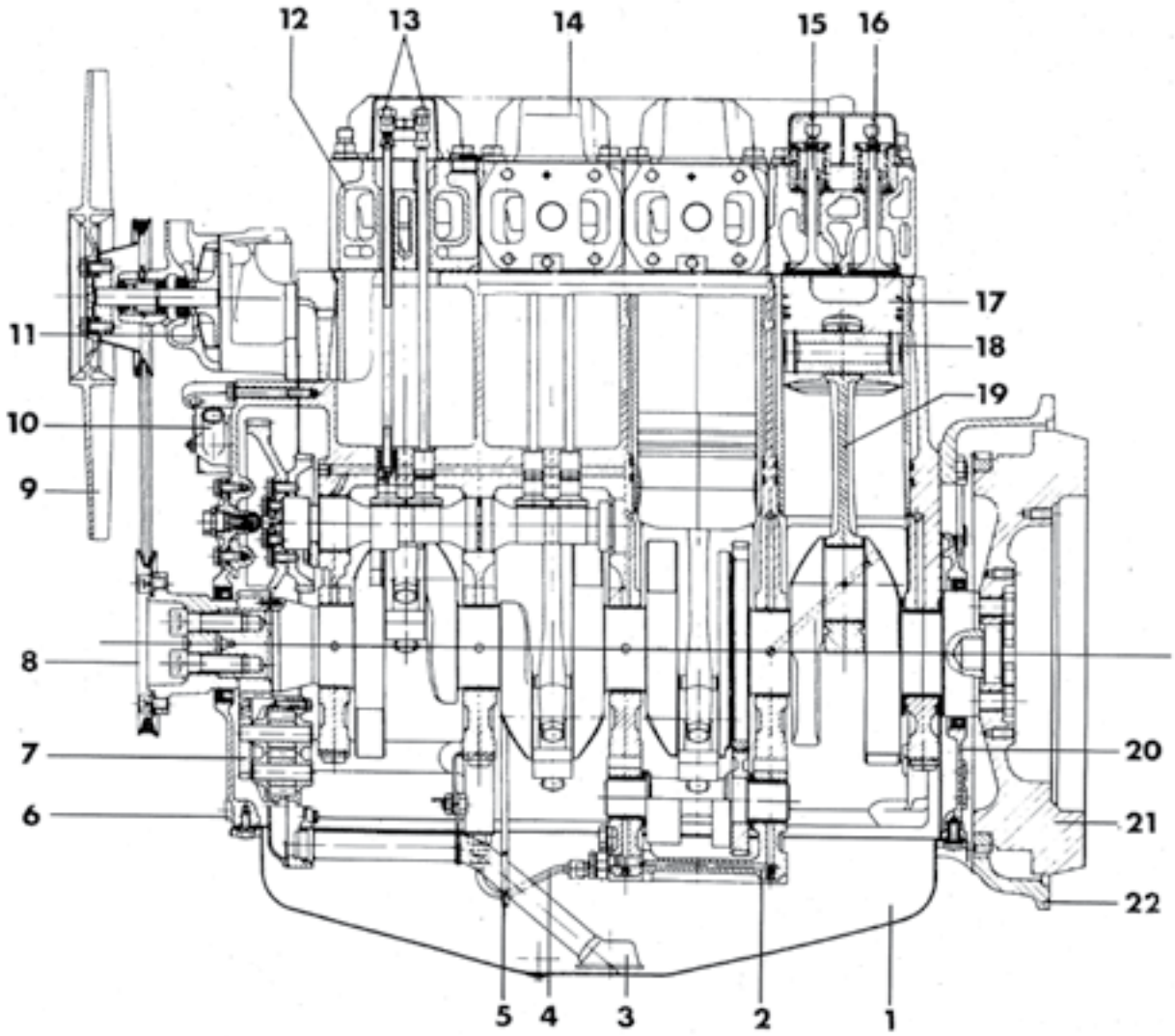
4.6 Speed Control Unit Wiring Diagram



5 Engine Construction

5.1 Longitudinal Section

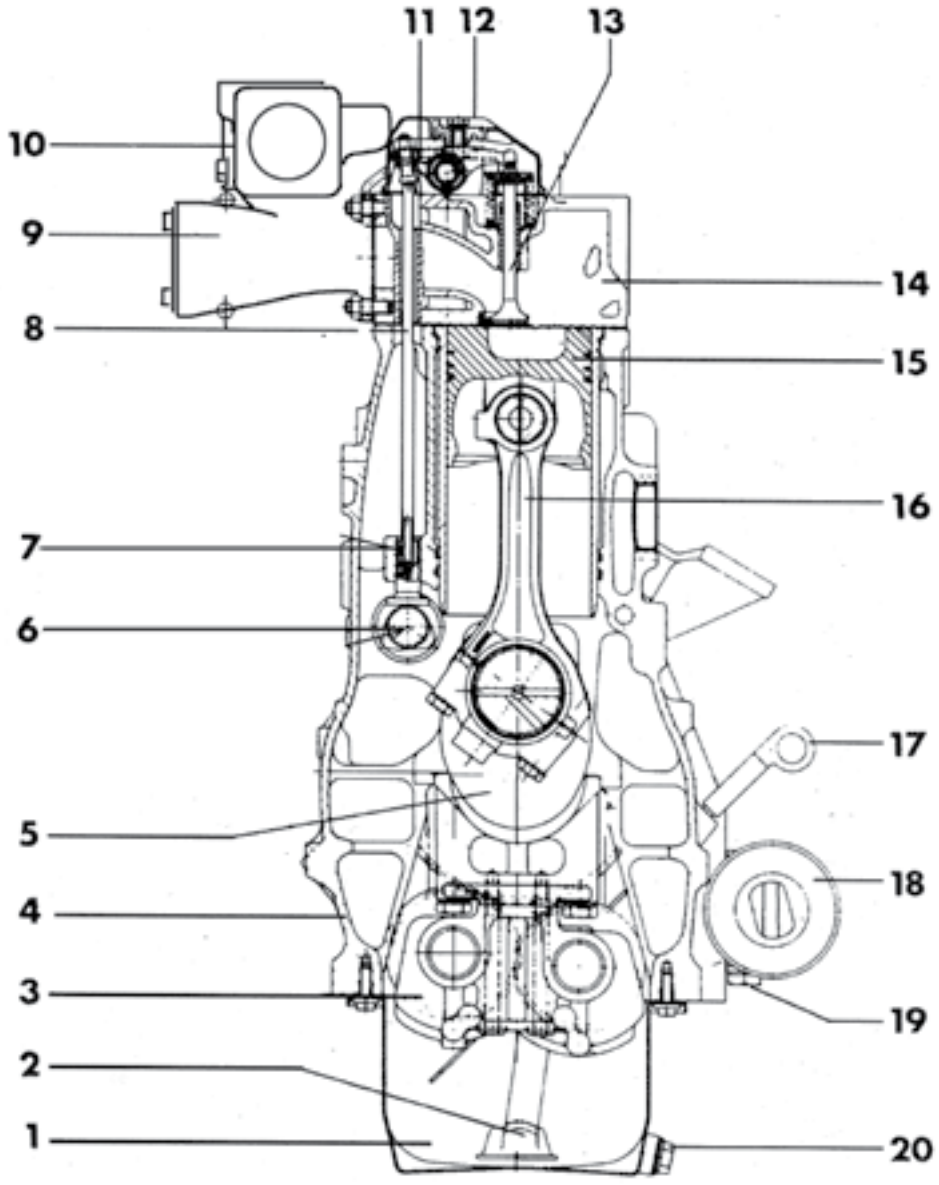
1	Oil Pan
2	Cradle Balancer
3	Strainer
4	Engine Oil Pipe to Secondary Balance Mechanism
5	Oil Gauge
6	Front Cover
7	Lubricating Oil Pump
8	Crankshaft Pulley
9	Fan
10	Crankcase Ventilation Device
11	Water Pump
12	Cylinder Head
13	Rocker Arm
14	Valve Cover
15	Intake Valve
16	Exhaust Valve
17	Piston
18	Cylinder Liner
19	Connecting Rod
20	Rear Oil Seal Cover
21	Flywheel
22	Flywheel Housing



5.2 Cross Section

1	Oil Pan
2	Strainer
3	Secondary Balance Mechanism
4	Engine Body
5	Crankshaft
6	Camshaft
7	Tappet
8	Push Rod
9	Exhaust Manifold
10	Intake Manifold

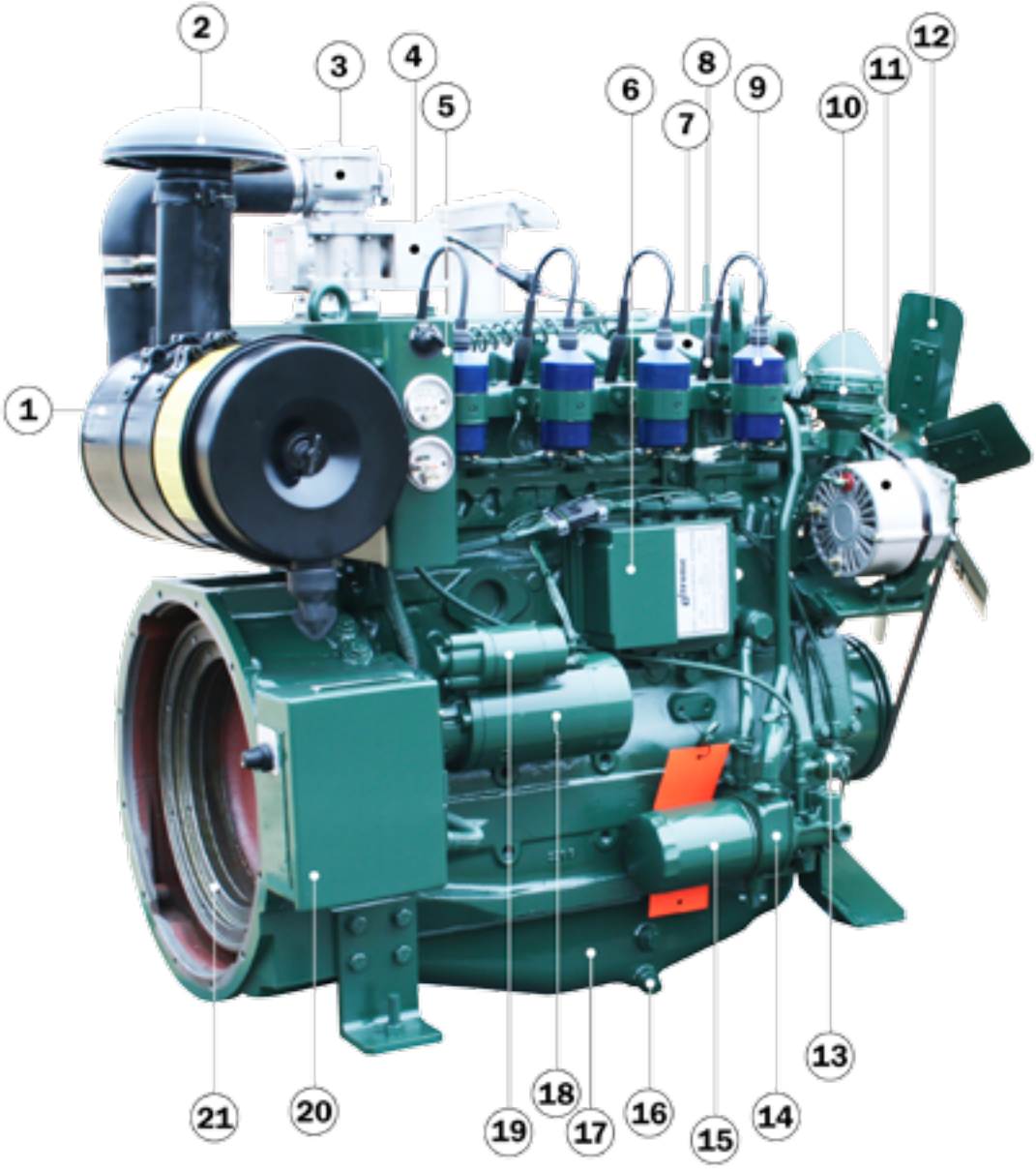
11	Rocker Arm
12	Cylinder Head Cover
13	Intake/Exhaust Valve
14	Cylinder Head
15	Piston
16	Connecting Rod
17	Dip Stick
18	Lubricating Oil Filter
19	Oil Pressure Safety Valve
20	Drain Plug



5.3 External View (Starter Side)

1	Air Cleaner
2	Pre Cleaner
3	Carburetor
4	Electronic Governor (GAC)
5	Control Panel
6	Ignition
7	Valve Cover
8	Spark Plug Wire
9	Coil
10	Crankcase Breather
11	Alternator

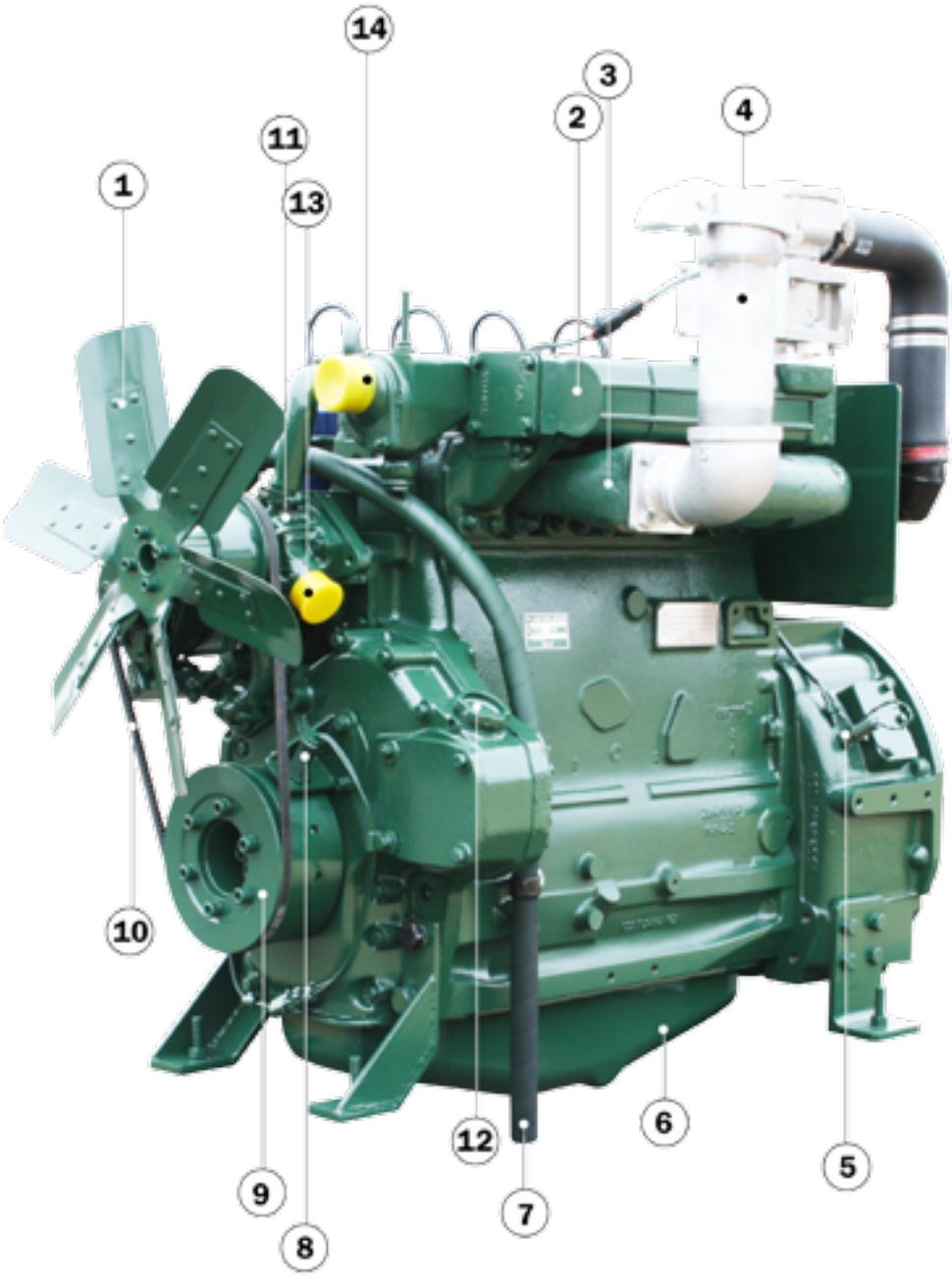
12	Fan
13	Secondary Oil Pressure Safety Switch
14	Engine Oil Cooler
15	Lubricating Oil Filter
16	Oil Pan Drain Plug
17	Oil Pan
18	Electric Starter
19	Solenoid
20	Governor Control Box (GAC)
21	Flywheel



5.4 External View (Intake/Exhaust Manifold Side)

1	Fan
2	Intake Manifold
3	Exhaust Manifold
4	Exhaust
5	Magnetic Pick-Up Sensor
6	Oil Pan
7	Crankcase Breather Tube

8	Sensor Timing Pickup
9	Crankshaft Pulley
10	Belt
11	Water Pump
12	Lube Oil Filler
13	Coolant Inlet
14	Coolant Outlet

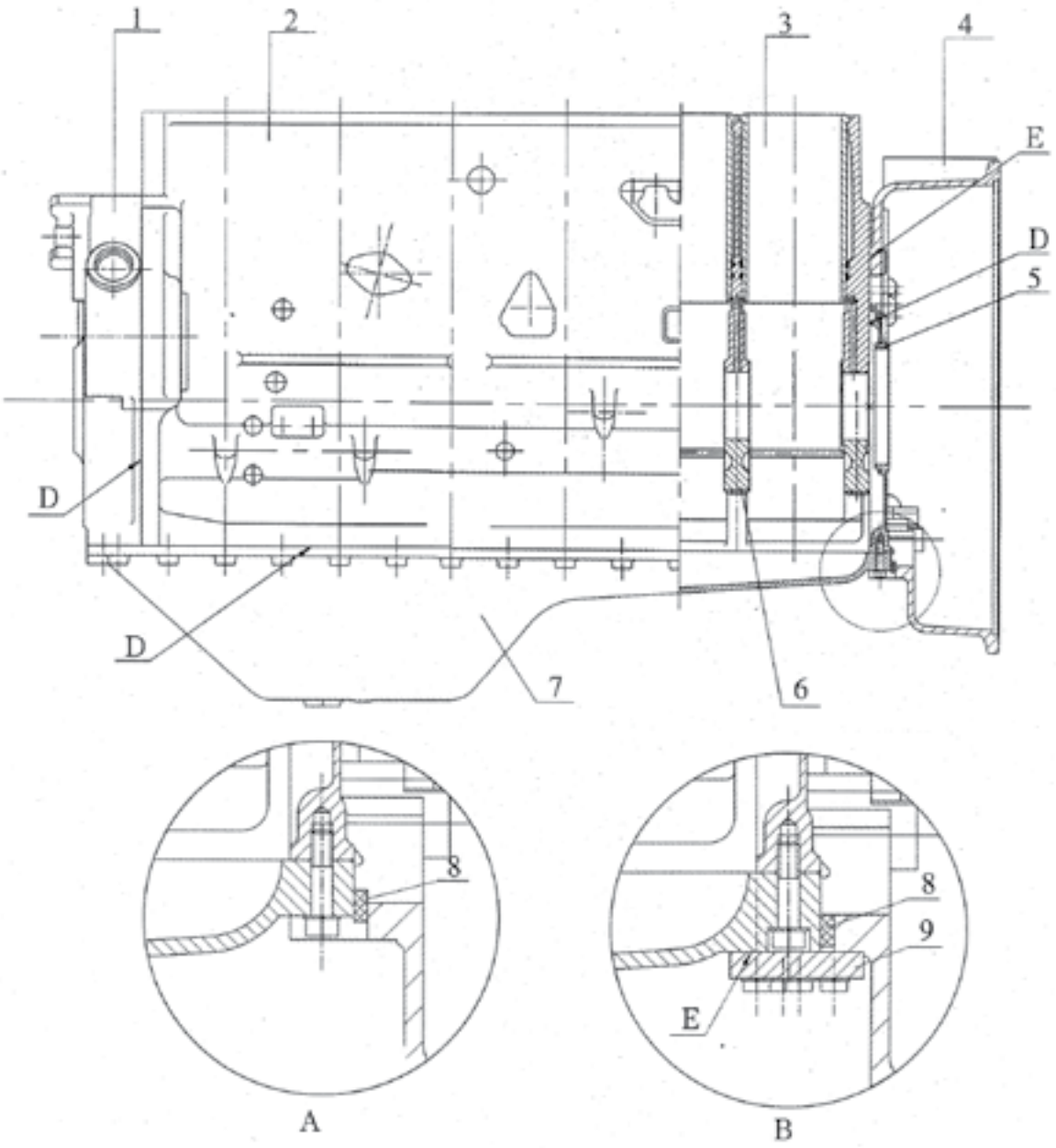


5.5 Cylinder Block Subassembly

Cylinder block subassembly consists of the cylinder block, liner, gear case, rear oil seal cover, flywheel housing and oil sump.

When **A** structure is adopted, coat seal glue on **D** joint face. When **B** structure is adopted, coat seal glue on both **D** and **E** joint faces.

1	Gear case front cover
2	Cylinder block
3	Cylinder liner
4	Flywheel housing
5	Rear oil seal cover
6	Main bearing cap
7	Oil sump
8	Seal strip
9	Seal plate



5.5.1 Construction

Cylinder block is made of high-strength cast iron for strength and rigidity. The A-32 has 3 cylinders and 4 main bearings, the A-42 has 4 cylinders and 5 main bearings, and the A-62 has 6 cylinders and 7 main bearings. The thrust ring is fitted on the first main bearing on the flywheel end.

5.5.2 Tightening Order

Tightening order is shown in Figure 1 below. First tighten the main middle bearing, then tighten the bearing on both ends. For the camshaft bearing holes in cylinder block, only the last one (free end) is fitted with the bronze camshaft bushing. There are two holes in the bushing. One of them is aimed at the oil hole in the cylinder block. The other should be facing upwards (see Figure 3). The engines will have a nozzle for cooling the piston on the right side of the engine body (from flywheel end).

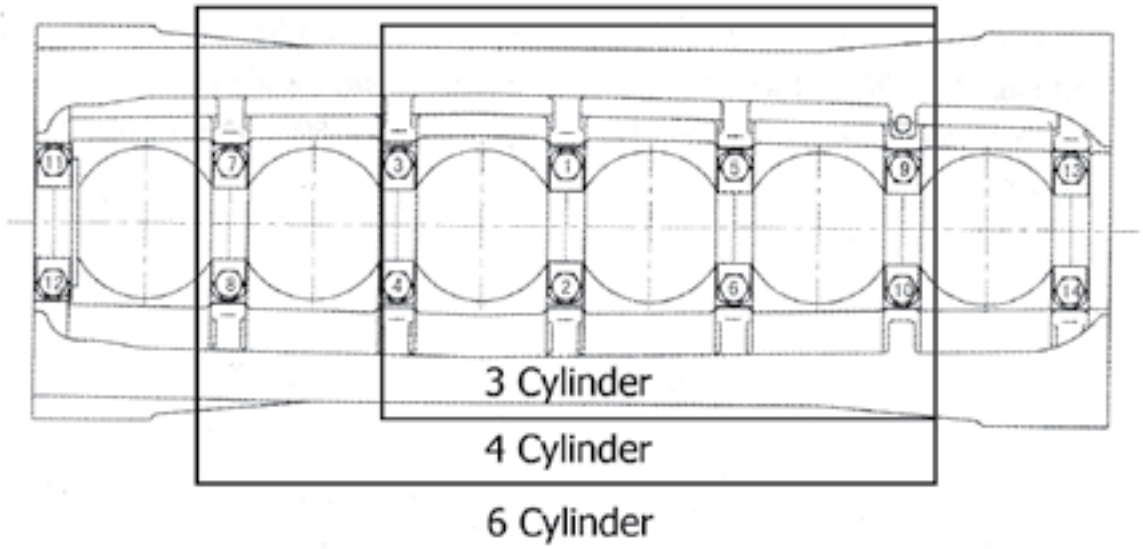


Figure 1 Cylinder Configuration

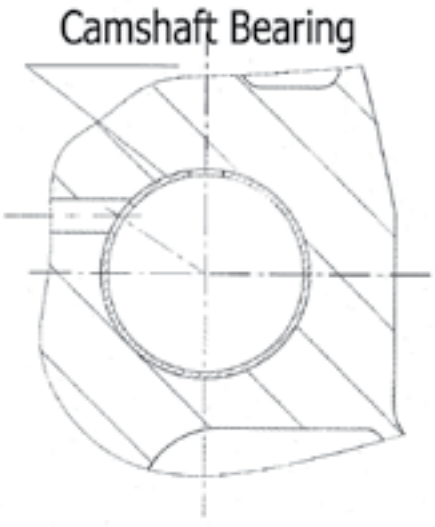


Figure 2 Camshaft Bearing

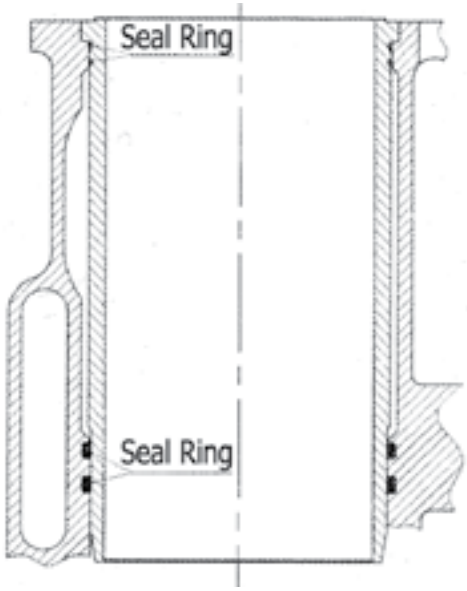


Figure 3 Seal Rings

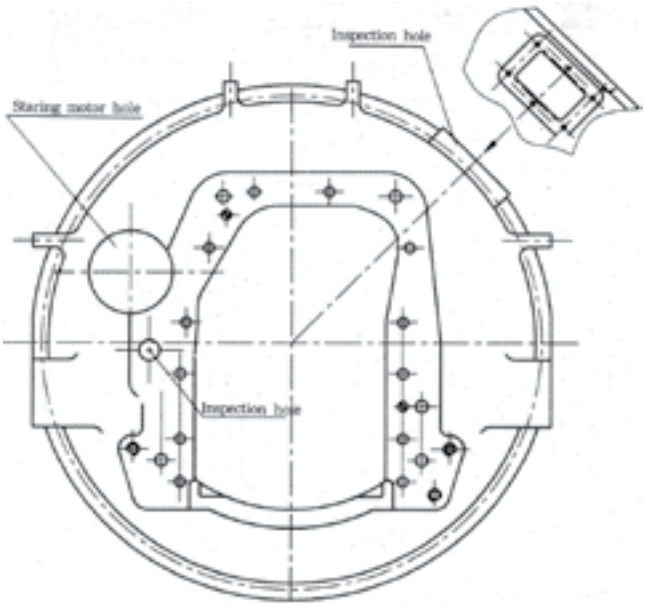


Figure 4 Observation Window

The A-32, A-42 (VR260), and A-62 (VR380) engines use a wet cylinder liner. In order to guarantee sealing after assembling, there are two rubber seal rings on the upper and lower locating positions of the liner respectively. The lower seal ring is set up in the seal groove on cylinder block and the upper one is set up in the seal groove on the upper end of the cylinder liner. Before mounting, coat the seal rings with O-ring lubricant. See Fig 3.

When mounting the gearbox cover on the rear oil seal cover, coat the contact surfaces of the cover and cylinder block with Loctite 5910 sealant (or alternative silicone sealant resistant to engine oil and with a good ability to withstand high joint movement.) The gear housing bolts (M8-8.8) should be tightened to 15-18 ft/lbs (20-25 Nm)

The 3, 4, and 6 cylinder engines use the SAE3 flywheel housing. There is an observation window on the top of the flywheel casing (Fig 5) for viewing the graduation on the flywheel and defining the ignition timing. The flywheel is fastened to the cylinder block with (M10-12.9) bolts tightened to 59±4 ft/lbs (80±5 Nm) and (M12-12.9) bolts tightened to 103±4 ft/lbs (140±5 Nm).

The oil sump has two structural forms: a cast part and a punched steel part. The connecting positions of the oil sump and the cylinder block gear case cover and lower bottom surface of rear seal cover are coated with Loctite 5910. It is fastened with (M8-8.8) bolts. A dust proof plate is fitted between the oil sump and flywheel housing.

5.6 Crankshaft and Connecting Rod Assembly

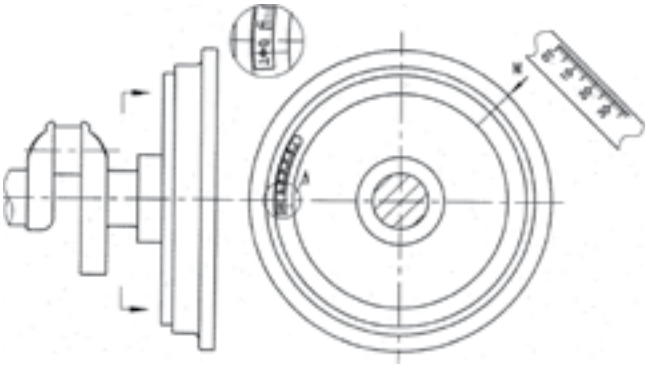


Figure 5 Timing Scale

The crankshaft and connecting rod assembly's primary components are the crankshaft, flywheel, piston, connecting rod, vibration damper and a balancer on the 4 cylinder engine.

5.6.1 Flywheel

The flywheel is fitted on the rear end of the crankshaft with six (M16-10.9) bolts which are pre-tightened to 52 ft/lbs (70 Nm). The timing scale is attached to the side surface of flywheel. See Fig 5. When the OT mark on the flywheel aligns with the pointer installed on the flywheel housing, it indicates the upper dead center of cylinders 1 and 6. For some models, the OT top center mark and scale is marked on the flywheel circumference and the inspection window is on the left side of the flywheel housing.

5.6.2 Balancer - A-42 (VR260) only

The balancer balances the reciprocating inertia force of the piston and the connecting rod subassembly and decreases vibration. The drive gear ring (1) of the transmitting balancer is mounted on the crankshaft it should be heated to 482°F (250°C) when mounting. The "0-0"

mark on the gear should be marked, if not already, on the specified position. See Fig 6. The mark "1" on the balancing shaft gear (2) of two stage balancing transmitting mechanism should be matched with the mark "1-1" on gear (3) The balancer is mounted on the main bearing cap. When mounting the mark "0-0" on gear ring should be matched with the mark on gear (2) of the balancing shaft. The gear side clearance is 0.00787" (0.2 mm). See Fig 8. The oil circuit should be unobstructed when mounting so as to ensure the lubrication of the balancer bearing.

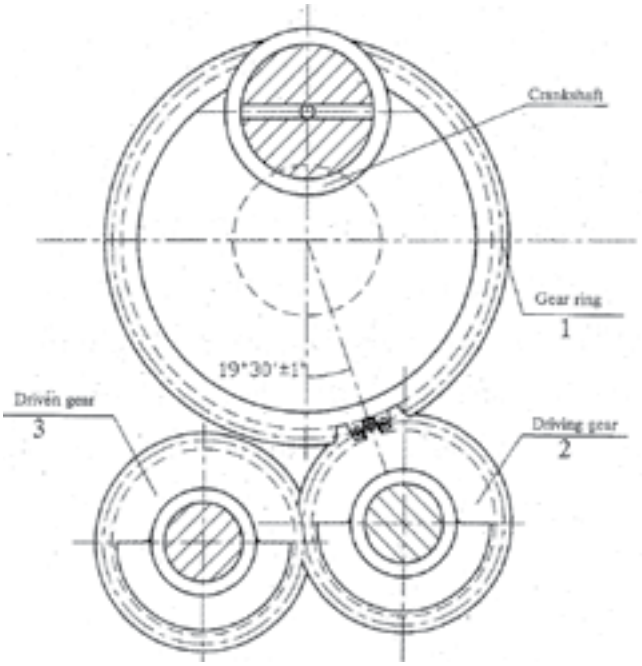


Figure 6 "0-0" Mark On Gear

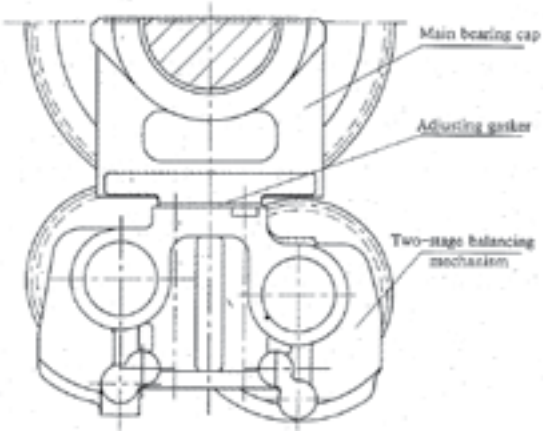


Figure 7 Gear Side Clearance

5.6.3 Connecting Rod

The connecting rod is mold forged and composed of the connecting rod body, connecting rod cap, small end bushing and connecting rod bolt. The big end is at a 45° angle and the mating face has a 60° tooth. There are two connecting rod bolts (M14 x l.5-12.9.) When mounting, tighten them with a torque of 22 ft/lbs (30 Nm) and then final torque of 80 ft/lbs.

CAUTION

The connecting rod bolt can be used only once. Attempting to reuse it may fracture the bolt leading to damage of the engine or injury.

The connecting rod body is machined with the cap and they are not interchangeable. There are mating marks on the body and cap. See Fig 8.

The connecting rod bearing shell is made of lead copper with a steel back. The alloy surface is plated with a three part alloy.

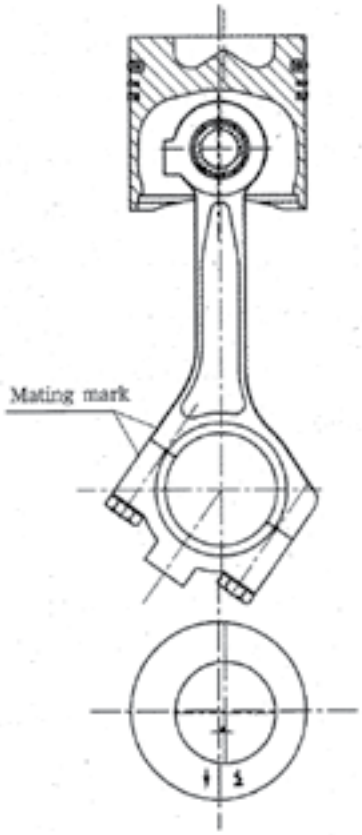


Figure 8 Mating Markings

5.6.4 Main Bearing

The main bearing shell is made of lead-copper with a steel back. The alloy surface is plated with a three part alloy. There are oil grooves on the upper half of the bearing shell. The main bearing shell has a spring pin. The lower half of this shell is quad alloy plated (optional.)

5.6.5 Crankshaft

The crankshaft is precision ground from a heat-treated steel forging. The crankshaft has flame-hardened main bearing journals which run in steel backed, alloy bearing shells. Connecting rod bearings are of similar construction for maximum serviceability.

The timing gear fits tightly on the front end of the crankshaft. Heat the timing gear to 482°F (250°C) and mount it so that the timing gear is aimed at the crankshaft dowel pin. The hub is fitted on the front of the gear with (M16-10.9) bolts and torqued at 177±7 ft/lbs (240±10 Nm) or (M16-12.9) bolts torqued to 221±7 ft/lbs (300±10 Nm). Lubricate the face of the crankshaft and mount the crankshaft front oil seal between the gear case and the hub. You may also press the timing gear case and crankshaft directly onto the hub.

5.6.6 Vibration damper

The vibration damper and pulley are fitted on the hub which is on the front end of the crankshaft. They are fastened with (M10-8.8) bolts at a torque of 32±4 ft/lbs (45±5 Nm) or (M10-10.9) bolts may be tightened to 48±4 ft/lbs. (65±5 Nm.)

5.6.7 Gear Train

When the piston of the first cylinder (counting from the flywheel end) is at the upper center, mark "0" on the crankshaft gear corresponding with the mark "0-0" on the camshaft timing gear. See Figure 9. Use four hexagon socket cap head M10 x 1.25-12-9 screws to fix camshaft gear tightly on the camshaft. The uneven distribution of bolt holes is used to assure the proper alignment of the cam and the gear mark. Tighten the bolts to 63+4 ft/lbs. (85+5 Nm.)

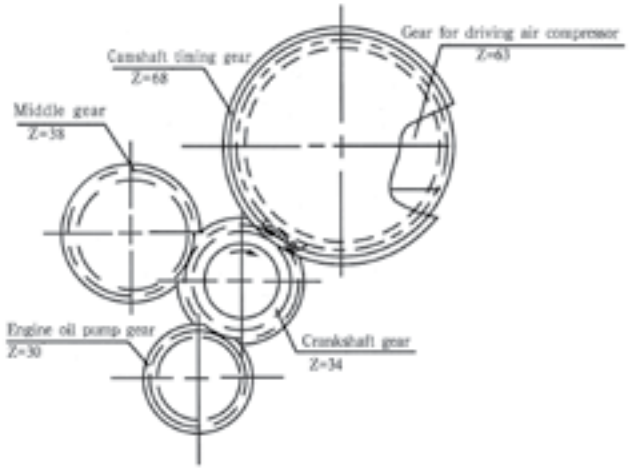


Figure 9 View From Free End

5.7 Cylinder Head & Valve System

5.7.1 Cylinder Head

The A-32, A-42 (VR260), and A-62 (VR380) have individual cylinder heads incorporating one intake and one exhaust valve each. The intake/exhaust ports are on the same side of the head. There are seat rings on both the intake and exhaust ports. The intake/exhaust valve seat angles are both 30°. See Fig 10.

The width of the valve seat face is 0.055”-0.078” (1.4-2.0 mm) on naturally aspirated engines and turbocharged engines.

There are two water outlet ports available - one is on the top face of cylinder head and the other is at the intake exhaust port flange. The relationship of cylinder heads and engines are as follows.

A-42	A-62
Part # 13024737	Part # 13024737-S
Intake/exhaust port flange	Intake/exhaust port flange
90° Intake Valve	90° Intake Valve
Natural aspiration air intake pipe and water outlet pipe are integral cast.	Natural aspiration air intake pipe and water outlet pipe are integral cast.

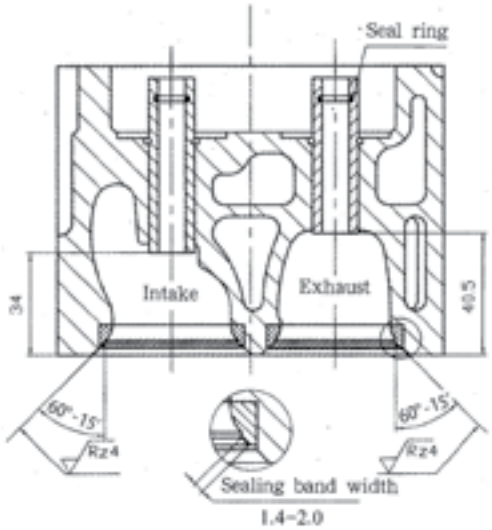


Figure 10 Valve Guides

5.7.2 Valve guide

The valve guides are made of phosphor cast iron with a phosphate coating. Exhaust valve guide length is 1.795” (58 mm), intake valve guide length is 2.027” (51.5 mm.) The mounting position of the valve guides is shown in Fig 10. There are grooves and a rubber seal ring on the inner wall of guide to prevent oil from entering into cylinder. Installed guide height .540.

5.7.3 Valve System

The valve system is composed of camshaft, tappet, push rod, rocker arm, rocker arm bracket, valve, valve spring and some accessories.

The oil inlet to the valve system is shown in Fig 11.

The oil coming from cylinder block enters into the tappet and the spherical surface of push rod through the ring groove on the tappet, and then into the hollow push rod, the rocker arm adjusting screw, the rocker arm and arm shaft to lubricate the surfaces of the rocker arm and valve.

Cold clearance of valve: Intake valve clearance 0.008” (0.2 mm); exhaust valve clearance 0.012” (0.3 mm)

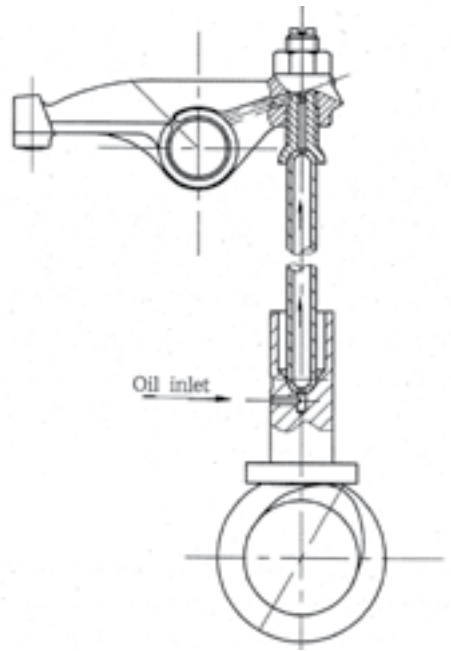


Figure 11 Oil Inlet

Coat the surface of camshaft hole in cylinder block with some clean oil before mounting the camshaft. The fan like stop plate for the camshaft should be mounted. The stop plate is

secured with two (M8-12.9) bolts tightened to 41±4 ft/lbs (55±5 Nm.)

Coat the surfaces of the rocker arm and rocker arm shaft with some oil when mounting. The rocker arm bracket is fixed with a (M10-8.8) bolt tightened to 30±4 ft/lbs. (40±5 Nm.) Lock up the rocker arm adjusting screw (M9x1) with a nut at 15±4 ft/lbs. (20±5 Nm.)

5.7.4 Head

After the cylinder heads are mounted on the cylinder block, all intake/exhaust flanges must be on one plane to ensure the sealing of the intake/exhaust manifold. Cylinder heads are secured with four (M14-12.9) bolts coated with oil (please do not use molybdenum disulfide.) The bolts should be tightened according to the sequence in Fig 12 three times in turn. First, tighten to 25 ft/lbs. (30 Nm), then 150 ft/lbs, and then 220 ft/lbs.

CAUTION

The cylinder head bolt will be elongated by 0.00787"-0.0236" (0.2-0.6 mm) If the length from the end of the bolt to the support face is up to 6.31" (160.5 mm), the bolt must be changed.

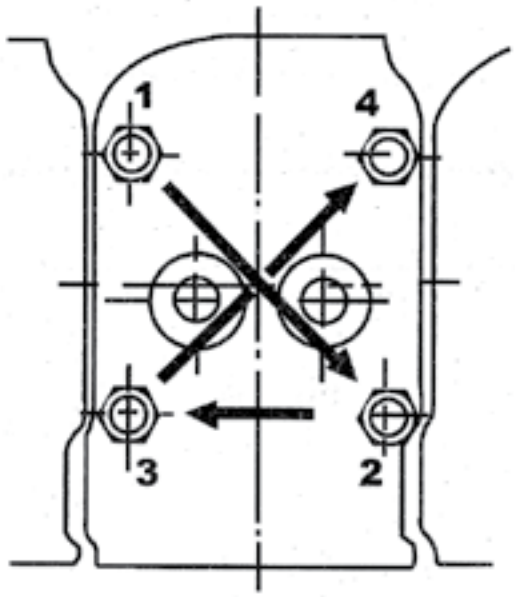


Figure 12 Tightening Sequence

5.8 Fuel Supply System

5.8.1 ATB Series Integral Throttle Body Actuator

The Actuator is located on the side of the carburetor, on the top of the intake manifold.

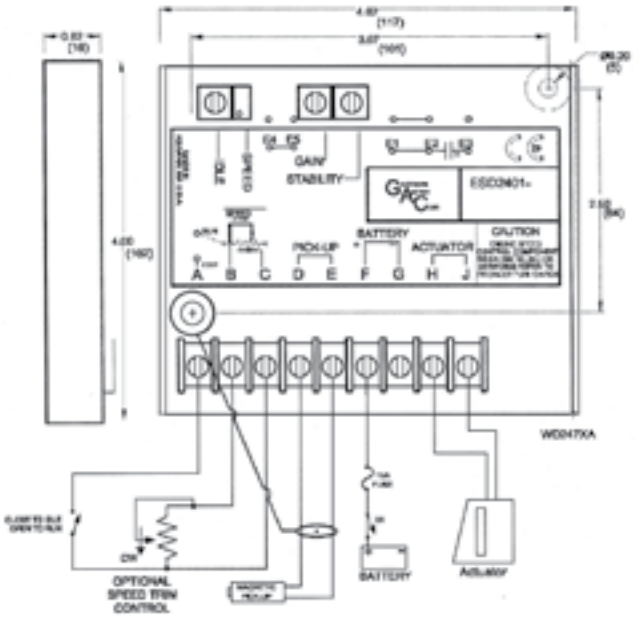


Figure 13 Actuator Wiring

The ATB SERIES integral throttle body electric actuator is designed to control the air/fuel mixture to the engine. The actuator is used to control the engine by working in tandem with the carburetor. The design baseline for the ATB SERIES incorporates fast response, multi-voltage usage, and proven reliability to allow for efficient and more precise control. The ATB SERIES actuator directly drives the throttle plate. Two internal return springs provide for a normally closed valve for fail-safe operation. This insures that the throttle plate returns to the minimum fuel position when the actuator becomes de-energized. ATB SERIES actuators are also designed to accept system battery voltages of either 12 or 24 VDC and are available with a throttle position feedback sensor.

ATB Series actuators are proportional electromagnetic devices designed for precise, efficient metering of airflow to a gaseous-fueled engine. When coupled with a speed control unit and speed sensor, a basic closed-loop governor system is established. Operation of this closed

loop governor system is as follows: The magnetic speed sensor, mounted strategically on the engine, will generate real-time electrical pulses, which are directly proportional to engine RPM. The electronic speed control unit monitors these pulses and compares them to a preset engine speed setting. If these pulses differ from the preset engine speed setting, the speed control unit will initiate a calculated response. This response is an increase or decrease in current flow to the actuator, which in turn changes the throttle plate's positioning. As the throttle plate's position changes, the amount of air and fuel is increased or decreased as necessary to cause the engine speed to return to the preset engine speed setting. The throttle plate's shaft rotation is proportional to the amount of actuator current and is counterbalanced by the internal return springs.

The ATB SERIES design uses steel, precision grade radial ball bearings to provide low friction support to the throttle shaft. Therefore, no maintenance is necessary. The results are a rapid, proportional response to actuator positional changes and outstanding reliability.

5.8.2 Carburetor

The A-32 uses Arrow 60; the A-42 (VR260) and A-62 (VR380) engines use the Arrow 100 carburetor which is suitable for use with natural gas. It is a demand carburetor which will allow only the amount of fuel to flow into the engine that the load demands.

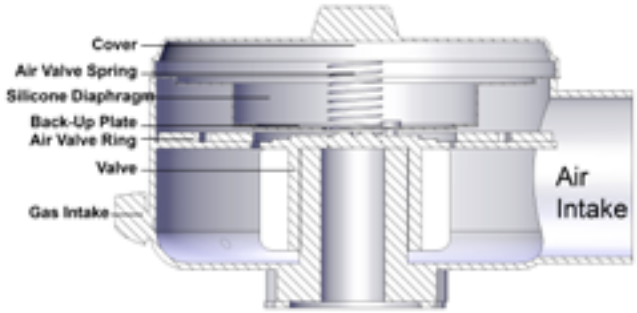


Figure 14 Arrow Carburetor

The Arrow 100 carburetor is structurally simple, consisting of a main body with a conventional butterfly throttle valve and a diaphragm operated gas metering valve. The amount of air going to the engine is measured by an airflow measuring valve. This valve rises in direct proportion to the air volume passing through it.

The gas metering valve is mechanically fixed to the air metering valve. As the air rises, the gas valve rises with it, thus opening the gas passage proportionally to the amount of air entering the engine. This establishes and holds a definite fuel/air ratio throughout the engine operating range.

5.9 Ignition

5.9.1 CD1

CD1 is a capacitor-discharge, electronic microcircuit based ignition system for 1 to 8 cylinder industrial engines. It may be powered by either 12 or 24 VDC, and has no moving parts. It works with the step-up coils (one per cylinder.)

Engine timing should be set to 24° BTDC for A-42 and A-62 engines. Set to 18° BTDC for A-32 engines.

Employing digital circuitry, the CD1 unit processes signal from a magnetic pickup, sensing drilled reference holes or protrusions. This provides accurate and consistent timing referenced directly to the crankshaft or camshaft. Indicating LED's convey whether proper pickup signals are being received and if the corresponding output signals are correct.

5.9.2 Altronic 1

The Altronic 1 ignition system consists of these basic components:

1. Altronic 1 Unit
2. Pick-up Module
3. Magnet Disc
4. Wiring Harness
5. Ignition Coils - one per cylinder; use only the following types: 501 061, 591 010, 591 040, 501 061-S, 591 010-S, 591 007, 591 011A, 591 011B, 591 012

The system alternator provides the power for the electronic box mounted to it. The electronic box rectifies the alternator's AC output to DC, stores the energy in a storage capacitor and contains SCR switching devices to release the stored energy to the ignition coils. The alternator provides no timing function; it can be either belt or coupling driven. Timing is set

by a magnet disc mounted to the engine's front crankshaft pulley. The pick-up module has 3 pick-ups, each of which serves either one or two engine cylinders. The system uses an ignition coil for each cylinder.

5.10 Lubricating system

Figure 15 Lubricating System Schematic

The lubricating system consists of the strainer, oil pump, oil cooler, oil filter and pressure limiting valve.

The strainer is the intake opening of the oil pump. The connection between the strainer and the inlet of oil pump is sealed by an O-ring and special attention should be taken to avoid leakage during installation of the connector otherwise the air sucked into the oil pump will influence oil supply and may result in serious damage to the bearings and engine. The oil from the oil pump enters into the filter seat which has a safety valve opening pressure of 78-109 psi (540-750 kPa.) The oil will be vented to the oil sump when the pressure of oil pumped from the oil pump exceeds the opening pressure value of the safety valve. There are sockets on the filter seat for the pressure sensor and oil cooler. The oil cooler is connected in series with the oil filter at the filter seat. The oil enters the oil cooler from filter seat through the oil filter and returns to the filter seat and then enters the main oil passage. Each finned oil cooler has nine cooling chips. The spin on oil filter may only be used only once. In the lubricating system, pressure lubrication is adopted for the main bearing, connecting rod bearing, cam bearing, two stage balance mechanism bearing, turbocharger and rocker bearing.

Cooling System

Besides becoming kinetic energy to do work, the heat energy produced by the fuel burning in the combustion chamber also heats up the cylinder head, liner, and so forth. Coolant is used to prevent the engine from overheating.

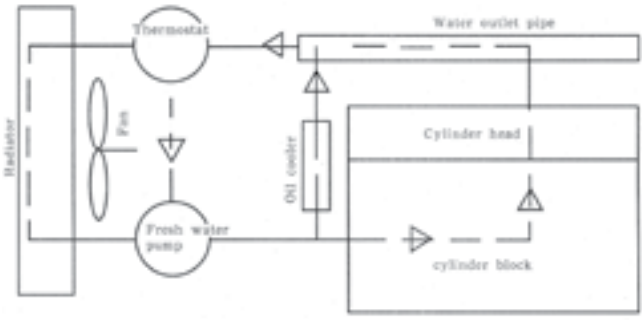


Figure 16 Cooling System Schematic

5.10.1 Water Pump

The A-32, A-42 (VR260), and A-62 (VR380) engines use a centrifugal type water pump. The vortex passage of water pump is at the intermediate gasket. The water pump is integrated with the intermediate gasket and mounted at the front end face of cylinder block. The cooling water enters into cylinder block through intermediate gasket.

5.10.2 Water Outlet Pipe

The structure of water outlet pipe has two structural components: one is the welded part and the other is the cast part connected with intake manifold. The water outlet of the cylinder head is located at the flange surface of the intake and exhaust ports and the built in thermostat inside the water outlet pipe. There is a vent (ø0.23" [ø6 mm]) at the top of the water outlet. This vent should be connected with the expansion tank or the upper cavity of the radiator. This al-

lows air/steam pockets in the cooling system to be released and thereby prevent the water from overheating due to air resistance.

5.10.3 Thermostat

The A-32, A-42 (VR260), and A-62 (VR380) use an outboard thermostat. The thermostats opening temperature is 167°F (75°C.) When the outlet temperature of the cooling water is lower than the opening temperature of the thermostat, the cooling water enters into the water pump via the outlet for minor circulation of the thermostat and the temperature of the cooling water is quickly raised to reach the water temperature which the engine needs for normal operation. When the temperature of outlet water is higher than the opening temperature, the thermostat opens fully allowing entirely or partially cooled water to enter the cooler and be cooled before it goes on to the water pump.

5.10.4 Cooling fan

The fan is mounted on the water pump. Suction and pusher fans are available for the following models.

18.35” (466 mm)	A-32
18.35” (466 mm)	A-42 (VR260)
21.25” (540 mm)	A-62 (VR380)

5.11 Intake/Exhaust System

This system includes air cleaner, intake manifold, exhaust manifold, exhaust, muffler, turbocharger and intercooler (when present) and connecting pipes.

5.11.1 Intake

The intake air for the engine should be clean, therefore the intake air must be filtered and resistance in the intake pipeline should be as absolutely minimal.

A dry type paper element air cleaner is supplied with the engine. An alternative air filter may be use depending upon the dust content of the ambient air at the installation site.

The dry type paper element filter usually has a primary filter, (that can make the air produce a swirling flow) paper cartridge and safety element as well as an auto dust extracting valve or exhaust arresting device installed after the primary filter to remove the dust from filtering. The resistance of the air cleaner should not be too great: the allowable max resistance under normal operating conditions is 0.43 psi (3 kPa) and that under overload conditions is 0.72 psi (5 kPa). There is a maintenance indicator mounted at the vent port of air cleaner. The red signal indicates that maintenance or replacement is required otherwise the performance and service life of the engine will be impacted.

When mounting the air cleaner and connecting pipe, users should pay special attention to its proper sealing. An inadequately sealed air filtration system can lead to greatly increased oil consumption, crankcase blow-by, decreased engine power and black smoke in the exhaust. When the filter loses its effectiveness the engine becomes subject to early wear and considerable shortening of its service life. Inadequate sealing may even cause serious wear of the cylinder liner and piston ring, breakage of piston ring as well as cylinder scuffing.

The intake manifold of the engine is cast by aluminum alloy. Where the intake manifold is mounted to the cylinder head, a compound material gasket is used. The stainless steel gasket should be mounted with its convex surface facing to the cylinder head. The tightening torque for the nuts on the intake manifold is 33±4 ft/lbs (45±5 Nm).

5.11.2 Exhaust

The A-32, A-42 (VR260), and A-62 (VR380) engines use a unitary exhaust manifold. The joint between exhaust manifold and cylinder head is sealed with a stainless steel gasket the convex surface of which should face to the cylinder head. The torque for tightening the nuts is 33±4 ft/lbs (45±5 Nm).

The exhaust resistance should be as small as possible therefore the exhaust manifold must have sufficient diameter or area and with as few bends as possible because the performance of engine will be influenced if the exhaust resistance exceeds a certain value. The combined resistance of the exhaust main and muffler should not be more than .72 psi (7.5 kPa).

Because of the very high surface temperatures caution should be taken with the exhaust system (pipe, muffler, expansion joints, etc.). The exhaust gas of the engine contains nitrogen oxides and carbon monoxide, among other impurities that may be present in wellhead gas. These exhaust gases can be harmful or fatal when inhaled - the exhaust should be properly vented to minimize exposure to people and other animals.

5.11.3 Turbocharger

The Turbocharged A-62 (VR380) engines use a radial flow type exhaust gas turbine turbocharger (12270137). Oil for the turbocharger comes from the oil galley and returns via the lower part of the engines crankcase.

Turbochargers operate at high speed and temperature. To prevent damage to the turbocharger, start and run the engine for 3-5 minutes with no load before gradually adding load. Do not stop an engine running at high speed and/or load - gradually reduce the load and speed for 5-10 minutes before stopping the engine.

If the turbocharger is removed or replaced, apply some clean engine oil to the oil inlet before securing.

The exhaust-driven turbine and its attached compressor are not connected to the working parts of the engine in any physical manner with the exception of the exhaust and intake manifolds and the oil lines. The turbocharger will not be troubled by gear train, belt, or other mechanical drive engine troubles. Moreover, since the supply of hot gases under high velocity supplied to the exhaust turbine is a reflection of the engine speed and load, the turbocharger output is closely matched to the engine air requirements. The high speed compressor driven by the exhaust turbine provides additional air for the combustion process and thus materially boosts the power output of the engine. The exhaust back pressure is actually very slight since it is the velocity of the gas and its unused energy that is put to work.

The turbine or driving member of the unit is made of a special heat resisting alloy. It is surrounded by a housing which directs the flow of exhaust gases onto the turbine blades. On the opposite end of the same shaft, which supports the compressor, the precision-made aluminum alloy impeller operates within surrounding diffuser housing. Both turbine and compressor turn at the same speed. The full load speed of the two units together with their shaft is approximately 90,000 rpm. These parts must be in a close to perfect balance as possible; for this reason, do not file, scrape, sandblast, drill, clean or perform any repair procedure that could conceivably remove or add metal. A very small amount of unbalance can cause severe damage at the speeds involved.

The possibility of excessive muffling or unusually restrictive exhaust pipe installations should always be considered when checking turbocharger efficiency. When additional muffling is required, contact your distributor or Arrow Engine.

5.11.4 Intercooler

The intercooler is used to reduce the intake air temperature after it passes through the turbocharger. The air is cooled by at least 108-122°F (42-50°C.) The A-62 (VR380) uses an air-air type intercooler mounted on the front of the radiator.

5.12 Torque Specifications

5.12.1 Main bolts tightening torque

NAME OF BOLT	SPEC	MAXIMUM TIGHTENING TORQUE Ft/lbs (NM)
Cylinder head bolt	M14-12.9	Pre-tighten with a torque of 25 ft/lbs (30 Nm,) turn then 150 ft/lbs, then again 220 ft/lbs.
Main bearing bolt	M14-10.9	Pre-tighten with a torque of 52 ft/lbs then 155-160 ft/lbs
Connecting rod bolt	M12-1.5-12.9	Pre tighten with a torque of 22 ft/lbs (30 Nm,) final torque of 80 ft/lbs
Fastening bolt of the mounting gear at the oil injector camshaft	M18-1.5 M14-1.5	81 (110 Nm) 73 (100 Nm)
Flywheel	M16-10.9	218 (295 Nm)
Fastening boss of crankshaft boss	M16-12.9 M16-10.9	229 (310 Nm) 184 (250 Nm)
Fastening bolt of high pressure fuel pipe	M14-1.5 M12-1.5	18 (25 Nm) 18 (25 Nm)
Fastening bolt of AC generator pulley	M14	30(40 Nm)
Fastening bolt of the flywheel housing and other fastening bolt and stud bolt	M12-12.9 M12-10.9 M10-12.9 M10-10.9	107 (145 Nm) 89 (120 Nm) 63 (85 Nm) 48 (65 Nm)
Fastening bolt of the pulley on the boss	M12-8.8 M10-10.9 M10-8.8	66 (90 Nm) 51 (70 Nm) 37 (50 Nm)
Fastening bolt of hydraulic pump	M10-10.9 M8-10.9	48 (65 Nm) 26 (35 Nm)
Fastening bolt of the dampener	M10-10.9 M10-8.8	52 (70 Nm) 37 (50 Nm)
Tightening bolt of the camshaft gear and the fastening bolt of camshaft gear	M10-1.25-10.9 Durlok M8-12.9	66 (90 Nm) 44 (60 Nm)
Tightening nut of intake pipe and exhaust pipe	M10-10	37 (50 Nm)
Fastening bolt of two stage balancing mechanism	M10-8.8	30 (40 Nm)
Bolt of rocker arm support	M10-8.8	33 (45 Nm)
Adjusting nut of rocker arm	M9-1	18 (25 Nm)
Fastening bolt of oil pump and the stud bolt with self-locking nut	Durlok M8-12.9 M8-8.8	30 (40 Nm) 18 (25 Nm)
Fastening bolt of oil pan	M8-10.9 M8-8.8	26 (35 Nm) 18 (25 Nm)
Fastening bolt of cylinder head	M8-8.8	11 (15 Nm)
Fastening nut of oil injector	M8	11 (15 Nm)
Fastening support for tightening the oil injection pump delivery valve		27 (37 Nm)

5.13 Horsepower Derates

Condition	Continuous Duty	Intermittent Duty
Altitude Naturally Aspirated	Deduct 3% for each 1,000' above 1,500'	Deduct 3% for each 1,000' above 500'
	Deduct 3% for each 305 m above 457 m	Deduct 3% for each 305 m above 152 m
Altitude Turbo Charged	Deduct 3% for each 1,000' above 3,000'	Deduct 3% for each 1,000' above 1,500'
	Deduct 3% for each 305 m above 914 m	Deduct 3% for each 305 m above 457 m
Temperature	Deduct 1% for every 10°F above 100°F	Deduct 1% for every 10°F above 85°F
	Deduct 1% for every 5.5°C above 38°C	Deduct 1% for every 5.5°C above 29°C
Duty Ratings & Standards	The load and speed that can be applied without interruption except for normal maintenance.	The highest load and speed that can be applied under specific conditions of varying load and/or speed.

All ratings are corrected to 500’ (152 m) altitude, 29.38 Hg (746 mm), and a temperature of 85°F (29°C).

Natural Gas ratings are based on the use of 900 BTU (33.5 J/cm^3) LHV gas.

5.14 Installation – Altronic Ignition (A-32 only)

Pulley-driven alternators should be driven between 1.0 and 1.5 times engine speed. At starting, the alternator speed should be at least 1000 RPM. Hardware for securing the alternator is provided in the field kits.

The electronic box has connectors for the pick-up module cable and wiring harness.

5.14.1 Installation – Pick-up Module / Magnetic Disc

See the diagrams included with these instructions for details on the mounting of the magnet disc and pick-up module. The air gap between the pick-up sensing hex heads and the magnet disc should be 1/8” (3 mm).

NOTE

Be sure the “A” pick-up bolt is well grounded to the engine.

5.14.2 Installation – Ignition Coils

Use only the Altronics or Arrow coils indicated in the first section.

Mount the ignition coils as close to the spark plugs as possible keeping the high-tension lead length to a minimum but also keeping them away from excessive temperatures during operation. On engines exposed to weather, it is preferable to point the high tension outlet down.

5.14.3 Primary Wiring (see sections 5.16-21)

Altronic 1 uses the exhaust stroke firing principle on 4-cycle engines. On 4- and 6-cylinder engines, two coils are wired in series and connected to one harness lead. Wiring must be as

shown in the wiring diagrams for the particular application. Do not use parallel connection of the coils.

Note the wiring for the common ground lead; there must be a ground wire from the coil shown in the wiring diagrams to the engine or coil mounting bracket. Use a short piece of no. 14-16 gauge wire for this purpose.

All connections should be made using ring type terminals specified for no. 14-16 gauge wire and #10 stud size. Terminals should either be soldered to the wire or attached with an appropriate staking tool. All primary wiring should be protected from physical damage, vibration and excessive temperatures.

5.14.4 Shutdown Wiring

The engine shutdown wires attach to the white lead of the pick-up module cable assembly. This lead must be grounded to shut off the ignition.

For proper operation of Murphy tattletale switches or fuel valve, use panel adaptor 501 213 as shown in the wiring diagrams.

Safety switches and associated wiring must be in good condition for proper operation with the Altronics 1 ignition system due to the low primary current output of the alternator. Take an ohmmeter reading of resistance between the safety shutdown wire and ground before installing the Altronics 1 system; on the RX10,000 scale, the reading should be infinite. All non-insulated switch connections that are exposed to weather should be insulated using silicone rubber adhesive (Altronic part no. 503 151).

5.14.5 Secondary Wiring

The spark plug leads should be a minium of 7 mm, silicone insulated, tinned copper conductor with suitable terminals and silicone spark plug boot. Keep spark plug leads as short as possible and in all cases not longer than 20 inches (500 mm). Spark plug leads should be kept at least 2 inches (50 mm) away from any grounded engine part. In deep spark plug wells, use rigid, insulated extenders projecting out of the well.

The use of a clear, silicone grease (such as Dow Corning DC-4, GE G-623 or GC Electronics Z5) is recommended for all high-tension connections and boots. This material helps seal out moisture and prevent corrosion from atmospheric sources.

5.15 Troubleshooting Altronic Ignition (A-32 only)

5.15.1 Troubleshooting Engine Wiring and Installation

If ignition problems are suspected, first check that all ignition wiring is in good condition. Make sure a ground lead is run from the negative terminal of the appropriate ignition coils to engine ground and back to the alternator housing. Check that the air gap between the pick-up module and magnet disc does not exceed 1/8".

5.15.2 Troubleshooting Engine Shutdown System

If the system appears to be installed correctly with all wiring in good condition, first remove all shutdown wires from the center terminal of the electronic box on the alternator. Attempt to start the engine. This will isolate the shutdown switches and wiring which may be causing the problem by partially or completely shorting out the ignition.

CAUTION

Do not leave the engine operating with the shutdown wires disconnected.

5.15.3 One Cylinder Misfiring

1. Check high tension lead for connection at coil and spark plug.
2. Check spark plug.
3. Change ignition coil.

5.15.4 Two or More Cylinders Misfiring

1. Check all ignition wiring and connections.
2. Disconnect the white shutdown lead of the pick-up module cable (5-pin connector) from all shutdown devices to be sure problem is not caused by a complete or partial short to ground in the shutdown switches or wiring.
3. Check electronic box and alternator - see UNIT CHECK section.
4. Change pick-up module.

5.15.5 Altronic 1 Unit Check

If a problem is suspected with the Altronic 1 unit, a further test may be performed to determine whether the problem is with the electronic box or the alternator stator winding. First, disconnect all connections to the unit and remove from engine. Proceed as outlined below.

NOTE

Erratic or continuous firing while the engine is operating indicates a faulty electronic box.

1. Remove the electronic box from the alternator and disconnect the two leads. The alternator stator winding can be checked in two ways:
    - Turn the alternator shaft with the two leads shorted together. If the alternator stator winding is OK, a loading effect will be noticed as compared with turning the shaft with the leads separated.
    - Check the stator winding for continuity using an ohmmeter on the RX100 scale; a correct reading is 950-1,250 ohms. An infinite reading should be obtained from either lead to the alternator case.
2. If either of the tests of above indicates a defective alternator stator, replace the alternator. If either of the tests indicates an operating stator winding, replace the electronic box.

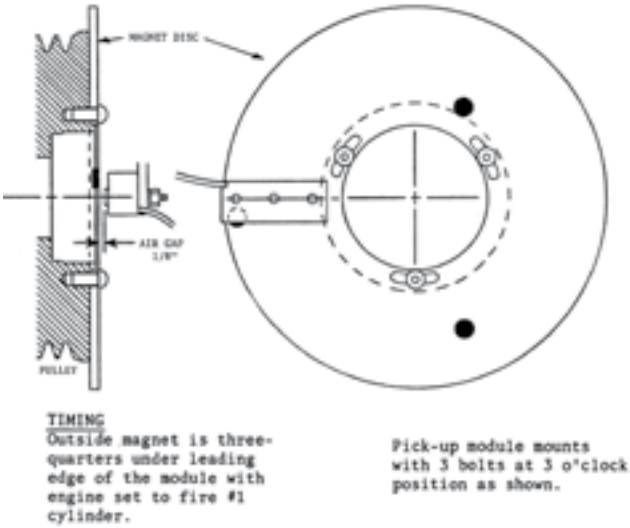


Figure 17 Alternator Stator

5.15.6 Spare Parts

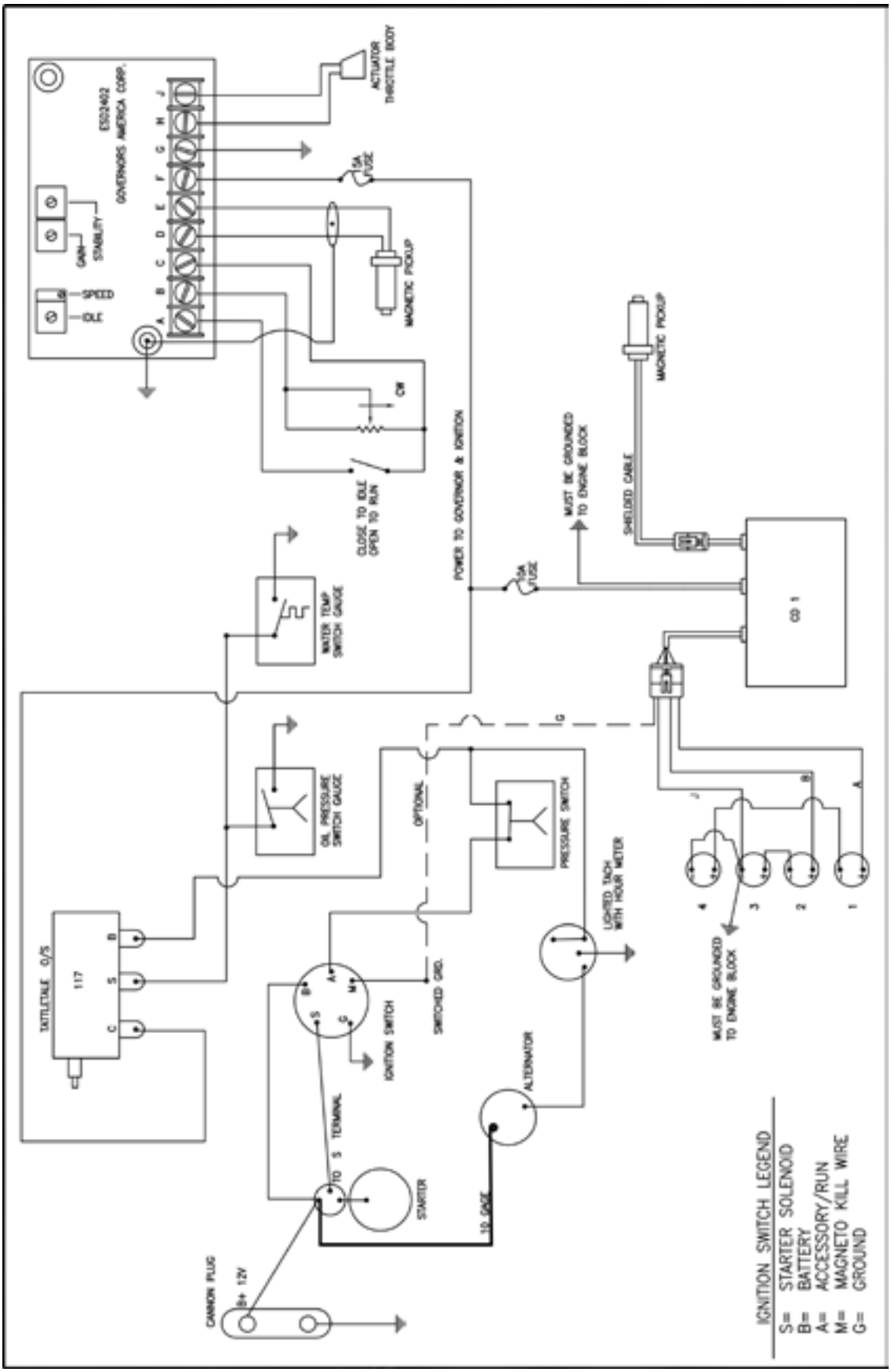
The following are spare parts for the Altronic 1 system:

Altronic 1 SPARE PARTS	
PART NO	**DESCRIPTION**
171 003	Stator winding
181 006*	Electronic box, standard
181006-X	Electronic box
191 003-12 Pick-up module	12” black lead
191 003-36 Pick-up module	36” black lead
191 003-72 Pick-up module	72” black lead
501 061	Ignition coil, unshielded

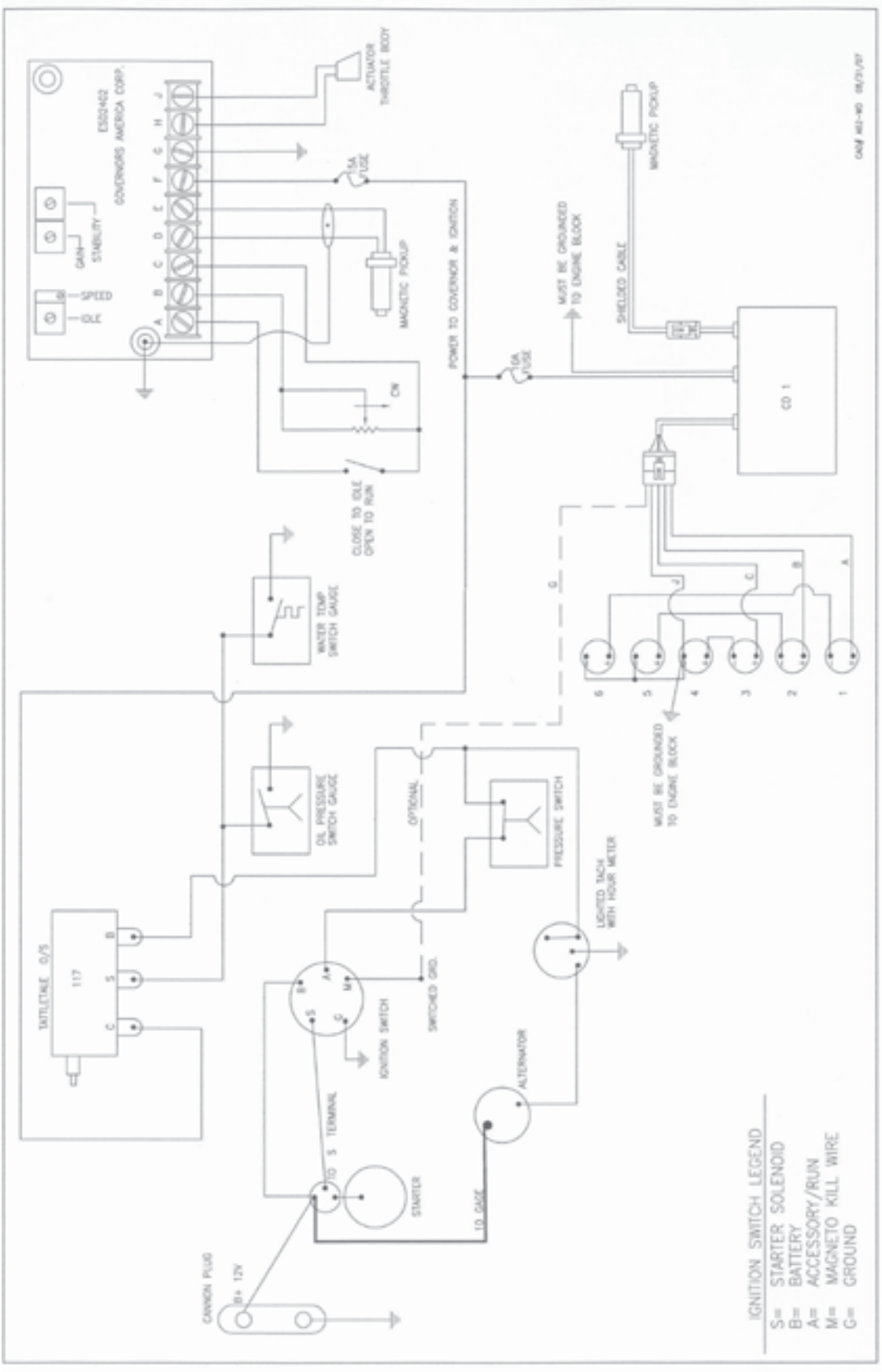
* Replaces prior part no. 181 003.

** Replaces prior part no. 181 003-X.

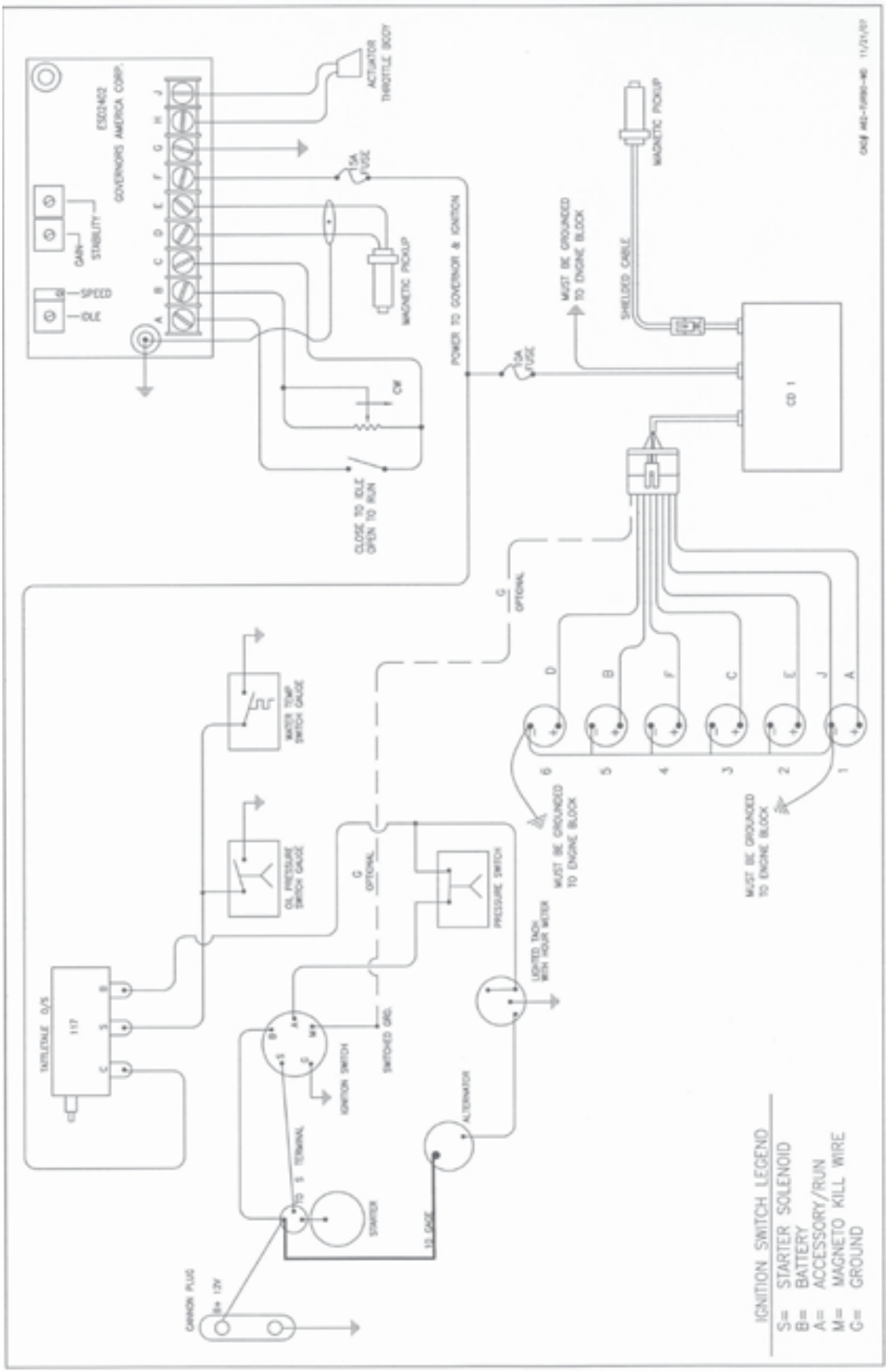
5.16 Wiring Diagram - Altronic CD-1



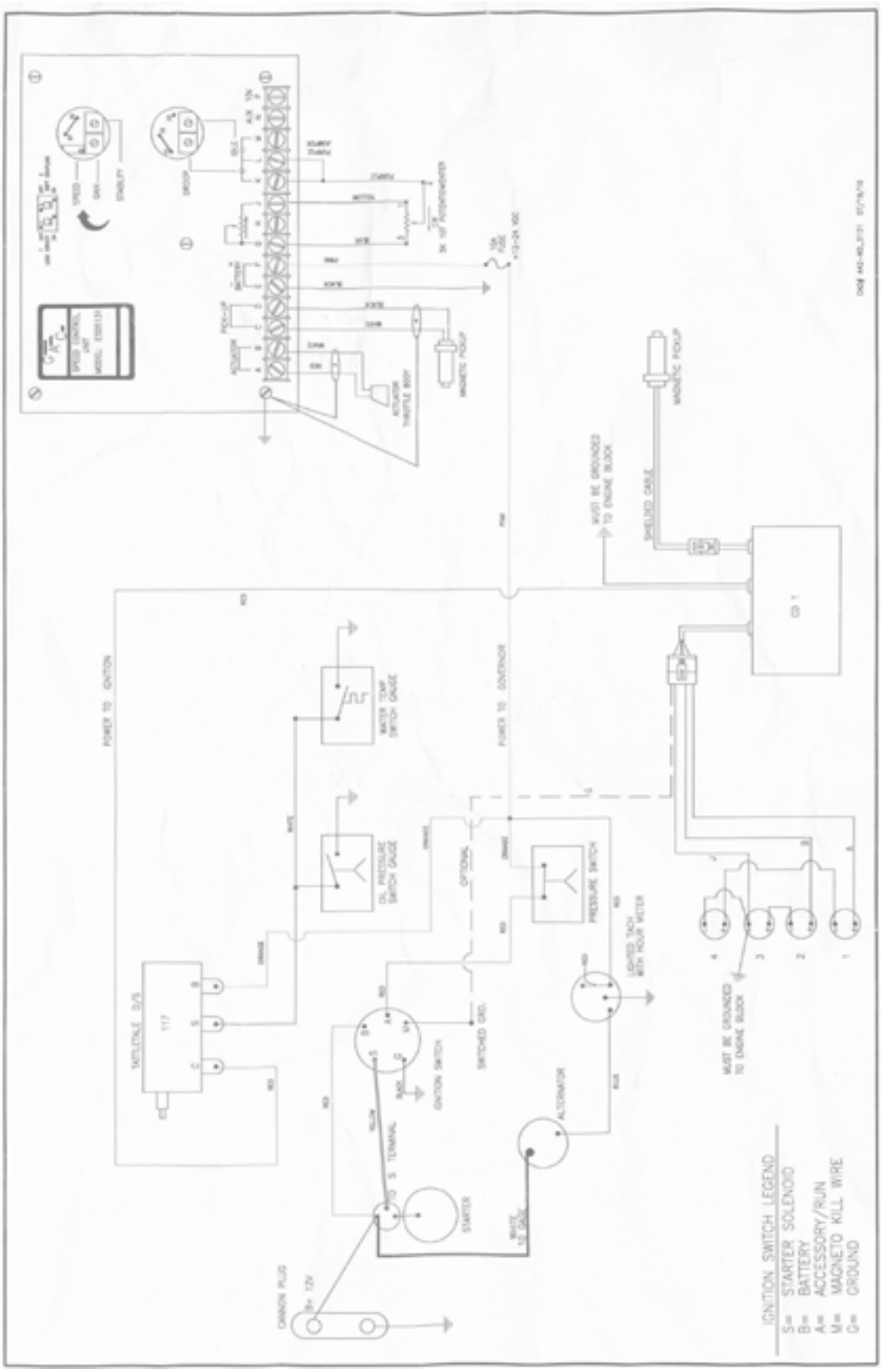
5.17 Wiring Diagram – Non-Turbo 6 Cylinder



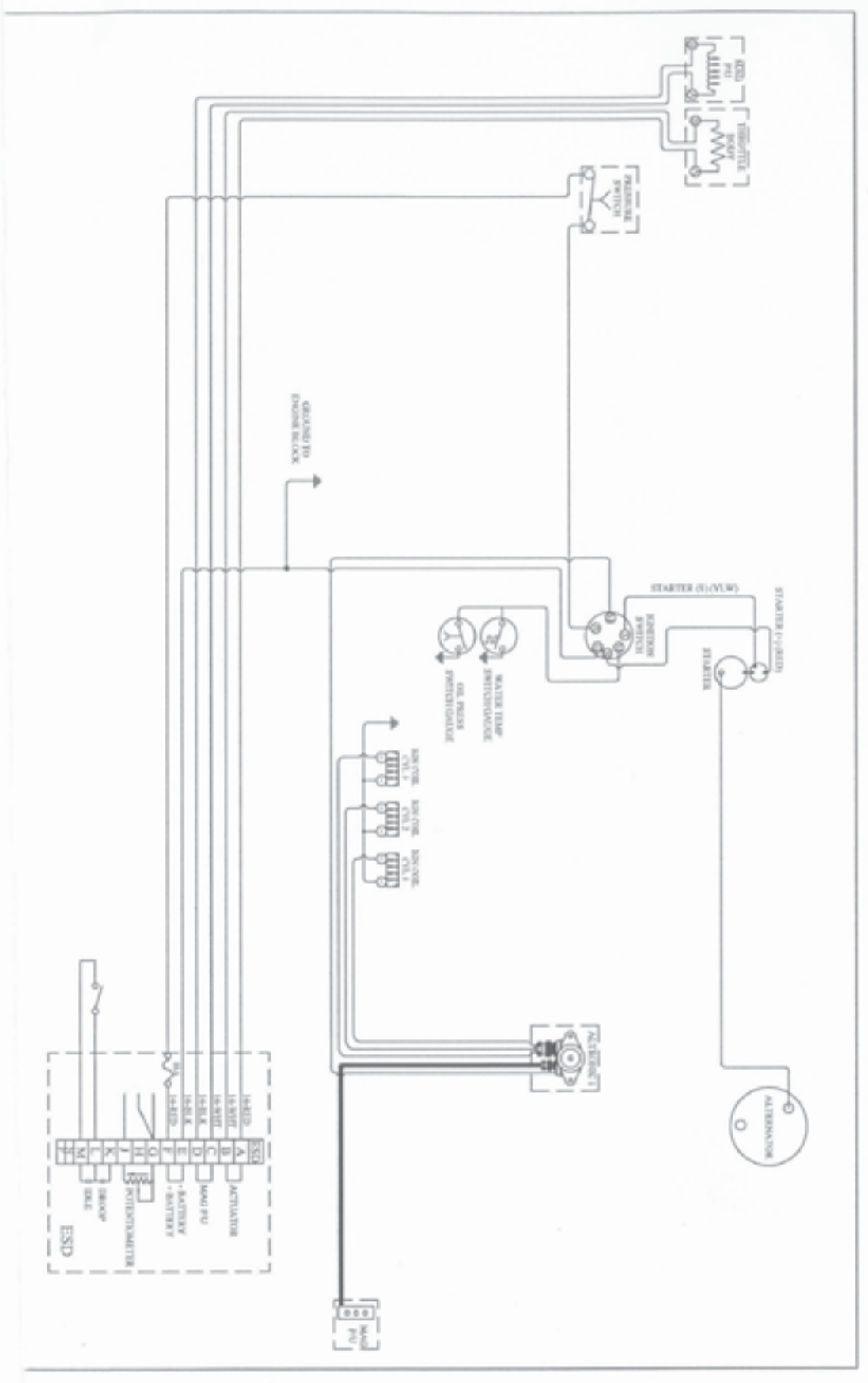
5.18 Wiring Diagram – Turbo 6 Cylinder



5.19 Wiring Diagram – 5131 4 Cylinder



5.20 Wiring Diagram – Altronic 1



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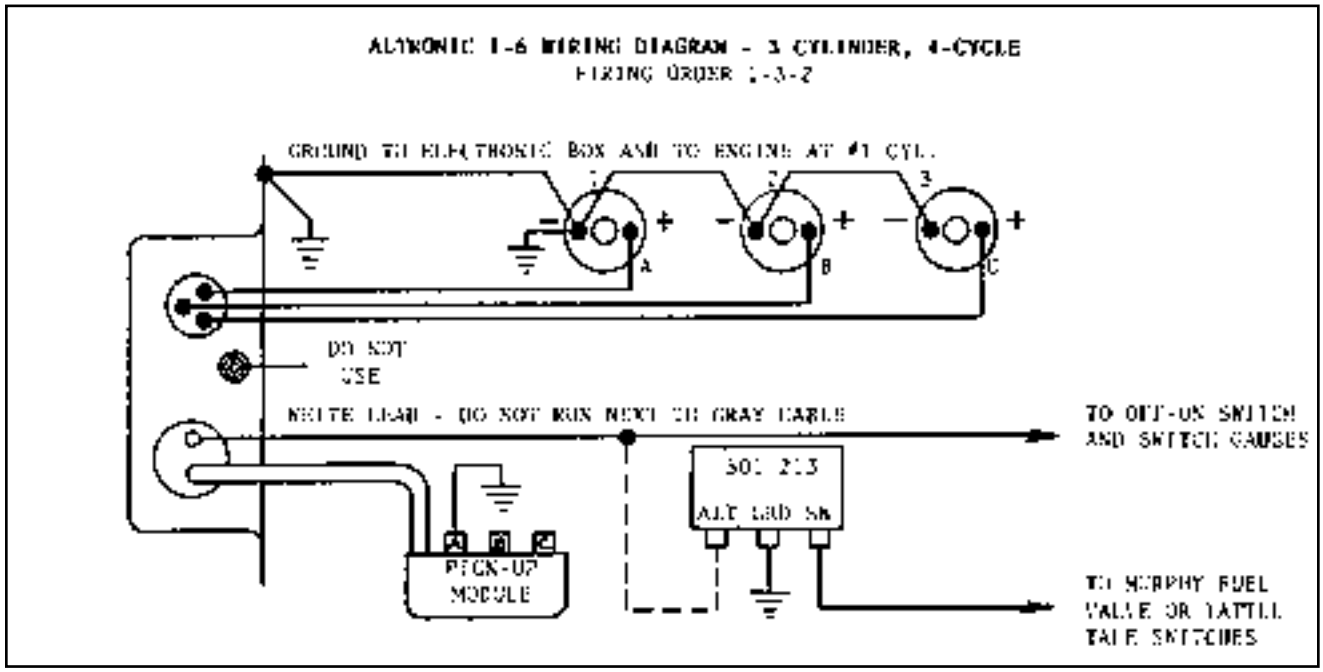
5.21 Wiring Diagram – Altronic 1 (3-cylinder, 4-cycle)



6 Installation

6.1 Cooling System

6.1.1 Cooling System Inhibitor

To prevent rust when using water alone, use a corrosion preventive or inhibitor.

6.1.2 Cooling System Recommendations

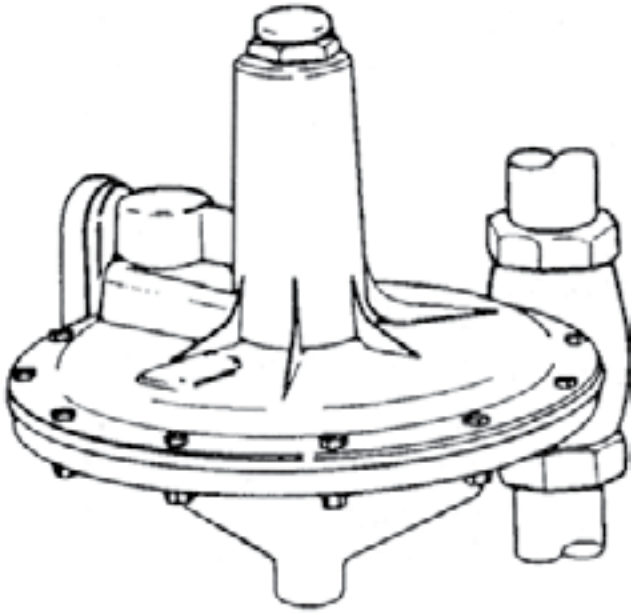
Prior to filling the cooling system, clean all dirt and welding spatter from low points in the system. Flush accessible sections of the piping and cooler to eliminate as much dirt as possible prior to operation of the engine.

After filling the system, check closely for leaks. Tighten all clamps and fittings prior to engine start up to avoid loss of time at start up.

The following installation suggestions are offered to improve cooling system performance and make future maintenance easier and less time consuming.

1. Mount all cooling system components, such as water inlet connections, control valves and raw water pumps, with at least enough clearance to permit normal maintenance and removal and replacement of accessories at the front of the engine without major disruption of the cooling system.
2. Use suitable couplings so large portions of the piping and valves and raw water pump complex may be disconnected and moved aside as a unit for engine repair and maintenance. This avoids removal of individual pieces of pipe and working backwards to reach a given threaded connection.
3. Provide convenient drainage points to remove water from both fresh water and raw water systems.
4. Provide easily opened air vents to remove air blocks from cooling system piping and allow immediate priming of system.
5. Mount all belt driven water pumps so belts may be tightened easily while operating. Locate pump couplings and drive pulleys so packing can be removed and replaced without major disassembly or pump removal.
6. Keep the system clean
7. Avoid electrolysis; use zinc anodes or other cathodic protection.

6.1.3 Fuel system



Generally, natural gas is supplied by utility owned lines that run to the installation site.

The major components in the natural gas fuel system are the regulators, piping and the carburetor.

Pressure regulators are designed to control the pressure of the gas as it enters the engine. Through an arrangement of a diaphragm and springs, the pressure of the natural gas coming to the engine is lowered and controlled. This supplies a constant steady supply of gas to the carburetor.

There are two common types of pressure regulators used: a high pressure line, or "Big Joe", regulator mounted near the main fuel line, and a low pressure engine regulator.

The line regulator brings the pressure in the lines leading to the engine regulator to 5-10 psi (.35 - .70 kg/cm^2). The engine regulator sets the gas pressure to the carburetor. From the engine mounted regulator the gas flows into the carburetor. Air is mixed with the gas, and it flows into the engine to be burned.

Low gas pressure will starve the engine of fuel and reduce engine output. High pressures could damage the regulator, allowing excessive fuel to flood the cylinders. This could lead to detonation and serious engine damage.

If possible, avoid fueling any gas operated equipment off of the supply line between the line regulator and the engine regulator. Regulators must be spaced according to the inner diameter of the pipe used. For a general rule of thumb, the maximum allowable distance between regulators is eight times the pipe ID. [For example, with a 2" pipe, the maximum distance between the regulators is 16" (406.4 mm)]. Some regulators must be mounted in an upright position. Consult the regulator manufacturer for specific information.

6.1.4 Air Intake System

Combustion air requirements for the A-32, A-42 (VR260), and A-62 (VR380) engines may be obtained from your Arrow sales engineer.

The following factors must be considered to ensure an adequate clean supply of combustion air for internal combustion engines:

1. Combustion air required for engines installed in heated and/or air conditioned buildings may upset heating and ventilating calculations unless it is supplied via an external air intake.

2. If an external air intake is required, it must be suitably designed to supply intake air of the proper temperature range (high intake air temperature results in power loss while extremely cold intake air may hinder starting of automatic standby units.) An external air intake must also prevent pick up of exhaust gas materials or exhaust from other industrial equipment prevent pick up of flammable vapors and prevent entry of rain and water.

3. All ducting, as well as air cleaner to manifold connections, must be airtight to avoid the intake of unfiltered air.

4. Restriction of the air intake system must be kept to a minimum. Restricted inlets, sharp or numerous bends and undersized ducting will all decrease air flow to the engine.

5. Engine heat radiation will affect ambient air temperatures in building installations. Properly located intake and exhaust fans will be required in warmer climates or seasons to ventilate engine rooms.

6.1.5 Exhaust System

The large quantities of combustion air consumed by internal combustion engines must be properly exhausted after combustion occurs. Therefore, every possible provision must be made to minimize restriction with resulting back pressure of an exhaust system.

Some of the adverse effects of excessive back pressure are loss of power, poor fuel economy, excessive valve temperatures and engine coolant overheating.

If exhaust back pressure is found to be excessive, check for undersized piping, an undersized or inefficient silencer or muffler or excessive bends or restrictions in the exhaust system (20" of WC max). Correct any deficiencies.

Exhaust pipes must be adequately sized and supported. A condensate trap and drain must be provided at some low point ahead of the engine exhaust manifold. The back pressures caused by overuse of elbows and other pipe bends prohibit their use in a well-designed exhaust system. Always use long radius elbows - the radius of the turn should be at least 4-5 times the pipe diameter to prevent exhaust restriction. Multiple exhaust connections to a common header are not recommended as this can result in erratic operation and damage. Sometimes, pulsing effects can set up interferences in a single sight pipe thus making it beneficial in some installation to locate the silencer as close to the engine as possible.

Attention must be given to adequate silencing of the engine as unnecessary noise is objectionable and may, over time, damage the hearing of the

operator and is a public nuisance. Objectionable noise is unnecessary today with the available mufflers which can be used for silencing.

Exhaust flow requirements for the A-32, A-42 (VR260), and A-62 (VR380) engines may be obtained from your Arrow sales engineer.

CAUTION

Maximum distortion of flexible exhaust connector, due to connected exhaust piping is ± ¼ inch (6.35 mm) offset and ± ¼ inch (6.35 mm) axial deflection.

Flywheel, Housing Runout, & Crankshaft Endplay

Even with the best maintenance, an engine can encounter trouble if such things as proper mounting, alignment with other equipment, flywheel and housing runout and sufficient crankshaft endplay are disregarded in the initial installation or in subsequent relocations of the engine. Although flywheel and housing runout and crankshaft endplay are firmly established within limits at the factory, such things as rough handling or improper installation of power take-offs or clutches may adversely affect these clearances and lead to serious engine damage. These items should be checked prior to operation.

A major factor in obtaining long service life from any engine and clutch or power takeoff assembly is the proper alignment of the flywheel housing, flywheel and pilot bearing bore. Distortion or lack of a common center on either of these parts will set up forces sure to be destructive to bearings, crankshaft, clutch and the driven equipment. In addition, because of normal manufacturing tolerances, when an engine is installed in a mounting formerly occupied by another engine, it is not safe to assume that the drive shaft of the power take off will automatically line up with a coupling located for the previous engine. In such circumstances, either the engine mounts must be shimmed or adjusted or the driven mechanism must be relocated and adjusted a few thousandths to bring the engine drive line from crankshaft bearing to driven shaft coupling into good alignment.

Check Housing Bore Runout

Make the following check for flywheel housing bore concentricity:

1. Support a dial indicator in the same general manner as shown and check the runout of the housing bore all the way around.
2. If the flywheel housing is out of alignment, loosen all of the flywheel housing bolts and proceed as follows.
3. Use a small bar inserted in a bolt hole to correct misalignment until the runout does not exceed 0.008” (0.2 mm) total indicator reading.
4. Tighten bolts partially, working back and forth across the housing. Recheck bore concentricity with dial indicator.
5. Relocate the dial indicator as shown to indicate the flywheel housing face.

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Check Housing Face Runout

Housing face runout should not exceed 0.008" (0.2 mm) total indicator reading. If correction is required, it should be done with a cutting tool mounted on a radius arm and firmly attached to the flywheel. Thus, by rotating the crankshaft by means of a suitable drive, the cutting tool will dress the housing face into a plane in alignment with the camshaft flange.

1. When making the above inspection, it is very important not to be misled by end movement of the crankshaft. To prevent this, use a pry bar to bring the shaft into full forward position at each point where the indicator reading is taken.

Check Pilot Bearing Bore Runout

Mount a dial indicator on the flywheel housing as shown and check the runout of the pilot bearing bore. Run out should not exceed 0.005" (0.127 mm) total indicator reading.

Check Flywheel Face Runout

Remount the dial indicator as shown to measure the runout of the flywheel face. Again it is emphasized that each reading must be taken with the crankshaft moved all the way forward to contact the thrust bearing. Unless handling

has somehow distorted the wheel or crankshaft flange, maximum runout should not exceed 0.008" (0.2 mm) total indicator reading.

Check Crankshaft Endplay

Measure crankshaft endplay with a dial indicator mounted on the crankcase. Use a small pinch bar to move the crankshaft fully forward. Set the indicator at zero and use the bar to thrust the shaft to fully rearward. Check endplay reading on dial indicator with the tolerance given in Section 9.

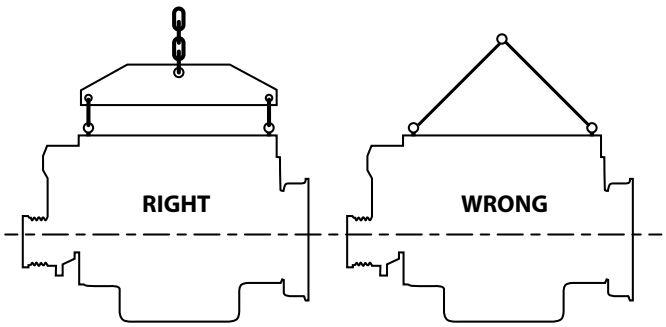
CAUTION

The importance of correct crankshaft endplay cannot be overstressed. Operation of an engine having insufficient or excessive crankshaft endplay can result in serious damage. Insufficient clearance will prevent proper lubrication of the thrust surfaces causing the main bearings to overheat and lock on the shaft.

6.1.6 Lifting Requirement

Inappropriate lifting might damage the engine while moving.

It is inappropriate to use a chain and a triangle to sling the engine up. In a triangle sling, the cylinder head bolt and the swinging ring are not kept in a line. The cylinder head bolt could be damaged or even fractured which may eventually lead to the failure of the engine.



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7 Operation

7.1 Preparation Before Start

Any resistance to free cranking should be thoroughly checked out; rust and corrosion can cause the engine to seize.

Check the connections for proper battery polarity. When a dry cell battery is used, the battery should be charged prior to use.

7.1.1 Filling the Engine With Oil

The oil must be of the proper weight and clean - see section 7.2.6 Lubricating Guide.

1. Make sure the oil drain plug is installed and properly tightened.
2. Open the oil cap and fill the case with correct oil (7.2.6 Lubricating Guide) until the oil reaches the full level on the dipstick.
3. Making sure that the engine is level, pull and check the dipstick. Fill the oil till it reaches the upper limit marked on the oil dipstick.
4. Replace the oil filler cap.

Check the oil level every time the engine is started.

7.1.2 Filling with Cooling Fluid

The cooling fluid is a mix of softened clean water and an anti-corrosive or antifreeze 50/50 mix. Please follow the antifreeze manufacturers recommended process and quantities.

NOTE

Frequent water adding and water changing might result in coolant deposits. Leaking of the cooling system should be repaired as soon as possible Add clean soft water if at all possible and avoid changing the cooling fluid if possible. The cooling fluid drained from the water tank may be recycled after being filtered through fabric and a fine mesh. Fill the cooling fluid into the water inlet of the radiator or heat exchanger and discharge the air of the cooling system. Refer to section 7.2.3 for more detailed information on the cooling fluid. The cooling fluid level must be checked every time the engine is started.

7.1.3 Attaching Gas Line

When starting the engine for the first time, purge air from the gas line. This will clear air and any foreign matter from the gas line and provide fuel for starting immediately.

CAUTION

Natural gas is highly explosive.

7.2 Start Up

7.2.1 Before Starting

1. Be sure the main clutch, circuit breaker, or other power transmission device is disengaged.
2. Trace through the external cooling system to make sure all control valves are properly opened and the drain cocks closed. Check the coolant level.
3. Inspect drive belts water pump alternator and other equipment. Examine for good condition and correct tension.
4. Make certain all guards are secure on engine and driven equipment.
5. Check the air restriction indicator, if engine is so equipped. Clean air filter element and dust cap if indicator shows red. Check oil bath type air cleaner daily.
6. Check the oil level as indicated on the oil dipstick prior to starting engine. Stop engine and recheck oil level after 5 to 10 minutes of operation at a low idle. Add oil as required to bring level to full mark.
7. If the engine has been out of service for an extended period of time, bar it over by hand to be sure it is free.
8. On the speed control unit, make sure the GAIN, Stability and (if applicable SPEED TRIM CONTROL are set to the mid position.

7.2.2 Start

Crank the engine and the actuator will energize to the maximum fuel position until the engine starts. The governor system should control the engine at a low idle speed. If the engine is unstable after starting, turn the "Gain" and "Stability" until the engine is stable.

7.2.3 Quick Trouble Check Chart

Check Controls	Follow starting steps, re-setting safety controls. Remote or automatic operation engines have special procedures.
Check Fuel System	Be sure fuel is getting to the engine. Check to assure that the valves are open. Check the possibility of water, rust or pipe scale.
Check the Cooling System	Check the coolant level and assure that the system is not air locked. Check that the radiator is not blocked by trash and that the shutter is open and the fan is operating. Check that the water valves are open to the heat exchanger.
Check the Intake/ Exhaust System for Blockages	Check to see if the air filter is dirty and check the air restriction indicator. Make sure the air intake or exhaust outlet is not capped.
Check Mechanical Components	Check the throttle and governor control linkage for freedom from sticking and interference. Examine the condition and tension of the accessory drive belts. If the cranking speed seems low, check the batteries condition.
Check Ignition	Check for water in/on the ignition parts and wires. Check for signs of corrosion at the wire terminals or for broken wires. Check for proper spark plug gap and condition.

If these checks do not solve the problem, refer to the Troubleshooting section.

7.2.4 Break-in Procedure

New or overhauled engines should receive a break-in run. This operation can be performed with the lube oil weight specified in 7.2.6 Lubricating Guide. After a warm up, proceed with a load and unload cycle. Repeated loading (minimum of half load, maximum full load) with equal idle periods in 5 minute intervals for a period of two hours, results in a rapid break-in and quick seating of piston rings. Never idle for more than 15 minutes during the break in or for the first 100 hours of operation.

NOTE

Stand by generator engines should follow this procedure using a load bank.

7.2.5 Exercise of Stand-by Unit

It is recommended that a generator set or other stand by unit be exercised once each week. A record should be maintained of performance, incidental servicing and output of both the engine and driven equipment.

Always operate the engine long enough to stabilize oil and water temperatures at the normal operating level expected under load. Do not operate under no load conditions for other than very brief periods. Loads of at least one third up to the normal rated capacity are recommended. Ordinarily, an exercise run of one to one and one half hours will be needed to stabilize temperatures. If the engine cannot be loaded it should not be exercised for more than 10 minutes each exercise period.

It is recognized that some types of driven equipment cannot be operated without fairly extensive procedures to put them on line. Examples are hospital generators in some types of switching configurations; air conditioning compressors which can only be loaded by changing over to chilled water from heating water circulation; and pumps which are not set up for waste discharge or recirculation. In such cases, weekly exercise periods may have to be reduced, where possible, to operational periods long enough only to prove the engines ability to crank and start or checkout of starting circuitry and safety equipment with the starter disabled. In this event, special attention must be taken to prevent internal corrosion, sticking and gumming of fuel controls

and deteriorated starting batteries. In all cases, arrangements should be made to run the engine and driven equipment under load at least every 90 days.

7.2.6 Light Load Operation

We recommend that the A-32, A-42 (VR260), and A-62 (VR380) engines consistently run above 50% load or higher. Contact Arrow factory if operating below 50% continuous load is necessary.

7.2.7 Engine Warm-Up

Proper engine warm up is important for long engine life. A warm up period allows for an even thermal expansion of engine components. Also, the lubricant warms up and attains normal viscosity during warm up. Oil pressure is also built up assuring proper oil distribution and lubrication of vital engine parts.

NOTE

Stand by units that require immediate full load pick up can be equipped to maintain a constant oil pressure and engine temperature. Consult your Arrow distributor for further information.

To warm the engine up, run the engine at a medium engine speed with no load. Warm up engine until oil pressure stabilizes and coolant temperature reaches at least 100°F - 120°F (37.78°C - 48.89°C.)

CAUTION

If adequate oil pressure is not indicated within 25 to 30 seconds shut the engine down at once and determine the cause. Never operate an engine without adequate oil pressure readings in the hope that a faulty gauge or cold oil is responsible. The problem could be something else and serious engine damage would result.

7.2.8 Governor Speed Setting

The Speed set point is increased by clockwise rotation of the "Speed" rotation pot.

Once the engine is at operating speed and at no load, the following governor performance adjustment may be made.

Rotate the "Gain" clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further counterclockwise to insure stable performance (270°pot.)

Rotate the "Stability" clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further counterclockwise to insure stable performance (270°pot.)

"Gain" and "Stability" adjustments may require minor changes after engine load is applied. Normally, adjustments made with no load achieve a satisfactory performance. A strip chart recorder can be used to further optimize the adjustments.

If instability cannot be corrected or further performance improvements are required, refer to the Troubleshooting section.

7.2.9 Stopping the Engine

Do not stop the engine with a full load. Decrease the speed before stopping the engine and let it run idly for another 5 to 10 minutes. Shut the power off after the engine is stopped

Any engine whose cooling fluid does not contain anti-freeze must have the cooling fluid drained off after the engine is stopped so as to prevent the engine from being damaged.

8 Maintenance

8.1 Timetable for Maintenance

8.1.1 Regular Maintenance Schedule:

WORKING ITEMS	OPERATING TIME IN HOURS					
	DAILY	WEEKLY	250	750	1000	ANNUALLY
Check air restriction indicator and clean filter if the indicator is red	X					
Check oil and coolant levels	X					
Check belts for tension and condition. Make sure guards are secure.		X				
Check electrolyte level in battery and fill as required. Inspect terminals for corrosion. A specific gravity of between 1.250-1.285 with all cells within 0.010 and 0.015 of each other indicates a well charted battery		X				
Clean the air filter element*			X			
Check hoses			X			
Clean the crankcase and inspect breather			X			
Spark Plugs - Inspect - gap 0.025” (0.635 mm)			X			
Change the oil and oil filter element				X		
Clean oil cooler				X		
Check valve clearance					X	
Check anti-freeze concentration					X	
Carburetor - Inspect diaphragm and replace if cracked or deteriorated						X
Lubricate clutch at the manufactures recommended intervals.						

* The change should be made earlier in a dusty location.

If the engine is stored for weeks, it must be sealed up.

8.1.2 Maintenance Schedule for Standby Usage.

TIME PERIOD	REQUIREMENT
Every month	Trial running with load
6 months	If the running time does not reach 500 hours after 6 months, carry out the required maintenance.
After 12 months	If the running time does not reach 1000 hours after 12 months, carry out the required maintenance.

8.1.3 Engine Performance Record

Engine operating information, recorded during regular inspections is necessary to apply proper Preventive Maintenance schedules. Accurate records help control costs by avoiding unnecessary servicing; ensuring needed servicing and provides trend information on the general engine condition. We recommend keeping a record of the following information, selecting items applying to your engine:

- Hour Meter Reading
- Tachometer RPM
- Fuel Meter Reading
- Engine Oil Pressure
- Engine Oil Temp
- Coolant Temperature
- Gas Pressure at the Carburetor Intake
- Manifold Vacuum
- Crankcase Pressure pos/neg
- Unusual Noise(s) or Vibration
- Oil Leaks
- Coolant Leaks
- Alternator Output

8.1.4 Fuels

Arrow A-32, A-42 (VR260), and A-62 (VR380) gas engines are designed to burn natural gas. All power ratings are based on natural gas with a heat value of 900 BTU/cu. ft. (LHV)

Required fuel conditions:

1. Methane content of at least 70% by volume or gross calorific value of 950-1100 BTU/per standard cubic foot.
2. Maximum liquid fuel hydrocarbons at the coldest expected engine mounted regulator fuel outlet temperature is 2% or less by gaseous volume.
3. Maximum total organic halide content, expressed as chlorine concentration (TOHC1), is 60 micrograms/liter.
4. Maximum permissible free hydrogen is 12% by volume.
5. Maximum solid particle size is 5 microns.
6. No liquid water is permitted at the outlet of the engine mounted fuel regulator at the coldest expected temperature.

8.2 Maintenance Procedures

8.2.1 Air Filter

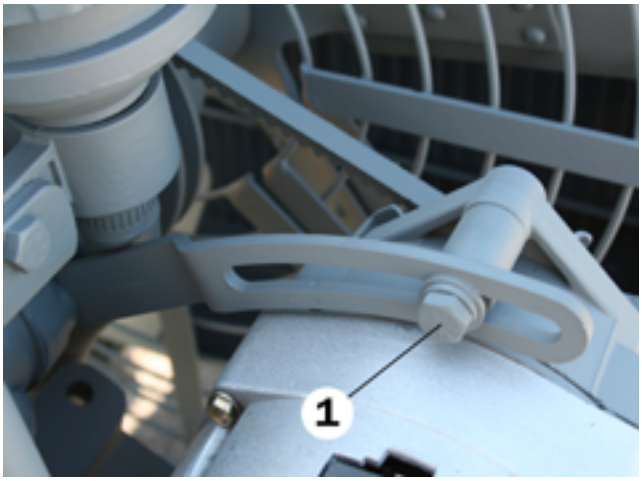
Follow the directions attached to the cleaner if any are present. An air restriction indicator device mounted in the piping from the circular style air filter serves as positive evidence when air filter service is necessary.

CAUTION

Unless the signal is locked in view indicating a clogged air cleaner, it will return to a normal setting upon engine shut down. Normally the element is serviced long before the gauge indicates a need but the operator is cautioned to check the gauge every day while the engine is running. After the element has been serviced, the reset button on the restriction indicator should be depressed to re-set it.

The A-32, A-42 (VR260), and A-62 (VR380) engines use a circular style air cleaner. This style cleaner is has a pre-cleaner built into each assembly. Dirt trapped by this pre cleaner will be collected in a dust cup or the end of the filter. When removing dust cup and filter element, be careful not to spill any dirt on the engine.

8.2.2 Check and Tension the V-belt



Press the v-belt. If the distortion is more than 3/8”-5/8” (10-15 mm) the belt should be replaced.

To tighten the belt through the alternator, loosen the bolt (1), pull the alternator outwards, then tighten the bolt and check the belt by hand.

8.2.3 Cooling System

The cooling water of the engine must be soft water mixed with an anticorrosive (in warmer climates) or anti-freeze (in cooler climates.)

8.2.4 Anti freeze

The cooling system of the bare engine holds about 10 quarts (9.46) of water (12-13 quarts [11.35 L - 12.3 L] with a radiator) without provision for other equipment. When adding anti-freeze compounds on a percentage basis remember to include the coolant volume of the radiator and other external parts of the cooling system. The following table may be used as a guide. Please refer to the anti-freeze manufacturer's instructions for the mixing ratio of long acting anti-freeze fluid.

The concentration of the anti-freeze should be checked once every 1,000 hours or once every season. The anti-freeze should be changed every two years to avoid corrosion.

Never fill the cooling system with water only in potential of subfreezing conditions. Freeze damage will occur in these conditions without correct antifreeze protection.

Glycol content %	Density at 60°F (15.6°C)	Radiator Glycerine (GPA) %	Boiling point	Freezing point	Min temperature appropriate
25		55		10±2°F (-12.2±1°C)	23°F (-5°C)
33	1.05	70	220.1±2°F (104.5±1°C)	-0.4±2°F (-18±1°C)	14°F (-10°C)
50	1.074	100	227.3±2°F (108.5±1°C)	-32.8±2°F (-36±1°C)	-14.8°F (-26°C)
56	1.082	100	230±2°F (110.0±1°C)	-49±2°F (-45±1°C)	-31°F (-35°C)

8.2.5 Cooling Water

The composition of the cooling water is as following:

Water quality	Min	Max
pH value	6 5	8 5
The content of chloride ion mg/dm^3	–	100
Content of carbonate mg/dms	–	100
Content of overall anion mg/dms	–	150
Degree of hardness when using the anti-freezing agent	3	12
Degree of hardness of the carbonate	3	–
Degree of hardness when using chemical anticorrosive agent. Note the manufacturer's instructions.	0	10

Thermostat

Under normal conditions the heat sensitive thermostat in the water outlet will maintain temperatures within the desired limits.

CAUTION

Never operate engine with thermostat removed as engine damage may occur.

8.2.6 Thermostat Removal and Testing

Ordinarily, thermostats will seldom need replacement in the field. They should be checked from time to time however and are quickly accessible by removing the thermostat housing at the forward end of the cylinder head. The steps necessary to accomplish this are simply the removal of the water outlet connection hose, and the cap screws securing the housing. Thermostats damaged by corrosion or other causes are not repairable and must be replaced.

Thermostats should be tested in hot water for proper opening. A bucket or other container should be filled with sufficient water to cover the thermostats and fitted with a good quality thermometer suspended in the water so that the sensitive bulb portion does not rest directly on the bucket bottom or side. A stove or torch is used to bring the water to a heat range of 180°F

(82.2°C) while the thermostat is submerged in the water. Stir the water for even heating. As the temperature passes the 175°F - 180°F (79.4°C - 82.2°C) range the thermostat should start to open, and should be completely open when the temperature has risen to 200°F - 202°F (93.3°C - 94.4°C) Lifting the thermostat into the colder temperature of the surrounding air should cause a pronounced closing action and the unit should close entirely within a short time. A large thermostat is used in order to ensure adequate reserve circulation for heavy operation and to pass large volumes of cooling water. Use care to seat the thermostat squarely and concentrically to avoid interference with the thermostatic action. Be certain the thermostat housing seal is in place.

Please note that the preceding test applies to the typical water temperature gauge used on Arrow engines. If engines contain special controls, test procedures may be obtained from Arrow Engine Company Customer Service Department.

8.2.7 Cleaning the Cooling System

When clean soft water is used as a coolant and when the proper inhibitors or antifreeze solutions are used, radiator and cooling passage accumulations will not be excessive. About once each year, however, the engine will benefit if the cooling system is cleaned of sludge and sediment. It is recognized that a number of excellent commercial cooling system cleaners are available

NOTE

ARROW ENGINE COMPANY SUGGESTS, HOWEVER, THAT AN OPERATOR CONSIDERING THE USE OF SUCH A CLEANER FIRST INVESTIGATE ITS POSSIBLE REACTION WITH THE COPPER AND BRONZE PARTS IN THE ENGINE. If such a cleaner is used, follow the manufacturer's recommendations carefully.

8.2.8 Water Pump

The belt driven water pump requires no special packing or attention during its service life. An internal seal used in combination with a permanently lubricated integral ball bearing and pump shaft provides a durable ruggedly constructed water pump.

NOTE

Change the belt if it is damaged or oily.

8.2.9 Treating of Waste Oil and Coolant

Both used oil and used anti-freeze are quite toxic. Both should be stored in labeled containers, never mixed with other substances, and sent in for recycling. In the US, each state will have its own requirements - for a listing of state and regional regulatory agencies go to: www.epa.gov/epaoswer/osw/comments.htm or call the EPA RCRA hotline at 1-800-424-9346. Please take care to avoid skin contact or ingestion of either used oil or coolant.

8.2.10 Lubrication Guide

Lubrication intervals listed are for normal operation and should coincide with other preventive maintenance services, however under unusual conditions; intervals should be shortened if there is evidence of dirt, sludge or breakdown of lubricant. The following precautions should be observed when lubricating the engine.

1. Keep all lubricants in closed containers and store them in a clean dry place away from heat. Always protect the lubricants from dust, dirt or moisture. Keep lubrication equipment clean and ready for use at all times.

2. Before lubricating, wipe surrounding areas clean to prevent dirt or other foreign matter from entering the lubrication system. Use a cloth moistened with solvent to remove any old or hardened lubricants. After lubricating, remove any excess lubricant and wipe any spilled lubricant from parts not requiring lubrication.

8.2.11 Lubricating Oils

The performance of a lubricant, like that of any manufactured product, is the responsibility of the refiner and producer. Also, the engine operator, to a large degree, controls the oil's performance, for the operator is the one who must make decisions on oil changes, filter changes, loads, general maintenance and operating conditions.

NOTE

Synthetic lubricating oils are not recommended by Arrow.

8.2.12 Service Conditions

Oil performance will reflect engine load, temperature, fuel quality, atmospheric dirt, moisture and maintenance. If oil performance problems arise or are anticipated, the oil supplier should be consulted.

Extended oil change intervals should be utilized with caution on any engine using highly dispersant oils, the dispersants function by absorption of particles of contaminants; however, when dispersant saturation is reached, these oils tend to "dump out" all of the suspended contaminants in a relatively short period of time. Laboratory analysis will not predict the "dump out" point precisely; consequently, closer operator attention to engine conditions is required when establishing an extended oil change interval.

When fuel is burned in an engine combustion chamber, any sulfur it contains is converted to sulfur oxides, which will combine with water vapor to form acids. These acids can cause serious corrosive damage to engine components. The engine oil should be compounded to neutralize thee acids and inhibit corrosion. This is done by building alkalinity into the oil via the additive formulation. The commonly used measure of relative alkalinity is termed Total Base Number (TBN). The higher this number, the greater the reserve alkalinity or acid neutralizing capacity of an oil. If an engine is going to be operated on fuel with H_2S, you should consult the factory.

Lube oil suppliers will supply information about the TBN levels of their products. An oil analysis program will keep the user informed of the TBN level of his oil in service so that adequate corrosion protection is maintained.

Since low operating temperatures promote condensation of acid-bearing fumes in the crankcase, engine coolant temperatures should also be maintained at 185°F (85°C) minimum when using such fuels

8.2.13 Selecting Oil Viscosity

The correct lubricating oil viscosity, often referred to as weight, must be determined with the engine operating under its normal loaded speed and temperature using SAE 30 oil.

1. Start and load engine as described under Start Up.

2. After oil and coolant temperatures stabilize, note the temperature of the oil in the oil pan. Use an accurate temperature gauge. Compare this temperature with the following chart. The correct oil viscosity will be found in the right hand column.

OIL TEMPERATURES METHOD	
Oil Pan Operating Temperatures	SAE Viscosity Numbers
210°F - 250°F (99°C - 121°C)	40
160°F - 210°F (71°C - 99°C)	30
130°F - 160°F (54°C - 70°C)	20

Engines operating with low oil temperatures (below 160°F /71.1°C) can be expected to show excessive sludge and wear. Engines operating with high oil temperatures (above 230°F/110°C) may experience lacquering and ring sticking due to oil oxidation. If oil temperatures cannot be corrected to the normal operating range, more frequent oil changes may help in extending engine life.

When the actual operating oil temperature is not known, an estimate of the SAE oil grade to use can be made by assuming the oil pan operating temperature will be 120°F/48.9°C degrees above the ambient air temperature in heavy duty service. For example, at an ambient air temperature of 70°F/21.1°C, estimated oil pan operating temperature would be 190°F/87.7°C. Use SAE 30 as indicated in the above table. NOTE: This is only an estimate since the type of installation determines the amount of air circulation for cooling around the oil pan. Actual oil pan operating temperatures should be measured whenever possible.

NOTE

Multi-viscosity oils, 10W30 for example, should be used only when cold starting conditions make it absolutely necessary. Oil change periods should be reduced by 50% for engines using multi-viscosity oil because multi-viscosity oils may rapidly lose their highest viscosity rating in industrial service.

8.2.14 Oil Consumption

Oil consumption should range from 0.0005 to 0.004 pounds per horsepower hour as determined by the following formula:

$$\text{LBS HP HR} = \frac{\text{1.82 x Quarts of oil used}}{\text{Operating HP x total hours of operation}}$$

8.2.15 Oil Changes

The oil level and condition should be checked prior starting the engine each morning. Replace oil at any time it is plainly diluted, broken down, thickened by sludge or otherwise deteriorated. Remember that some modern oils cannot be judged on the basis of color alone because the additives are intended to hold carbon particles in suspension. The standard filters supplied will not remove these particles. The dark appearance of the oil is not necessarily an indication that the oil should be changed. Whenever oil is changed the filters must be serviced. Oil performance will reflect engine load, temperature, fuel quality, atmospheric dirt, moisture and maintenance. Where oil performance problems arise or are anticipated, the oil supplier should be consulted.

Recommended oil change intervals for engines receiving normal maintenance are as follows:

Hours	
750	For continuous duty operation at continuous duty rating. Clean environment with oil sump temperature of 230°F (110°C)
200	For engines operated in excess of continuous duty rating.
500	For engines operated consistently down to 50% of continuous duty rating (light load operation).
300	For engines in standby service.

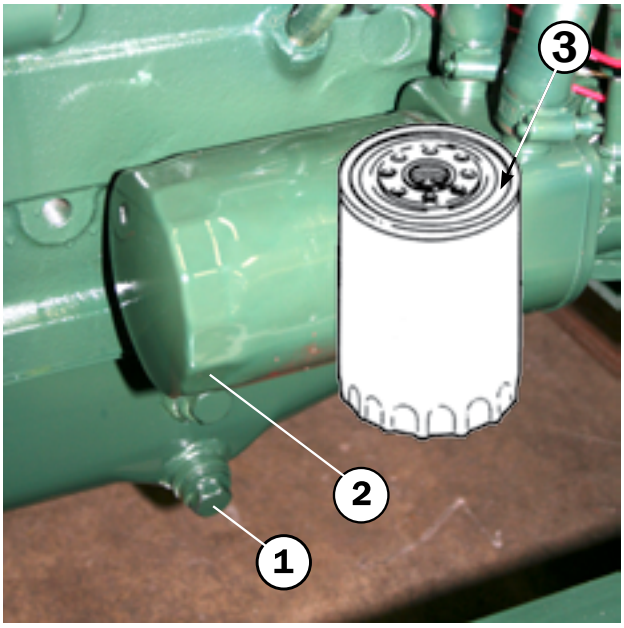
If stand-by service is less annually than hourly intervals listed, change oil annually.

Extended oil change intervals should be utilized with caution on any engine using highly dispersant oils. The dispersants function by absorption of particles of contaminants; however when dispersant saturation is reached, these oils tend to "dump out" all of the suspended contaminants in a relatively short period of time. Laboratory analysis will not predict the dump out point precisely. Consequently, close attention to engine conditions by the operator is required when establishing an extended oil change interval.

When using engine oil you have no previous operating experience, a well monitored maintenance program should be conducted to observe the engines performance and interval condition for the first years usage. This procedure will help in determining if the new oil is compatible to your type of operation.

CAUTION

The use of some types of oil, as well as dusty environment, marginal installation, internal engine condition and/or operating the engine with malfunctioning carburetion equipment may require more frequent oil changes. We suggest the lubricating oil be monitored with a good oil analysis program. Contact your local Arrow Distributor for periodic engine maintenance.



8.2.16 Oil Change Procedure

1. Start the engine and stop it after reaching the operating temperature.
2. Place an oil pan under the engine.
3. Remove the drain plug, (1), paying attention the seal ring on the plug.
4. Drain the oil.
5. Replace the drain plug (1) with seal ring
6. Replace the oil filter element.
   a. Remove the oil filter (2)
   b. Apply clean oil on the seal ring (3) and install the new oil filter element by hand.
7. Fill with clean oil to the full mark on the dipstick. Do not overfill.
8. Operate the engine for a few minutes in order to circulate the oil throughout the system. Check for leaks.
9. Stop the engine and check to see if any additional oil is required - bring the engine to the "full" mark.

Not all oils in every type of engine will give maximum service. Therefore be careful to examine the oil after the first draining to determine whether it is standing up in service. Trial periods of 10 hours are suggested. At the end of such periods make a careful inspection of the oil depth gauge for sludging, frothing and emulsification. Such conditions call for more frequent changes or different oil.

NOTE

Reference emissions section for oil recommendation in engine models.

8.2.17 Oil Filter

Full flow filters are an integral part of the lubrication system. Never block off the filter even temporarily when running the engine. ALL OIL GOING TO THE ENGINE MUST PASS THROUGH THE FILTER. Dirty oil may reduce engine life considerably.

8.2.18 Oil Pump Inlet Screen

The inlet of the oil pump of some models may have a screen before the pump to protect it from large debris. If any indications of low or fluctuating oil pressure appear, it is recommended that the pump screen be very thoroughly washed in a suitable solvent.

8.2.19 Valves

Accurate valve clearance settings materially prolong engine life and aid performance. In addition to impairing performance, excessive clearances are detrimental to cams and tappets.

On the other hand when clearances are too tight, timing is disturbed and the possibility of burned valves becomes much greater.

Valve clearances specified are for normal room temperatures, NOT FOR HOT ENGINES.

The prime consideration during valve adjustment is the accurate positioning of the camshaft in relation to the valve being adjusted. Valve clearance must be set only when the cam follower is on the base circle of the camshaft - that is to say the cam follower must not be on any part of the camshaft lobe.

8.2.20 Valve Adjustment Procedure

Normal order of operation procedures when adjusting engine valves

1. Remove the rocker arm cover and bar the engine over until number 6 cylinder and number 4 on 4 cylinder engine is at the overlap point. This is when the exhaust valve is closed and the intake valve is just begin-

ning to open. Number 1 cylinder is now on its compression stroke and at this point the adjustment can be made on both intake & exhaust valves on cylinder number 1.

2. Use a feeler gauge to check the clearance between the valve stem and the rocker arm. To adjust the clearance, loosen the jam nut on the adjusting screw and turn the screw until you feel a slight drag on the feeler gauge. Tighten the jam nut and verify the clearance again.

3. The remaining cylinders are checked and adjusted the same way according to the firing order of the engine and its paired cylinder. The following charts can be used for documentation purposes. Paired cylinder does not apply to the 3 cylinder engine.

4. Check boxes as completed.

Date:	S/N:
Make:	Model:

A-32	
Adjust valves on the cylinder	At this cylinder's overlap point:
#1-Intake ☐ Exhaust ☐	N/A
#3-Intake ☐ Exhaust ☐	N/A
#2-Intake ☐ Exhaust ☐	N/A

A-42 (VR260)	
Adjust valves on this cylinder:	At this cylinder's overlap point:
#1-Intake ☐ Exhaust ☐	#4
#3-Intake ☐ Exhaust ☐	#2
#4-Intake ☐ Exhaust ☐	#1
#2-Intake ☐ Exhaust ☐	#3

A-62 (VR380)	
Adjust valve on this cylinder:	At this cylinder's overlap point:
#1-Intake ☐ Exhaust ☐	#6
#5-Intake ☐ Exhaust ☐	#2
#3-Intake ☐ Exhaust ☐	#4
#6-Intake ☐ Exhaust ☐	#1
#2-Intake ☐ Exhaust ☐	#5
#4-Intake ☐ Exhaust ☐	#3

3 Cylinder Engines

A-32 – Valve Clearance
(A-32 Int .008 & Exh .012")
Firing Order ..... (1-3-2)
PAIRED CYLINDER ..... (No Paired Cylinders)

Note

Valve adjustment on 3 cylinder engine would require watching the valve action to determine that the rocker arms are closed and on the flat section of the cam, before adjusting.

4 Cylinder Engines

A-42 (VR260) – Valve clearance
(A-42 (VR260) Int .008" & Exh. .012")
FIRING ORDER..... (1-3-4-2)
PAIRED CYLINDER..... (1 and 4) - (3 and 2)

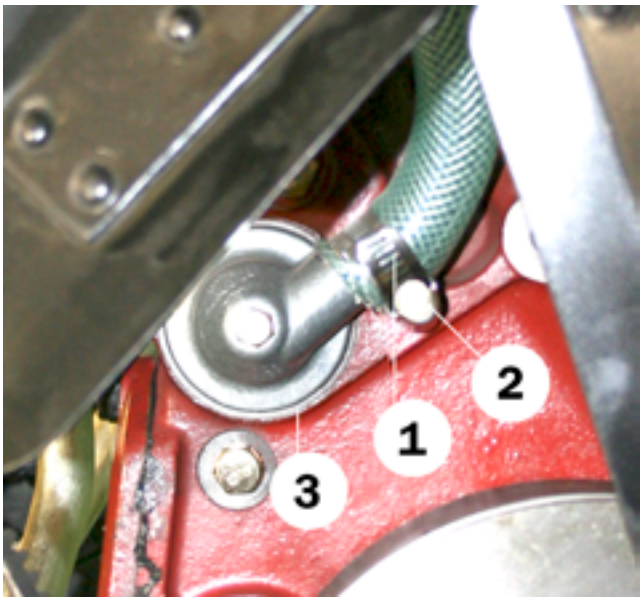
6 Cylinder Engines

A-62 (VR380) – Valve Clearance
(A-62 (VR380) Int. .008" & Exh. .012")
FIRING ORDER..... (1-5-3-6-2-4)
PAIRED CYLINDER..... (1 and 6) - (5 and 2) - (3 and 4)

8.2.21 Compression Testing

To check the compression a standard automotive type compression tester with a threaded adaptor may be used. Follow equipment maintenance instructions.

8.2.22 Clean Breather Body



1. Loosen the hexagon nut or screw (1.)
2. Loosen hose clip (2.)
3. Disassemble breather body (3.)
4. Pay attention to the O-ring seal.
5. Clean the breather body in solvent.
6. Mount the breather body, replace O-ring seal if necessary.
7. Tighten the hose clip (2.)
8. Tighten the hexagon nut or screw (1.)

8.2.23 Manifold Vacuum Test

Operate the engine until it is at normal operating temperature.

Connect vacuum gauge to the intake manifold and test with engine operating at idle speed with no load.

GAUGE READINGS	ENGINE CONDITION
18”-19” Hg (457-483 mm) at Idle Speed (apx.)	Normal
High and Steady	Good
Low and Steady	Loss of power in all cylinders possibly caused by late ignition or valve timing, or loss of compression due to leakage around the rings.
Very Low	Manifold, carburetor or cylinder head gasket leak
Needle fluctuates steadily as speed increases	A partial or complete loss of power in one or more cylinders caused by: a leaking valve, cylinder head or intake manifold gasket leak, a defect in the ignition system or a weak valve spring.
Gradual drop in reading at engine idle	Excessive back pressure in the exhaust system.
Intermittent Fluctuation	An occasional loss of power possibly caused by a defect in the ignition system or a sticking valve.
Slow fluctuation or drifting of the needle	Improper idle mixture adjustment, or carburetor, spacer, or intake manifold gasket leak.

8.2.24 Spark Plug Adjustments

Misfiring or erratic operation may be due to faulty spark plugs caused by carbon accumulations and burning of the electrodes. They should be cleaned, inspected and the gaps checked approximately every 250 hours of operation or more often if the engine idles for prolonged periods. After 500 hours, it is advisable to replace the entire set when any spark plug is defective.

Scraping the insulator is not recommended since the resulting scratches increase the tendency of carbon deposits to form.

Adjust the gap to 0.025” (0.635 mm) by bending the outer electrode. As the spark plugs will have

a tendency to burn the electrodes and widen the gap, it is important that gap be checked whenever the plugs are removed from the engine. Missing at low speeds is very often due to a wide spark plug gap.

Examine for cracked porcelain, leakage, burned electrodes, deposits on center insulator, correct gap, good washers and clean threads and seating surface. Remember a plug may appear satisfactory and still miss.

NOTE

When replacing spark plugs, use new gaskets if applicable. Proper seating of the gasket is necessary for sealing the combustion chamber and transferring heat from the plug. Use spark plug tap to clean threads, allowing for proper heat transfer.

8.2.25 Oil Cooler Cleaning

Maintenance of the oil cooler unit on the A-32, A-42 (VR260), and A-62 (VR380) engines consists largely of periodic cleaning and inspection for clogging, corrosion or an inoperative by pass valve. Improper or fluctuating oil pressure or an undesirable increase in oil temperature may indicate the need for servicing the cooler more frequently. In general, the cooler should be removed from the engine, disassembled and cleaned after each 500 hours of operation. Long service or expediency may make it more practical to replace the oil cooler with a new unit. All rust and lime deposits should be removed from the water passage area of the cooler at this time the sludge deposits within the cooler core may be cleaned out by several solvents and methods but in all cases it is recommended that cleaning take place as quickly as possible after removing the cleaner from the engine. Ordinarily, a cleaning solvent or a commercial sludge and carbon remover will be effective if pumped vigorously through the cooler plates.

NOTE

Observe all fire and safety precautions.

8.2.26 Adjusting the Carburetor (A-42 and A-62 non emission engines only)

To adjust the carburetors, take the following steps:

1. Open the gas regulating valve at the carburetor fuel inlet and verify correct fuel supply pressure.
2. With the engine at desired speed and load, adjust the carburetor inlet mixture screw so that the engine runs the desired Air Fuel ratio with no knocking, deceleration, or fluctuation of speed.
3. Proper fuel adjustments are important to insure efficient operation, full-rated power, and longest life.

8.2.27 Speed Control Unit

The governed speed set point is increased by clockwise rotation of the SPEED adjustment pot.

To adjust the performance of the governor, please take the following steps:

1. Bring the engine to its normal operating speed with no load
2. Rotate the GAIN adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further to insure stable performance (270° pot.)
3. Rotate the STABILITY adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further to insure stable performance (270° pot.)
4. GAIN and STABILITY adjustments may require minor changes after engine load is applied. Normally, adjustments made at no load provide satisfactory performance.

If instability cannot be corrected or further performance improvements are required, please refer to Troubleshooting Section 12.6 Governing Systems.

8.2.28 Idle Speed Setting

After the governor speed setting has been adjusted, place the optional external selector switch in the IDLE position. The idle speed set point is increased by the clockwise rotation of the IDLE adjustment control. When the engine is at idle speed, the speed control unit applied droop to the governor system to insure stable operation.

8.2.29 Integral Throttle Body Actuator Idle Adjustment

The idle adjustment is preset at the factory.

8.2.30 Wiring

All throttle body actuators are pre-wired. For applications where EMI is still a concern, shielded cable for the actuator is recommended.

8.2.31 Cleaning Intercooler and Turbocharger (A-62 only)

If the resistance within the intercooler increases beyond 5.5 kPa or it fails to cool the air more than 108°F (42°C) then intercooler should be cleaned. A loss of pressure or temperature could indicate that the turbocharge-intercooler piping system has developed a leak or loose connection. All air duct and gasket connections should be routinely checked for tightness and leaks. Repair loose or leaking connections immediately. Ingestion of dirt into the compressor can cause severe wear and damage to the turbocharger as well as the engine. Excessive dirt buildup in the compressor can also cause a considerable loss of power and overheating. Remove the air inlet connection at the compressor to inspect for dirt accumulation on the compressor surfaces. If dirt is found, never scrape away such material with a screwdriver, dirty rag, sandpaper, or emery or steel wool.

Observe scheduled lube oil change intervals to ensure normal service life of the turbocharger bearings. Use the recommended lube oil and genuine Arrow replacement filters.

Turbocharged engines should be idled for several minutes after starting and before shutdown to prevent "oil lag" failures to turbocharger bearings. This is particularly important during cold weather or when the equipment has not been in use for extended periods.

NOTE

Because the turbine side of the turbocharger can flex when it is hot, care should be taken to ensure that the weight of the exhaust system is not carried by the turbocharger. The muffler and its piping should be supported independently and connected to the turbocharger by a flexible coupling.

« RETURN TO TOC

9 Engine Storage

9.1 Storage Requirements

Preservation of engines and generators in storage involves several basic requirements. For new engines and generators, these are as follows:

1. Protection of machined metal surfaces, cylinders, valves, bearings and so on, from the effects of both dampness and salt or other corrosive substances in the atmosphere.

2. Protection of openings into the engine against the entrance of dirt, abrasive material and foreign matter of all types.

3. Protection of accessory equipment including carburetors, gas regulators, ignitions, starters, alternators and fan belts against corrosion, dirt, moisture saturation and progressive deterioration.

4. Protection of cooling system intercoolers and LPG vaporizers against freezing, rusting or seizure of water pump seals.

5. Protection of a general nature against the elements - rain, snow and extremes of temperature.

6. Protection of batteries by disconnecting and removing them to a slow charging station where they can be kept fully charged. If this is neglected, the plates may be damaged or ruined by becoming sulfated.

7. Protection of the alternator by covering all openings to prevent the entry of dust, moisture, dirt and rodents. A heavy craft paper will serve this purpose, where these openings are in the form of screened or louvered guards or covered plates, the protective paper should be placed under these removable parts. If this is not possible, a pressure sensitive tape can be used to hold the paper in position. Do not use masking tape - it is not suitable for this type of service and will be very difficult to remove after extended use. Application of protective paper should be on both inside and outside of large fixed louvered surfaces. Large open areas should have a corrugated cardboard backing for the paper.

8. Protect switchboards in the same manner as the alternators.

   In the case of engines previously operated, additional items must be considered...

9. Protection of interior engine parts - particularly bearings, cylinder walls and valves against corrosion by the products of combustion combined with atmospheric moisture and corrosion by lubricating oil contaminants.

The extent of the attention given to each of the foregoing points of possible damage depends on the judgment of the person in charge of the equipment. Generally speaking, the following factors should be taken into consideration before deciding how much or how little preservation is required...

1. The period of time the equipment is likely to be inoperative.

2. The severity of the weather and atmospheric conditions at the point of storage. The problems of storing equipment in a high humidity area, for example, differ greatly from storage problems in a location where the air is very dry and dusty.

3. The accessibility of the equipment for periodic inspection and attention. An engine on a showroom floor that may be turned over occasionally and given periodic oiling requires less extensive treatment than engines crated and stocked in a warehouse.

CAUTION

The A-32, A-42 (VR260), and A-62 (VR380) engines received from the factory are internally protected for up to six months for storage indoors. If the storage period exceeds six months, the engine should receive additional storage preservatives. Engine stored outdoors or in a humid environment may require more frequent re-preservation.

9.2 Storing Engines

Engines recently received from the factory and not intended to be used for an indefinite period may be stored successfully in the following manner. Engines stored outdoors or in a humid environment may require more frequent preservation treatment.

9.2.1 Engine in Operable Condition (can run)

1. Mix inhibitive type preservative oil with the engine lubricating oil in the proportions recommended by the manufacturer of the preservative oil. Operate engine until oil is hot. Cooling water used in this run should have inhibitor added in accordance to manufacturer's instructions.

2. Remove air cleaners of gas engines with manually operated sprayer, squirt can or other means, and inject preservative oil of a suitable type into the air intake while the engine is running. Approximately one minute is ordinarily adequate. If possible, stop engine by slugging enough oil through intake to stall. Continue injecting oil until the engine stops turning.

3. Drain oil and water while hot. If extra protection is desired, the rocker arm covers may be removed and a quantity of preservative oil poured over the rocker arm and valve mechanisms.

4. For gas engines not stopped by slugging, remove spark plugs and squirt or spray several teaspoons of preservative oil into each combustion chamber. Coat spark plugs and reinstall.

5. Wipe engine clean and dry. Apply wax type masking tape or like material to all openings such as intake openings in air cleaners, exhaust outlets, breathers and open line fittings.

6. Relieve tension on belts. This is important because continual tension on belts without the working action that occurs in normal operation causes deterioration of the rubber.

7. Apply a coating of heavy preservative compound with brush to all exposed machined surfaces such as flywheels.

Engines treated in accordance with these instructions will normally be protected for one year or longer. Continual inspection, however, is the only way to determine if protection is adequate. If possible, crank the engine by hand for one or two turns about once a month. This helps prevent seizure of water pump seals. If this is done, however, it is usually best to add more preservative oil to each cylinder. Some types of preservative oil are not well suited to periodic engine rotation because they are scraped from the cylinder walls which are then unprotected. Other oils are not scraped away and for this reason the operator should carefully investigate the characteristics of the preservative oil used.

9.2.2 When Engine is Not Operable (cannot run)

1. Open drains as required to remove oil and water.

2. Remove the spark plugs and pour or squirt about a teaspoon of preservative oil into each cylinder.

3. Crank engine in normal direction about one quarter turn and spray each cylinder again. Do this about eight times or until engine has been turned through two complete revolutions. The purpose of this procedure is to bring each valve into an exposed position so the preservative oil will coat it.

4. Depending on the judgment of the operator as to the severity of storage conditions, open valve rocker covers, gear cover plates and as many points as possible where oil may be sprayed, poured or squirted over the interior parts. Replace all plugs and covers.

5. Remaining steps may be the same as listed in 5 and 6 for an operable engine.

9.2.3 Preservative Oil

In general the properties making oil suitable for preservative requirements are good aging stability; high resistance to gumming, oxidation and polymerization; low pour point and viscosity; freedom from acids, asphalts, resins, tars and water.

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10 Preparing Engine for Operation

The steps needed to bring an engine into active service after storage in accordance with these instructions are about the same as those normally carried out on any new engine. These are inspection, checking for free rotation, adequate cooling water or antifreeze, ample lubricating oil of the correct type and viscosity and proper adjustments. In addition, accumulated dust and dirt should be wiped or washed from the exterior before removing the covers over the engine openings. Removal of installed protection should occur upon normal inspection of the engine generator and switch gear interiors prior to start up. Partial removal may be necessary in the course of installation but this should be kept at a minimum. Engines that have not been rotated for some time should be oiled through the spark plug openings and cranked by hand or with the starting equipment before actually running. Any resistance to free cranking should be investigated - rust and corrosion can cause severe seizure that cannot be forced clear without engine damage.

CAUTION

All generators and switch gear which have been stored must be checked for installation resistance with a "Megger" prior to being put into service. The megger used should produce 500 VDC Disconnect voltage regulator, rotating diodes, suppressors and any other solid state devices which may be connected to the stator or rotor windings. The megger value should be: operating voltage ÷ 1000+1 (i.e., machine voltage of 480 VAC ÷1000=0.480+1=1.480 mega ohms.) If any circuit to ground measures less than calculated value, consult the Arrow Engine Customer Service Department for any corrective measures as may be necessary.

Never attempt to start an engine that has been stored without first cranking it over with the spark plugs out. Spurting oil, water or preservative compound from these openings indicates possible hydraulic lock if an attempt had been made to operate. Continue to crank engine with starter until liquid is no longer ejected from openings. Inspect intake/exhaust passages and manifolds for thickened preservative oil. Oil accumulated in this condition may melt when the engine warms up and cause a runaway.

SPECIFICATIONS FOR PROTECTIVE MATERIALS	
Internal Surfaces - Cylinders, etc.	External Surfaces
U.S. Army Spec 2-126, available as SAE 10 or SAE 30	U.S. Army Spec 2-121 (Waxy Coating) Army Ordinance Spec AXS 673 (Harder Black Coating)

11 Wear limits

NO	PART NAME MEASURING POINT	DIMENSION - INCHES (mm)		
		Limit on New Parts		
		MAX	MIN	MAX WEAR LIMIT
1	Crankshaft			
	Dia of main journal	2.755” (69.97 mm)	2.754” (69.951 mm)	2.753” (69.93 mm)
	Dia of con rod journal	2.479” (62.97 mm)	2.478” (62.951 mm)	2.477” (62.93 mm)
	Length of thrust main journal	1.419” (36.05 mm)	1.417” (36.00 mm)	36.07” (36.07 mm)
	Axial clearance measured after mounting	0.008” (0.20)	0.002” (0.05 mm)	0.015” (0.38 mm)
2	Main bearing			All the two bearings must be replaced if the plated trimetal layer or guard alloy layer is worn down
3	Con rod bearing			
4	Thickness of crankshaft thrust washer	0.137” (3.47 mm)	0.135” (3.42 mm)	
5	Dia of con rod small end bushing	1.381” (35.08 mm)	1.379” (35.03 mm)	1.384” (35.15 mm)

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NO	PART NAME MEASURING POINT	DIMENSION - INCHES (mm)		
		Limit on New Parts		
		MAX	MIN	MAX WEAR LIMIT
6	Piston pins external cylindrical surface - outside dia of piston pin	1.3779″ (35.0 mm)	1.3777″ (34.994 mm)	Replace if there is scoring 1.3775″ (34.99 mm)
7	Piston assembly			
	First ring groove trapezoid			Replace if worn
	Second ring groove			0.083″ (2.10 mm)
	Third ring groove			0.162″ (4.11 mm)
	Piston pin bore			Replace if there is evident clearance
	Contact surface of piston skirt	0.0815″ (2.07 mm)	0.0807″ (2.05 mm)	Replace if there is vertical scoring
	End clearance of piston ring all	0.1598″ (4.06 mm)	0.1591″ (4.04 mm)	Replace if there is vertical scoring
	First piston ring trapezoid ring			Replace if there is wear on inclined end face of the ring 0.079″ (2.00 mm)
	Clearance of second piston ring in groove			0.0079″ (0.20 mm)
	Clearance of third piston ring oil ring in groove			0.0059″ (0.15 mm)
8	Cylinder liner			
	Inside diameter	4.1347″ (105.022 mm)	4.1338″ (105.00 mm)	4.1437″ (105.250 mm)
	Honing surface			Replace if vertical scoring exceeds 0.002″ (0.05 mm)
9	Valve and valve guide			
	Dia of valve stem	0.3531″ (8.970 mm)	0.3524″ (8.952 mm)	0.3522″ (8.945 mm)
	Dia of valve guide bore	0.3549″ (9.015 mm)	0.3543″ (9.000 mm)	0.3567″ (9.060 mm)
	Height between valve bottom face and cylinder head face	0.0559″ (1.42 mm)	0.0405″ (1.03 mm)	0.0708″ (1.80 mm)
10	Rocker seat			
	Dia of rocker shaft	0.6292″ (15.984 mm)	0.6286″ (15.966 mm)	0.6279″ (15.950 mm)
11	Dia of rocker bearing bore	0.6306″ (16.018 mm)	0.6299″ (16.000 mm)	0.6315″ (16.040 mm)

NO	PART NAME MEASURING POINT	DIMENSION - INCHES (mm)		
		Limit on New Parts		
		MAX	MIN	MAX WEAR LIMIT
12	Camshaft			
	Intake exhaust cam face			Replace if there is wear
	Dia of camshaft journal	1.849″ (46.960 mm)	1.848″ (46.940 mm)	1.847″ (46.920 mm)
	Width of camshaft locating slot	0.2831″ (7.190 mm)	0.2795″ (7.10 mm)	0.2842″ (7.220 mm)
	Axial clearance of camshaft after mounting			Axial clearance 0.015 7″ (0.40 mm)
13	Dia of camshaft bearing bore on cylinder block			
	Bore with bearing mounted in gear end	1.8522″ (47.045 mm)	1.85″ (46.990 mm)	1.8527″ (47.060 mm)
	Bore without bearing mounted in	1.8514″ (47.025 mm)	1.8504″ (47.000 mm)	1.8524″ (47.050 mm)
	Inside Dia of tappet hole on cylinder block	0.6897″ (17.518 mm)	0.689″ (17.500 mm)	0.6901″ (17.530 mm)
14	Thick of tooth sector for camshaft location	0.2758″ (7.005 mm)	0.2697″ (6.850 mm)	0.2657″ (6.750 mm)
15	Outside dia of tappet	0.6887″ (17.494 mm)	0.6883″ (17.483 mm)	0.688″ (17.475 mm)
16	Two stage balance shaft assembly			
	Dia of balance shaft journal	1.3376″ (33.975 mm)	1.3366″ (33.950 mm)	1.3362″ (33.940 mm)
	Axial clearance of balance shaft assembly after mounting			Axial clearance 0.019 7″ (0.5 mm)
17	Inside dia of balance shaft bearing bushing	1.3405″ (34.050 mm)	1.339″ (34.010 mm)	1.3417″ (34.080 mm) after mounting
18	Thick of balance shaft thrust washer	0.1398″ (3.55 mm)	0.1358″ (3.45 mm)	0.1319″ (3.35 mm)

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12 Troubleshooting

12.1 Operating Controls

Most A-32, A-42 (VR260), and A-62 (VR380) engines are equipped with the following operating controls

1. Water temperature gauge
2. Oil pressure gauge
3. Throttle
4. Starter switch
5. Ignition switch

12.2 Electrical System

The engine electrical system consists of a heavy duty starter, alternator, switches and circuits. The engine is started by closing a circuit from battery to starter with the instrument panel switch that actuates the magnetic switch. Positive engagement of the pinion before cranking commences is accomplished by the starting motor solenoid. After cranking is completed and the engine starts, the alternator replenishes energy expended by the battery. Voltage regulator controls the alternators output and protects the system from excessive charging rates. Arrow Engine Company supplies engines with negatively grounded electrical equipment only. This standardization of electrical system polarity is standard practice for most equipment manufacturers and thus increases compatibility between Arrow supplied electrical equipment and that supplied by the equipment builder.

The engines electrical system is available in either 12 or 24 volts.

12.3 Cooling System

Reference the diagram in section 3.9. The cooling system used on the A-32, A-42 (VR260), and A-62 (VR380) is of the pressure circulating type. The centrifugal pump pulls this supply of cool water through the pump body and into a passage leading directly into the engine cylinder jacket. The water enters the engine in the area of the cylinder sleeve lower ends. From here, the water flow is directed about the cylinder sleeves in an even manner until it passes upward from the crankcase and into the cored passages in the cylinder heads. These passages are carefully designed to allow cooling water access to all areas around the valves. Water is collected from the cylinder head and enters thermostat housing at the forward end. The thermostat controls the exit temperature of the water.

12.4 Air Intake System

With the exception of adequate supplies of clean oil and water, probably no other single service item contributes so much to engine life as a properly working air cleaner. This is particularly true under dusty and agricultural operating conditions, but surprising amounts of abrasive dirt are present in most atmospheres. When carried into the engine through the air inlet, such abrasives rapidly wear away cylinder walls, valve stems, bearings and other working parts.

Because the dust particles are so small, yet possess the ability to cause great damage, it is absolutely mandatory that air inlet connections be kept in tight condition to avoid taking in unfiltered air.

Although various installations will have differences in air cleaner types and arrangements, it is important for the operator to realize that the common purpose of all air cleaners is to collect dirt and grit. Thus the cleaner itself must be cleaned as often as dirt accumulations start to build up. Sometimes this may be several times each day if conditions are especially dusty.

12.5 Exhaust System

Proper disposal of the exhaust of an engine is a very critical problem when you visualize its breathing function. An engine consumes an incredible amount of air and after combustion takes place the air and exhaust gases must be pushed out of the cylinders manifolds and exhaust piping. Every possible provision must be made to minimize the restriction or back pressure on an exhaust system.

Some of the adverse effects of excessive back pressure are:

- Loss of power.
- Poor fuel economy.
- Excessive valve temperatures and premature wear.
- Jacket water overheating

The exhaust system of an engine with a particularly long exhaust pipe can accumulate quite a bit of condensed moisture. If allowed to run back through the piping into the engine after it is shut down the obvious rusting and sticking of valves rings etc. and the possibility of a hydraulic "lock" become serious. Always provide a condensate trap and drain at some low point ahead of the engine manifolds.

12.6 Governing Systems

12.6.1 ESD2400 Speed Control Unit

The engine's standard equipment includes the EDS2400 Series Speed Control Unit and the ATB Series Electronic Governor. The speed control unit is factory set at approximately engine idle speed (1,000 Hz., speed sensor signal).

12.6.2 System Inoperative

If the engine governing system does not function, the fault may be determined by performing the voltage tests described in Steps 1-4. Positive (+) and negative (-) refer to meter polarity. Should normal values be indicated during troubleshooting steps, the fault may be with the actuator of the wiring to the actuator. Tests are performed with battery power on and the engine off, except where noted. See the Actuator section with in the Troubleshooting section for information on its testing procedure.

STEP	TERMINALS	NORMAL READING	PROBABLE CAUSE OF ABNORMAL READING
1	F(-) & G(+)	Battery Supply Voltage (12,24, or 32 VDC)	1) DC Battery power not connected. Check for a blown fuse. 2) Low battery voltage. 3) Wiring error.
2	B(+) & C(-)	0-2.7 with speed trim 4.8-5.4 without speed trim	1) Speed trim shorted or miswired. 2) Defective unit.
3	D(+) & E(-)	1.0 VAC RMS min. while cranking	1) Gap between speed sensor and gear teeth too great. Check the gap. 2) Improper or defective wiring to the speed sensor. Resistance should be between 30 to 1200 ohms. 3) Defective speed sensor.
4	J(-) & F(+)	0.5-1.5 V while cranking	1) Wiring error to actuator. 2) Defective speed control unit. 3) Defective actuator.

12.6.3 Unsatisfactory Performance

If the governing system functions poorly, perform the following steps...

SYMPTOM	TEST	PROBABLE FAULT
Engine Overspeed	1) Do not crank. Apply DC power to the governor system.	Actuator goes to full fuel. Disconnect the speed sensor wires. If the actuator is still at full fuel, the speed control unit is defective. If the actuator is at minimum fuel position, then there is an erroneous speed signal. Check the speed sensor cable.
	2) Manually hold the engine at the desired running speed. Measure the DC voltage between terminal J(-) & F(+) on the speed control unit.	1) If the voltage reading is 0.5 to 1.5 VDC, a) "Speed" adjustment is set above the desired speed. b) Defective Speed Control Unit. 2) If the voltage reading is above 1.5 VDC, the actuator or linkage is binding. 3) Set point of overspeed shutdown is set too low. 4) If the voltage reading is below 0.5 VDC, defective speed control unit.
Actuator does not energize fully when cranking	1) Measure the DC voltage between terminal J(-) & F(+) on the speed control unit. Should be 0.8 to 1.5 volts.	1) Replace battery if weak or undersized. 2) Actuator wiring incorrect. 3) If voltage is below 1.5 V, "Speed" set too low
	If not... 2) Momentarily connect terminal F & J. The actuator should move to the full fuel position.	1) Actuator or battery wiring in error. 2) Actuator or linkage binding. 3) Defective actuator.
Engine remains below desired governed speed	Measure the actuator output, terminals H & J, while running under governor control.	1) If voltage measured is within 1.5 volts or more of the battery supply voltage level, then fuel control restricted from reaching the full fuel position. Possibly due to mechanical governor, carburetor spring or linkage interference. 2) If not, increase speed setting.

12.6.4 Insufficient Magnetic Speed Signal

A strong magnetic speed sensor signal will eliminate the possibility of missed or extra pulses. The speed control unit will govern well with 0.5 volts RMS speed sensor signal. A speed sensor signal of 3 volts RMS or greater at governed speed is recommended. Measurement of the signal is made at Terminals D and E.

The amplitude of the speed sensor signal can be raised by reducing the gap between the speed sensor tip and the engine ring gear. The gap should not be any smaller than 0.020 in (0.45 mm). When the engine is stopped, back the speed sensor out by ¾ turn after touching the ring gear tooth to achieve a satisfactory air gap.

12.6.5 Electromagnetic Compatibility (EMC) EMI Susceptibility

The governor system can be adversely affected by large interfering signals that are conducted through the cabling or through direct radiation into the control circuits.

All GAC speed control sensors contain filters and shielding designed to protect the units' sensi-

tive circuits from moderate external interfering sources.

Although it is difficult to predict levels of interference, applications that include magnetos, solid state ignition systems, radio transmitters, voltage regulators or battery chargers should be considered suspect as possible interfering sources.

If it is suspected that external fields, either those that are radiated or conducted, are or will affect the governor systems operation, it is recommended to use shielded cable for all external connections. Be sure that only one end of the shields, including the speed sensor shield, is connected to a single point on the case of the speed control unit. Mount the speed control to a grounded metal back plate or place it in a sealed metal box.

Radiation is when the interfering signal is radiated directly through space to the governing system. To isolate the governor system electronics from this type of interference source, a metal shield or a solid metal container is usually effective.

Conduction is when the interfering signal is conducted through the interconnecting wiring to the governor system electronics. Shielded cables and installing filters are common remedies.

In severe high-energy interference locations such as when the governor system is directly in the field of a powerful transmitting source, the shielding may require to be a special EMI class shielding. For these conditions, contact Governor America Corp. application engineering or Arrow Engine for specific recommendations.

12.6.6 Electric Governor Troubleshooting Multicylinder Engines (ESD2402)

These are basic troubleshooting and set-up procedures for more detailed instruction please refer to the GAC manuals.

12.6.7 Actuator

To determine if there is a problem with the actuator, perform the following:

1. If the engine does not start, check the voltage on terminals H&J to confirm 12 VDC is going to the actuator.

   a. If no voltage is present proceed to Controller troubleshooting.

   b. If voltage is there, you will need to determine if the actuator butterfly is open or not.

   c. Easiest way is to remove the four screws on the spring end of the actuator (not motor end) and you can see the butterfly shaft open and close. If the valve opens with the voltage applied, there is nothing wrong with the actuator. If it does not open, check that the throttle opens when you push it. If not the throttle stops may have been adjusted improperly not allowing it to open. If it opens freely the actuator needs replacing.

2. With the engine running at rated speed and with no load, unplug the actuator connector.

   a. If the engine odes not change speed there is a problem with the actuator (spring broke actuator stuck, etc.) Replace the actuator.

   b. If the engine speed drops to idle or the engine dies, there is nothing with the actuator. Proceed to troubleshooting controller.

Note

Before condemning check that the throttle set screws are not screwed in to far not allowing the actuator to close.

12.6.8 Controller

To Determine if there is a problem with the controller, perform the following.

1. Check all wire connections and connectors.

2. Confirm the following:

   a. Disconnect wires from terminal "A, B, & C" to eliminate the potentiometer or toggle switch is a problem.

   b. Battery positive connected to "F" terminal and battery negative connected to "G" terminal.

   c. That you have a good battery supply!

d. Actuator wiring connected at terminals "H & J". Typically red wire to "H" and white wire to "J".

e. Magnetic pick-up wires are run to terminals "D & E". Magnetic pick-wire should be twisted pair and/or shielded wire.

12.6.9 Troubleshooting Controller

1. Confirm battery voltage within 10% of controller rating (12 volt system at least 10.8 volt DC)

2. Check magnetic pick-up, while cranking the engine you should have about 1 VAC (running should have about 6 VAC).

   a. If you do not have any voltage, you should check the magnetic pick for dirt on the end of the sensor or the clearance is excessive between the magnetic pick-up and ring gear teeth (should be about 1/2 to 3/4 turn out).

   b. If you still do not any voltage, double check the voltage right at the pick-up (if not already). If still no voltage replace magnetic pick-up. If you have voltage at the pick-up but not at the controller, there is a wiring problem.

3. Check voltage out to actuator (based on 12 VDC systems). At cranking the voltage should go to full battery voltage (12 VDC) which means the actuator is wide open. Once the engine comes up to the rated speed setting the voltage should drop to about 6 Volt DC (depending on speed setting).

   a. If speed is not reducing (over speeding), turn down the rated speed pot. If this solves the problem refer to the "set-up" section.

   b. If this does not do anything, replace the controller.

12.6.10 Setup of Controller

1. At this point have confirmed the actuator, controller, battery power and magnetic pick-up is operating properly. We now need to reconnect terminals "A, B, & C".

   a. Confirm the toggle switch is in the open position (usually up position)

   b. Turn the potentiometer all the way clockwise.

   c. Turn the "idle" pot full counter clockwise then go about a 1/4 turn. Turn the "speed" pot counter clockwise until you feel it click which indicates it is all the way down, then turn it 4 turns clockwise to allow the engine to start. Now start the engine.

   d. Turn the "speed" pot (small gold) clockwise until you achieve your maximum RPM (typically 1800 RPM) you want on your potentiometer adjustment. Now you should turn the potentiometer and confirm it will lower the speed all the way down to 1000 RPM. If it does not there is a problem with the potentiometer, replace it.

   e. Turn the "gain" pot clockwise until instability develops, then turn it slowly counter clockwise until the engine stabilizes. Turn the pot one letter/number more counter clockwise to ensure you are not too close to the instability area.

   f. Turn the "Stability" pot clockwise until instability develops, then turn it slowly counter clockwise until the engine stabilizes. Turn the pot one letter/number more counter clockwise to ensure you are not too close to the instability area.

   g. Take the engine back to max speed, switch the toggle switch down or to the closed position and adjust the "Idle" pot on the controller to a minimum of 1000 RPM.

   h. Setup Complete

12.7 Integral Throttle Body Actuator

These tests are to check for proper operation of the actuator only. If the actuator passes these

tests, the problem is more than likely elsewhere in the system. Refer to the previous Section - 10.6 Speed Control Unit.

If the governor system fails to operate, the following test can be performed. Shut engine down, disconnect the actuator cable and measure the resistance through the wires while rotating the throttle plate. Next, check resistance from each wire to actuator housing again while rotating the throttle plate (See table below). The resistance will fluctuate when you manually rotate the plate, but the reading should settle back to a fixed value based on the table below. This test is only to insure that there is no obstruction, wire breakage or metal-on-metal contact inside the throttle body.

Measure the resistance from:

Red to White (12 VDC) ..... 2 ohms

Red to White (24 VDC) ..... 8 ohms

Red to Actuator Housing ..... < 5 Mega ohms

White to Actuator Housing ..... < 5 Mega ohms

Make sure to reconnect the actuator cable.

Next, energize the actuator to full fuel position (follow steps in the speed control publication) and manually move the actuator throttle plate to the de-energized position. You should feel no binding or sticking of the throttle plate

12.8 Troubleshooting Chart

SYMPTOM	PROBABLE CAUSE	REMEDY
Crankshaft cannot be barred over **CAUTION:** **Do not attempt to rotate the crankshaft with the starter.**	Seized piston.	Replace piston assembly and possibly sleeve. Determine cause of the seizure - insufficient ring gap, insufficient lubrication, inadequate cooling or overload.
	Coolant or obstruction in the cylinder.	Remove spark plugs and crank engine to vent cylinders of accumulated coolant.
	Cracked head.	Replace head.
	Cracked sleeve.	Replace sleeve.
	Blown head gasket.	Replace head gasket.
	Bearings to tight:	
	1) High spot on bearings.	Replace bearings.
	2) Improper torque.	Loosen bearing caps and re-torque.
	3) Main bearing caps installed out of location.	Check each bearing cap, place in proper location.
	Load not disengaged from the engine.	Disengage load.
Engine will crank but not start.	**Insufficient cranking speed:**	
	1) Run down battery or electric starter malfunction.	Charge or replace battery; check the starter system.
	2) Lube oil viscosity is too high.	Change to a lower viscosity oil.
	Poor compression:	
	1) Worn rings.	Renew rings.
	2) Leaking valves.	Recondition head and valves.
	3) Leaking head gasket.	Replace head gasket.
	Fuel system inoperative:	
	1) Insufficient fuel supply	Check gas pressure and carburetor adjustments.
	2) Ruptured line pressure regulator.	Replace diaphragm.
	3) Stiff carburetor diaphragm or worn air-gas valve assembly.	Replace air-gas assembly.
	4) Bent line pressure regulator control rod.	Replace control rod.
	Clogged intake air filter.	Remove and clean or replace.
	Safety shut-down control not re-set.	Re-set safety shut-down control.

SYMPTOM	PROBABLE CAUSE	REMEDY
Engine stops suddenly.	**Fuel:**	
	1) Insufficient fuel supply.	Check gas pressure.
	2) Loose fuel control linkage.	Readjust and tighten.
	3) Clogged fuel supply line.	Replace line.
	Obstructed exhaust manifold.	Determine obstruction and remedy.
	Clogged intake air filter.	Remove and clean.
	Engine overspeed causes safety control to shut down engine.	Determine and correct cause of overspeed.
	Excessive load causes engine to stall.	Determine and correct cause of overload.
	Piston seizure:	
	1) Insufficient ring gap (applicable only immediately after overhaul.)	Replace scored piston, sleeve and rings. Adjust ring gap.
	2) Insufficient lubrication.	Replace scored piston, sleeve and rings. Clean oil passages and/ or determine cause of lack of lubrication.
	3) Insufficient cooling.	Replace scored piston, sleeve and rings. Clean and/or fill the cooling system.
	Seizure of bearing, main connecting rod, piston pin or camshaft.	Replace bearings - clean up or replace crankshaft, camshaft or piston pins as required.
	Dirt in lubricating oil.	Check lubricating oil filter.
	Obstruction in cylinder.	Replace all parts that failed.
	Low oil pressure causes safety control to shut the engine down.	Inspect the lubricating oil system and components and correct the cause.
	High coolant temperatures causes safety control to shut down the engine.	Inspect cooling system and components and correct the cause.

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SYMPTOM	PROBABLE CAUSE	REMEDY
Engine power loss.	**Low compression pressure:**	
	1) Leaking head gasket	Replace head gasket - inspect for warped cylinder head and/or crankcase - replace if necessary.
	2) Leaking exhaust-intake valves.	Recondition head and valves.
	3) Worn rings (excessive blow-by.)	Replace rings.
	4) Worn piston/liner.	Replace as necessary.
	5) Cracked piston.	Replace.
	6) Cracked cylinder head.	Replace.
	7) Maladjusted intake and exhaust valves (if recently overhauled.)	Adjust valves.
	8) Intercooler, Turbo or duct work dirty.	Check and clean.
	9) Restriction in intake and/or exhaust system.	Check for obstruction.
	10) Insufficient warm up period.	Follow recommended procedures.
	Insufficient fuel:	
	1) Cracked fuel lines.	Replace cracked line.
	2) Low gas pressure.	Check gas fuel system.
	Excessive exhaust system back pressure.	Correct as required.
	Dirty air intake.	Remove and clean or replace.
Engine will not reach rated speed.	**Engine overload.**	Determine and correct cause of the overload.
	Tachometer inaccurate.	Calibrate or replace tachometer.
	Insufficient fuel supply.	Check fuel supply system.
	Governor maladjusted or faulty.	Measure the actuator output, terminals H & J, while running under governor control. If the voltage measurement is within 1.5 volts of the battery supply voltage level, the fuel control restricted from reaching full fuel position. Possibly due to mechanical governor, carburetor spring or linkage interference. If not, increase speed setting.
	Restricted air intake.	Correct cause.
Engine hunts or surges.	**Governor maladjusted or faulty.**	Reprogram or replace the governor.

SYMPTOM	PROBABLE CAUSE	REMEDY
Low or fluctuating lubricating oil pressure. **CAUTION:** **Shut down engine immediately.**	**Insufficient oil.**	Add oil as required.
	Gauge inaccurate.	Compare to master gauge, replace gauge.
	Oil gauge line plugged.	Renew gauge line.
	Engine operated at angles in excess of maximum safe tilt angles.	Operate within maximum safe tilt angles.
	Crankcase oil pressure relief valve relieves at low pressure.	Replace relief valve spring and or shim it to increase pressure to 25-30 psi (172.36-206.84 kPa)
	Lubricating oil pressure regulating valve stuck in the open position.	Free valve.
	Lubricating oil filter plugged (full flow only.)	Change the element and clean the filter.
	Worn lubricating oil pump.	Repair or replace the pump.
	Worn bearing (connecting rod, main and crankshaft.)	Replace worn bearings.
	Lubricating oil dilution.	Change oil and filter element. Determine and correct the source of dilution.
	Cracked or leaking lubricating oil.	Repair or replace the piping.
	Low oil viscosity.	Change to a higher viscosity oil, as recommended in Lubricating Oil section.
	Lubricating oil foaming.	Use oil grade recommended in Lubricating Oil section.
	Clogged oil inlet screen.	Remove and clean screen.
High lubricating oil pressure.	**Gauge inaccurate.**	Compare to the master gauge and replace as needed.
	Oil temperature too low.	Raise temperature.
	Oil pressure regulating valve stuck in closed position.	Free valve.
	Oil viscosity is to high.	Change to a lower viscosity oil as recommended in the Lubricating Oil section.

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SYMPTOM	PROBABLE CAUSE	REMEDY
Low cooling water temperature.	**Gauge inaccurate.**	Compare to master gauge - replace as needed.
	Inoperative thermostat.	Replace thermostat.
High cooling water temperature **CAUTION:** **Cool water slowly.**	**Gauge inaccurate.**	Compare to master gauge - replace as needed.
	Cooling system is air bound.	Purge air from the cooling system.
	Low coolant level.	Fill cooling system.
	Worn water pump.	Replace or overhaul the water pump.
	Frozen coolant.	Completely thaw the cooling system before starting the engine.
	Poor coolant circulation.	Check entire coolant system.
	Blown head gasket	Replace head gasket.
	Insufficient circulation of air.	Correct as required.
	Cracked head.	Replace head.
	Cracked sleeve.	Replace sleeve.
	Inoperative thermostat.	Replace thermostat.
	Late ignition timing.	Re-time.
High lubricating oil consumption.	**Oil leaks in lubricating oil system.**	
	Improper viscosity.	Change to recommended viscosity.
	Leaking oil seal(s) - rear and/or front.	Change seal/s.
	Worn intake valve guides.	Change head/renew guides or valve stem seals.
	Stuck or worn piston rings.	Renew rings.
	One or more pistons with rings upside down (if recently overhauled.)	Remove piston and correct the position of the rings.
	Excessive connecting rod bearing running clearance.	Replace bearings.
	Crankcase breather plugged.	Clean.

SYMPTOM	PROBABLE CAUSE	REMEDY
Lubricating oil contaminated. **NOTE:** **Change oil before running the engine.**	**Lubricating Oil Contaminated With Water:**	
	1) Sleeve seals leaking or sleeve cracked.	Replace sleeve and/or rings.
	2) Cracked crankcase.	Replace the crankcase. Yes, really.
	Lubricating oil contaminated with dirt:	
	1) Lubricating oil filter by-pass valve opening because the element is plugged.	Replace the element.
	2) Lubricating oil filter element punctured.	Replace element.
	3) Air intake punctured.	Replace the air intake filter.
Excessive vibration **NOTE:** **Stop the engine at once to investigate the cause.**	**Foundation bolts:**	
	1) Loose.	Torque.
	2) Cracked.	Replace and torque all bolts.
	Crankshaft:	
	1) Cracked.	Replace and conduct a complete investigation of the entire engine.
	2) Main bearing bolt loose.	Replace the main bearing bolts. Determine reason for loosening, and carefully check the entire lower crankcase before torquing and subjecting the engine to use.
	Loose flywheel.	Replace and/or torque as required.
High lubricating oil temperature.	**Gauge inaccurate.**	Compare to master gauge - replace as needed.
	Engine overload.	Determine and correct the cause of the overload.
	High cooling water temperature.	See High Cooling Water Temperature section of the chart.
	Low lubricating oil pressure.	Low Lubricating Oil Pressure causes.

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SYMPTOM	PROBABLE CAUSE	REMEDY
Knocking or unusual noises.	**Engine overload.**	Determine and correct cause of overload.
	Overly advanced ignition timing.	Re-time.
	Loose bearings (failed.)	Replace bearings.
	Loose piston pins (failed.)	Replace piston pins and/or pin bushings as required.
	Damaged or excessively worn accessory drives.	Repair and replace components as required.
	Excessive crankshaft end play.	Replace main thrust bearing.
	Excessive valve clearance.	Readjust valve clearance.
	Sticking valves or rocker arms.	Free up or replace.
	Misfitted or excessively worn timing gears.	Replace.
Excessive fuel consumption.	**Leaks in the fuel system.**	Repair as required.
	Late ignition timing.	Re-time.
	Engine overload.	Determine and correct causes of overload.
	Poor compression.	Determine causes and repair.
	Improper matching of torque convertor to engine and load.	Replace torque convertor.
Low gas pressure.	**Incorrectly adjusted gas regulator.**	Readjust.
	Insufficient line pressure.	Increase line pressure.
	Incorrect orifice and/or spring in the gas regulator.	Replace orifice and/or spring.
	Undersize gas regulator.	Replace with gas regulator of adequate size.
	Undersize piping.	Replace with piping of adequate size.
	Gas regulator mounted too far from engine.	Remount gas regulator as close to the carburetor as possible.
High gas pressure.	**Incorrectly adjusted gas regulator. Readjust.**	
	Incorrect orifice and/or spring in the gas regulator.	Replace orifice and/or spring.
	Excessive line pressure.	Reduce line pressure.

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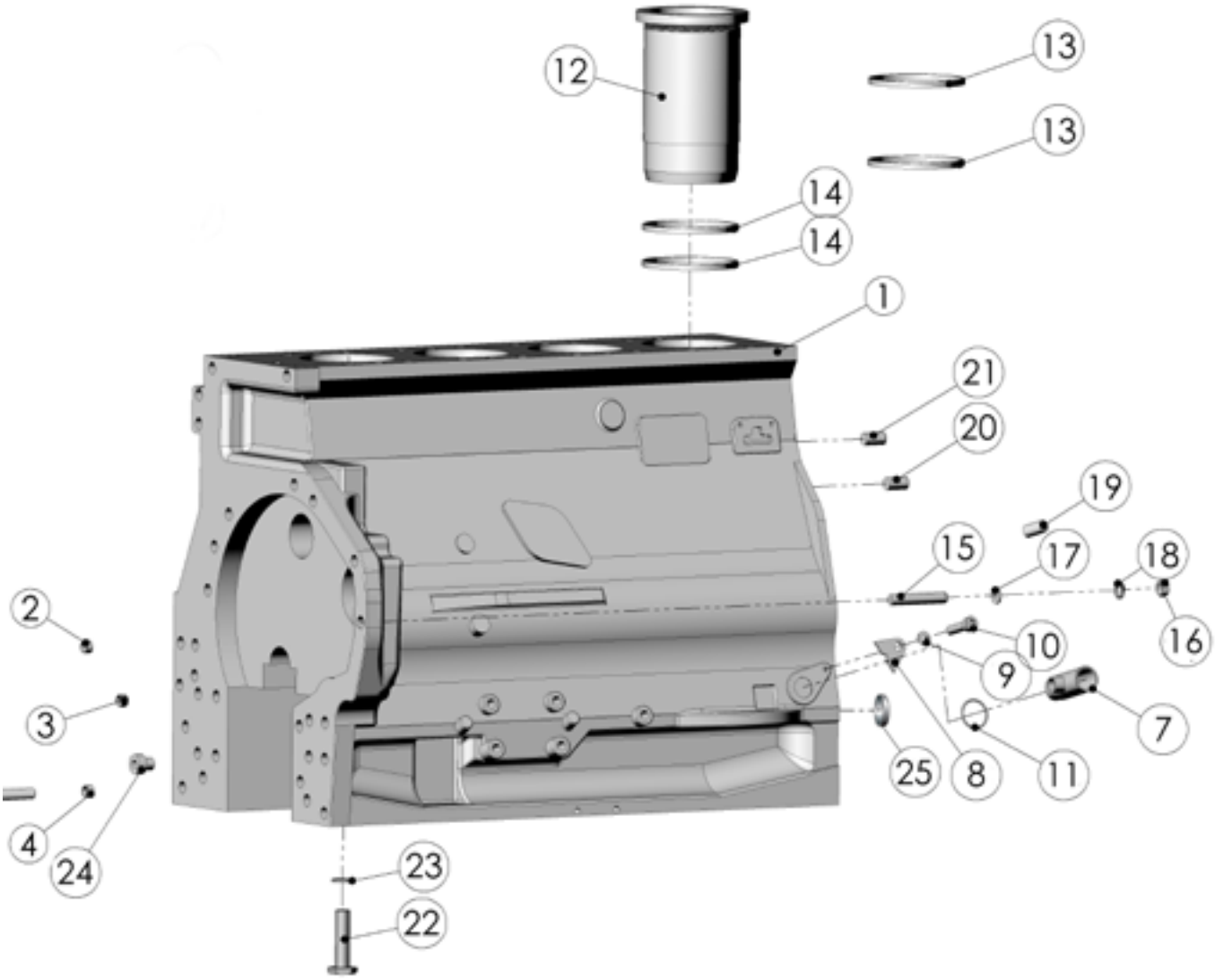
13 Parts

13.1 Crankcase Assembly



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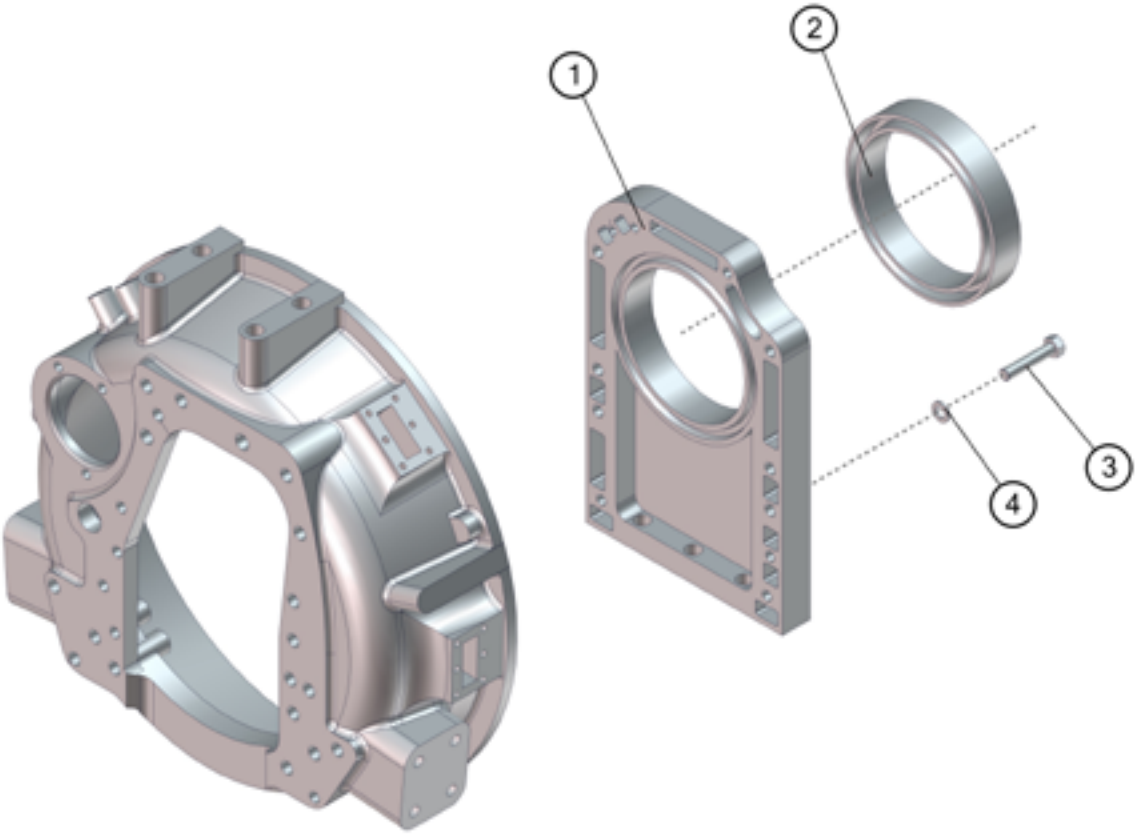
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	13033238	ENGINE BLOCK			1
	12273340			1	
	WA50149		1		
2	12151365	FREEZE PLUG	6	8	7
3	12273515	FREEZE PLUG	2	2	2
4	12273557	FREEZE PLUG	3	2	2
5	12159599	CAMSHAFT BUSHING	1	1	1
6	01153348	STUD	1	1	1
7	12160117	MANIFOLD	1	1	1
8	12160129	RETAINING PLATE		1	1
9	01177981	SPRING LOCK WASHER		1	1
10	01151498	CHEESE HEAD SCREW		1	1
11	01153869	O-RING		1	1
12	13024173	CYLINDER LINER	3	4	6
13	01153805	O-RING	6	8	12
14	01153804	O-RING	6	8	12
15	01113477	STUD	4	4	4
16	01139401	HEXAGON NUT	4	4	4
17	12163182	PLAIN WASHER			4
	01152752		4	4	
18	01117867	TOOTH LOCK WASHER	4	4	4
19	01115413	STRAIGHT PIN	4	5	7
20	01105156	PARALLEL PIN	3	2	3
21	13033415	PARALLEL PIN	2	4	2
22	01118952	HEXAGON BOLT		1	2
23	12165568	WASHER	1	1	1
24	12159445	SLEEVE	1	1	1
25	WC17000	PLUG CORE 26MM	1	1	1
26*	13037380	MAIN BEARING CAP BOLTS	6	10	12
27*	WA00005	MAIN BEARING BOLT W/STUD	2	2	2

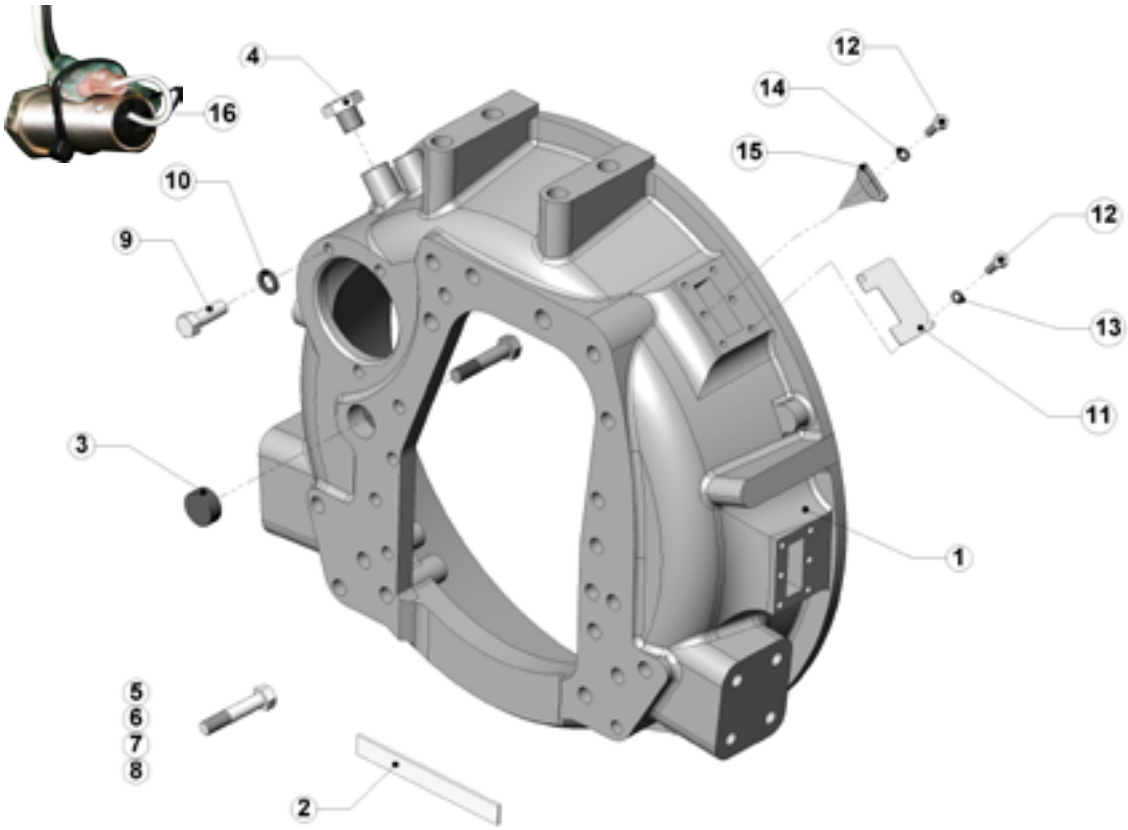
* Not Shown

13.2 Rear Oil Seal Cover Assembly



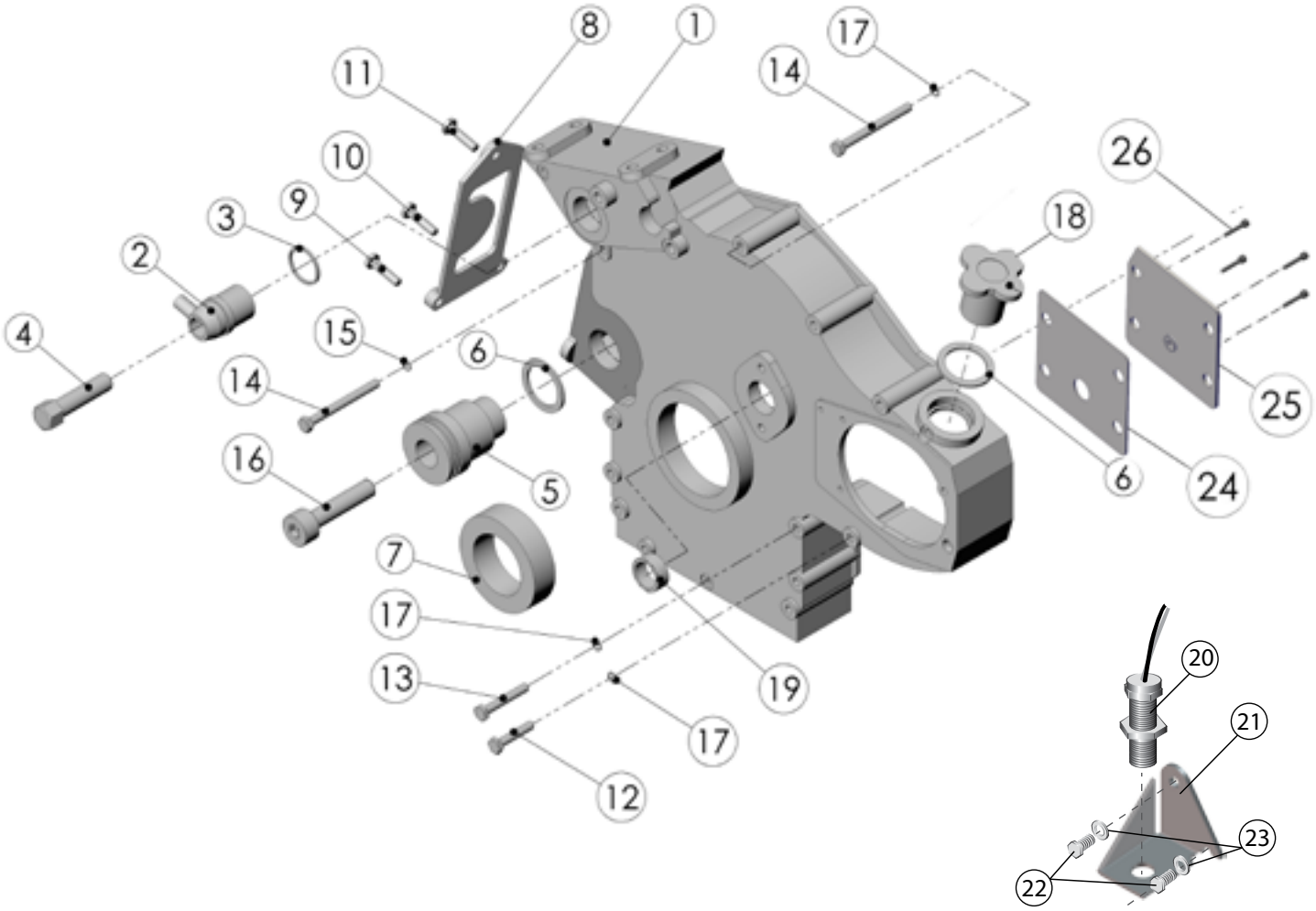
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12272177	REAR OIL SEAL COVER	1	1	1
2	12189888	REAR SEAL	1	1	1
3	01112331	HEXAGON BOLT, M8X25	10	10	10
4	01107281	SPRING WASHER	10	10	10

13.3 Flywheel Housing Assembly



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	13024241	FLYWHEEL HOUSING	1	1	1
2	01157512	RUBBER STRIP	1	1	1
3	01097624	PLUG	1	1	1
4	13022205	HEXAGON BOLT	2	2	2
5	01139338	HEXAGON BOLT	10	10	10
6	01153777	HEXAGON BOLT	2	2	2
7	01178940	HEXAGON BOLT	2	2	2
8	01112551	HEXAGON BOLT	4	4	4
9	01112427	HEXAGON BOLT	3	3	3
10	01178365	SPRING LOCK WASHER	3	3	3
11	13021291	COVER	1	1	1
12	01112238	HEXAGON BOLT	3	3	3
13	01107095	PLAIN WASHER	3	3	3
14	01178307	SPRING LOCK WASHER	3	3	3
15	130215931	FINGER	1	1	1
16	MSP675	MAG PICK UP, GOVERNOR	1	1	1
	7910151	MAG PICK UP IGNITION 2" LONG		1	1
	7910162	MAG PICK UP IGNITION 3.5" LONG		1	1

13.4 Gear Cover – A-32 / A-42 (VR260)



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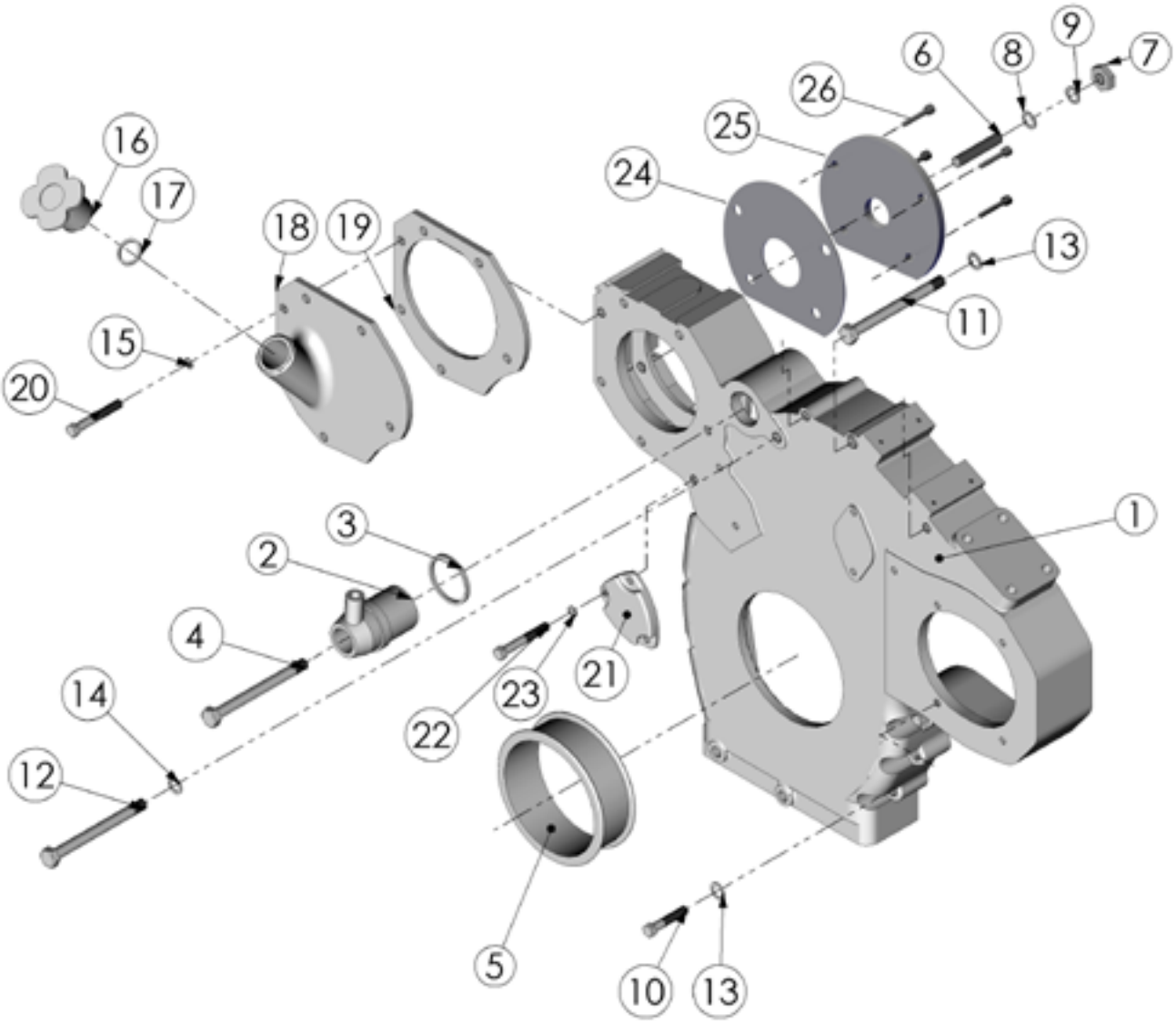
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42
1	13021714	CRANKCASE END COVER	1	1
2	12158431	HOUSE/CASE	1	1
3	01161340	O-RING	1	1
4	01111096	HEXAGON BOLT	1	1
5	12190581	FLANGED BUSH	1	1
6	06214722	O-RING	2	2
7	12188100	ROTARY SHAFT SEAL	1	1
8	13020243	SHIELD - END COVER	1	1
9	01112331	HEXAGON BOLT	1	1
10	01137083	HEXAGON BOLT	1	1
11	01112416	HEXAGON BOLT	1	1
12	01139584	HEXAGON BOLT	1	1
13	01111151	HEXAGON BOLT	5	5
14	01111184	HEXAGON BOLT	6	6
15	01118647	SEAL RING	1	1
16	01151462	ALLEN HEAD SCREW	1	1
17	01177981	SPRING LOCK WASHER	11	11
18	12165572	LUBE OIL FILLER	1	1
19	01152711	COVER	1	1
20	7910151	MAGNETIC PICK-UP FOR IGNITION		1
21	208512-MP-A-42	SENSOR BRACKET		1
22	M8X20	BOLT		2
23	M08WS	WASHER		2
24	208512-A42G	GASKET, BLOCK OFF PLATE	1	1
25	208512-A42	BLOCK OFF PLATE	1	1
26	M8X20	BOLT	4	4

13.5 Gear Cover – A-62 (VR380)



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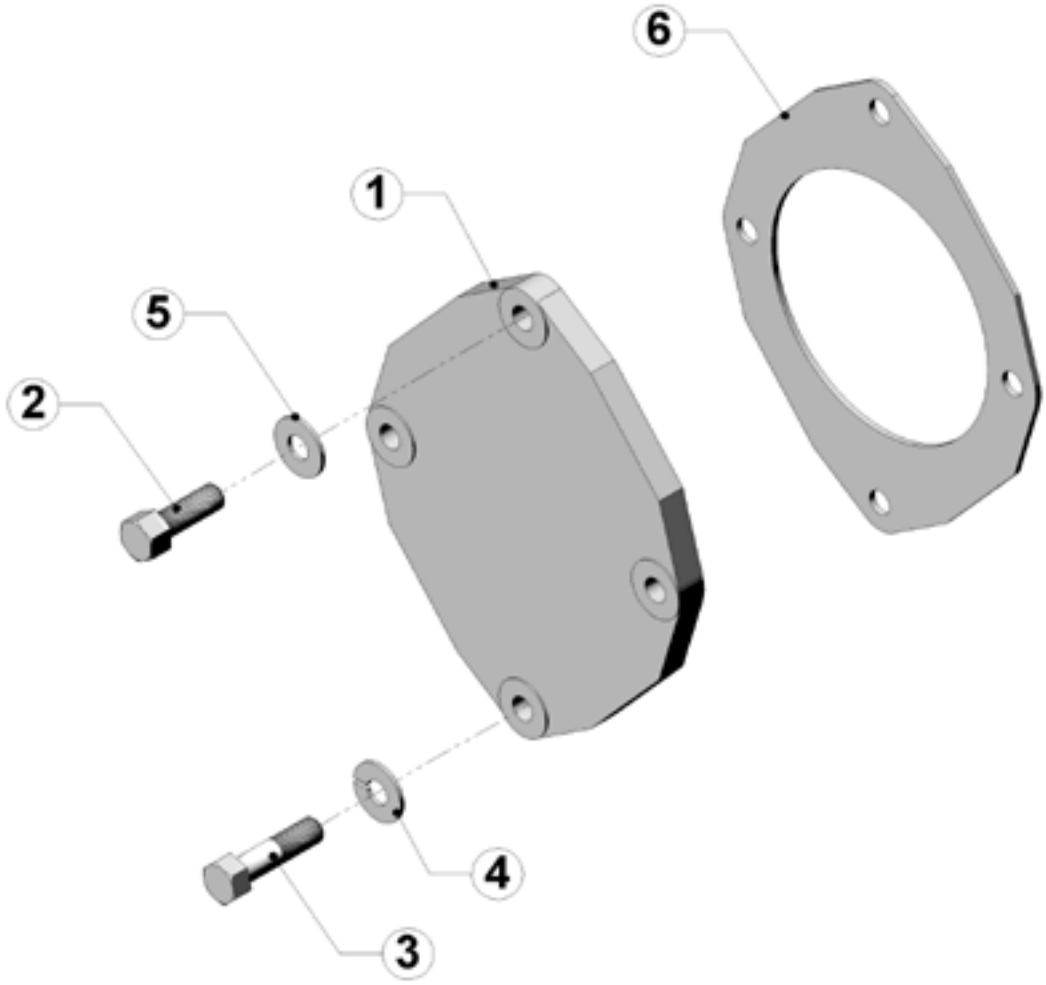
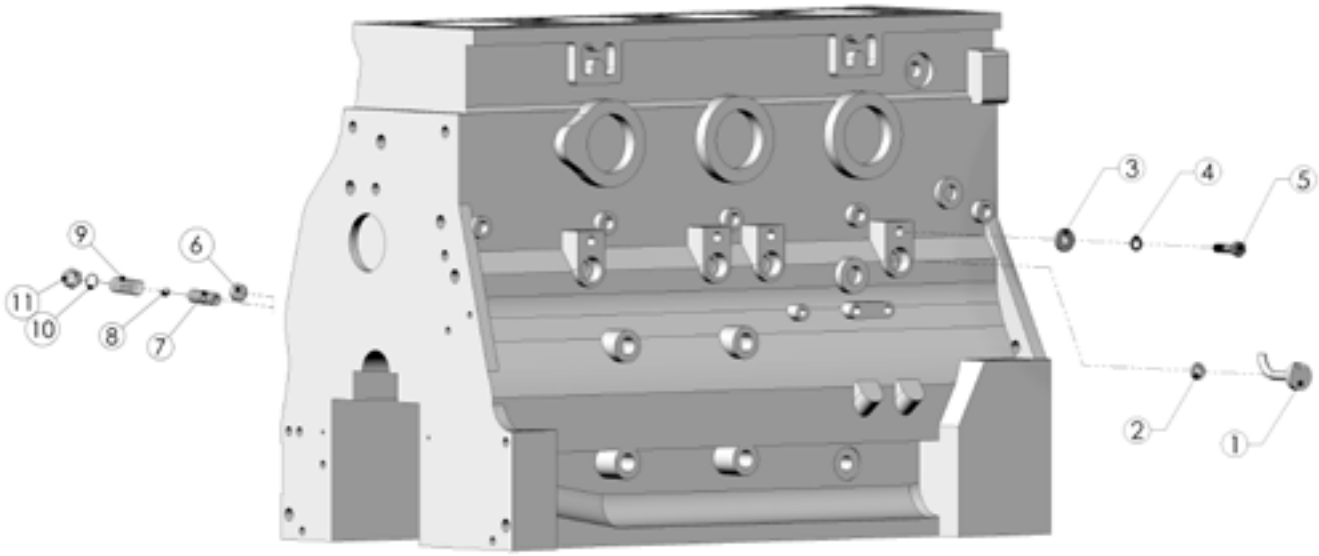
ITEM	PART NUMBER	DESCRIPTION	A-62
1	13025151	CRANKCASE END COVER	1
2	12158431	HOUSING/CASE	1
3	01161340	O-RING	1
4	01111096	HEX BOLT	1
5	12188100	FRONT SEAL	1
6	01113472	STUD	4
7	13021999	HEX NUT	4
8	01152752	PLAIN WASHER	4
9	01117867	TOOTH LOCK WASHER	4
10	01111151	HEX BOLT	5
11	01111184	HEX BOLT	4
12	01111195	HEX BOLT	1
13	01177981	SPRING LOCK WASHER	21
14	12159859	SEALING RING	1
15	01177981	WASHER	21
16	12165572	PLUG	1
17	01161340	O-RING	1
18	13022333	SHIELD	1
19	13022341	GASKET	1
20	01112331	HEX BOLT	8
21	13022340	SHIELD	1
22	01151567	HEX BOLT	3
23	01118641	WASHER	3
24	208512-A62G	GASKET, BLOCK OFF PLATE	1
25	208512-A62	BLOCK OFF PLATE	1
26	M8X20	BOLT	4

13.6 Cover plate



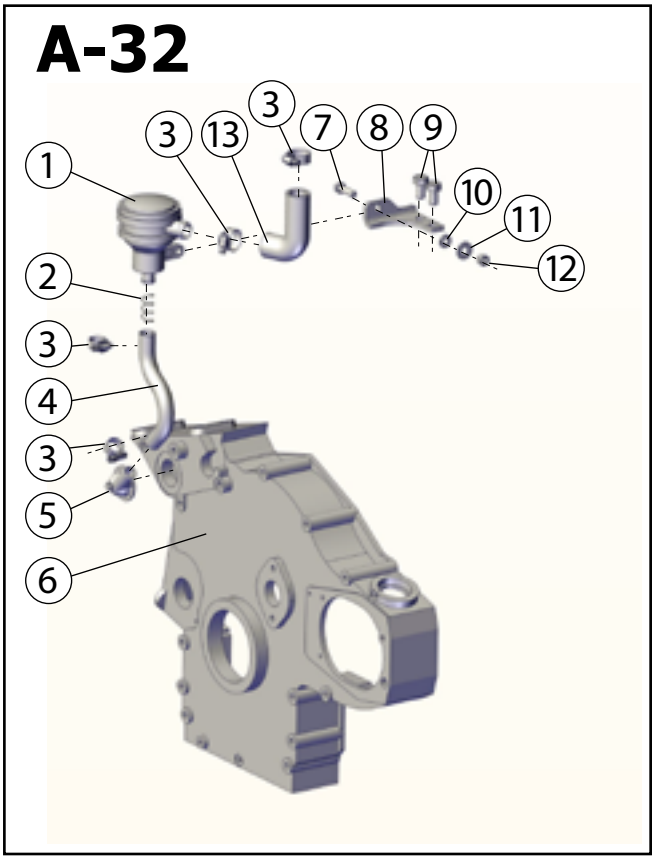
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12166808	COVER	1	1	1
2	01112331	HEXAGON BOLT	1	1	1
2	01112339	HEXAGON BOLT			1
3	01111198	HEXAGON BOLT	2	2	2
4	01177981	SPRING LOCK WASHER	4	4	4
5	01118654	SEAL RING	1	1	1
6	12189678	GASKET	1	1	1
	PF18-1/4	PLUG	1	1	1

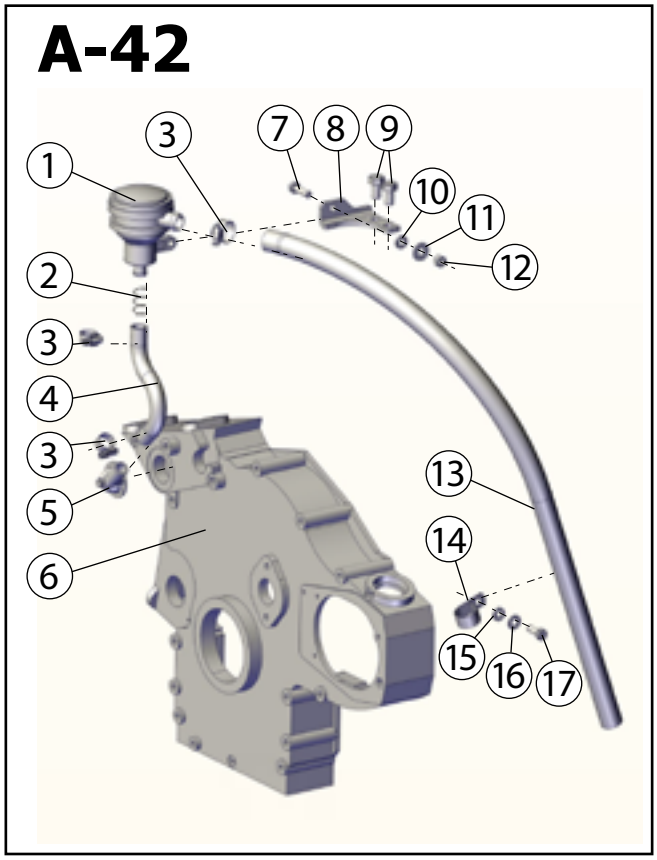
13.7 Crankcase Fittings



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12273763	NOZZLE	3	4	6
2	01166001	O-RING	3	4	6
3	12164637	PLAIN WASHER	3	4	6
4	01177981	SPRING LOCK WASHER	3	4	6
5	01151569	HEXAGON BOLT	3	4	6
6	01152717	CORE PLUG	2	3	5
7	12167053	SCREW FITTING		1	1
8	01116958	BALL		1	1
9	01220356	COMPRESSION SPRING			1
	01221356			1	
10	01118707	O-RING			1
	01118664			1	
11	12167057	ACORN NUT		1	1

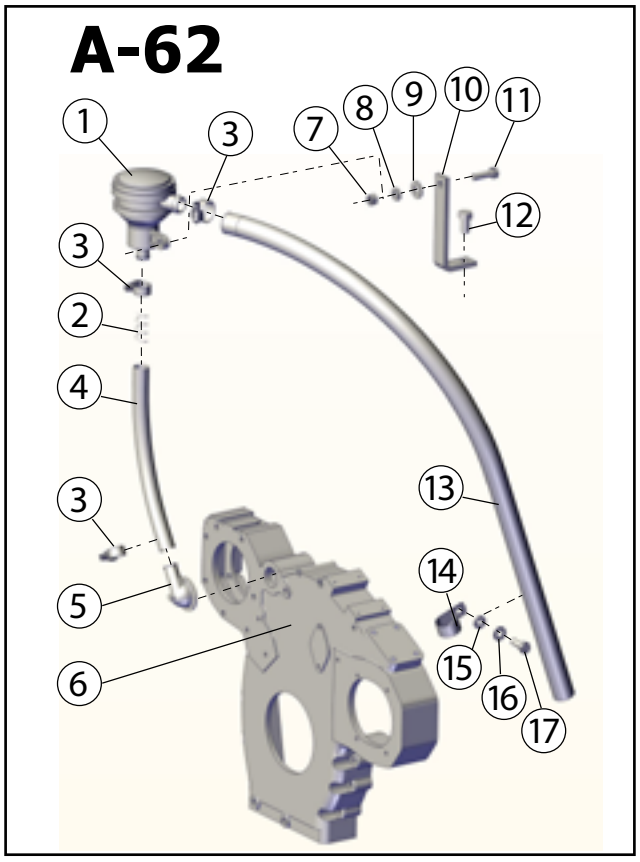
13.8 Crankcase Breather – A-32 / A-42 (VR260)





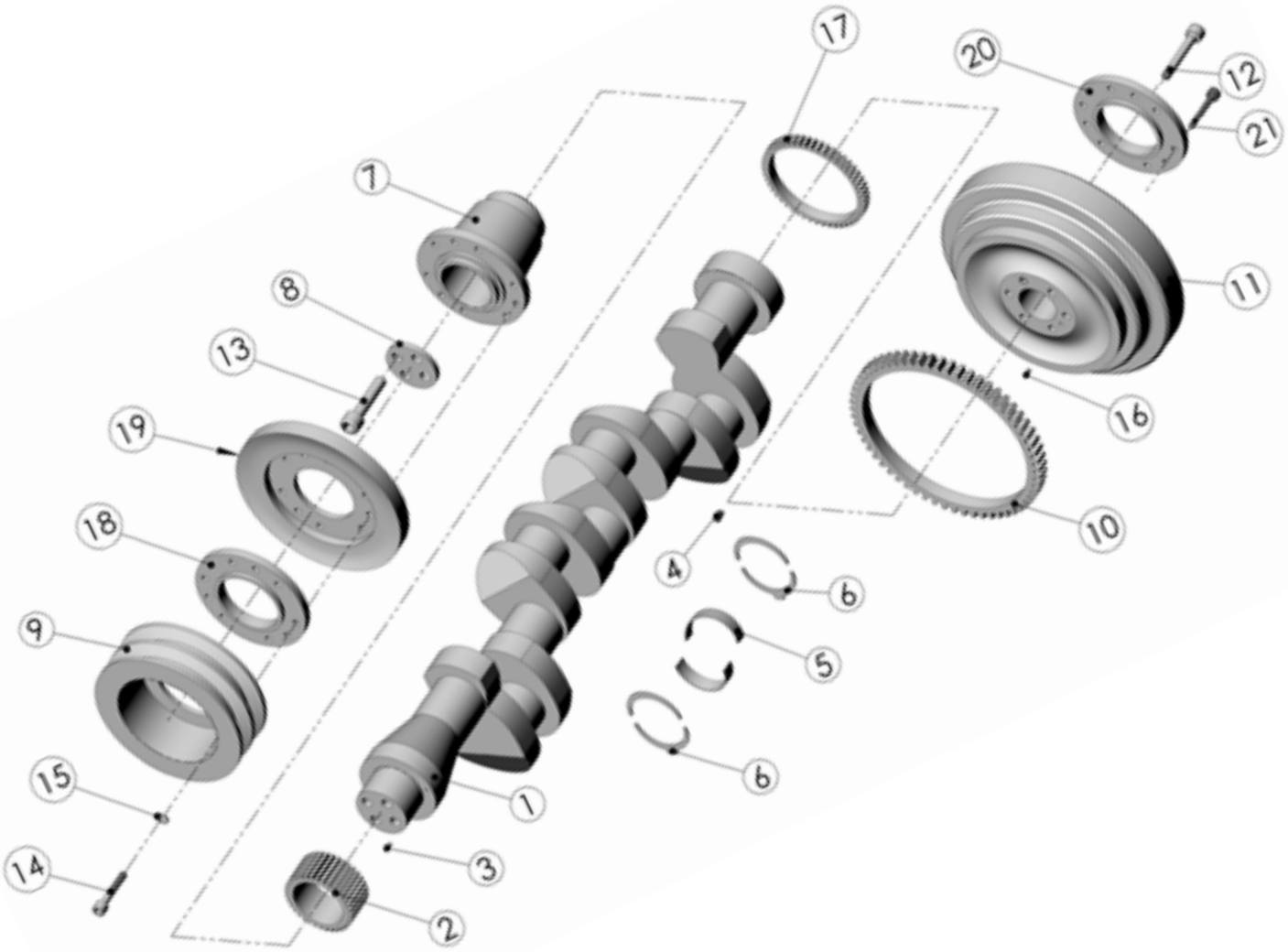
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42
1	12270387	OIL AND GAS SEPARATOR	1	1
2	12270389	SPRING	1	1
3	1137412	HOSE CLIP	4	3
4	13031745	REINFORCED VINYL TUBING	1	1
5	12158431	HOUSING/CASE	1	1
6	13021714	CRANKCASE COVER	1	1
7	1112339	HEXAGON BOLT	1	1
8	13024068	BRACKET	1	1
9	1112405	HEXAGON BOLT	2	2
10	1177981	SPRING LOCK WASHER	1	1
11	1152752	PLAIN WASHER	1	1
12	M08NF	NUT	1	1
13	13022800	HOSE		1
	WA05001		1	
14	01177986	HOSE CLIP		1
15	M08WS	SPLIT WASHER		1
16	M08WF	FLAT WASHER		1
17	M08X20	BOLT		1

13.9 Crankcase Breather – A-62 (VR380)



ITEM	PART NUMBER	DESCRIPTION	A-62
1	12270387	OIL AND GAS SEPARATOR	1
2	12270389	SPRING	1
3	1137412	HOSE CLIP	3
4	1396634	REINFORCED VINYL TUBING	1
5	12158431	HOUSING/CASE	1
6	13021714	CRANKCASE COVER	1
7	M08NF	NUT	1
8	1177981	SPRING LOCK WASHER	1
9	1152752	PLAIN WASHER	1
10	WC08009	BRACKET	1
11	1112339	HEXAGON BOLT	1
12	1112405	HEXAGON BOLT	1
13	13022800	HOSE	1
14	01177986	HOSE CLIP	1
15	M08WS	SPLIT WASHER	1
16	M08WF	FLAT WASHER	1
17	M08X20	BOLT	1

13.10 Crankshaft Assembly



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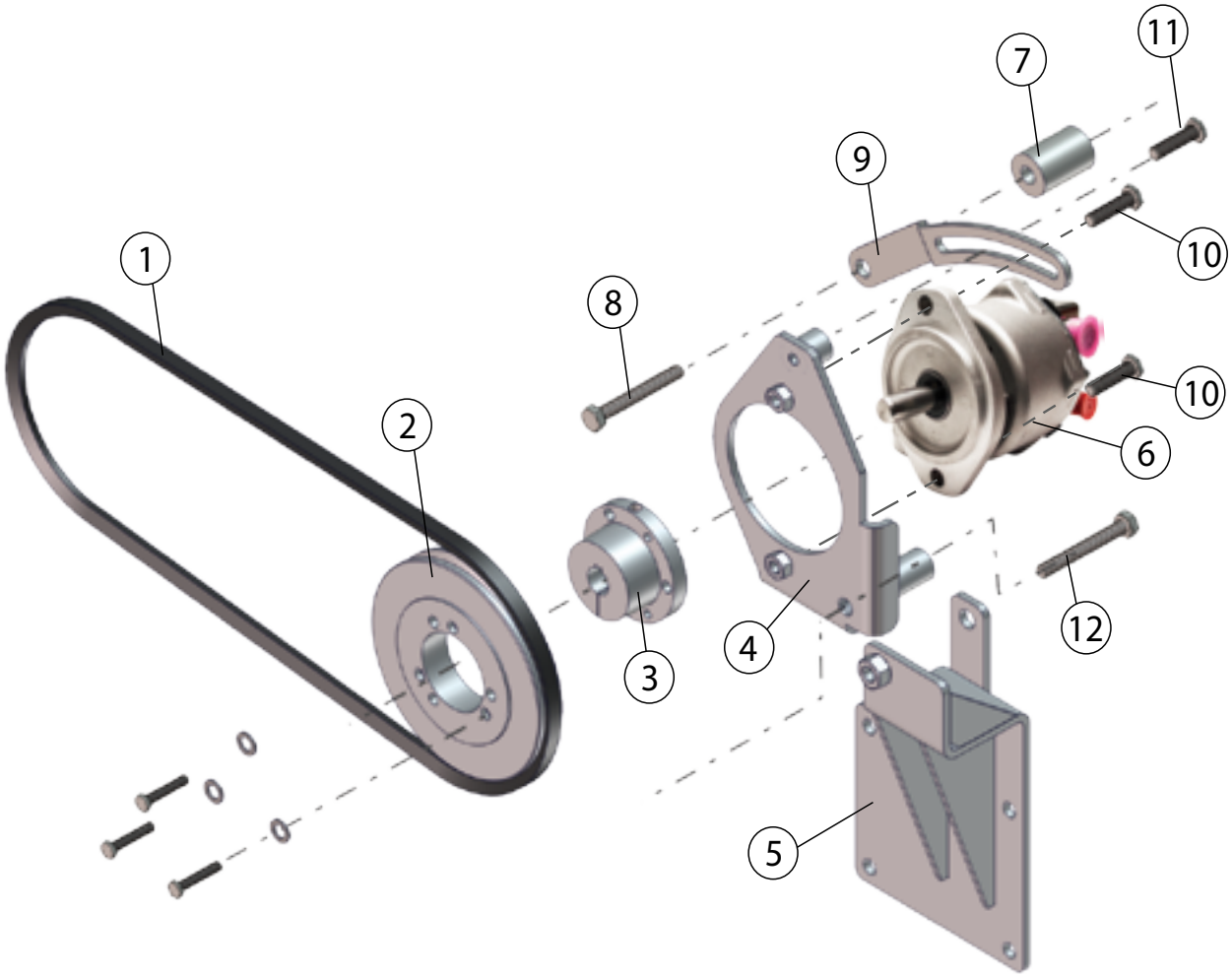
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12272496	CRANKSHAFT ASSEMBLY			1
	12272490			1	
	WA50147		1		
2	13022334	CRANKSHAFT TIMING GEAR			1
	12273248		1	1	
3	01115416	DOWEL PIN	1	1	1
4	12151364	PLUG	3	4	6
5A	13034916	MAIN BEARING, LOWER	4	5	7
5B	13034908	MAIN BEARING, UPPER	3	4	6
5C*	WA50163	MAIN BEARING, UPPER, W/ OIL HOLE OFFSET	1	1	1
6	12160535	THRUST PIECES	2	2	2
7	13029794	HUB			1
	12188222-3			1	
	WA50150		1		
8	12160534	PLAIN WASHER	1	1	1
9	WC50034	V-GROOVED PULLEY			1
	WA50158	OPTIONAL 4-GROOVE	1	1**	
	13022503	V-GROOVE PULLEY	1	1	
10	12166719	RING GEAR	1	1	1
11	13023261-4	FLYWHEEL			1
	13023261		1	1	
12	01112682	HEXAGON BOLT	6	6	6
13	WA00006	CRANKSHAFT HUB BOLT	4		4
	01110847			4	
14	13021520	CRANKSHAFT PULLEY BOLT			9
	01110659		6	6	
	M10X45S			6**	
15	01178365	SPRING LOCK WASHER	6	6	6
16	01125638	STRAIGHT PIN	1	1	1
17	12166718	MASS BALANCER GEAR RIM		1	
18	13022924	ADAPTOR			1
19	12272805	VIBRATION DAMPER			1
20	216013PB	PILOT BEARING HOUSING	1	1	1
21	7A-5/1618X11/4	BOLT	1	1	1
	13034908	MAIN BEARING, UPPER		5	7
	13034916	MAIN BEARING, LOWER		5	7
22*	G-918-142	MAIN BEARING SET		1	
	G-918-162				1
	G-918-132		1		

*Not shown

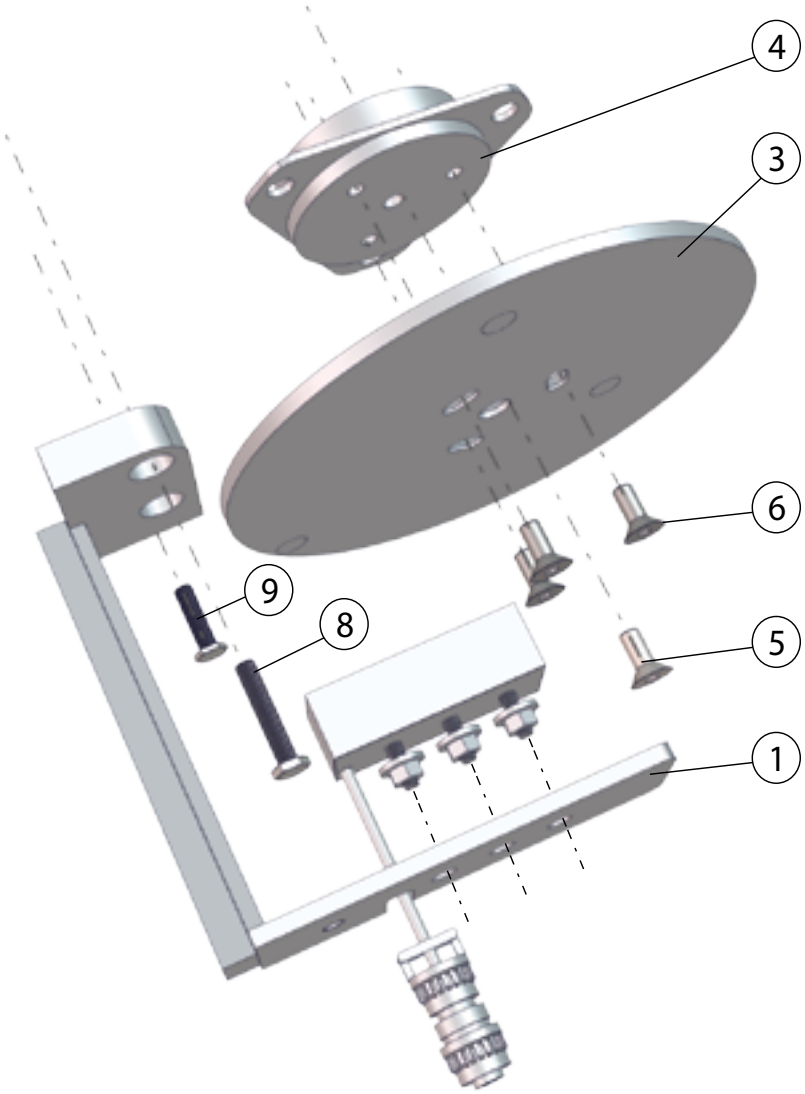
**Requires new mounting bolts.

13.11 A-32 Ignition System



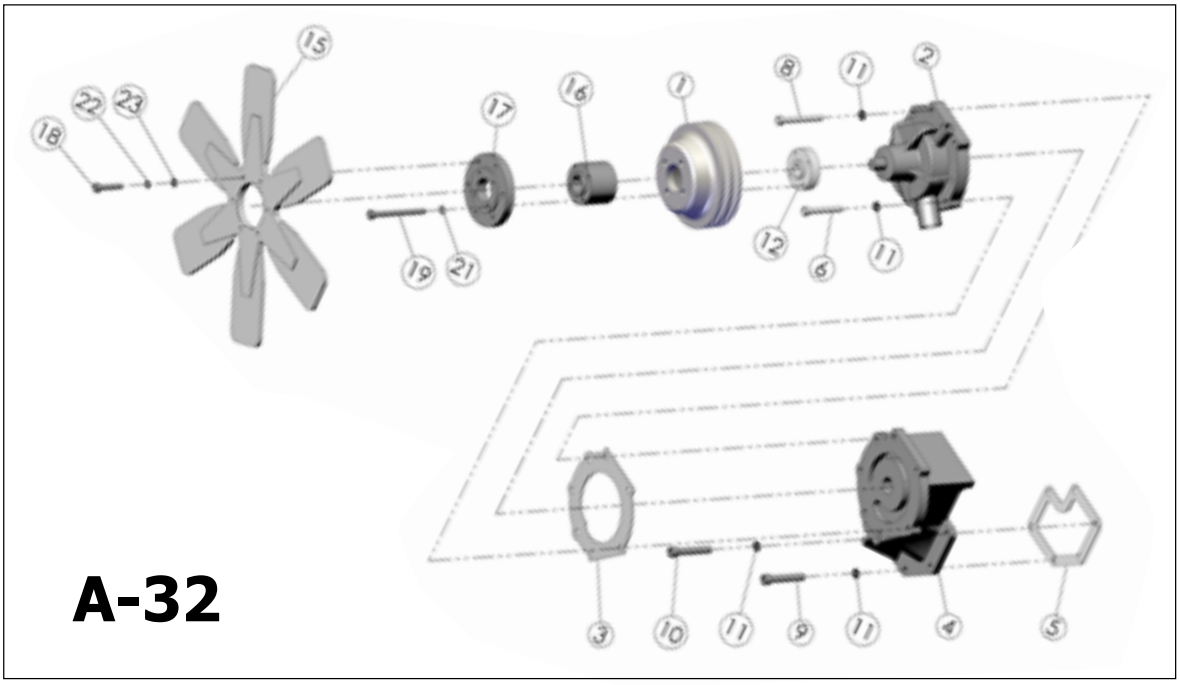
ITEM	PART NUMBER	DESCRIPTION	A-32
1	WA04000	BELT V MAG DRIVE	1
2	WA50003	5” MAGNETO PULLEY	1
3	WA50004	PULLEY HUB	1
4	WA05006	BRACKET MAG CARRIER	1
5	WA08003	MOUNTING BRACKET, MAGNETO	1
6	WA50008	BELT DRIVEN MAGNETO	1
7	WA08001	SPACER, ALTERNATOR STRAP	1
8	M10X65	STRAP TO BLOCK BOLT	1
9	199094D	ALTERNATOR BELT ADJUSTMENT STRAP	1
10	M8X25	MAG TO BRACKET/ADJUSTMENT BOLT	3
11	M8X35	HEXHEAD CAPSCREW	1
12	??	HEXHEAD CAPSCREW	1

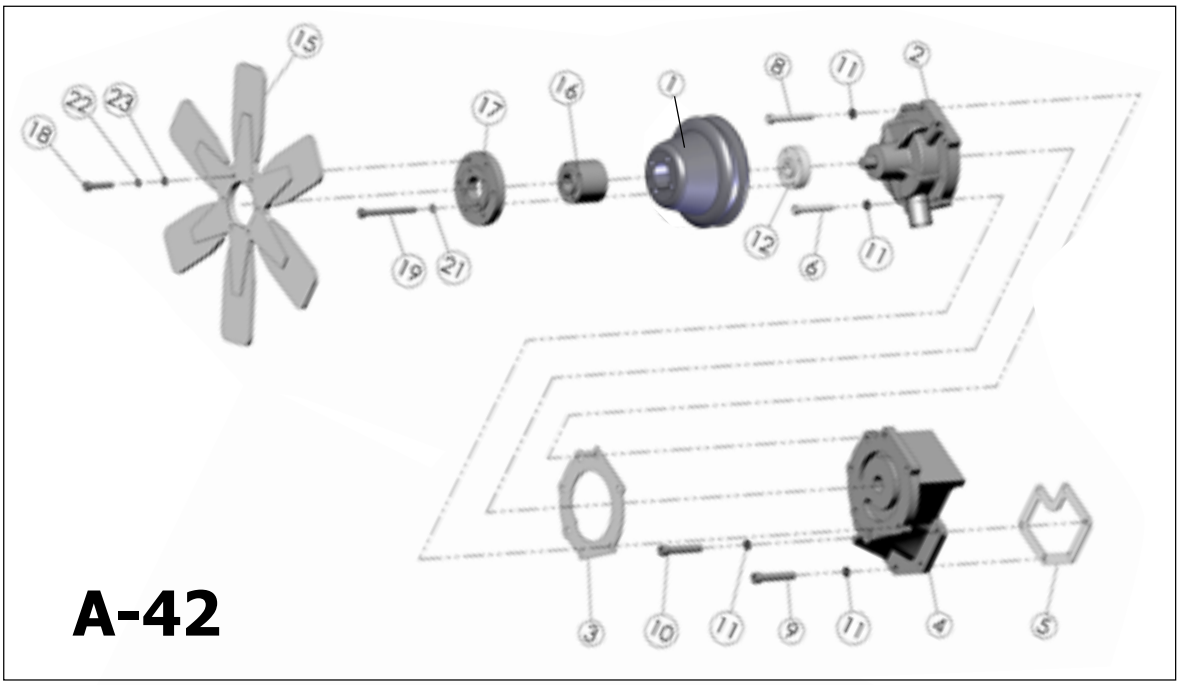
13.12 A-32 Ignition Disc/Pickup

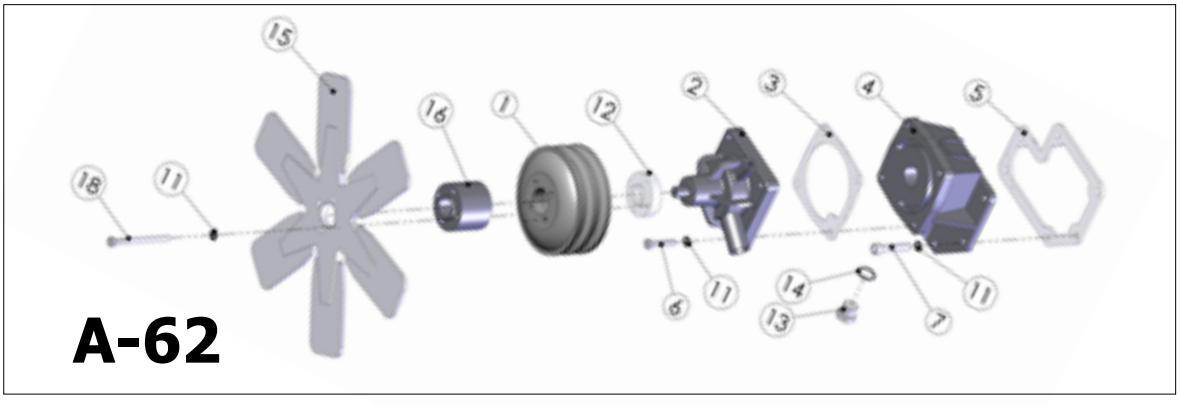


ITEM	PART NUMBER	DESCRIPTION	A-32
1	WA08002	BRACKET MAGNETIC PICKUP MOUNTING	1
2	WA50005	PICKUP MODULE	1
3	WA50007	MAGNETIC DISC	1
4	WA16002	CRANK PULLEY ADAPTOR	1
5	21377	SCREW, MAGNETIC DISC CENTER	1
6	28636	SCREW, ADAPTOR	3
7	M18X45	BOLT, PICKUP ARM	1
8	M18X55	BOLT, PICKUP ARM	1

13.13 Fan Assembly







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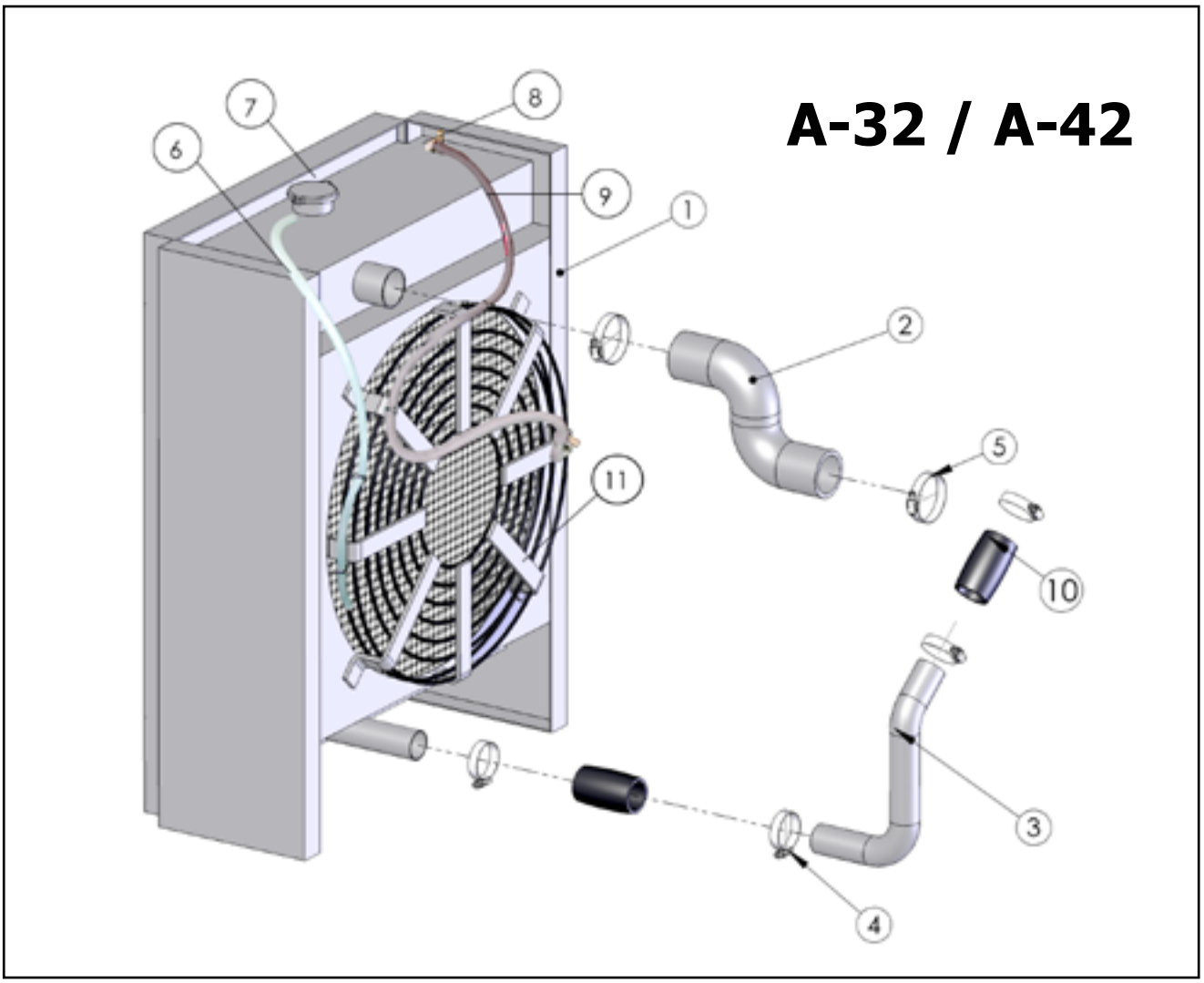
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	216194-A42	STANDARD DUAL PULLEY	1		
	13020583	STANDARD V-GROOVE PULLEY		1	
	216194-A42	OPTIONAL DUAL PULLEY		1	
	12213366	STANDARD DUAL PULLEY			1
2	13023061	WATER PUMP			1
	12273212		1	1	
3	12200650	GASKET, WATER PUMP			1
	12270869		1	1	
4	13023052	ADAPTOR			1
	13020587		1	1	
5	12158513	GASKET, ADAPTOR TO BLOCK	1	1	1
6	01111151	HEXAGON BOLT			5
	01139584		4	4	
7	01112331	HEXAGON BOLT	6	6	
8	13024407	HEXAGON BOLT			2
9	01151500	CHESS HEAD SCREW			4
10	01152347	CHESS HEAD SCREW			2
11	01177981	SPRING LOCK WASHER	14	14	17
12	13020587	FLANGE	1	1	1
13	01118960	HEXAGON BOLT	1	1	
14	13023360	SEALING RING	1	1	
15	13021535	PUSHER FAN, 4 BOLT			1
	WC13001	SUCKER FAN, 4 BOLT			1
	13021367	PUSHER FAN	1	1	
	WA13000	SUCKER FAN	1	1	
	13021190*	PUSHER FAN, 6 BOLT 380 TURBO			1
16	12159208	SHAPED FLANGE			1
	13024404		1	1	
17	13024832	SHAPED FLANGE			1
18	01110618	WATER PUMP BOLT			4
	01112405		4	4	
*	13020581	ADAPTOR	1	1	
19	13024408	HEXAGON BOLT			4
*	01152752	GASKET			6
*	01132562	GASKET			4
22	01178365	SPRING LOCK WASHER			6
23	01152752	GASKET			6
24*	13024257	BYPASS HOSE			1
	13020586		1	1	

*Not shown

« RETURN TO TOC

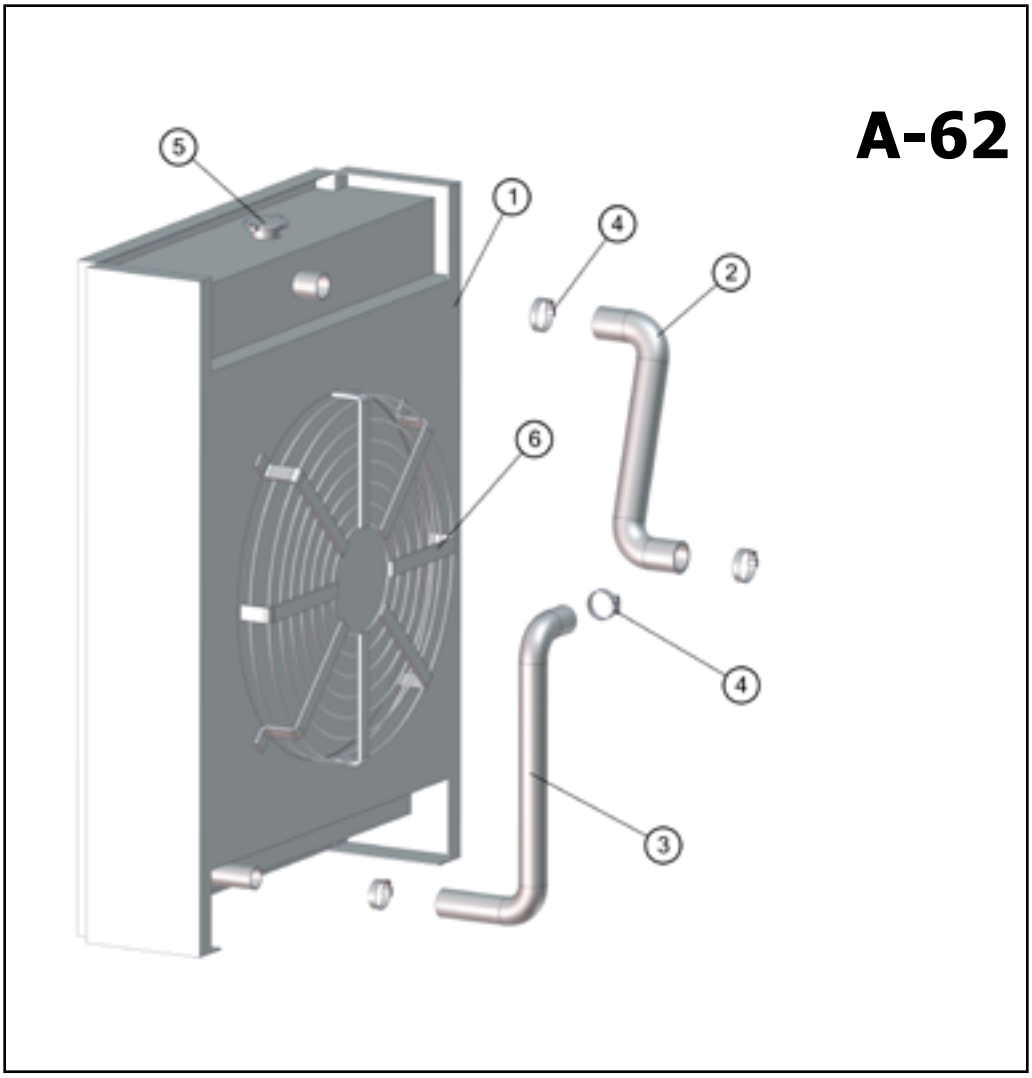
13.14 Radiator Assembly – A-32 / A-42 (VR260)



ITEM	PART NUMBER	DESCRIPTION	A-32 / A-42
1	13037733	RADIATOR	1
2	13021980	UPPER RADIATOR HOSE	1
3	13021981	INLET PIPE	1
4	HC-64	CLIP	4
5	01133878	CLIP	6
6	H461	OVERFLOW DRAIN HOSE, 3’	1
7	207945	RADIATOR CAP	1
8	118224	HOSE CLAMP	2
9	H146	HOSE TO WATER MANIFOLD, 5/16’ D	1
10	13022596	RUBBER HOSE	2
11	13021989	FAN GUARD, TWO PIECE	1
*	13024409	DRAIN FITTING	1

*Not shown

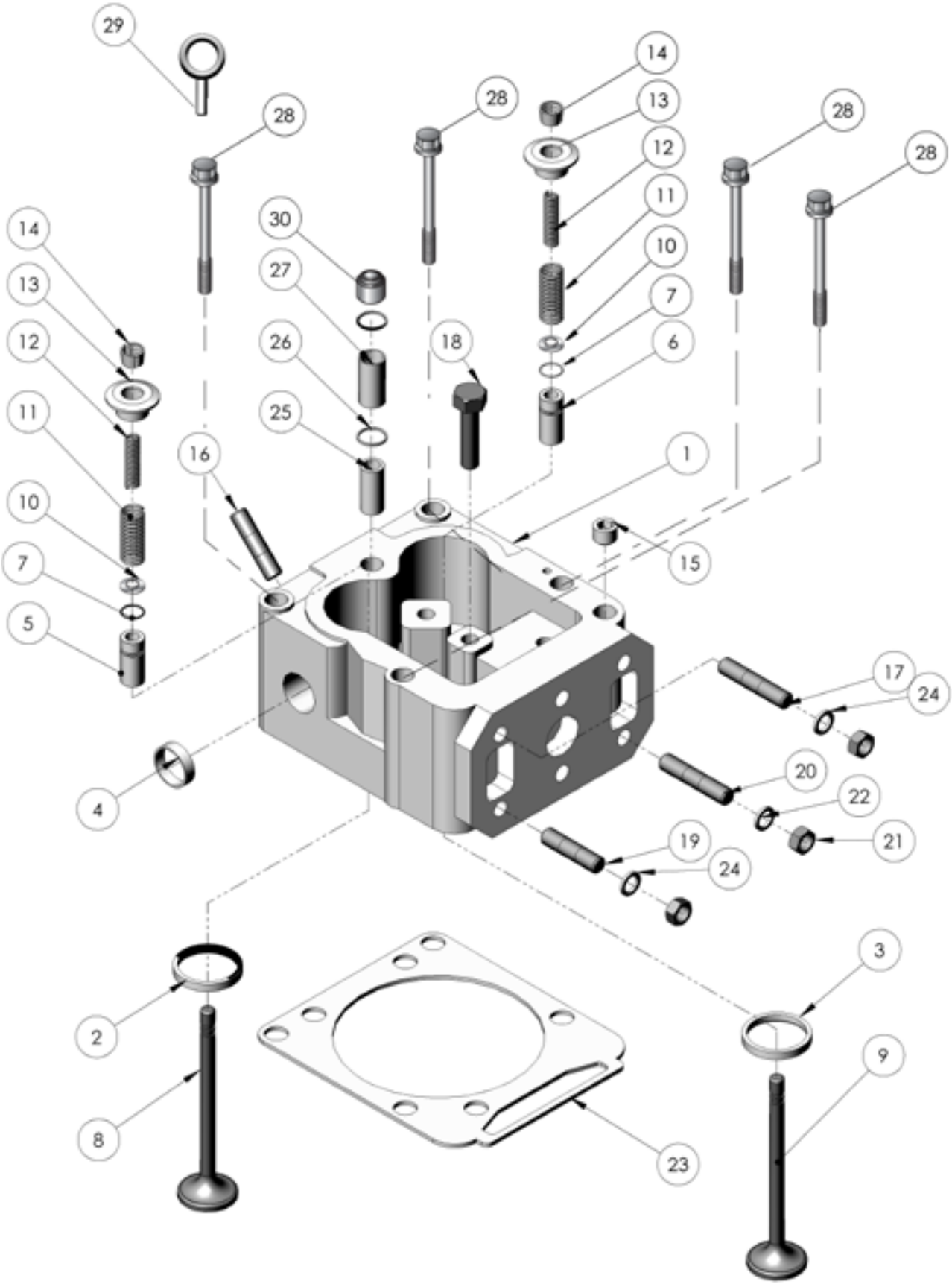
13.15 Radiator Assembly – A-62 (VR380)



ITEM	PART NUMBER	DESCRIPTION	A-62
1	13021903	RADIATOR, NATURALLY ASPIRATED	1
*	13021901	RADIATOR, TURBO	1
2	208773-380	UPPER RADIATOR HOSE	1
3	208774-380	LOWER RADIATOR HOSE	1
4	HC-64	CLIP	4
5	207945-A62	RADIATOR CAP	1
6	13021902	FAN GUARD	1
*	13024257	UPPER BYPASS HOSE	1
*	13024409	DRAIN FITTING	1

*Not shown

13.16 Cylinder Head Assembly

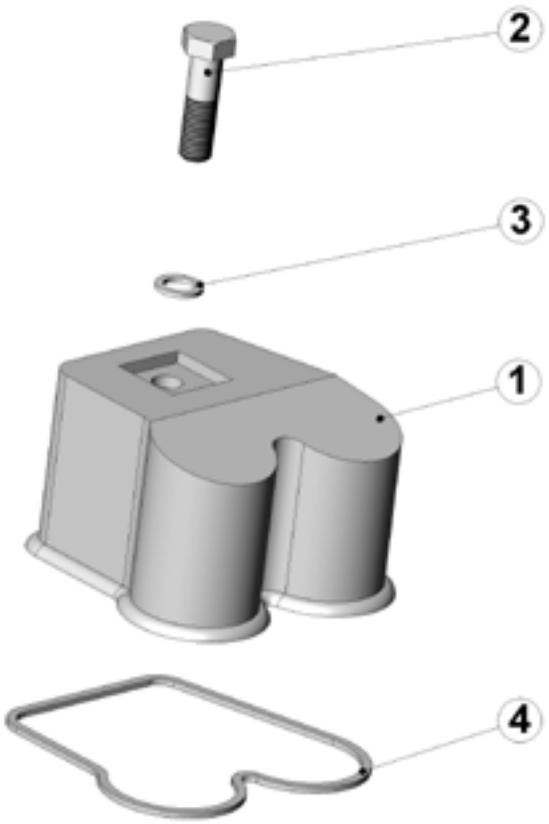


ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	13024737	CYLINDER HEAD, COMPLETE, NON-SHIELDED, 12MM SPARK PLUGS	3	4	6
	13024737-S	CYLINDER HEAD, COMPLETE, SHIELDED, 14MM SPARK PLUGS	3	4	6
2	13039778	INLET VALVE SEAT	3	4	6
3	13039779	EXHAUST VALVE SEAT	3	4	6
4	01152710	CORE PLUG	9	12	24
5	13026863	INTAKE VALVE GUIDE	3	4	6
6	13026872	EXHAUST VALVE GUIDE	3	4	6
7	13023391	STEM SEAL	6	8	12
8	13039782	INLET VALVE	3	4	6
		INLET VALVE - TURBO			6
9	13039783	EXHAUST VALVE	3	4	6
		EXHAUST VALVE - TURBO			6
10	12167040	RETAINER, VALVE (REF 13024293)	6	8	12
11	01222051	COMPRESSION SPRING	6	8	12
12	01222009	COMPRESSION SPRING	6	8	12
13	12164645	SPRING CAP	6	8	12
14	12164698	VALVE COLLET	12	16	24
15	01104736	SCREW PLUG	6	8	6
16	01152538	HOSE CLIP	6	8	12
17	01152500	STUD	3	4	12
18	01112445	HEXAGON BOLT	6	8	12
19	01113465	STUD			12
	01113472	SCREW PLUG	6	8	
20	13032347	STUD	6	8	12
21	13020378	NUT	15	20	30
22	12163182	PLAIN WASHER	6	8	12
23	13025787	CYLINDER HEAD GASKET	3	4	6
24	12167216	PLAIN WASHER	9	12	
25	12188750	PIPE CONNECTION			6
26	12151665	HOST CLIP			12
27	12200327	TUBING CONNECTION			6
	13023391	STEM SEAL	6	8	12
	G-979-32	COMPLETE HEAD GASKET SET	1		
	G-979-42	COMPLETE HEAD GASKET SET		1	
	G-979-62	COMPLETE HEAD GASKET SET			1
	G-979-42SH	SINGLE HEAD GASKET SET	1	1	1
28	WA00002	BOLT, CYLINDER HEAD	6	10	16
	WA00003*	BOLT, CYL HEAD SHORT STUD	4	4	6
	WA00004*	BOLT, CYL HEAD LONG STUD	2	2	2
29	13020212	EYE BOLT	1	1	1
30	13023391	SEAL, STEM	1	1	1

*Not Shown

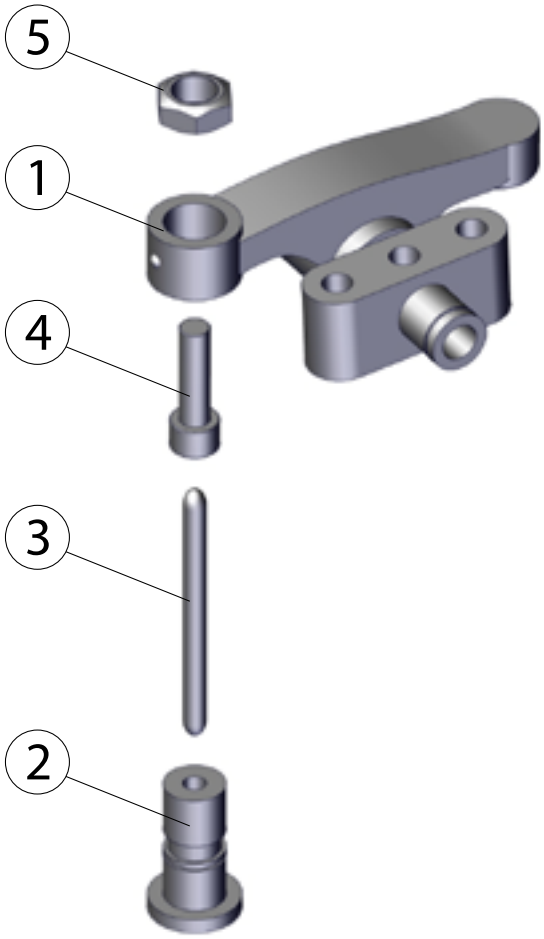
« RETURN TO TOC

Cylinder Head Cover Assembly



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12159819	CYLINDER HEAD COVER	3	4	6
2	01139584	HEXAGON BOLT	3	4	6
3	01118654	SEALING RING	3	4	6
4	12270879	GASKET, CYLINDER HEAD COVER	3	4	6

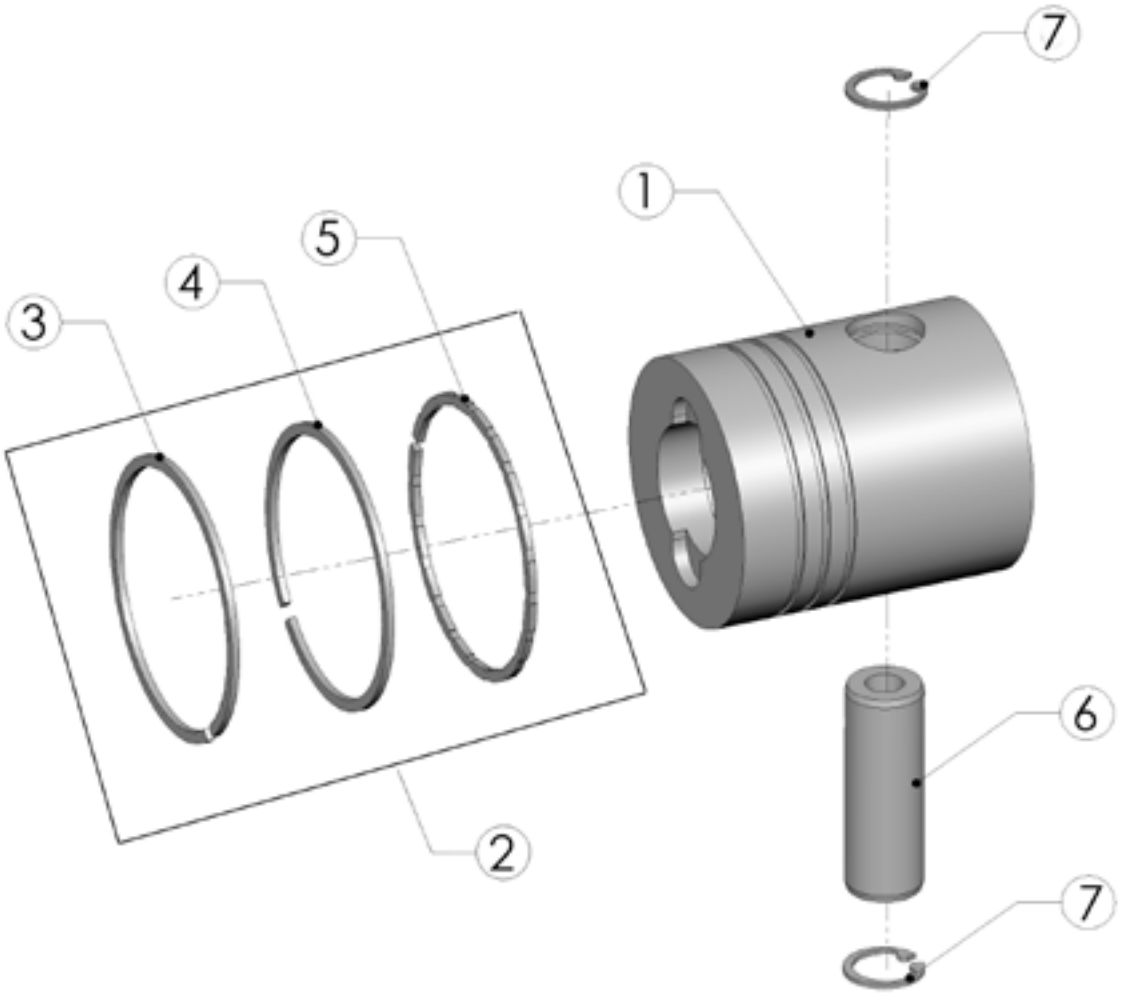
13.17 Rocker Arm Bracket Assembly



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12159631	ROCKER ARM ASSY	3	4	6
2	12273399	TAPPET	6	8	12
3	12159194	PUSH ROD	6	8	12
4	12159522	ADJUSTING SCREW	6	8	12
5	12159526	HEX NUT	6	8	12

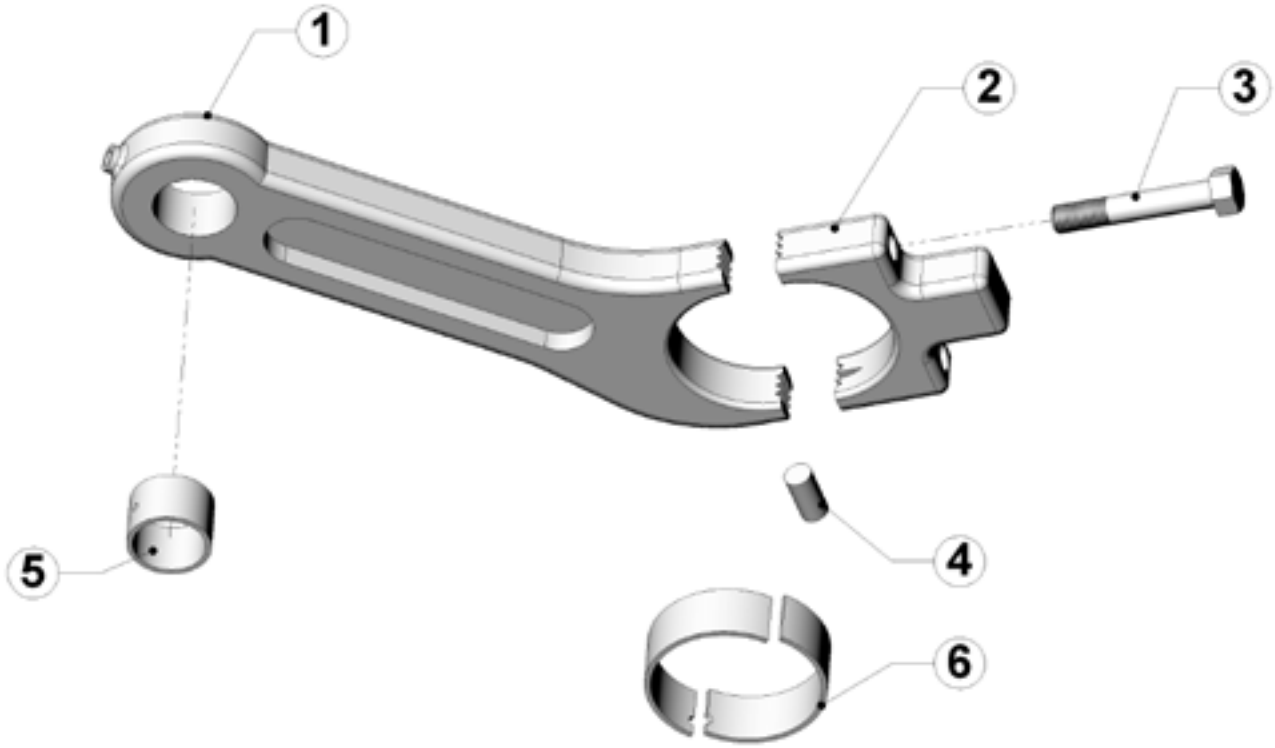
« RETURN TO TOC

13.18 Piston Assembly



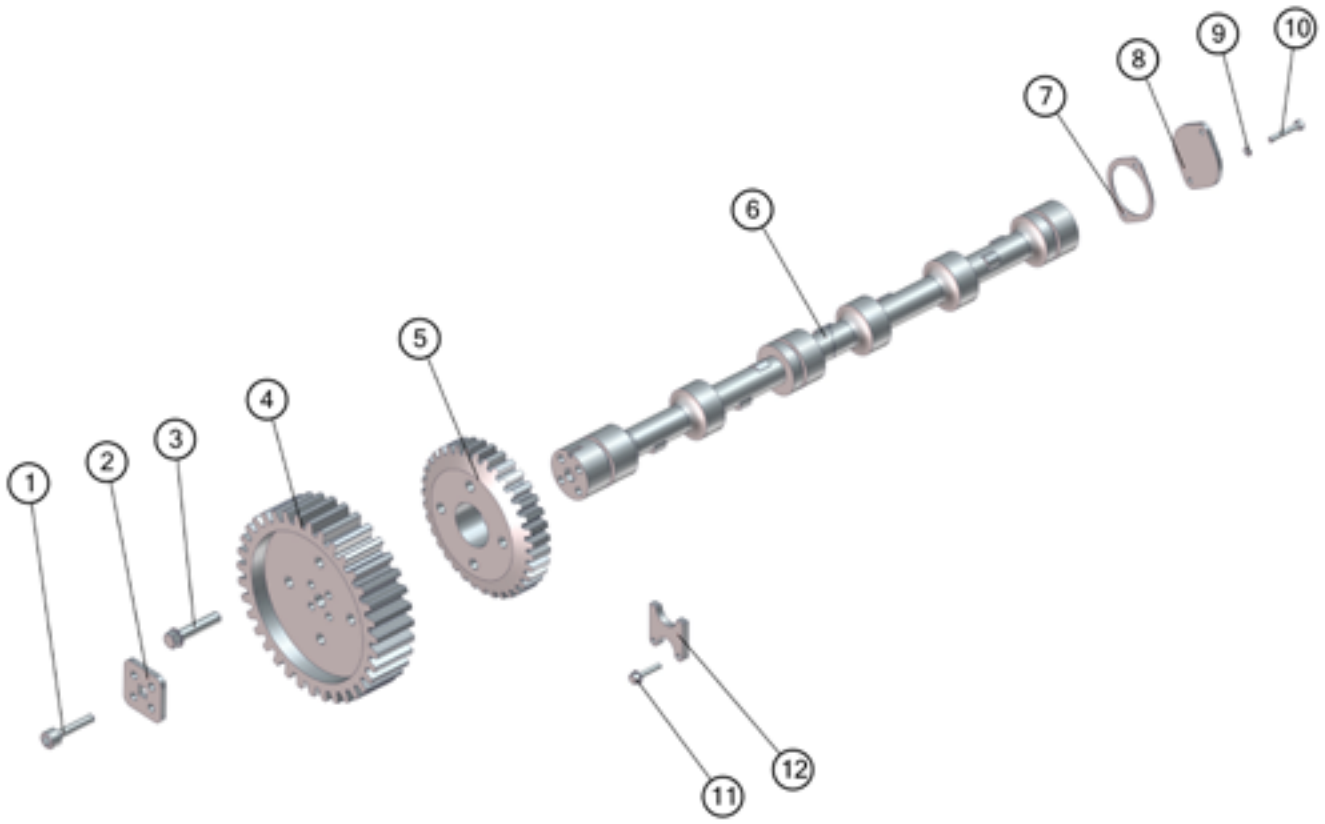
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	13020922	PISTON	3	4	6
2	G-907-142	COMPLETE SET OF PISTON RINGS - ITEMS 3, 4 & 5	3	4	6
3	13022348	PISTON RING, TOP	3	4	6
4	13022349	PISTON RING, MIDDLE	3	4	6
5	13022350	PISTON RING, OIL	3	4	6
6	12152378	PISTON PIN	3	4	6
7	12151395	SPRING CLIP	6	8	12

13.19 Connecting Rod Assembly



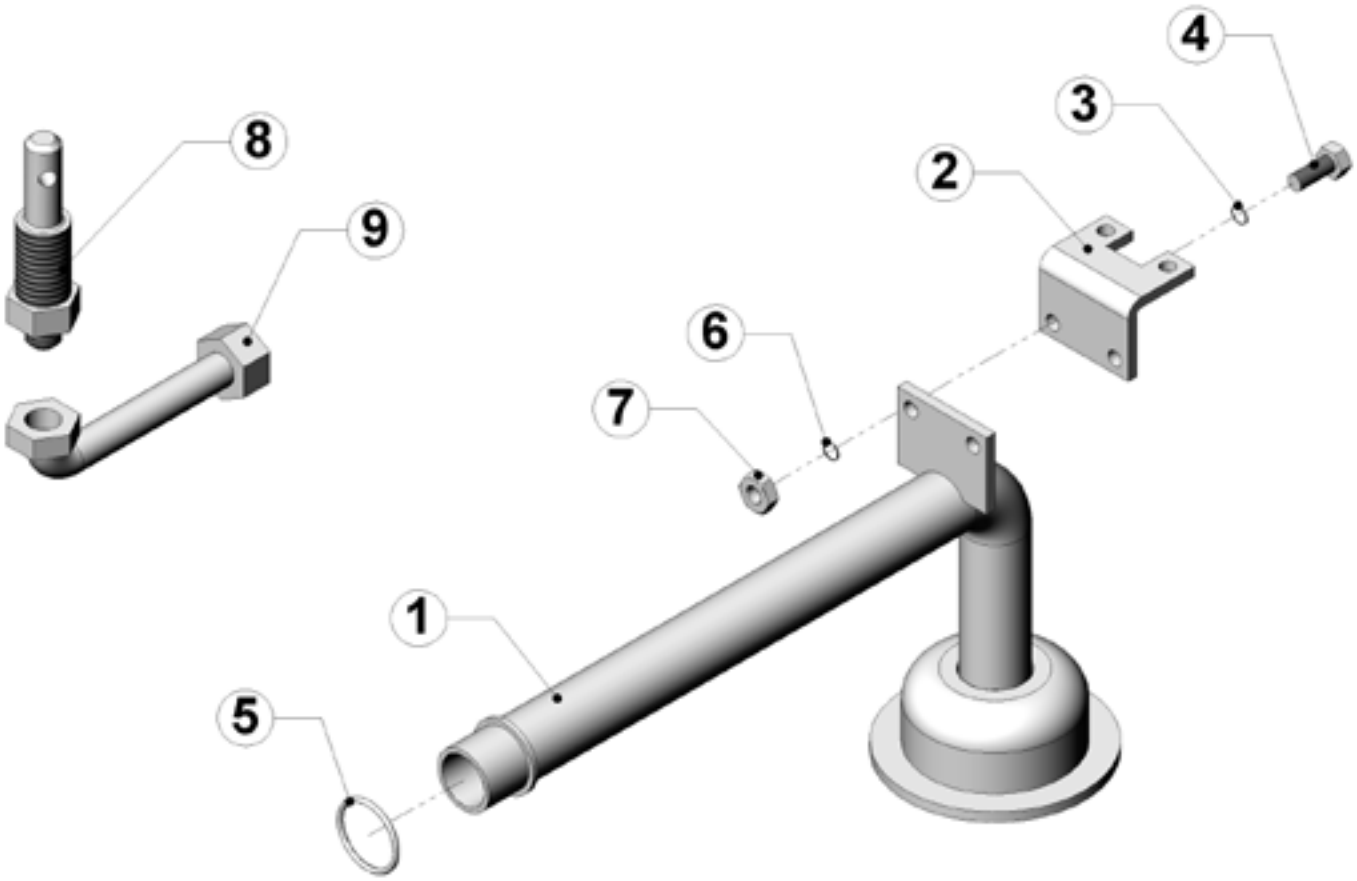
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12160519	CONNECTING ROD (ASSEMBLY)	3	4	6
2	12273054	CONNECTING COVER	3	4	6
3	12167047	BIG END BOLT	6	8	12
4	01154162	STRAIGHT PIN	3	4	6
5	12159598	WRISTPIN BUSHING	3	4	6
6	12160570	CONNECTING ROD BEARINGS (UPPER AND LOWER)	3	4	6
	13024279	CONNECTING ROD BEARINGS (UPPER)	3	4	6
	12273939	CONNECTING ROD BEARINGS (LOWER)	3	4	6

13.20 Camshaft Assembly



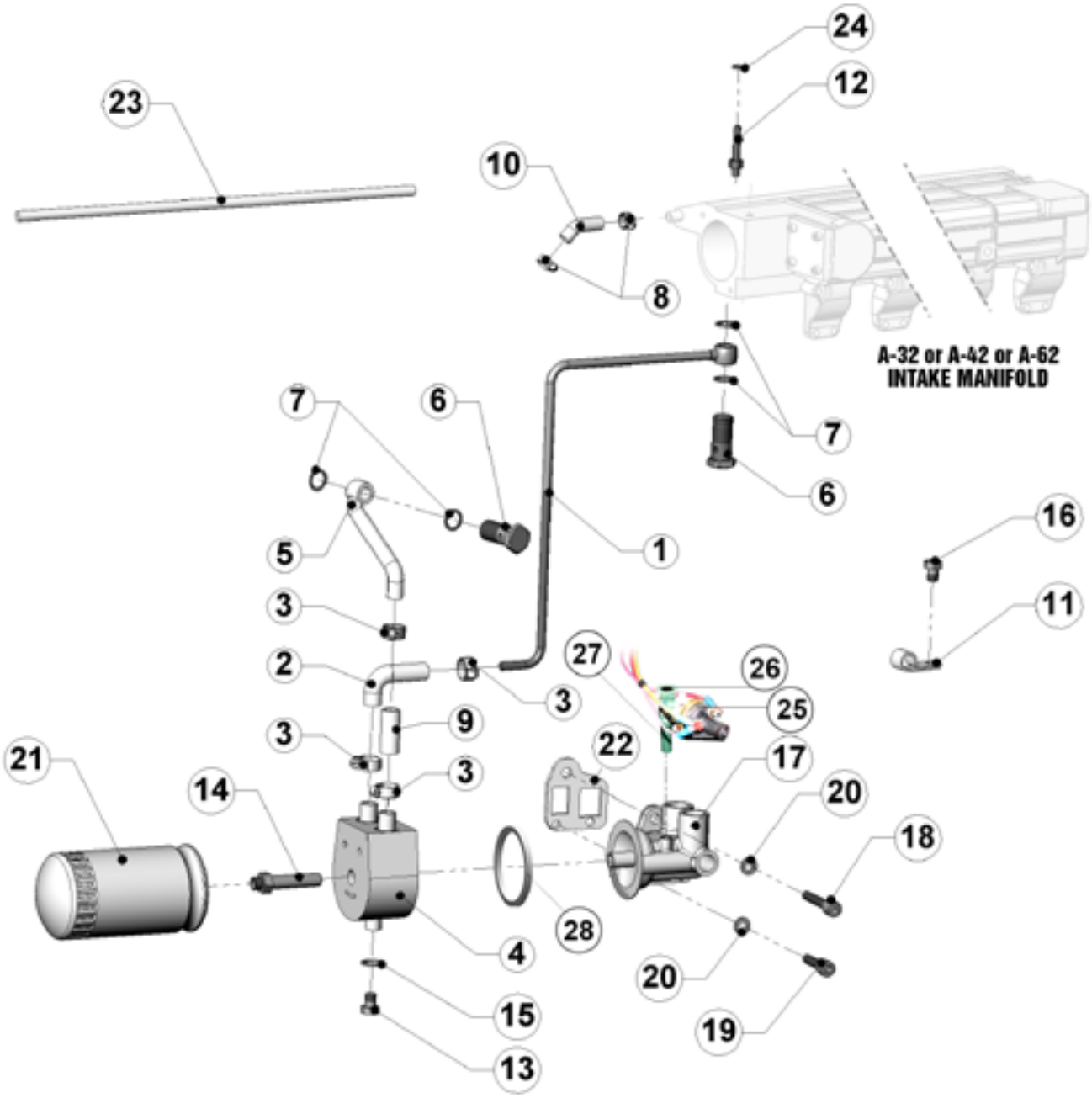
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	01139989	HEXAGON BOLT	4	4	4
2	12189558	SHAPED FLANGE	1	1	1
3	01157293	LOCKING SCREW	4	4	4
4	12189556	CAMSHAFT DRIVE GEAR	1	1	1
5	13024211	OIL PUMP DRIVE GEAR			1
	12189557			1	
	12189537		1		
6	13031471	CAMSHAFT			1
	13024219			1	
	WA50148		1		
7	12190248	GASKET	1	1	1
8	12160109	SHAPED FLANGE	1	1	1
9	01157294	LOCKING SCREW	2	2	2
10	01137083	HEXAGON BOLT	2	2	2
11	01177981	SPRING LOCK WASHER	2	2	2
12	12159721	QUADRANT/PLATE	1	1	1

13.21 Lubricating Oil Line Assembly



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12159895	LUBRICATING OIL LINE ASSEMBLY			1
	12189078			1	
	WA50151		1		
2	12160163	ANGLE PLATE		1	1
3	01214459	PLAIN WASHER		2	2
4	01112331	HEXAGON BOLT		2	2
5	WC03000	O-RING			1
	01153868		1	1	
6	01177981	SPRING LOCK WASHER		2	2
7	01112829	II-HEXAGON NUT		2	2
8	12166701	THREADED JOINT		1	
9	12166832	LUBRICATING OIL SUCTION PIPE		1	
10	01157294	LOCKING SCREW	1		
11	01151453	SCREW PLUG	1		

13.22 Oil Cooling System Assembly

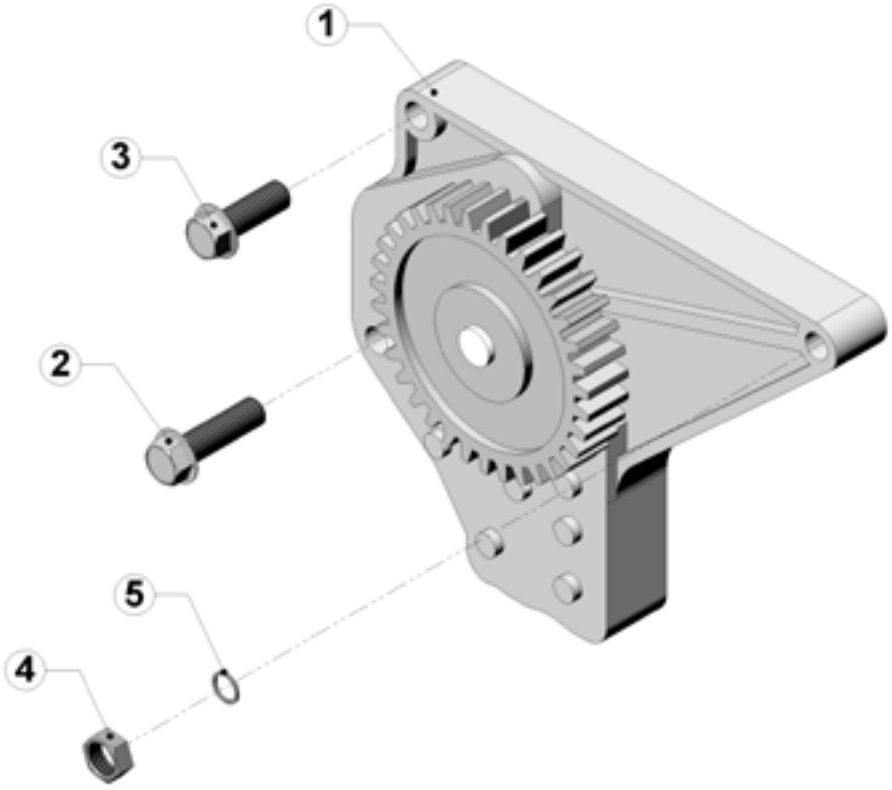


« RETURN TO TOC

POSITION	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12270761	COOLING WATER LINE	1	1	
	13026007				1
2	12188448	RUBBER SYPHON	1	1	1
3	01137412	TUBE CLIP	4	4	4
4	13024128	OIL COOLER			1
	12273290		1	1	
5	13024225	COOLING WATER LINE	1	1	1
6	01119254	HOLLOW SCREW	2	2	2
7	13023364	SEALING RING	4	4	4
8	01177986	TUBE CLIP	2	2	2
9	01154103	RUBBER TUBE	1	1	1
10	13024257	UPPER BYPASS HOSE			1
	13020586		1	1	
11	12151721	TUBE CLIP	1	1	1
12	13020659	TUBE, COOLANT VENT	1	1	
13	13021317	PLUG			1
	13024409	BRASS DRAIN VALVE		1	1
14	12273021	CONNECTING BOLT BUSH	1	1	
	13024129	CONNECTING BOLT BUSH			1
15	13023358	SEALING RING	1	1	1
16	01112331	HEXAGON BOLT	1	1	1
17	12273107	OIL COOLER SEAT	1	1	1
18	01136431	CHEESE HEAD SCREW	1	1	1
19	01139277	CHEESE HEAD SCREW	2	2	2
20	01107284	SPRING WASHER	3	3	3
21	162709-A62	SPIN-ON FILTER			1
	162709A		1	1	
22	12270878	SEALING GASKET	1	1	1
23	13023186	RUBBER HOSE	1	1	1
24	13023187	SPRING CLIP	1	1	1
25	60356	OIL SENSOR	1	1	1
26	PF3-1/8	1/8" TEE PIPE	1	1	1
27	PF1-8X2	1/8" X 2" NIPPLE PIPE	1	1	1
28	12273066	COOLING SYSTEM GASKET SEAL			1
	LOR-A-42		1	1	

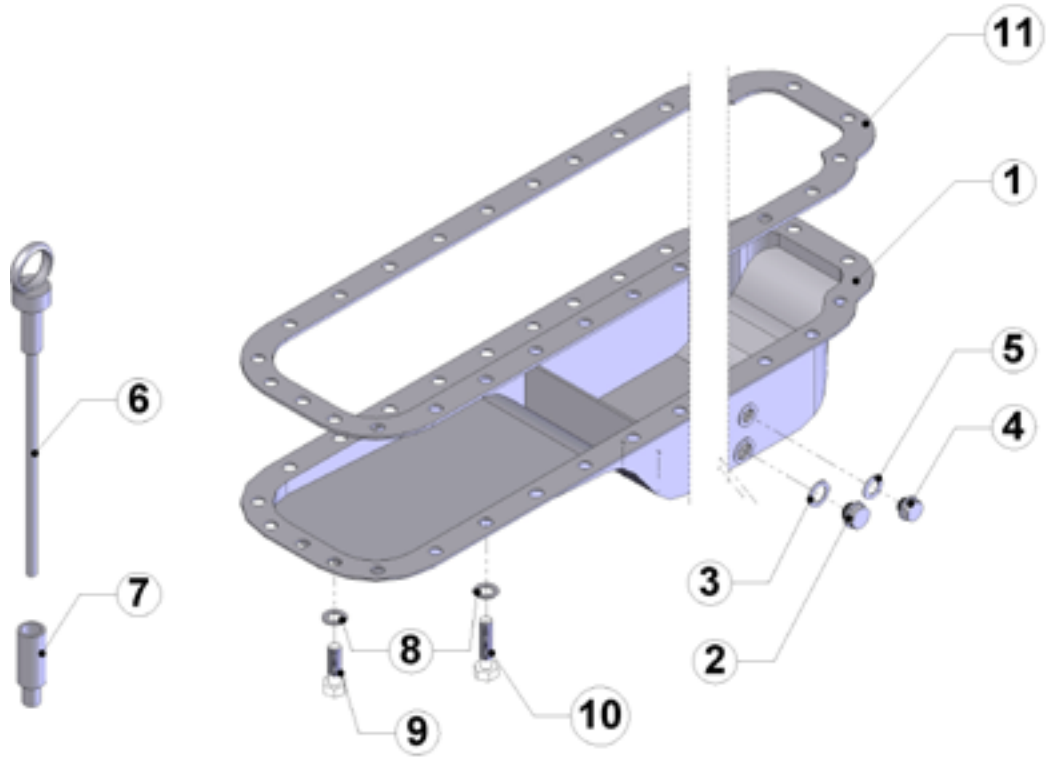
« RETURN TO TOC

13.23 Lubricating Oil Pump Assembly



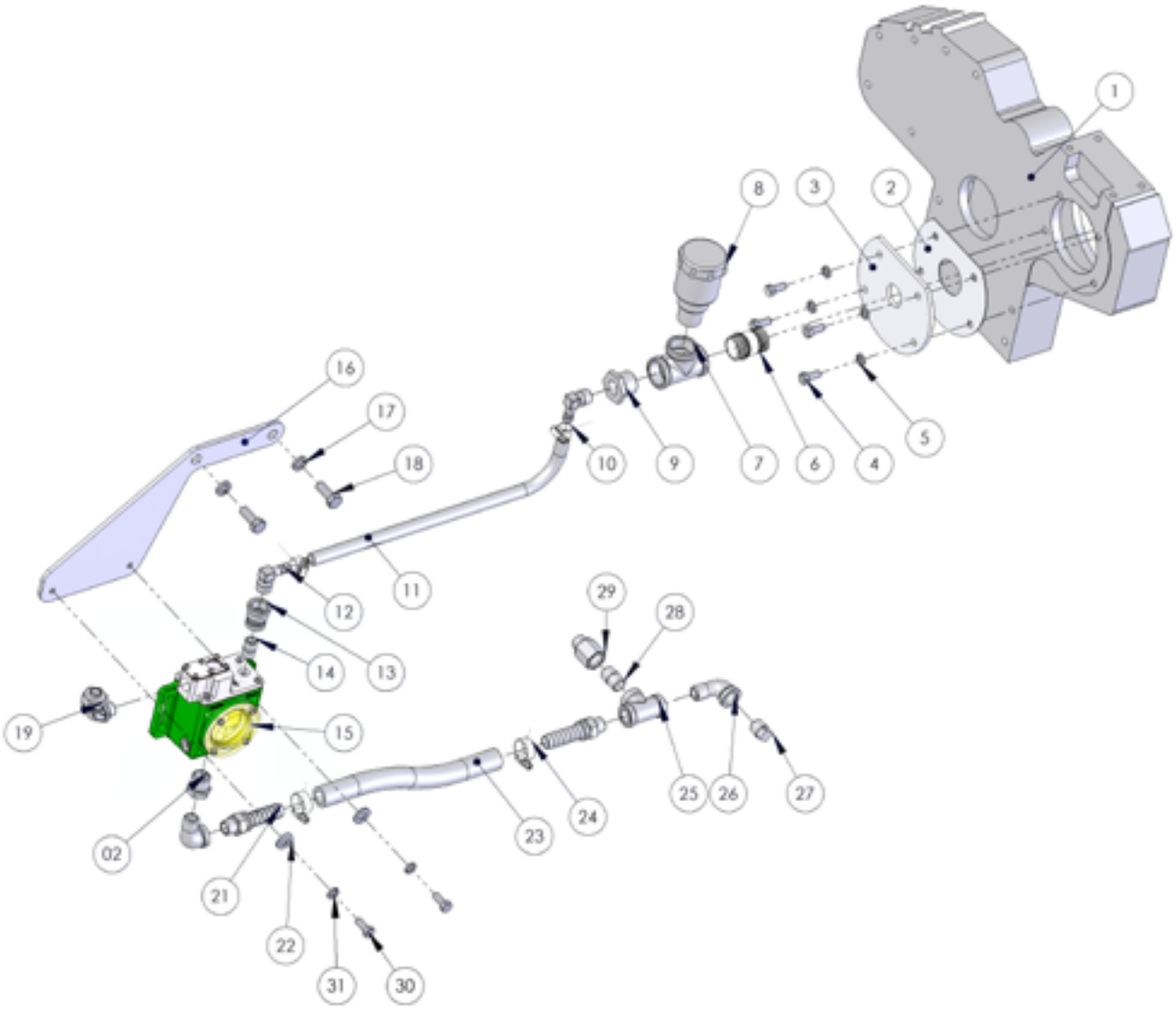
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	12159765	ASSEMBLY, OIL PUMP			1
	12166779			1	
	WA50152		1		
2	01156339	LOCKING SCREW	1	1	1
3	01157293	LOCKING SCREW	1	1	1
4	12151228	NUT	1	1	1
5	12159468	PLAIN WASHER	1	1	1

13.24 Oil Pan Assembly



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	13022882	OIL PAN			1
	12274896			1	
	WA50153		1		
2	01110445	SCREW PLUG	1	1	1
3	13023364	SEAL RING	1	1	1
4	01133632	SCREW PLUG	1	1	1
5	13023362	SEAL RING	1	1	1
6	12272672	DIP STICK			1
	12270444			1	
	WA50154		1		
7	12190556	TUBE			1
	13020273		1	1	
8	01214459	PLAIN WASHER	21	25	33
9	01137083	HEXAGON BOLT	7	7	7
10	01112339	HEXAGON BOLT	14	18	26
11	13022863	OIL PAN GASKET			1
	12270876			1	
	WA50155		1		
	76909M	1/2" NPT X 1/2-14 BSP ADAPTOR	1	1	1
	76909M20	1/2" NPT X M20 - 1.5 METRIC ADAPTOR	1	1	1

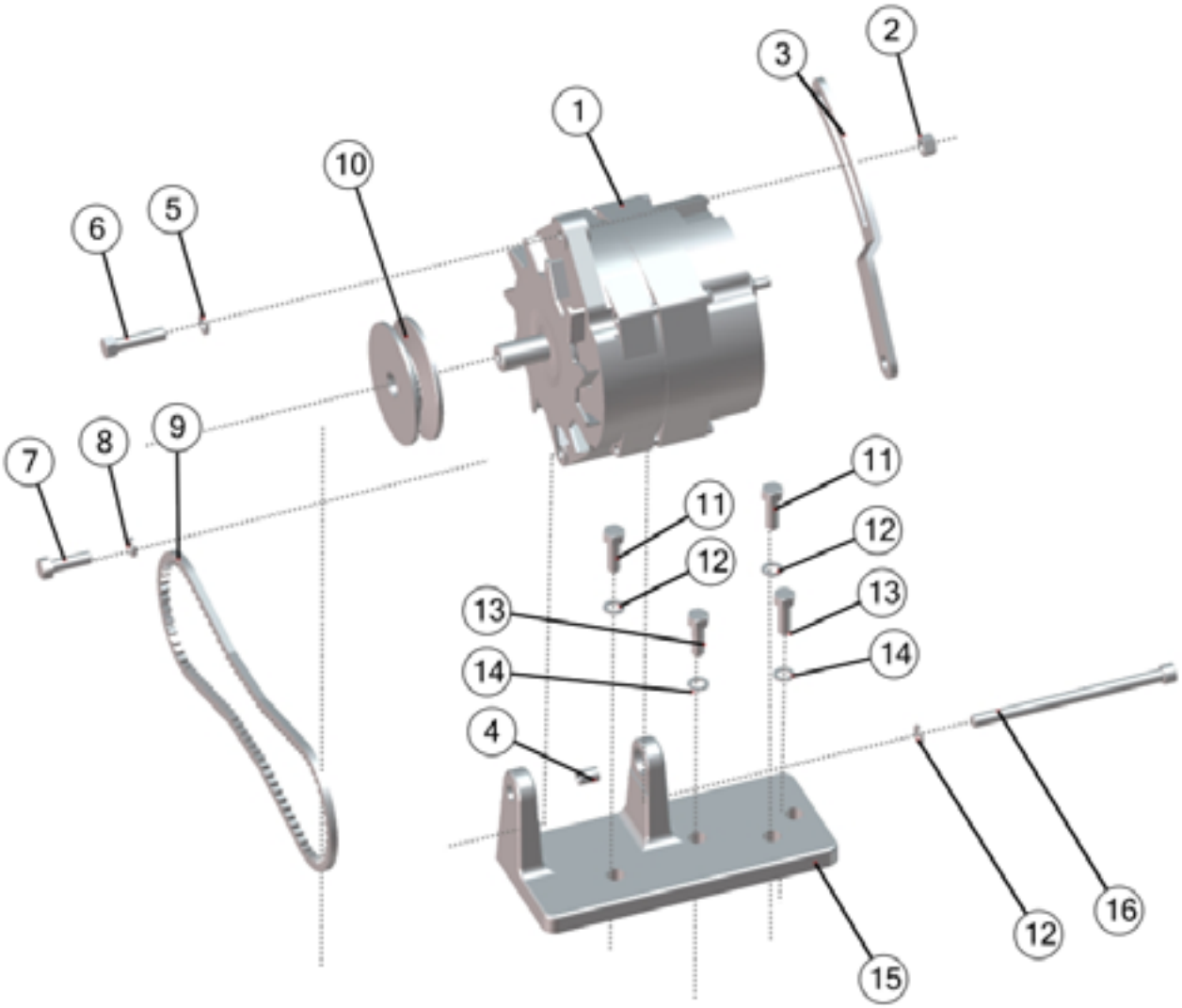
13.25 Oil Level Indicator – Optional



« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	13021714	CRANKCASE END COVER	1	1	1
2	208512-A-62G	GASKET, GOV BLOCK OFF			1
3	208512-A-62	PLATE, GOV BLOCK OFF			1
4	M10X20	10 MM X 20 MM HEX BOLT			4
5	M10WS	10 MM SPLIT WASHER			4
6	PF1-1X2	PIPE NIPPLE			1
7	PF3-1	PIPE TEE			1
8	ASP-3-FM	WATER FILLER			1
9	PF9-1X1/2	PIPE BUSHING			1
10	118224	HOSE CLAMP .69-1.25			2
11	7/16 RUBBER HOS	HOSE BREATHER	1		1
12	PF5-1/2X7/16	ELBOW, STANDARD 90° PLATED			2
13	PF6-1/2X5/8	BELL REDUCER			1
14	PF2-3/8	NIPPLE CLOSE			1
15	512-12	OIL LEVEL CONTROLLER WITH #12	1	1	1
16	OLR-BRKT-A62	OIL LEVEL REGULATOR BRACKET			1
	WA05007	OIL LEVEL MOUNT BRACKET	1		
17	M14WS	METRIC SPLIT LOCKWASHER			2
18	M14X30	METRIC HHCS			2
19	PF-5090	CONNECTOR, LIQUID TIGHT 90°	1	1	1
20	PF9-3/4X1/2	3/4 X 1/2 PIPE BUSHING			1
21	KCN-1/2	NIPPLE	2		2
22	M10FW	10 MM FLATWASHER, ZINC PLATED			2
23	3/4 RUBBER HOSE	3/4" RUBBER HOSE (H131)			3
24	118224	HOSE CLAMP .69-1.25			2
25	PF3-1/2	1/2" T #150			1
26	PF5-1/2	1/2" ST N:N			2
27	PF4-1/2	1/2" PLUG			1
28	PF2-1/2	NIPPLE CLOSE			1
29	76909M20	OIL LEVEL REGULATOR ADAPTOR	1		1
30	M10X25	HEX BOLT			2
31	M10WS	SPLIT WASHER			2
32	13020232	OIL RETURN PLATE	1	1	

13.26 A-32 / A-42 / A-62 Alternator & Bracket Assembly



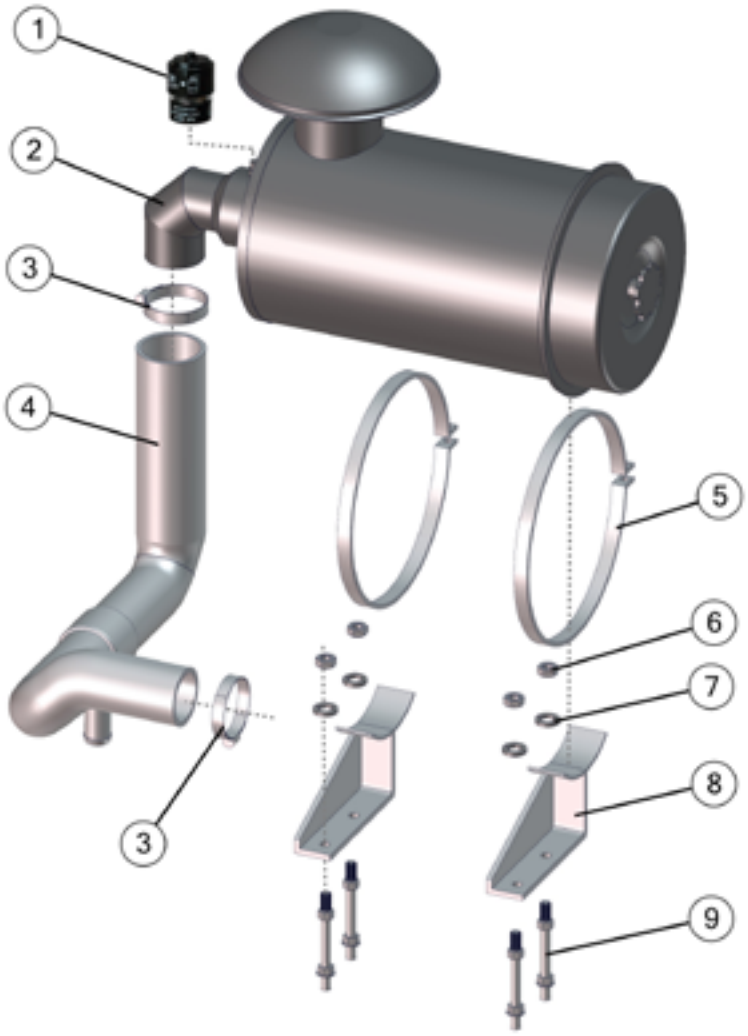
« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	69753A	12 ALTERNATOR	1	1	1
	69753LV		1	1	1
	24V ALT	24V ALTERNATOR		1	1
	3005-A42	12V ALTERNATOR, AC DELCO		1	1
	3006-A62	24V ALTERNATOR, AC DELCO			1
2	1112829	HEXAGON NUT	1	1	1
3	199094D	ADJUSTMENT STRAP	1	1	1
4	WA16011	BUSHING, ALTERNATOR	1	1	1
5	1155765	PLAIN WASHER	1	1	1
6	111166	HEXAGON BOLT	1	1	1
7	1139584	HEXAGON BOLT	1	1	1
8	1152752	PLAIN WASHER	1	1	1
9	13020641	NARRON V-BELT	1	1	
	13024457	NARRON V-BELT			2
10	216096E	SINGLE GROOVE PULLEY, ALTERNATOR	1	1	
	216096C*	DOUBLE GROOVE PULLEY, ALTERNATOR			1
11	1112405	HEXAGON BOLT	2	2	
12	1152752	PLAIN WASHER	2	2	
13	1110618	HEXAGON BOLT			2
14	1152752	PLAIN WASHER			2
15	WA08004	BRACKET, ALTERNATOR	1	1	1
16	1110618	SOCKET HEAD SCREW	1	1	1

*NOT SHOWN

« RETURN TO TOC

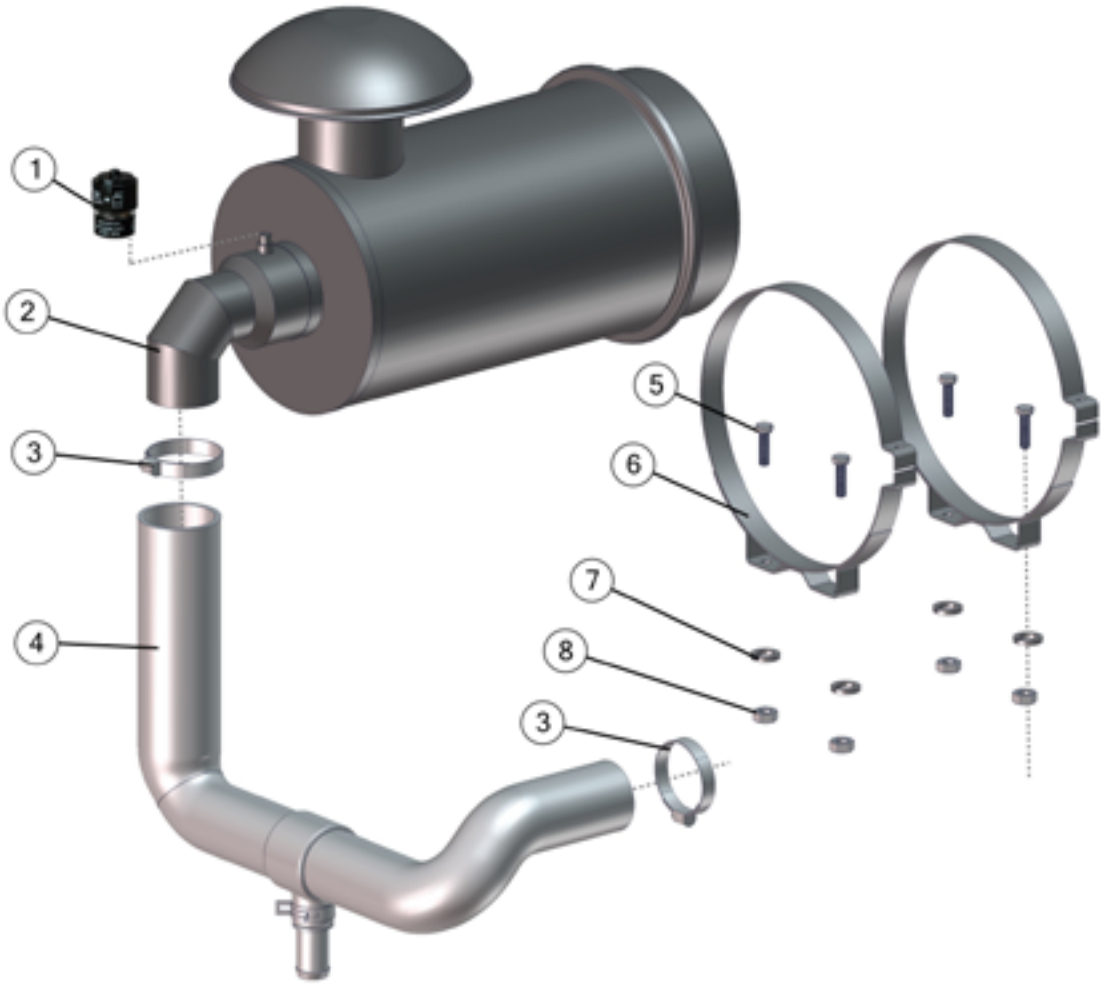
13.27 Air Filter Assembly – A-32 (Open Unit)



ITEM	PART NUMBER	DESCRIPTION	A-32
1	153789	AIR FILTER GAUGE	1
2	13022962	AIR CLEANER AND PRE-CLEANER ASSEMBLY	1
3	HC-64	HOSE CLAMP	2
4	WA05000	CRANKCASE VENT HOSE	1
5	13020720	AIR FILTER MOUNTING BAND	2
6	1143995	HEXAGON NUT	4
7	M08WS	8 MM SPLIT LOCKWASHER, ZINC PLATED	4
8	13022519	BRACKET	2
9	13022462	SPACER ADAPTOR	4
*	13023207	AIR FILTER ELEMENT WITH PRE-CLEANER FILTER	1

*Not Shown

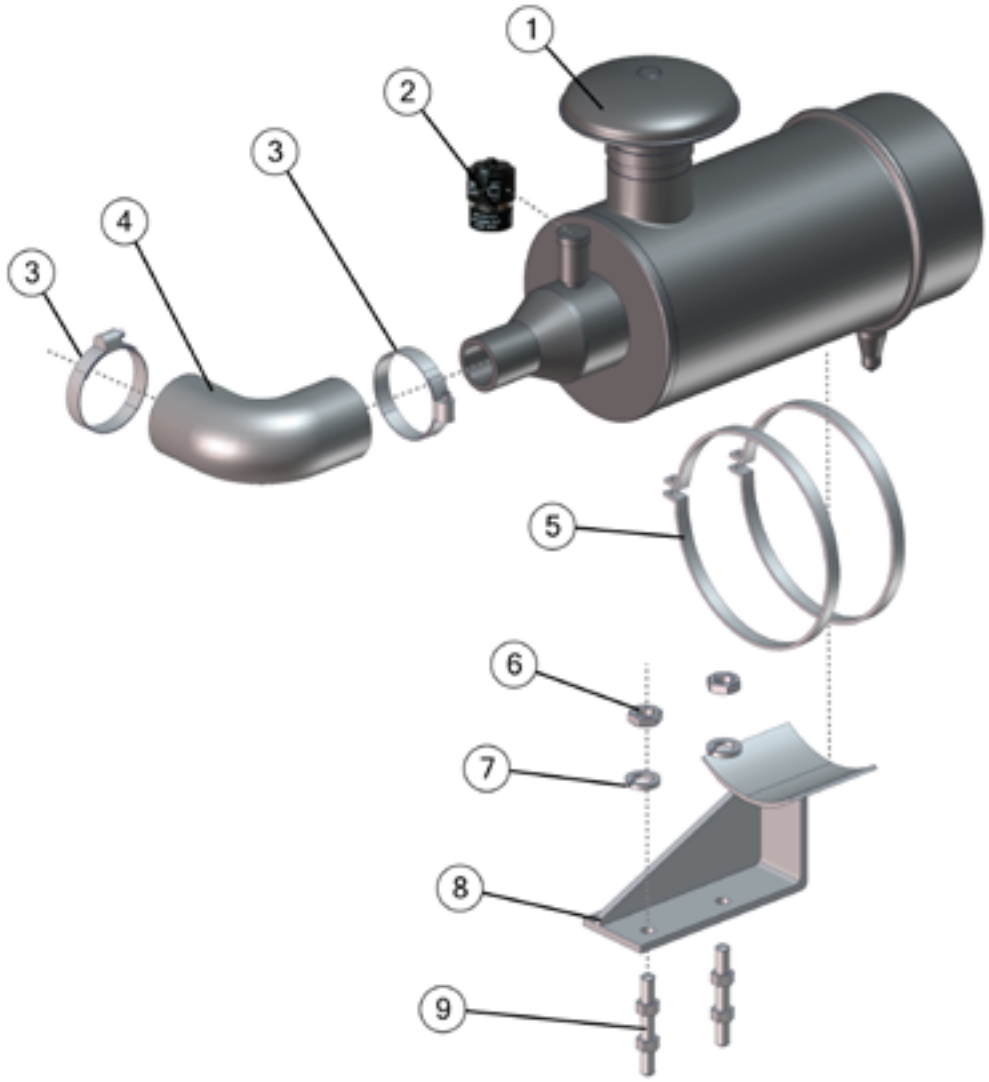
13.28 Air Filter Assembly – A-32 (with sheet metal)



ITEM	PART NUMBER	DESCRIPTION	A-32
1	153789	AMERICAN AIR FILTER GAUGE	1
2	13022962	AIR CLEANER AND PRE-CLEANER ASSEMBLY	1
3	HC-64	HOSE CLAMP	2
4	WA05000	CRANKCASE VENT HOSE	1
5	M8X20	HEXAGON HEAD CAPSCREW, MM	4
6	152802	AIR FILTER MOUNTING BAND	1
7	M08WS	8 MM SPLIT LOCKWASHER, ZINC PLATED	4
8	1143995	NUT	2
*	13023207	REPLACEMENT AIR FILTER WITH PREFILTER	1

*Not Shown

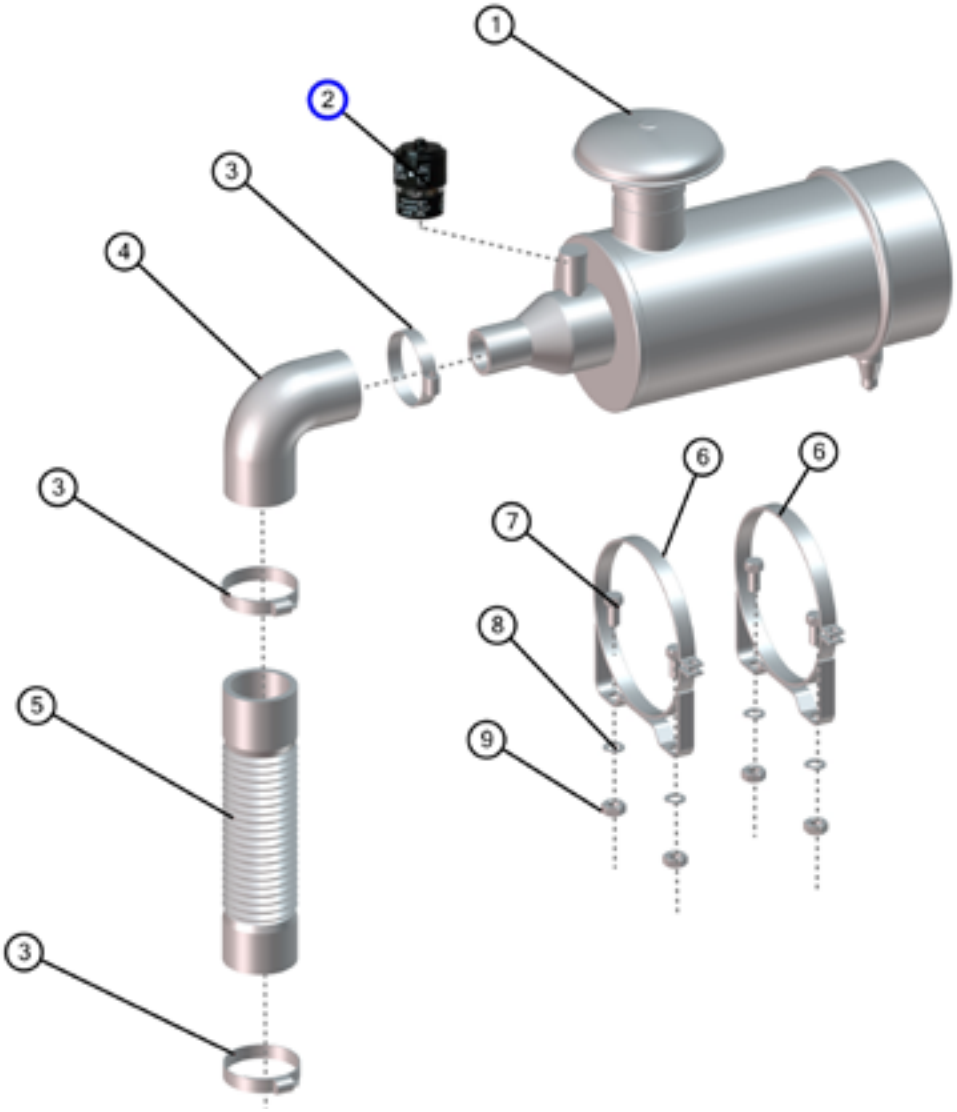
13.29 Air Filter Assembly – A-42 (Open Unit)



ITEM	PART NUMBER	DESCRIPTION	A-42
1	13022962	AIR CLEANER AND PRE-CLEANER ASSEMBLY	1
2	153789	AMERICAN AIR FILTER GAUGE	1
3	HC-64	CLIP	2
4	208860-260	CRANKCASE VENT HOSE	1
5	13020720	AIR FILTER MOUNTING BAND	2
6	01143995	NUT	2
7	M08WS	8 MM SPLIT LOCKWASHER, ZINC PLATED	2
8	13022959	BRACKET	1
9	13022462	JOINT BOLT	2
*	13022962	AIR FILTER ELEMENT WITH PRE-CLEANER FILTER	1

*Not shown

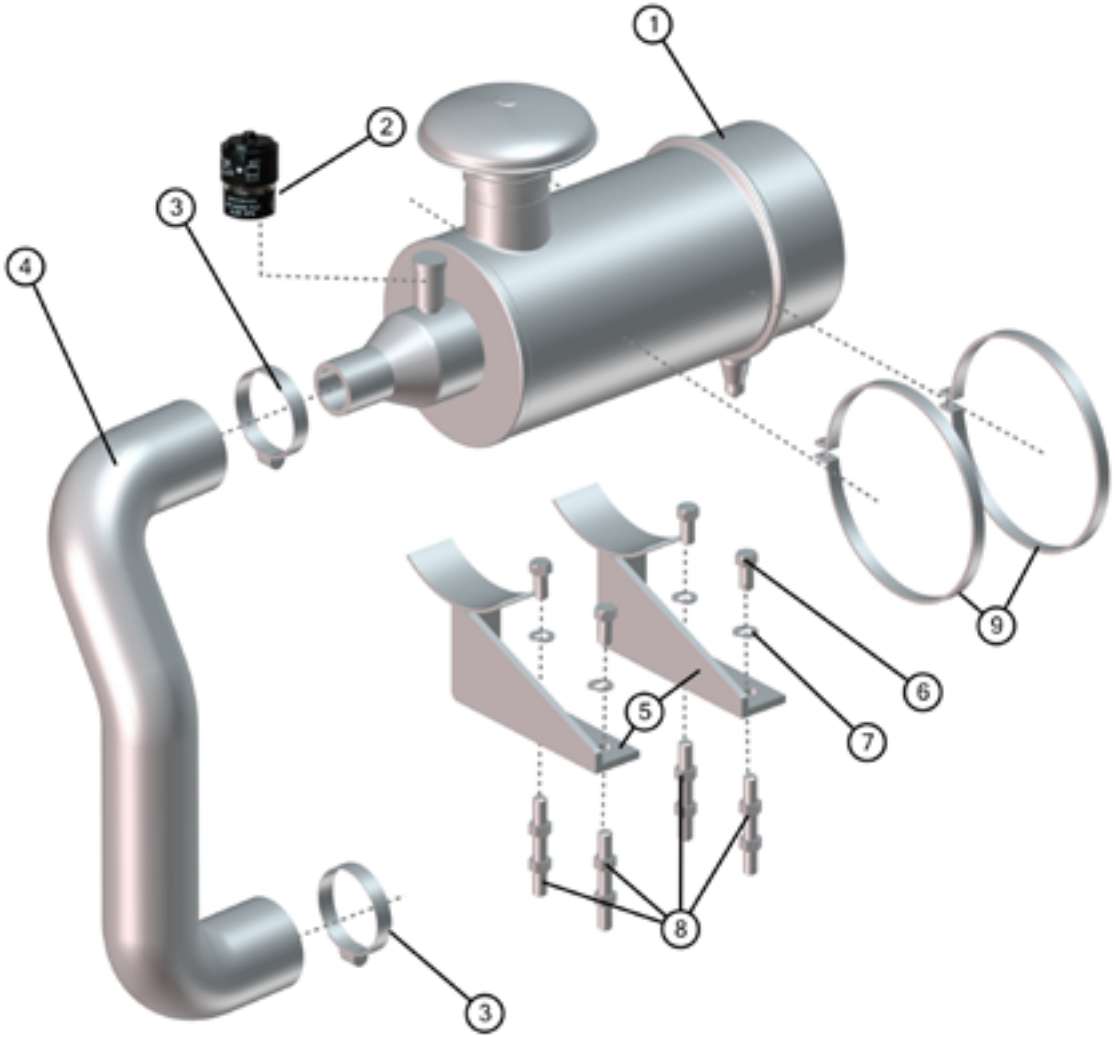
13.30 Air Filter Assembly – A-42 (Sheet Metal)



ITEM	PART NUMBER	DESCRIPTION	A-42
1	13022962	AIR FILTER ASSEMBLY	1
2	153789	AMERICAN AIR FILTER GAUGE	1
3	HC-64	CLIP	3
4	208860-260	CRANKCASE VENT HOSE	1
5	208860-A-42	HOSE	1
6	13020720	AIR FILTER MOUNTING BAND	2
7	M8X20	HEXAGON HEAD CAPSCREW, MM	4
8	M08WS	8 MM SPLIT LOCKWASHER, ZINC PLATED	4
9	01143995	NUT	4
*	13022962	AIR FILTER ELEMENT WITH PRE-CLEANER FILTER	1

*Not shown

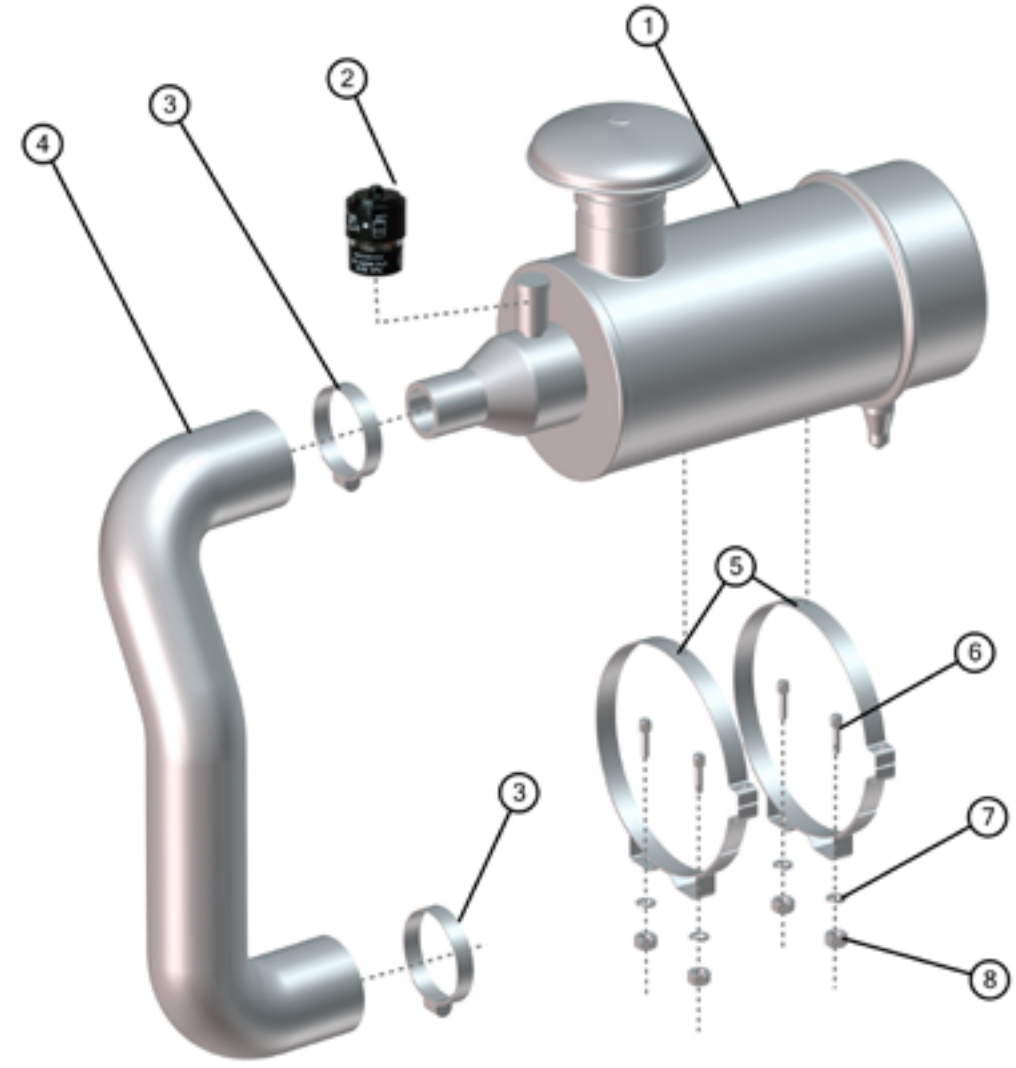
13.31 Air Filter Assembly – A-62 (Open Unit)



ITEM	PART NUMBER	DESCRIPTION	A-62
1	13024892	AIR CLEANER AND PRE-CLEANER ASSEMBLY	1
2	153789	AMERICAN AIR FILTER GAUGE	1
3	HC-64	HOSE CLAMP	2
4	208860-380	HOSE	1
5	13022519	BRACKET	2
6	M8X20	HEXAGON HEAD CAPSCREW, MM	4
7	M08WS	8 MM SPLIT LOCKWASHER, ZINC PLATED	4
8	13020714	JOINT BOLT	4
9	13020720	AIR FILTER MOUNTING BAND	2
*	13023273	AIR FILTER ELEMENT WITH PRE-CLEANER FILTER	1

*Not shown

13.32 Air Filter Assembly – A-62 (Sheet Metal)

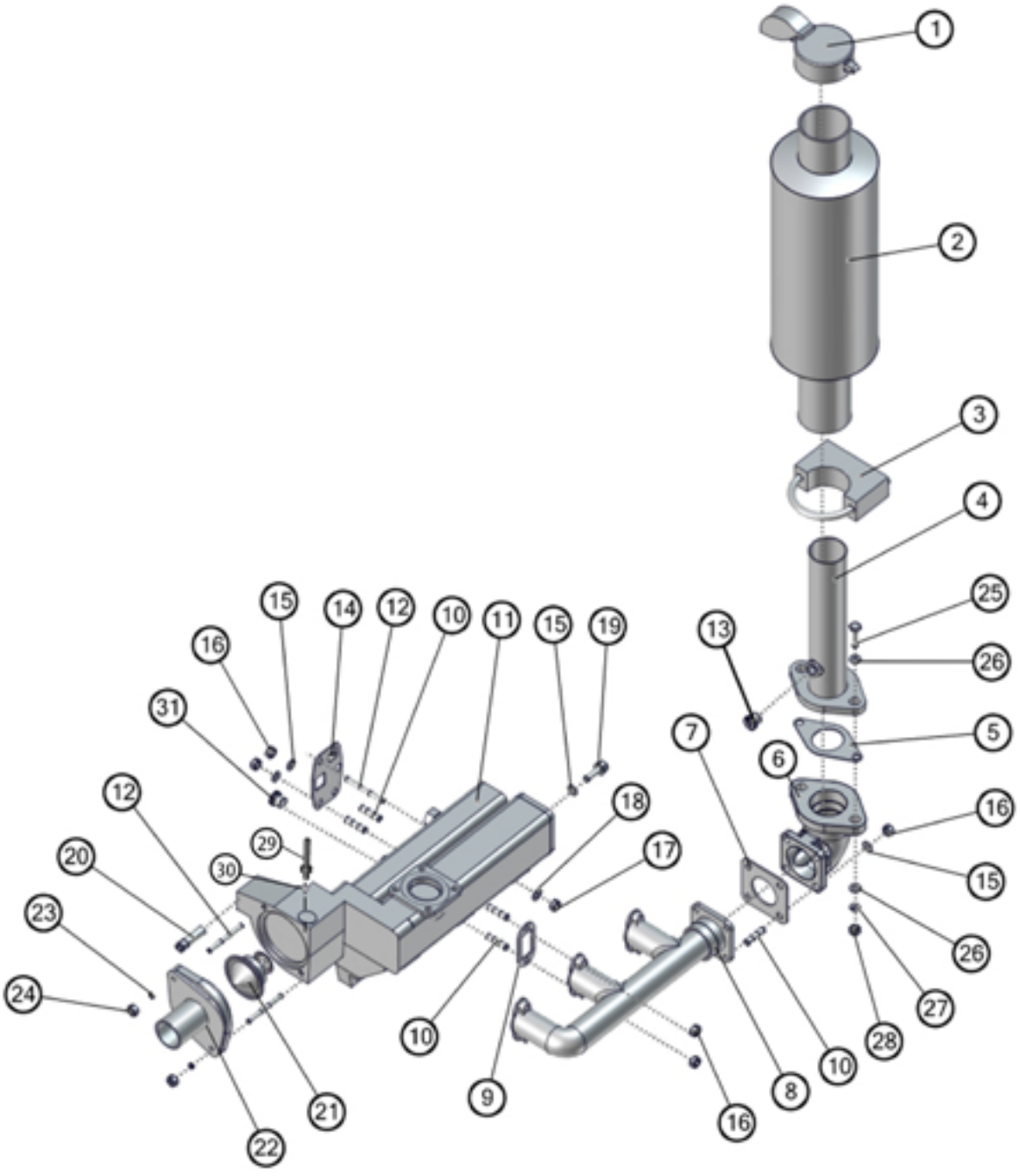


ITEM	PART NUMBER	DESCRIPTION	A-62
1	13024892	AIR CLEANER AND PRE-CLEANER ASSEMBLY	1
2	153789	AMERICAN AIR FILTER GAUGE	1
3TOP	41236A	HOSE CLAMP	1
3BTM	HC-64	HOSE CLAMP	1
4	208860-A-62	HOSE	1
5	13020720	AIR FILTER MOUNTING BAND	2
6	M8X20	HEXAGON HEAD CAPSCREW, MM	4
7	M08WS	8 MM SPLIT LOCKWASHER, ZINC PLATED	4
8	01139401	Nut	4
*	13023273	Air Filter Element with Pre-Cleaner Filter	1

*Not shown

« RETURN TO TOC

13.33 Intake/Exhaust System – A-32

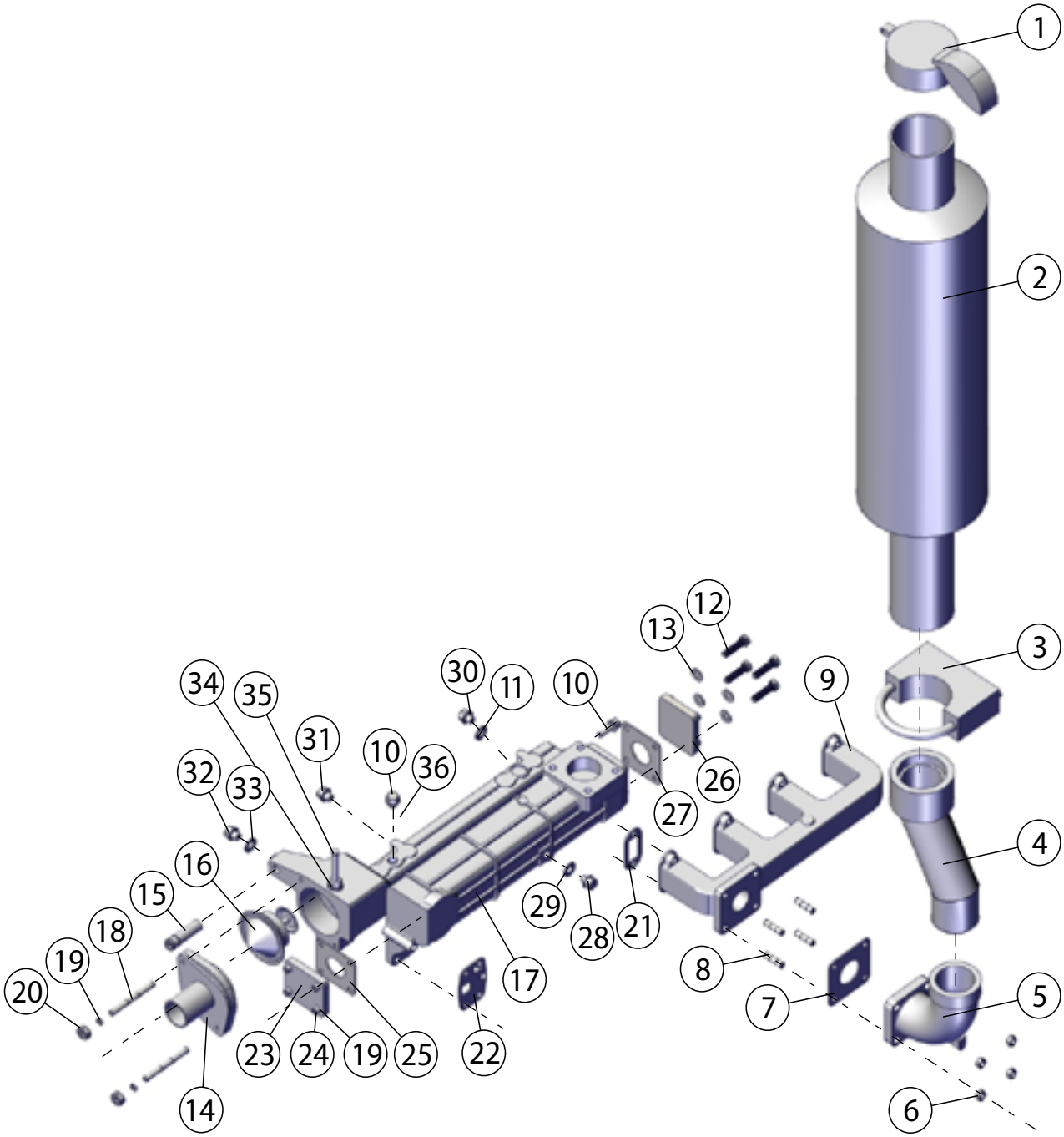


« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32
1	WA50020	RAIN CAP	1
2	WA50009	MUFFLER	1
3	WA07000	CLAMP	1
4	WA50010	MUFFLER ADAPTOR	1
5	208595G	GASKET	1
6	208878-1	EXHAUST ELBOW	1
7	208878G	GASKET	1
8	WA50142	EXHAUST MANIFOLD	1
9	12272783	EXHAUST GASKET	3
10	1143285	STUD	6
11	WA50002	INTAKE MANIFOLD	1
12	1151397	STUD	3
13	KA17001	18 X 1.5 PLUG	1
14	12190460	GASKET, INTAKE MANIFOLD	3
15	M08WS	FLAT WASHER	5
16	M10NF	CRUSH NUT	4
17	1127589	PLUG	1
18	1302363	SEALING RING	3
19	M08X25	BOLT	4
20	12188750	PIPE-JOINT	1
21	13021132	THERMOSTAT, 170°F	1
22	12270944	THERMOSTAT COVER	1
23	1177981	LOCK WASHER	2
24	1112829	HEX NUT	2
25	7A-1/213X2 1/2	BOLT	2
26	1N-1/2	FLAT WASHER	4
27	1A-1/2	LOCK WASHER	2
28	29A-1/213	NUT	2
29	13020659	TUBE, COOLANT VENT	1
30	13023358	SEAL RING	1
31	1/2 IN NPT	TEMP SENDER ADAPTOR	1
32*	WB03000	THERMOSTAT GASKET	1
33*	199454A-SA	CRITICAL GRADE MUFFLER OPTION	1
34*	WA50162	MUFFLER ADAPTOR FOR CRITICAL GRADE MUFFLER OPTION	1
35*	WA16014	SPACER BRACKET FOR CRITICAL GRADE MUFFLER (SHEET METAL)	1

*Not shown.

13.34 Intake/Exhaust System – A-42 (VR260)

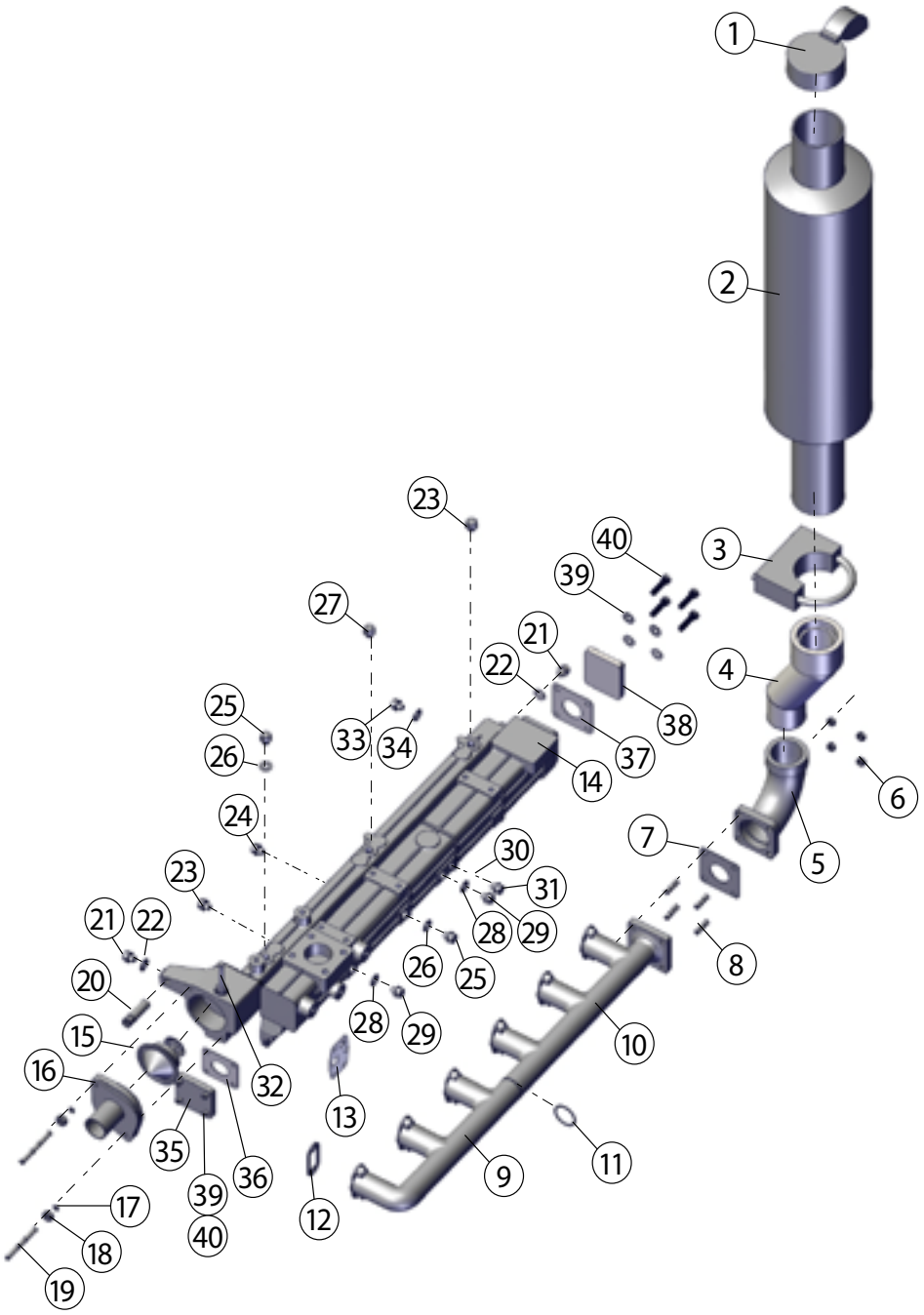


« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-42
1	155938T	RAIN CAP	1
2	199454A	MUFFLER	1
3	168094-A-62	MUFFLER CLAMP	1
4	208878NS	MUFFLER ADAPTOR	1
5	208878-1	EXHAUST OUTLET ELBOW	1
6	M10NF	CRUSH NUT	4
7	208878G	GASKET	1
8	1143285	STUD	4
9	13020910	EXHAUST MANIFOLD	1
10	PF18-M16X1.5	PLUG	1
11	13023360	SEAL RING	1
12	M08X25	BOLT	8
13	M08WS	WASHER	8
14	12270944	THERMOSTAT COVER	1
15	12188750	PIPE-JOINT	1
16	13021132	THERMOSTAT, 170°F	1
17	13024834	INTAKE MANIFOLD	1
18	1151397	STUD	2
19	1177981	LOCK WASHER	3
20	1112829	HEX NUT	2
21	12272783	GASKET	4
22	12190460	GASKET, INTAKE MANIFOLD	4
23	13024455	COVER PLATE	1
24	1112331	HEX BOLT	4
25	159884-A-42	ASYMMETRICAL GASKET	1
26	13024007	COVER PLATE	1
27	208643-A-42	GASKET	1
28	1127589	SCREW PLUG	1
29	13023363	SEALING RING	1
30	01118960	SCREW PLUG	1
31	WC16008	TEMP SENDER ADAPTOR	1
32	WC17002	PLUG	1
33	13023364	SEAL RING	1
34	13023358	SEAL	1
35	13020659	TUBE, COOLANT VENT	1
36*	1152710	CORE PLUG	1
37*	199454A-SA	CRITICAL GRADE MUFFLER OPTION	1

*Not shown.

13.35 Intake/Exhaust System – A-62 (VR380)

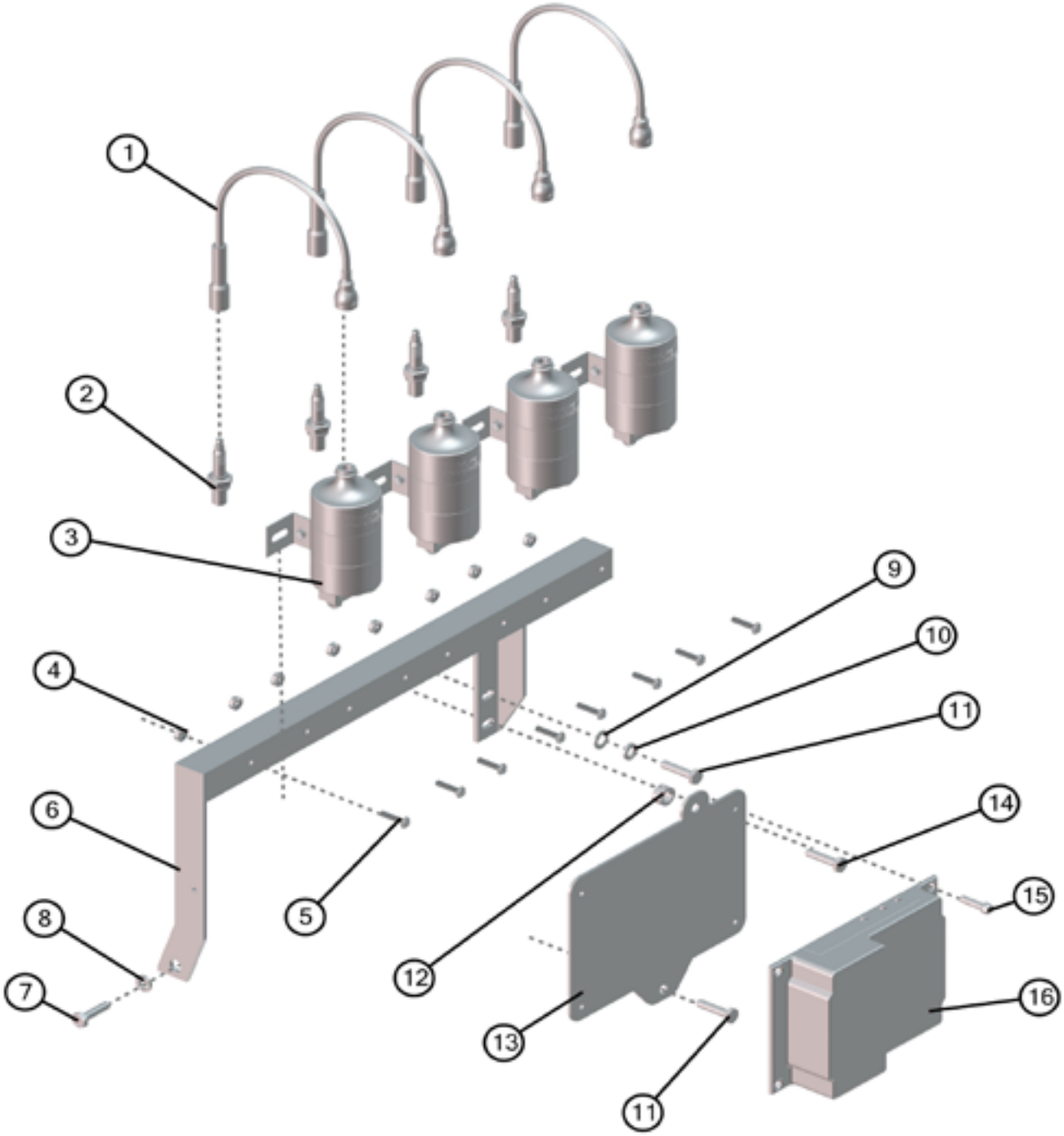


ITEM	PART NUMBER	DESCRIPTION	A-62
1	155938T	RAIN CAP	1
2	199454A	MUFFLER	1
3	168094	MUFFLER CLAMP	1
4	208878NS	MUFFLER ADAPTOR	1
5	208878-1	EXHAUST OUTLET ELBOW	1
6	M10NF	CRUSH NUT	4
7	208878G	GASKET	1
8	01143285	STUD	4

9	13024732	EXHAU	1
	13026791	TURBO EXHAUST MANIFOLD, 1	1
	13024003		1
10	13024730	EXHAUST MANIFOLD, 2	1
	13026792	TURBO EXHAUST MANIFOLD, 2	1
	13024004		1
11	12188124	O-RING	1
12	12272783	GASKET	6
13	12190460	GASKET, INTAKE MANIFOLD	1
14	A13023763	INTAKE MANIFOLD	1
15	13021132	THERMOSTAT, 170°F	1
16	12270944	THERMOSTAT COVER	1
17	1177981	LOCK WASHER	2
18	1112829	HEX NUT	2
19	1151397	STUD	2
20	12188750	PIPE-JOINT	1
21	WC17002	HEX PLUG	1
22	13023364	SEAL RING	1
23	PF4X1/2	SCREW PLUG	4
24	WC16008	ADAPTOR, TEMP GAUGE	4
25	1118952	PLUG	1
26	13023358	SEAL RING	1
27	3/4NPT	PLUG	1
28	13023363	SEAL RING	1
29	1125789	PLUG	1
30	6.126E+11	SEAL RING	1
31	1152105	SCREW PLUG	1
32	13020659	TUBE, COOLANT VENT	1
33	1118960	SCREW PLUG	1
34	13023360	SEAL RING	1
35	1302445	MANIFOLD END CAP (FRONT PLATE)	1
36	208643-A42	GASKET, BLOCK OFF PLATE (FRONT)	2
37	159884-A42	GASKET, MANIFOLD TO ADAPTOR (BACK)	1
38	13024007	END CAP (BACK PLATE)	1
39	M08WS	SPLIT WASHER	8
40	M08X25	HEX BOLT	8
41*	13023358	WASHER	1
42*	208878-AFR	EXHAUST OUTLET ELBOW - CATALYST EQUIPPED ENGINES	1
43*	208595G	GASKET FOR 208878-AFR ELBOW	1
44*	13024082	TURBO	1
45*	12161833	TURBO EXHAUST MOUNTING GASKET	1
46*	A100907-A62	EXHAUST RISER SHEET METAL	1
47*	WB03000	THERMOSTAT GASKET	1

*Not Shown.

13.36 Ignition, Coil and Spark Plugs

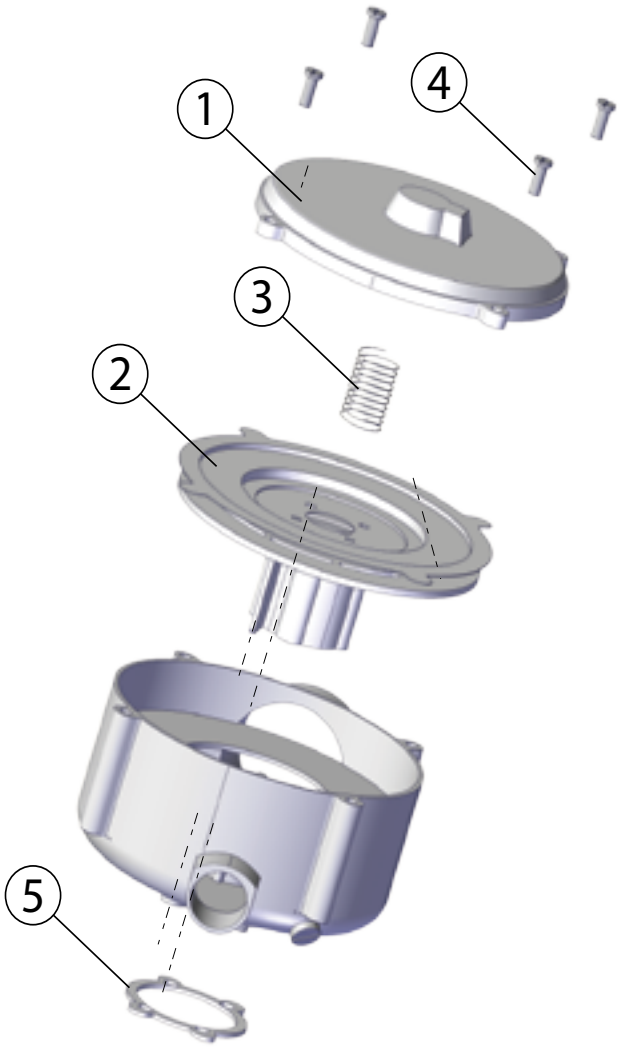


« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	69462A-A-42-A-62	SPARK PLUG WIRE	3	4	6
	7930486	WIRING HARNESS FOR THE IGNITION		1	1
2	330-18-A-42	SPARK PLUGS	3	4	6
3	330-2-A1-46	COIL	3	4	6
4	SW34DPS	1/4-20 LOCKNUT	6	8	12
5		12-28 MACHINE SCREW	6	8	12
6	208391-A-62	COIL BRACKET			1
	208391-A-42			1	
	WA08000		1		
7	12/25BCHS	BOLT	1	1	1
8	M12WS	LOCK WASHER	1	1	1
9	M08WS	FLAT WASHER	3	3	4
10	M08WS	LOCK WASHER	3	3	4
11	M8X25	BOLT		2	3
12	217067CD-S-A-42	SPACER		1	1
13	217067-A-42	IGNITION MOUNTING PLATE		1	1
14	M8X40	BOLT		1	1
15	M6X20	SCREW		4	4
16	7910106	CD1 IGNITION		1	1
*	791080-6	CD-200, SHIELDED (OPTIONAL)		1	1
*	WA15001	ENGINE WIRING HARNESS OPEN	1		
*	WA15003	ENGINE WIRING HARNESS SHEET METAL	1		
*	WA15000	IGNITION COIL WIRE HARNESS	1		
*	WA50157	12MM SHIELDED PLUG & WIRE	3	4	6
*	3345SS	14MM SHIELDED PLUG & WIRE	3	4	6
*	A501-0615	SHIELDED COIL	3	4	6

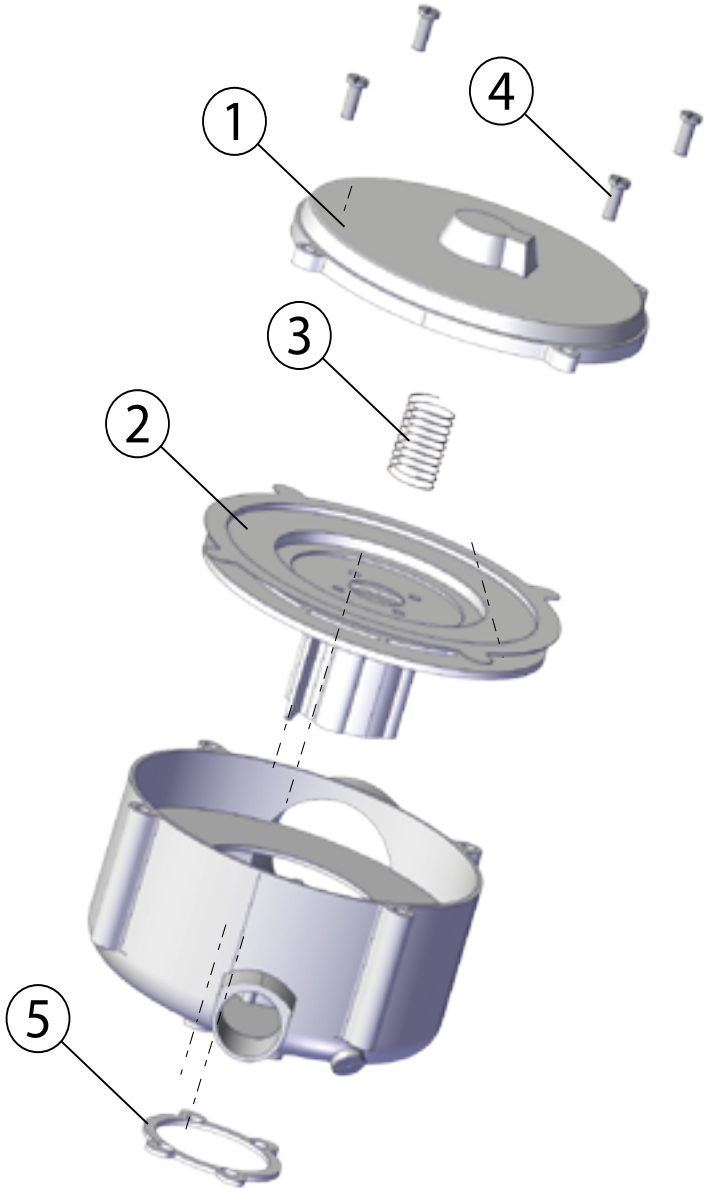
*Not shown

13.37 Arrow 60 Carburetor (A-32)



ITEM	PART NUMBER	DESCRIPTION	A-32
1	WA14000	ARROW 60 CARBURETOR ASSEMBLY	1
2	AV1-25	DIAPHRAGM ASSEMBLY	1
3	S2-35	SPRING	1
4	S1-3	MACHINE SCREWS	4
5	G1-11	GASKET	1

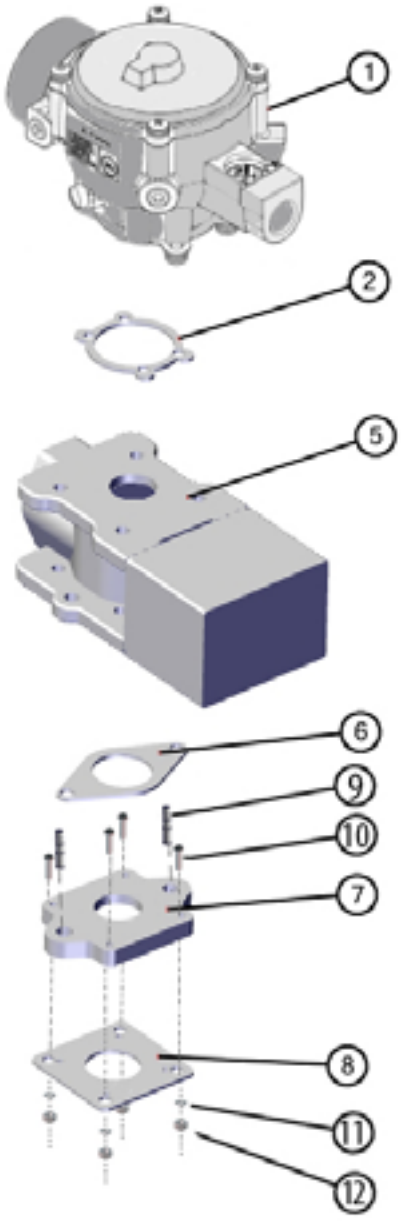
13.38 Arrow 100 Carburetor (A-42/62)



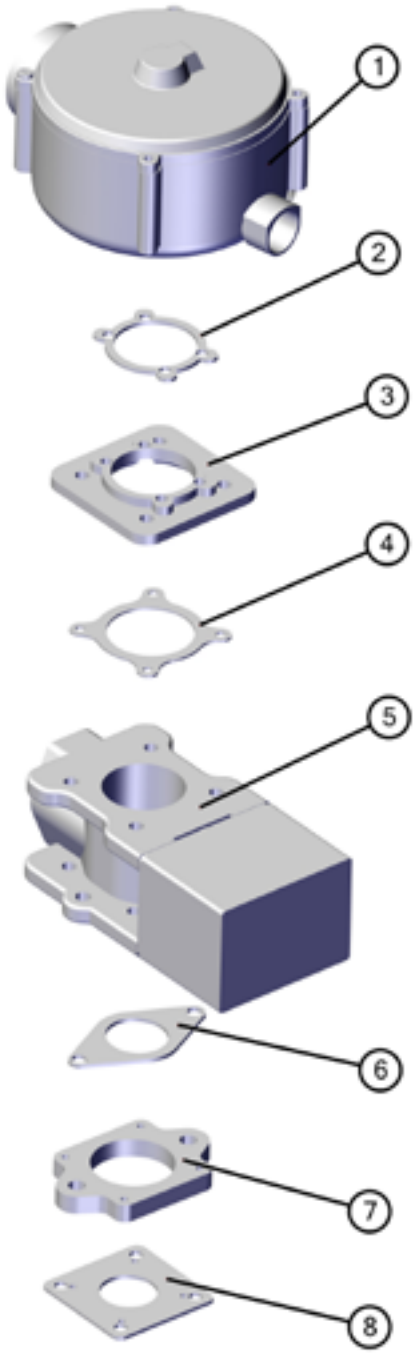
ITEM	PART NUMBER	DESCRIPTION	A-42	A-62
1	199097A	ARROW 100 CARBURETOR ASSEMBLY	1	1
2	499220	DIAPHRAGM ASSEMBLY	1	1
3	S2-13	SPRING	1	1
4	S1-3	MACHINE SCREWS	4	4
5	G1-11	GASKET	1	1

13.39 Governor

A32



A42/A62



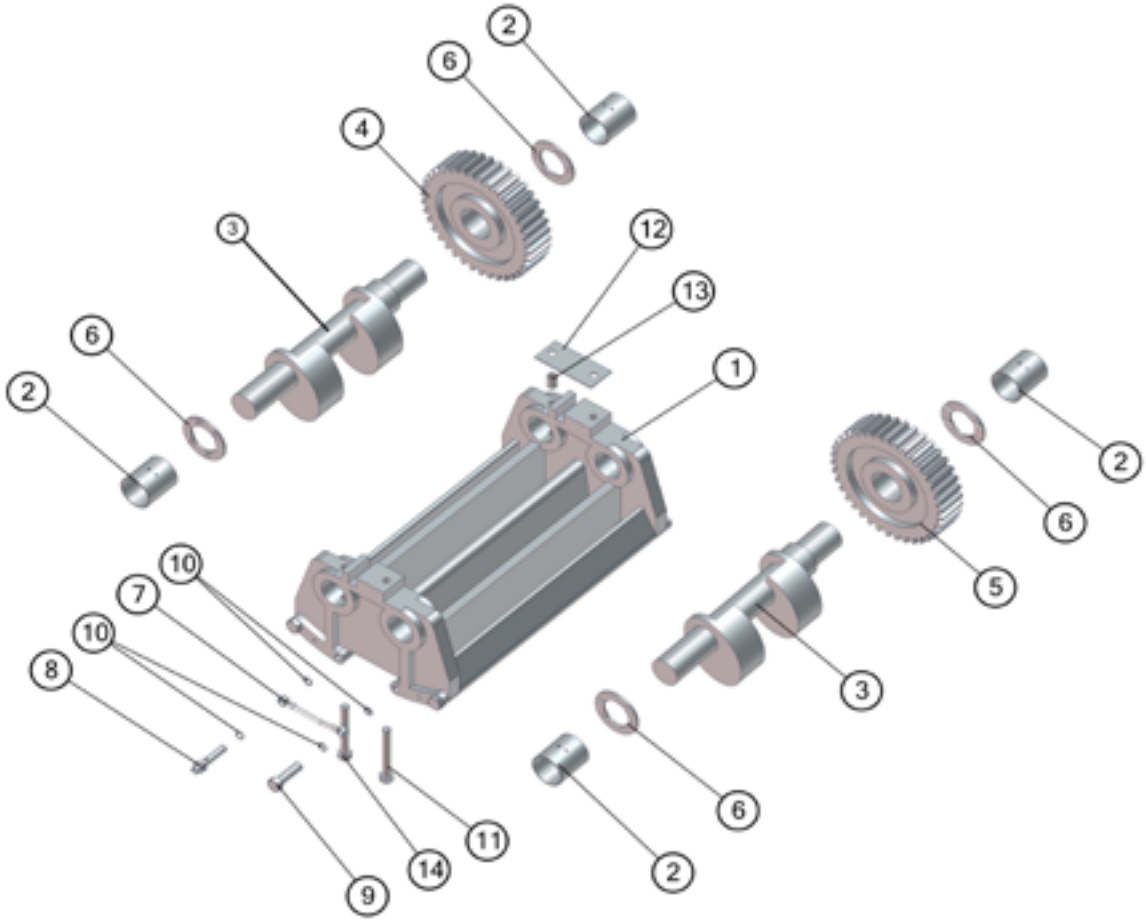
« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	199097A	ARROW 100 CARBURETOR		1	1
	WA14000	ARROW 60 CARBURETOR	1		
2	G1-11	GASKET	1	1	1
3	WA16001	CARB ADAPTOR		1	
	8404-A-42	CARB TO GOVERNOR ADAPTOR		1	1
4	6343-G	CARB TO GOVERNOR GASKET		1	2
5	WA50006	THROTTLE BODY, 25 MM, 12V	1		
	6321	THROTTLE BODY, 45 MM, 12V		1	1
	WA50161	THROTTLE BODY, 25 MM, 24V	1		
6	261-106	GASKET, THROTTLE BODY		1	
	WA03001		1		
7	6321-ADAPTOR	GOVERNOR ADAPTOR	1	1	
	8404-ADAPTOR	ADAPTOR			1
	WA16001	CARB ADAPTOR		1	
8	208643-A-42	GASKET	1	1	1
9	M10X25	STUD	2		
10	M8X25S	SCREW	4		
11	M10FW	WASHER	4		
12	M10NF	NUT	4		

* Not shown

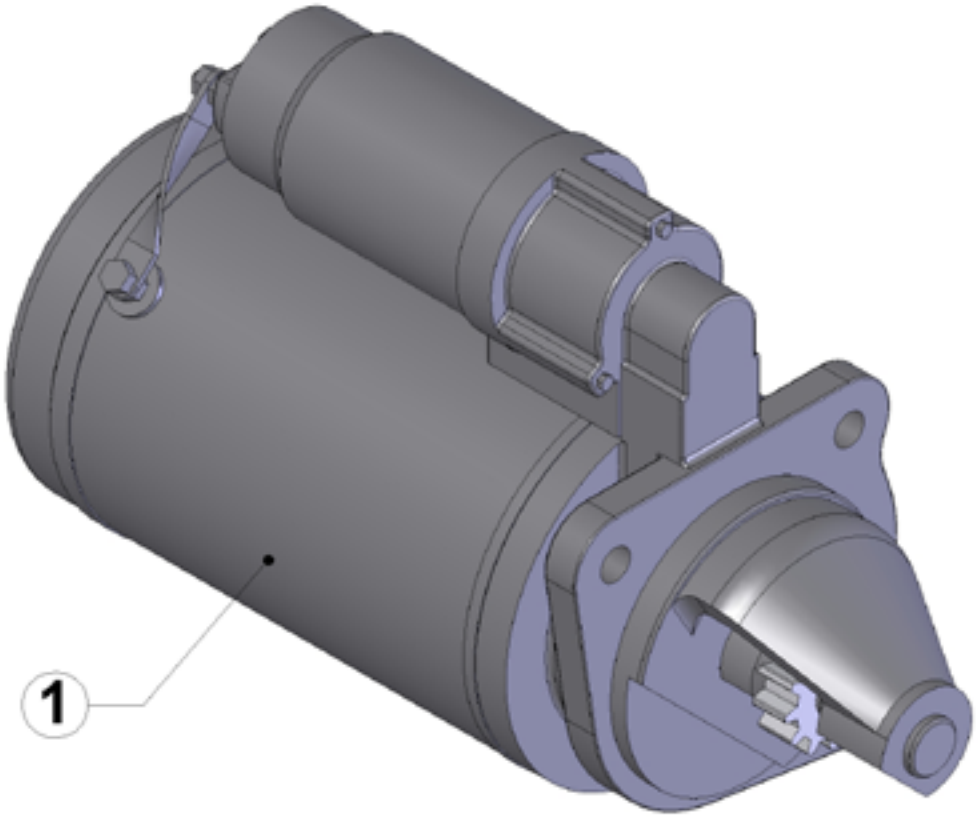
« RETURN TO TOC

13.40 Mass Balancer Assembly A-42 (VR260) Only



ITEM	PART NUMBER	DESCRIPTION	A-42
	13031232	MASS BALANCER ASSEMBLY	
1	12200346	MASS BALANCER	1
2	12200347	LINING	4
3	12200348	SHAFT	2
4	12200351	DRIVING GEAR	1
5	12200352	DRIVEN GEAR	1
6	12200353	THRUST PIECES	4
7	12158826	LUBRICANT OIL PIPE	1
8	12158759	TIE-IN	1
9	01153236	HOLLOW SCREW	1
10	01118664	SEAL RING	4
11	01151514	HEXAGON BOLT	2
12	12160137	SHIM	6
13	12159449	LOCALIZER	2
14	13021979	HEXAGON BOLT	2

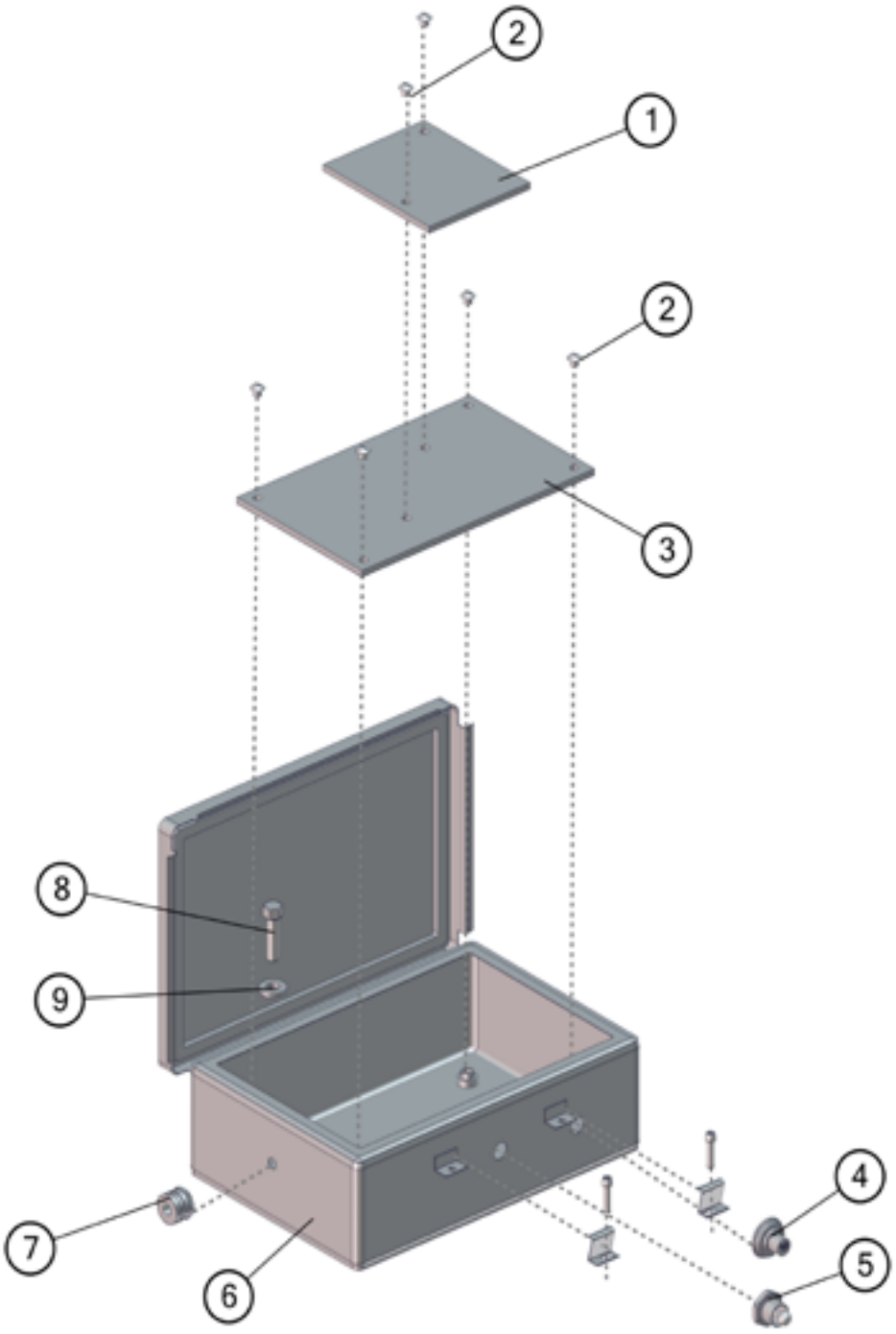
13.41 Starter Assembly



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	13023606	24V STARTER	1	1	1
	13022233	12V STARTER WITH NOSE	1	1	1
*	9000A-A42	AIR GAS STARTER	1	1	1
*	13022233-NS	HEAVY DUTY W/O NOSE	1	1	1

*Not shown

13.42 Speed Control Unit



« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	6322	ESD5131 SPEED CONTROL UNIT	1	1	1
2		SCREW			
3	AS1-1-P	MOUNTING PLATE FOR SPEED CONTROL UNIT	1	1	1
4	208435-1	TOGGLE SWITCH	1	1	1
5	6321-CB	CIRCUIT BREAKER	1	1	1
6	AS1-A-42	BOX	1	1	1
7	PF-5090	FITTING FOR WIRING	1	1	1
8	M8X25	BOLT	4	4	4
9	M08WS	WASHER	4	4	4
*	M08NF	NUT	4	4	4
*	117428	SPACER	4	4	4

* Not shown

6322 KIT	12 VOLT DC KIT	6322-24 KIT	24 VOLT DC KIT
ATB452T2N-12	Actuator (12 VDC)	ATB452T2N-24	Actuator (24 VDC)
ESD5131	Controller	ESD5131	Controller
MSP675	Magnetic Pick-up	MSP675	Magnetic Pick-up
TP503	Speed Potentiometer*	TP503	Speed Potentiometer*
ESD-HARNESS	Harness to Actuator	ESD-HARNESS	Harness to Actuator
261-106	Gasket	261-106	Gasket

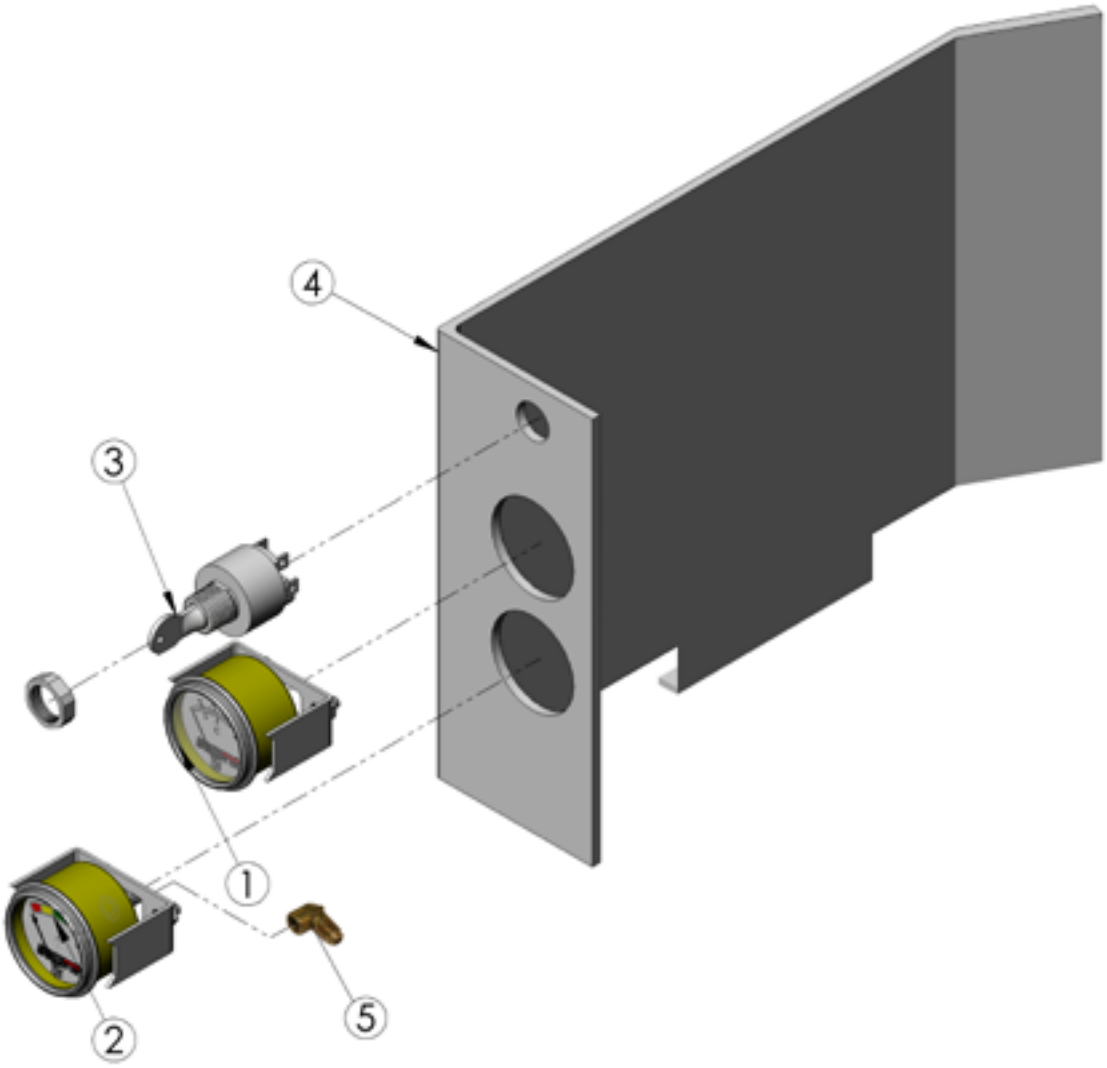
*Screw driver adjust/lockable

Options: (order separately - will work with any of the above systems)

TP503	Speed Potentiometer (Screw driver adjust/lockable. Included in the 6322 kits.)
100KT-105B	Speed Potentiometer (Knob adjust/non locking)

« RETURN TO TOC

13.43 Control Panel

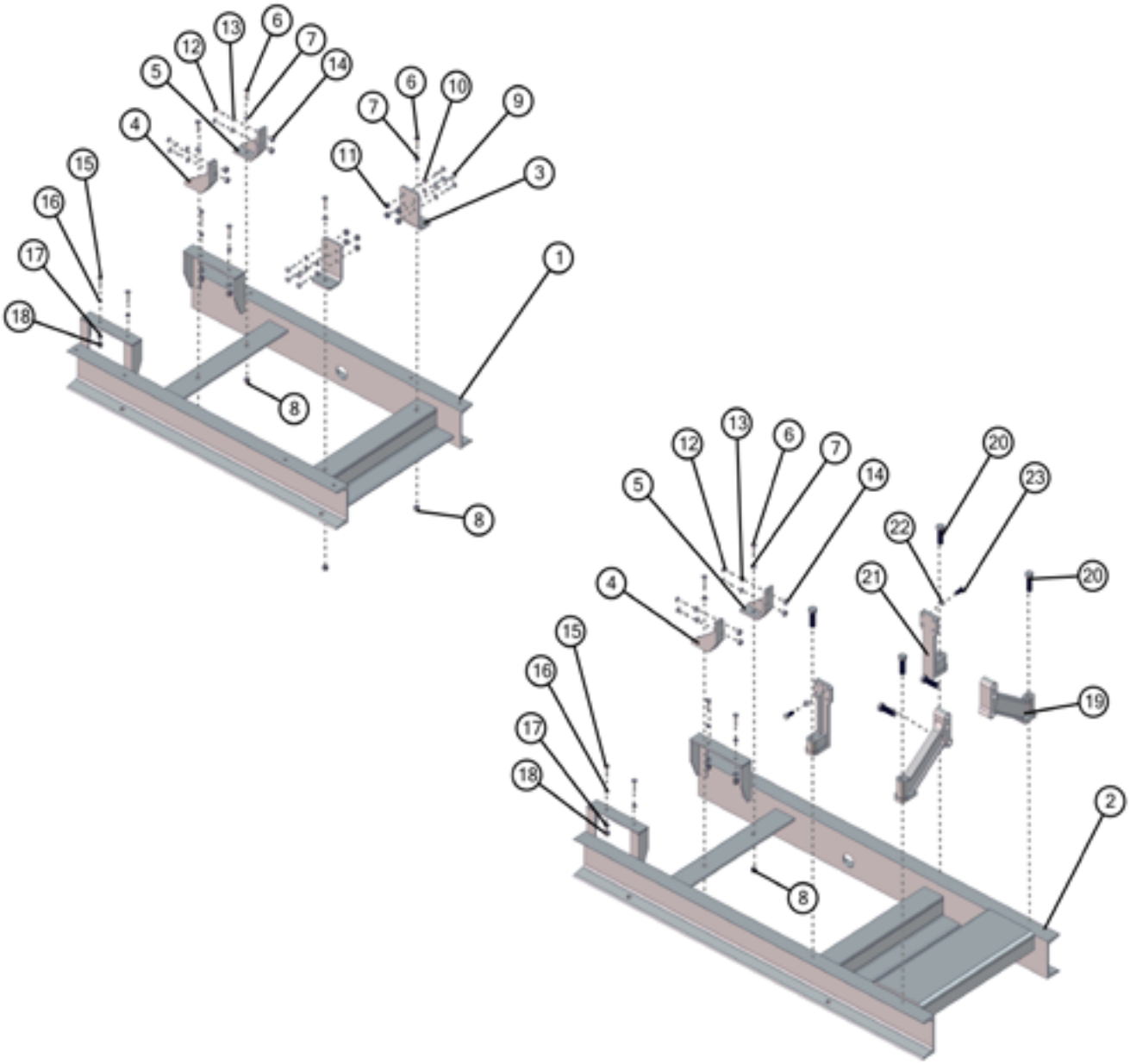


« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	120843-H	WATER TEMPERATURE GAUGE	1	1	
2	120844	OIL PRESSURE GAUGE	1	1	
3	868-A-255	IGNITION KEY	1	1	
4	208843-A-62	CONTROL PANEL BRACKET			1
	208843-A-42			1	
	WA500040		1		
*	OL-A-62	OIL LINE	1		1
	OL-A-42	OIL LINE	1	1	
	609-A-62	WIRING HARNESS			1
	152934	MAGNETIC SWITCH (TATTLETALE)		1	1
	103684	TACHOMETER		1	1
*	ECD-WIRHAR	A-62 WIRING HARNESS COMPLETE			1
*	WA50040	A-32 CONTROL PANEL	1		
*	60662-K6	TINY TACH	1		

*Not shown

13.44 Skids



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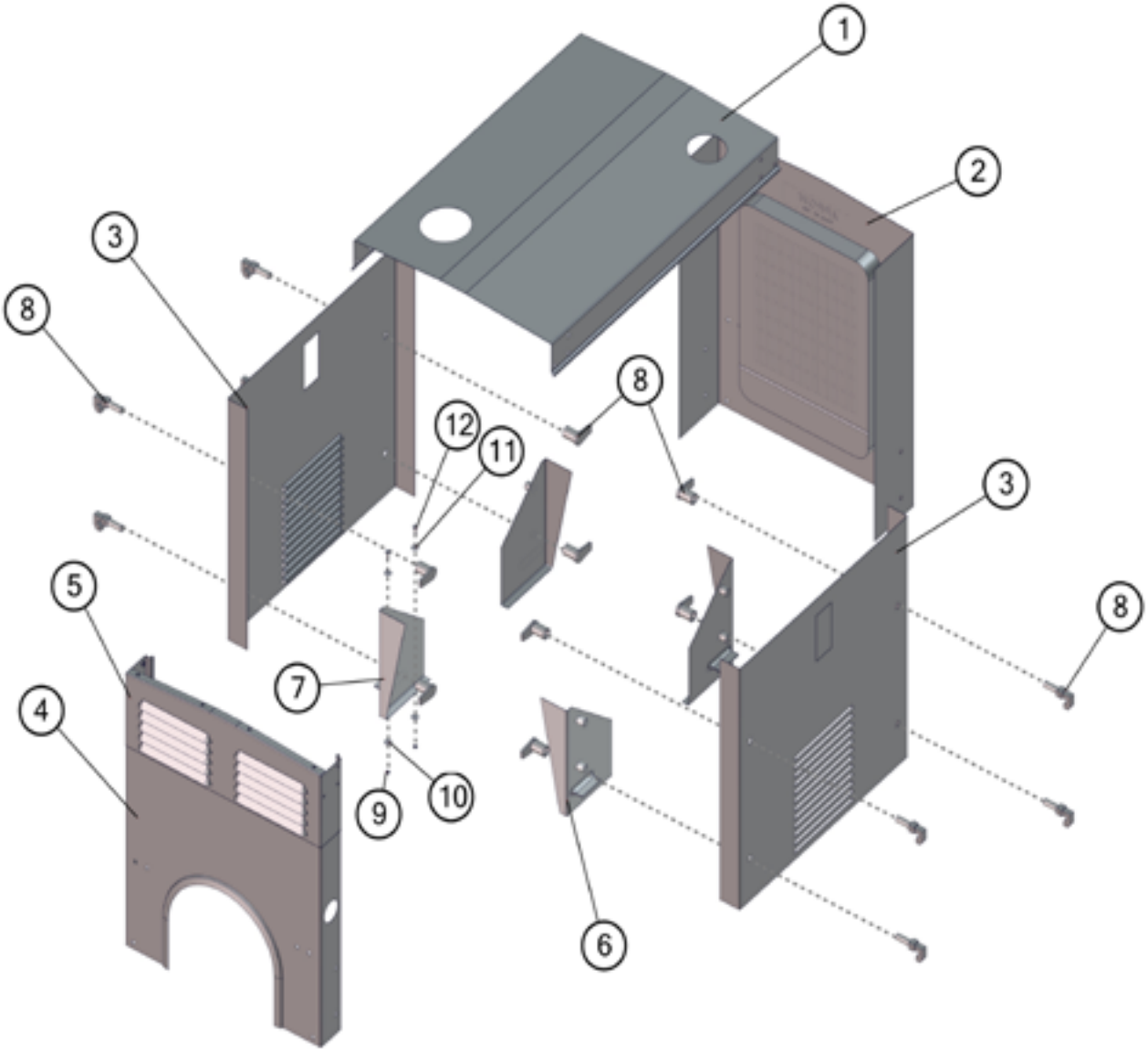
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	209015-A-62-TA	ENGINE SKID			1 (TURBO)
	209015-A-62				1
	209014NS			1	
	WA50000		1		
2	209014NS-1	GENSET SKID		1	
	209015-G-A-62				1
3	209020NS	REAR BRACKET	2	2	2
4	209019NS	FRONT LEFT BRACKET	1	1	1
5	209018NS	FRONT RIGHT BRACKET	1	1	1
6	M14X30	BOLT		4 (2 GENSET)	4
7	M14WF	WASHER		4 (2 GENSET)	4
8	M14NF	NUT		4 (2 GENSET)	4
9	M12X30MM	BOLT	4	4	4
10	M12WS	WASHER	8	8	8
11	M12NS	NUT	8	8	8
12	M18X45	BOLT	4	4	4
13	M18WS	WASHER	4	4	4
14	M18NS	NUT	4	4	4
15	M12X30	BOLT	4	4	4
16	M12WS	LOCK WASHER	4	4	4
17	M12WF	FLAT WASHER	4	4	4
18	M12NF	NUT	4	4	4
19	13021906	FRONT FEET		2	2
20	13022652	HEX BOLT		10	10
21	13021907	BACK FEET			2
	13022070			2	
22	01178366	SPRING LOCK WASHER		8	8
23	01151548	HEX BOLT		8	8

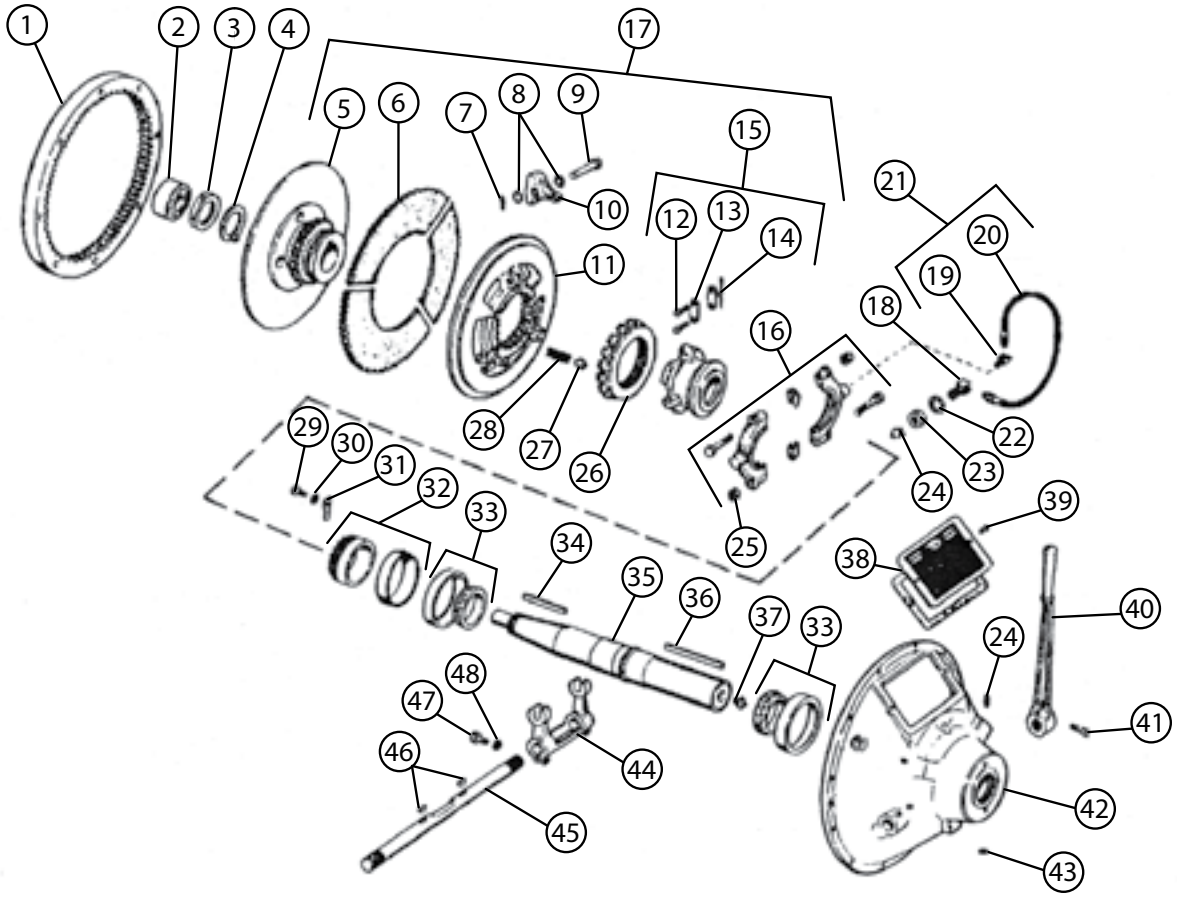
13.45 Sheet Metal



« RETURN TO TOC

ITEM	PART NUMBER	DESCRIPTION	A-32	A-42	A-62
1	A208777-A-62-TA	HOOD			1
	A208777-A-62				1
	A208778NS			1	
	WA50070		1		
2	A208749-A-62-TA	RADIATOR SHELL			1
	A208749-A-62				
	A208749-A-42		1	1	
3	A208751-A-62	OPTIONAL SIDE DOOR			2
	A208751-A-42			2	
	WA50080		2		
4	A208753-A-62	INSTRUMENT PANEL			1
	A208753NS		1	1	
5	A208754-A-62	UPPER REAR PANEL			1
	A208754NS		1	1	
6	A209016-A-62	RIGHT HAND SUPPORT BRACKET			2
	A209016NS		2	2	
7	A209017-A-62	LEFT HAND SUPPORT BRACKET			2
	A209017NS		2	2	
8	208772	DOOR LATCH		8	8
9	M10NF	NUT	40	40	40
10	M10FW	WASHER	40	40	40
11	M10WS	WASHER	40	40	40
12	M10X30	BOLT	40	40	40
*	AES-72	CANNON RECEPTACLE	1	1	1
*	A208778-BR	BRACE		1	1

13.46 Clutch, Single Row



ITEM	PART NUMBER	DESCRIPTION	A-32	A-42
	SP-111-HP-3	A-32/A-42 CLUTCH ASSEMBLY	1	1
1	6625-A	11" DRIVE RING	1	1
2	M-167	10" PILOT BEARING	1	1
3	1092	11" HUB NUT	1	1
4	A-1588	10" LOCKWASHER	1	1
5	ZA-6505-A	11" HUB BACK PLATE ASSEMBLY	1	1
6	O-6310-J	DRIVE PLATE, ALUM TEETH	1	1
	O-6310-L	DRIVE PLATE, SS TEETH	1	1
	A-5579-E	11" 3 PC DRIVE PLATE	1	1
7	2B-5/32X1/2	TEE HEAD COTTER PIN	4	4
8	M-2115-D	WASHER	8	8
9	B-1538-A	11" FINGER LEVER PIN	3	3
10	B-1304	11" FINGER LEVER	3	3
11	XB-2343	11" FLOATING PLATE	1	1

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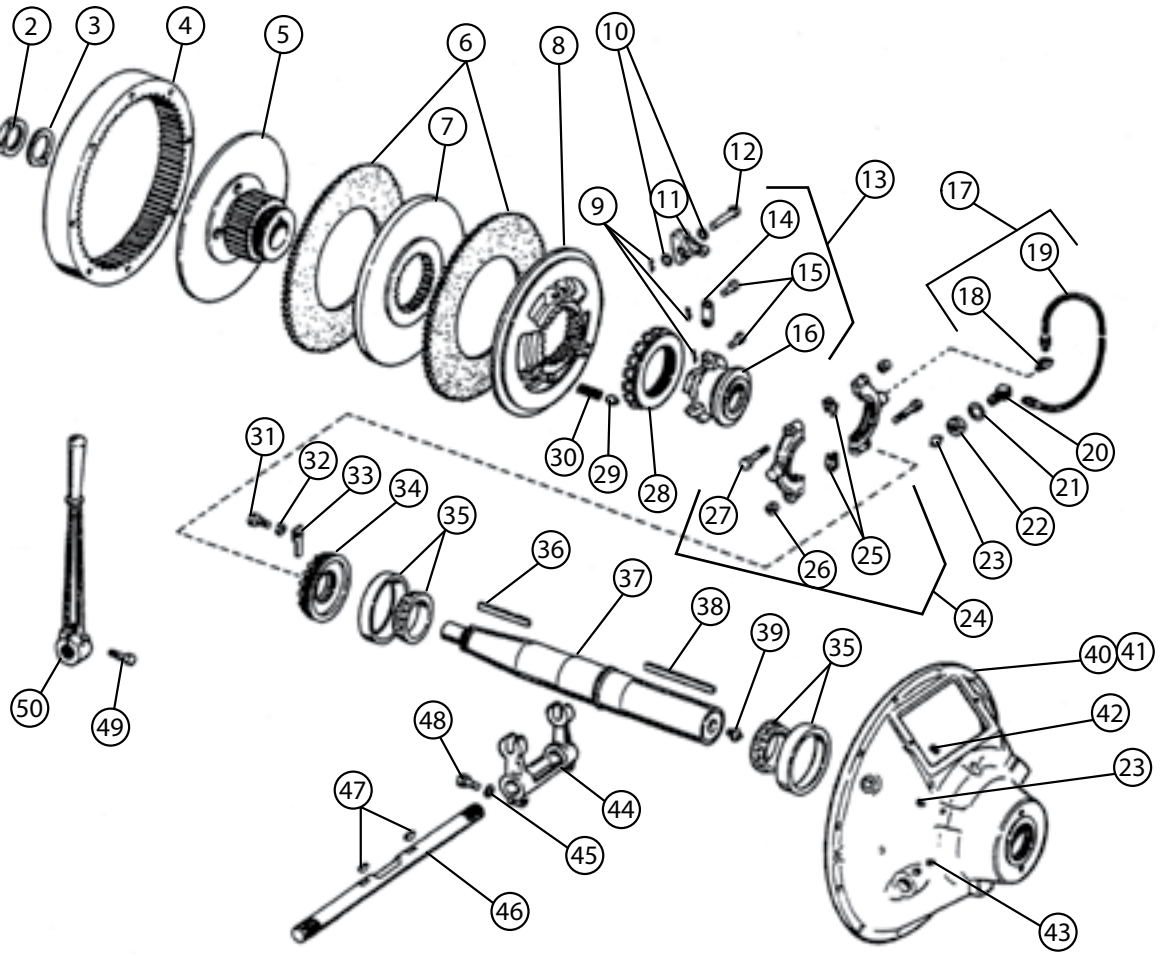
ITEM	PART NUMBER	DESCRIPTION	A-32	A-42
12	B-1537-D	10" LEVER LINK PIN	8	8
13	2617	11" LEVER LINK	1	1
14	41A-3/32X5/8	ROLL PIN	2	2
15	S-601	11" SI SLEEVE ASSEMBLY	1	1
16	X-117	11" COLLAR ASSEMBLY	1	1
17	XA-6527	CLUTCH ASSEMBLY - SINGLE ROW	1	1
18	M-1283	7, 8, 10" FITTING	1	1
19	M-1284	7, 8, 10" FITTING	1	1
20	M-1292-B	FLEX HOSE	1	1
21	A-1663-A	11" HOSE ASSEMBLY	1	1
22	2C-5/8	INTERNAL LOCKWASHER	1	1
23	29D-5/818	JAM NUT, FINISHED HEX	2	2
24	M-268	LUBE FITTING, MALE	2	2
25	32A-3/824	LOCKNUT	8	8
26	A-4238	ADJUSTABLE RING, C-106	1	1
27	B-1272	11" ADJUSTABLE LOCK PIN	1	1
28	115	10" ADJUSTABLE LOCK SPRING	1	1
29	7A-5/1618X5/8	CAPSCREW, HEX HEAD	1	1
30	2C-5/16	INTERNAL LOCKWASHER	1	1
31	1216-A	10" BEARING RETAINER SHAFT	1	1
32	B-2147	10" BEARING SPACER	1	1
33	M-207	10" CLUTCH BEARING	2	2
34	6A-3/8X3/8X21/2	KEY, SQ ENDS	1	1
35	A-5188	11" CLUTCH SHAFT	1	1
36	6A-5/8X5/8X53/8	KEY, SQ ENDS	1	1
37	M-287	7, 8, 10" SHAFT FITTING	1	1
38	ANP-22-A	SPECS PLATE, C-SERIES	1	1
39	12A-1/420X1/2	MACHINE SCREW, ROUND HEAD	1	1
40	X-3799-E	7, 8, 10" HAND LEVER	1	1
41	7A-1/213X13/4	CAPSCREW, HEX HEAD	2	2
42	8255	11" CLUTCH HOUSING	1	1
43	M-503	GREASE FITTING, SHAFT	1	1
44	X-125-A	11" THROW OUT YOKE	1	1
45	1144-E	11" OPERATING SHAFT	1	1
46	104A-#15	WOODRUFF KEY	2	2
47	7A-3/816X11/2	CAPSCREW, HEX HEAD	1	1
48	2C-3/8	INTERNAL LOCKWASHER	2	2

13.47 Clutch, Double Row



ITEM	PART NUMBER	DESCRIPTION	A-62
	102540F	A-62 CLUTCH ASSEMBLY	1
1	M-224-A	PILOT BEARING, 2 PC	1
2	B1509-B	HUB NUT	1
3	B1511-E	LOCK WASHER	1
4	X6931	DRIVING RING	1
5	ZA-6684-A	HUB, BLACK PLATE ASSEMBLY	1
6	A-5579-E	11" DRIVING PLATE, 3 PC	2
7	A-6690	CENTER PLATE	1
8	HTA-6505-B	FLOATING PLATE	1
9	B-1537-B	COTTER PIN	3
10	M-2115-C	SPRING WASHER	6
11	B-1304	FINGER LEVER	3
12	B-1538-A	LEVER PIN	3

ITEM	PART NUMBER	DESCRIPTION	A-62
13	S-634	SLIDING SLEEVE ASSEMBLY	1
14	2617	LEVER LINK	6
15	B-1537-D	LEVER PIN	6
16	BA-4422	SLIDING SLEEVE	1
17	A-1663-A	HOSE ASSEMBLY	1
18	M-1284	FITTING	1
19	M-1292-B	14" FLEX HOSE	1
20	M-1283	FITTING	1
21	2C-5/8	LOCK WASHER	1
22	29D-5/818	JAM NUT	1
23	M-268	FITTING	2
24	X-117-C-10	COLLAR ASSEMBLY	1
25	1294	FITTING	2
26	M-1930-F	HEX NUT	2
27	7A-3/824X21/4	HEX HEAD CAPSCREW 3/8-24 X 2 1/4	2
28	A-4238	ADJUSTING RING - C-106	1
29	B-2341	ADJUSTING BLOCK PIN	1
30	A-2702-BE	SPRING	1
	A-2704-BB		1
31	7A-1/420X5/8	HEX HEAD CAPSCREW 1/4-20 X 5/8	1
32	1A-1/4	LOCK WASHER	1
33	1216	BEARING RETAINER LOCK	1
34	B-1430	BEARING RETAINER	1
35	M-2196	ROLLER BEARING	2
36	6A-3/8X7/8X21/2	KEY	1
37	A-6691-AC	CLUTCH SHAFT W/ KEY	1
38	6A-5/8X5/8X53/8	KEY	1
39	M-287	SHAFT FITTING	1
40	9682	HOUSING #2 SAE	1
41	9977-A	HOUSING #3 SAE NLA	1
42	12A-1/420X1/2	ROUND HEAD SCREW	2
43	M-503	FITTING	1
44	X-3507	THROW OUT YOKE	1
45	1A-3/8	LOCK WASHER	2
46	1144-F	10" OPERATING SHAFT	1
47	104A-#15	WOODRUFF KEY	2
48	7A-3/816X11/2	HEX HEAD CAPSCREW 3/8-16 X 1 1/2	2
49	7A-1/213X13/4	HEX HEAD CAPSCREW 1/2-13 X 1 3/4	1
50	X-3799E	HAND LEVER	1
*	ANP-22-A	INSTRUCTION COVER PLATE	1

*Not shown

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13.48 Turbo Retrofit Kits

ITEM	PART NUMBER	DESCRIPTION	A-62 TURBO
1	13024082	TURBO, A-62 COMPLETE	1
2	1110571	HEAD SCREW	2
3	1119248	BOLT	1
4	12151665	HOSE CLAMP	6
5	12161797	GASKET	1
6	12161798	GASKET	1
7	13021548	LUBRICATING OIL LINE	1
8	13023361	RING, SEALING	2
9	13024456	PIPE, INTAKE	1
10	13026005	HOSE, RUBBER	1
11	1112271	HEXAGON BOLT	1
12	1178307	SPRING WASHER	2
13	1151569	HEXAGON BOLT, BAFFLE	1
14	1153869	O-RING	1
15	1177981	SPRING LOCK WASHER	5
16	12160117	ELBOW, EXHAUST PIPE	1
17	12160129	RETAINING RING	1
18	1143285	DOUBLE, STUD	4
19	1321456	M10-1.5 SELF CLINCHING NUT	4
20	12161833	GASKET, TURBO	1
21	12272783	GASKET, EXHAUST MANIFOLD	6
22	13024003	MANIFOLD, TURBO EXHAUST	1
	13024004		1
23	1178365	SPRING WASHER	8
24	13021190	FAN A-62 TURBO	1
25	13021193	FLANGE, A-62 TURBO FAN	1

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ITEM	PART NUMBER	DESCRIPTION	A-62 TURBO
26	1133878	CLAMP	7
27	13021887	INLET PIPE	1
28	13022206	RUBBER PIPE	1
29	7910162-TP	TIMING PLATE	1
30	209666-A380	AIR OUTLET, INTERCOOER	1
31	209667-A380	TUBE, INTERCOOLER\THROTTLE	1
32	155938	RAINCAP	1
33	208610	GASKET, INTAKE MANIFOLD	1
34	A100907-BRKT	EXHAUST PIPE BRACKET	1
35	7A-1/420X11/2	CAPSCREW	0
36	1A-1/4	LOCKWASHER, PLATED	0
37	M8X40	HHCS METRIC	0
38	M08FW	8 MM FLATWASHER, PLATED	0
39	M08WS	8M SPLIT LOCKWASHER, PLATED	0
40	HC-64	HOSE CLAMP	2
41	S1-41	SCREW	4
42	ASIC-7-C	200 CARBURETOR W\FLANGE	1
43	7910162	MAGNETIC PICK UP	1
44	13021901	RADIATOR, A-62 TURBO	1
45	12188619	SEALS	4
46	ANP-E-380TA	DECAL, EMISSION CONTROL	1
47	209668-A380	EXHAUST RISER, A-62 TURBO	1
48	209666A-A380	HOSE HUMP, SILICONE 2.5 ID	1
49	209667A-A380	HOSE HUMP, SILICONE 2.75 ID	2
50	N00-4097A	100 CARB ADAPTOR	1

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14 Repair Kits

14.1 A-32 COMPLETE GASKET SET

G-900-132

PART #	QTY.	DESCRIPTION
01153805	6	O-RING
01153804	6	O-RING
13023364	2	SEAL WASHER
12189888	1	REAR MAIN SEAL
01161340	1	O-RING
06214722	2	O-RING
0111873	3	SEAL RING
12189678	1	COVER GASKET
01166001	3	O-RING
12270869	1	W/P GASKET
12158513	1	Adaptor GASKET
13023391	6	STEM SEAL
13023362	1	RING, SEAL
G-979-32	1	HEAD GASKET SET
01153868	1	O-RING
12270878	1	SEALING GASKET
LOR-A-42	1	OIL COOLER SEAL
WA50155	1	OIL PAN GASKET

14.2 A-42 COMPLETE GASKET SET

G-900-142

PART #	QTY.	DESCRIPTION
13023360	3	SEALING WASHER USE WITH 01118960
13023364	4	SEAL WASHER
12270878	1	SEALING GASKET, OIL FILTER ADAPTOR
12270876	1	OIL PAN GASKET
12270879	4	GASKET, CYLINDER HEAD COVER
12190248	1	GASKET
01153869	1	O-RING
13023361	1	RING, SEALING
1161340	1	O-RING
6214722	2	SEAL
1153868	1	O-RING
12161797	1	GASKET
12161798	1	GASKET
13023358	2	SEALING RING
6214701	4	O-RING
12158513	1	GASKET
12272783	4	GASKET EXHAUST MANIFOLD
12190460	4	GASKET INTAKE MANIFOLD
1118681	1	O-RING
13020718	1	GASKET
111873	1	RING, SEALING
13025787	4	GASKET, CYLINDER HEAD
13023391	8	SEAL, STEM
12188100	1	ROTARY SHAFT SEAL FRONT
12189888	1	SEAL CRANKSHAFT REAR
12270869	1	GASKET, WATER PUMP A32/A42

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14.3 A-62 COMPLETE GASKET SET

G-900-162

PART #	QTY.	DESCRIPTION
1107281	10	SPRING WASHER
1157512	1	RUBBER STRIP
1178307	5	SPRING WASHER
6214722	1	SEAL
13022341	1	GASKET
12189678	1	GASKET
12273763	6	PISTON COOL INJECTION NOZZLE
1166001	6	O-RING
12164637	6	WASHER
12200650	1	GASKET, MOUNTING, WATER PUMP A62
12163182	12	WASHER
13025787	6	GASKET, CYLINDER HEAD
12151665	12	HOSE CLAMP
1118654	7	COPPER WASHER
12270879	6	GASKET, CYLINDER HEAD COVER
12190248	1	GASKET
13023364	3	SEAL WASHER
13023358	1	SEALING RING
12270878	1	SEALING GASKET, OIL FILTER ADAPTOR
13023187	1	SPRING CLAMP
13022863	1	GASKET, OIL PAN
208512-A62G	1	GASKET, PLATE GOV BLOCK OFF A62
M10WS	0	10MM SPLIT LOCKWASHER ZINC PLTD
12165765	1	PLAIN WASHER
1152752	16	WASHER
1178365	11	SPRING WASHER
12272783	6	GASKET EXHAUST MANIFOLD
12190460	6	GASKET INTAKE MANIFOLD
159884-A42	1	GASKET MANIFOLD TO Adaptor
13023391	12	SEAL, STEM
12188100	1	ROTARY SHAFT SEAL FRONT
12189888	1	SEAL CRANKSHAFT REAR
208878G	1	GASKET FOR EXHAUST FLANGE
12158513	1	GASKET

14.4 HEAD REBUILD KIT

G-936-142 (A-32, A-42, A-62)

PART #	QTY.	DESCRIPTION
13039782	1	INTAKE VALVE NEW STYLE
13039783	1	EXHAUST VALVE NEW STYLE
13026872	1	VALVE GUIDE EXHAUST
13026863	1	VALVE GUIDE, INTAKE
13039778	1	INTAKE VALVE SEAT NEW STYLE
13039779	1	EXHAUST VALVE SEAT NEW STYLE
1222051	2	OUTER VALVE SPRING
1222009	1	INNER VALVE SPRING
13023391	2	SEAL, STEM
12164645	2	SPRING CAP
12164698	4	VALVE COLLET

14.5 SINGLE HEAD GASKET KIT

G-979-42SH (A-32, A-42, A-62)

PART #	G-979-42SH	DESCRIPTION
13025787	1	GASKET, CYLINDER HEAD
12270879	1	GASKET, CYLINDER HEAD COVER
12272783	1	GASKET EXHAUST MANIFOLD
12190460	1	GASKET INTAKE MANIFOLD
13023364	2	SEAL WASHER

14.6 SLEEVE KIT

G-932-142 (A-32, A-42, A-62)

PART #	G-932-142	DESCRIPTION
13024173	1	CYLINDER LINER
1153805	2	O-RING
1153804	2	O-RING
12151395	2	SPRING RING
G-907-142	1	RING SET, PISTON
12152378	1	PISTON PIN
13020922	1	PISTON, GAS, 9:1
LUBE-1	1	LUBE SUPER O-RING, 2 GRAM

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14.7 A-32 BASIC OVERHAUL KIT

G-970-A32

PART #	QTY.	DESCRIPTION
G-900-132	1	GASKET SET, COMPLETE A42
G-932-142	3	SLEEVE KIT
G-936-142	4	260/380 HEAD KIT
G-918-132	1	BEARING SET, MAIN
12160570	3	CONN ROD BEARING, UPPER AND LOWER
12159598	3	WRIST PIN BUSHING
12159599	1	CAMSHAFT BUSHING GEAR END
12167047	6	BOLT, END
12273399	6	TAPPETS
WA00002	6	CYLINDER HEAD BOLT
WA00003	4	CYLINDER HEAD BOLT WITH STUD HEAD
WA00004	2	CYLINDER HEAD BOLT

14.8 A-42 BASIC OVERHAUL KIT

G-970-260

PART #	QTY.	DESCRIPTION
G-900-142	1	GASKET SET, COMPLETE A42
G-932-142	4	SLEEVE KIT
G-936-142	4	260/380 HEAD KIT
G-918-142	1	BEARING SET, MAIN
12160570	4	CONN ROD BEARING, UPPER AND LOWER
12159598	4	WRIST PIN BUSHING
12159599	1	CAMSHAFT BUSHING GEAR END
12167047	8	BOLT, END
12273399	8	TAPPETS
WA00002	10	CYLINDER HEAD BOLT
WA00003	4	CYLINDER HEAD BOLT WITH SHORT STUD
WA00004	2	CYLINDER HEAD BOLT WITH LONG STUD

14.9 A-62 BASIC OVERHAUL KIT

G-970-380

PART #	QTY.	DESCRIPTION
G-932-142	6	SLEEVE KIT
G-936-142	6	260/380 HEAD KIT
12160570	6	CONN ROD BEARING, UPPER AND LOWER
12159598	6	WRIST PIN BUSHING
12159599	1	CAMSHAFT BUSHING GEAR END
12167047	12	BOLT, END
G-900-162	1	GASKET SET. COMPLETE A62
G-918-162	1	BEARING SET, MAIN, A62
12273399	12	TAPPETS
G-927-A62	1	CAM BUSHING SET
WA00002	16	CYLINDER HEAD BOLT
WA00003	6	CYLINDER HEAD BOLT WITH STUD HEAD
WA00004	2	CYLINDER HEAD BOLT

14.10 A-32 COMPLETE OVERHAUL KIT

G-970-A32U

PART #	QTY.	DESCRIPTION
WA50148	1	CAM
WA50512	1	OIL PUMP
12273212	1	W/P
13021132	1	THERMOSTAT
G-900-132	1	GASKET SET, COMPLETE A42
G-932-142	3	SLEEVE KIT
G-936-142	4	260/380 HEAD KIT
G-918-132	1	BEARING SET, MAIN
12160570	3	CONN ROD BEARING, UPPER AND LOWER
12159598	3	WRIST PIN BUSHING
12159599	1	CAMSHAFT BUSHING GEAR END
12167047	6	BOLT, END
12273399	6	TAPPETS
WA00002	6	BOLT CYLINDER HEAD
WA00003	4	BOLT CYLINDER HEAD SHORT STUD
WA00004	2	BOLT CYLINDER HEAD LONG STUD

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14.11 A-42 COMPLETE OVERHAUL KIT

G-970-260U

PART #	QTY.	DESCRIPTION
G-900-142	1	GASKET SET, COMPLETE A42
G-932-142	4	SLEEVE KIT
G-936-142	4	260/380 HEAD KIT
G-918-142	1	BEARING SET, MAIN
12160570	4	CONN ROD BEARING, UPPER AND LOWER
12159598	4	WRIST PIN BUSHING
12159599	1	CAMSHAFT BUSHING GEAR END
13024219	1	CAMSHAFTS FOR VR260
12273399	8	TAPPETS
12166779	1	OIL PUMP A42
12273212	1	WATER PUMP, COMPLETE, A32/A42
13021132	1	THERMOSTAT
12167047	8	BOLT, END
12273763	4	PISTON COOL INJECTION NOZZLE
WA03004	1	GASKET WATER PUMP A32/A42
WA00002	10	BOLT CYLINDER HEAD
WA00003	4	BOLT CYLINDER HEAD SHORT STUD
WA00004	2	BOLT CYLINDER HEAD LONG STUD

14.12 A-62 COMPLETE OVERHAUL KIT

G-970-380U

PART #	QTY.	DESCRIPTION
G-900-162	1	GASKET SET. COMPLETE A62
G-932-142	6	SLEEVE KIT
G-936-142	6	260/380 HEAD KIT
G-918-162	1	BEARING SET, MAIN, A62
12160570	6	CONN ROD BEARING, UPPER AND LOWER
12159598	6	WRIST PIN BUSHING
13031471	1	CAMSHAFT, A62
12273399	12	TAPPETS
12159765	1	OIL PUMP A62
13023061	1	PUMP, WATER, A62
13021132	1	THERMOSTATS
12167047	12	BOLT, END
12272805	1	DAMPER, VIBRATION A62
G-927-A62	1	CAM BUSHING SET
12273763	6	PISTON COOL INJECTION NOZZLE
WA00002	16	BOLT CYLINDER HEAD
WA00003	6	BOLT CYLINDER HEAD SHORT STUD
WA00004	2	BOLT CYLINDER HEAD LONG STUD

14.13 COMPLETE HEAD GASKET KIT

A-32, A-42, A-62

PART #	G-979-32	G-979-42	G-979-62	DESCRIPTION
13025787	3	4	6	GASKET, CYLINDER HEAD
12270879	3	4	6	GASKET, CYLINDER HEAD COVER
12272783	3	4	6	GASKET EXHAUST MANIFOLD
12190460	3	4	6	GASKET INTAKE MANIFOLD
208878G	1	1	1	GASKET FOR EXHAUST FLANGE
13023364	2	2	2	SEAL WASHER
01153869	1			O-RING
12270878	1			SEALING GASKET
WA50155	1			OIL COOLER SEAL

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K-SERIES	K6					
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REPLACEMENT PARTS

CATERPILLAR®	G379	G398	G399	G3304	G3306
WAUKESHA®	F2895 F3521 F5108	L5790 L7042	P9390	145G/F817 140G/F554	F18 H24 WAK/1197
FAIRBANKS®	ZC-118	ZC-208	ZC-503	ZC-739	ZC-346
AJAX®	5× 6½	EA-22, 6½ × 8 CMA EA30, 7½ × 10 CMA EA-30, 7¼ × 8 CMA E-42, 8½ × 10 CMA		DP-60, 9½ × 10 CMA DP-115/230, 13½ × 16 DP-70/80/160, 11 × 14 CMA	