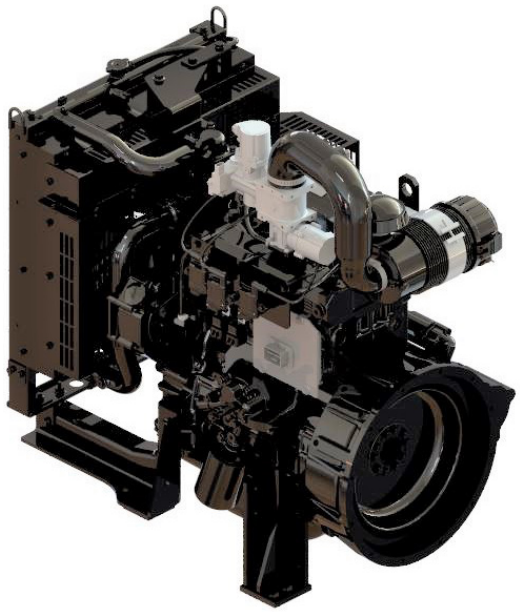
ARROW ENGINE
ENGINES & COMPRESSION

Original Equipment.

Engineered Solutions.

KP3

PARTS AND OPERATIONS MANUAL



2024 EMERGENCY STANDBY

ARROW ENGINE
ENGINES & COMPRESSION

ARROW ENGINE COMPANY
2301 E. Independence St., Tulsa, OK 74110
www.arrowengine.com

KP3-POM-JAN2024

KP3

PARTS AND OPERATIONS MANUAL

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2301 E. Independence St.

Tulsa, OK 74110

1. Maintenance Providers

Maintenance and repair services may be performed by you or any qualified engine service provider you choose. However, your engine warranty does not cover damage or failure caused by improper maintenance or repairs.

2. Operations Manual and Maintenance Log Storage and Use

Store this Operations Manual and Maintenance Log in a safe, visible place near your engine. The maintenance log must be updated whenever your engine is serviced.

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U.S. EPA Legal Requirements

This engine has been certified by the U.S. Environmental Protection Agency (EPA) as a stationary and constant-speed mobile engine. It is illegal to operate this engine in a variable-speed (foot-pedal speed-control) application.

To ensure emissions compliance, the U.S. EPA requires you to perform one of the following two options:

1. Operate and maintain your engine as specified in this Operations Manual. In addition, you are required by law to keep detailed maintenance records.
2. If you do not operate and maintain your engine as specified in this Operations Manual, your engine will be considered a noncertified engine.

In this case, you must:

- Keep a maintenance plan and records of conducted maintenance.
- To the extent practicable, maintain and operate the engine in a manner consistent with good air pollution control practices for minimizing emissions.

Per section 113 of the U.S. Clean Air Act, failure to abide by these legal requirements can result in fines of the following amounts: up to $49,342 per engine for manufacturers and $49,342 per day for owner-operators.

A maintenance plan and log are provided at the back of this manual for you to record your engine maintenance. Update this log each time you service your engine.

Preface

Recommended Spare Parts

6-month Spare Parts
Six-month spares are intended to satisfy parts required for start-up spares, and consist primarily of gaskets, O-rings, and common-wear parts. Because valves are sometimes damaged from debris in the piping during start-up, Arrow Engine Company recommends having a full set of replacement valves on hand. Arrow also has available valve repair kits.

1-year Spare Parts
One-year spare parts include the one-year plus the six-month spare parts. We have recommended some parts such as pumps, belts, divider block, etc. — not because these parts are expected to wear out in one year, but because they could be damaged as a result of neglect, abuse, or abnormal wear and tear from extreme or dirty operating conditions.

2-year Spare Parts
Two-year spare parts include the two-year parts, the one-year parts, plus the six-month parts. This is a more complete list of parts recommended as though the unit is in a remote area with limited replacement parts access, or for operating in a critical service. We have recommended some major parts such as a crankshaft and connecting rods — not because these parts are expected to fail in two years, but they could be damaged as a result of neglect, abuse, or abnormal wear and tear from extreme or dirty operating conditions.

This list could also be used as a recommended overhaul repair kit to be used when a complete overhaul becomes necessary.

PARTS

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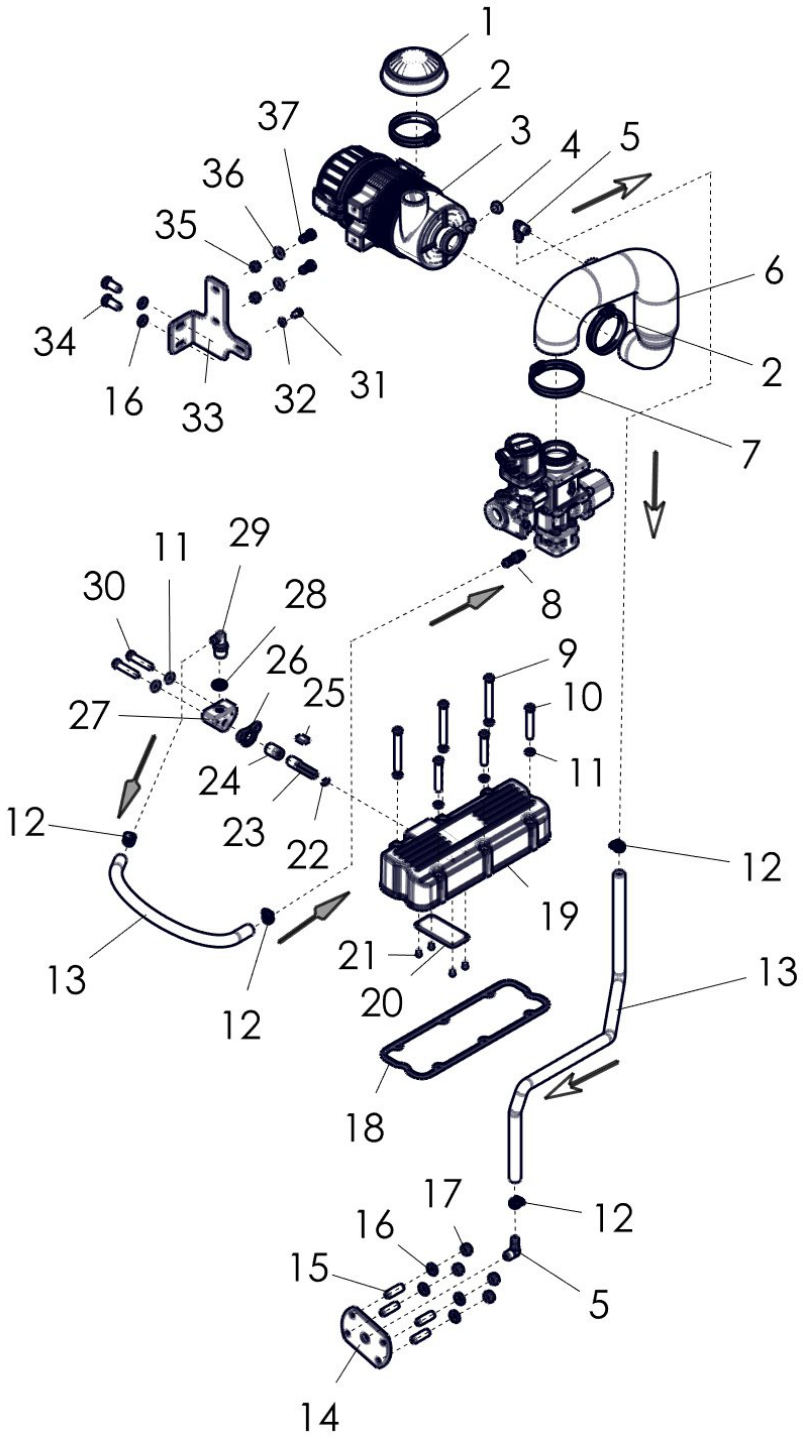
Special Tools

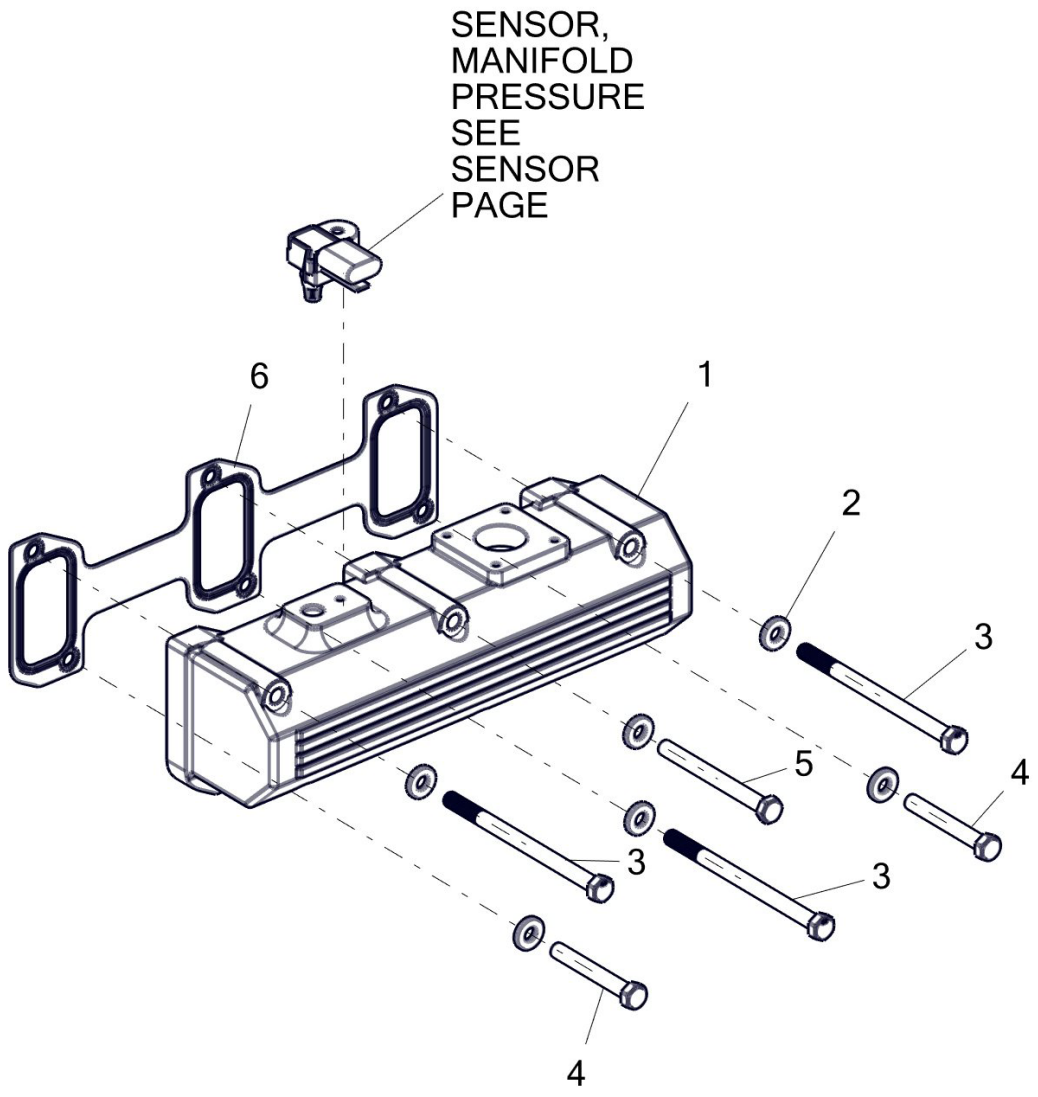
Special Tools			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB22000	(GEAR END) FRONT COVER OIL SEAL INSTALL	1
2	KB22001	(FLYWHEEL END) REAR OIL SEAL INSTALL	1
3	KB22002	CYLINDER LINER REMOVAL	1
4	KB22003	PISTON INSTALL	1
5	KB22004	VALVE SPRING COMPRESSOR	1
6	KB22005	STEM SEAL FITTING	1

Positive Crankcase Ventilation (PCV) Air Cleaner Valve Cover



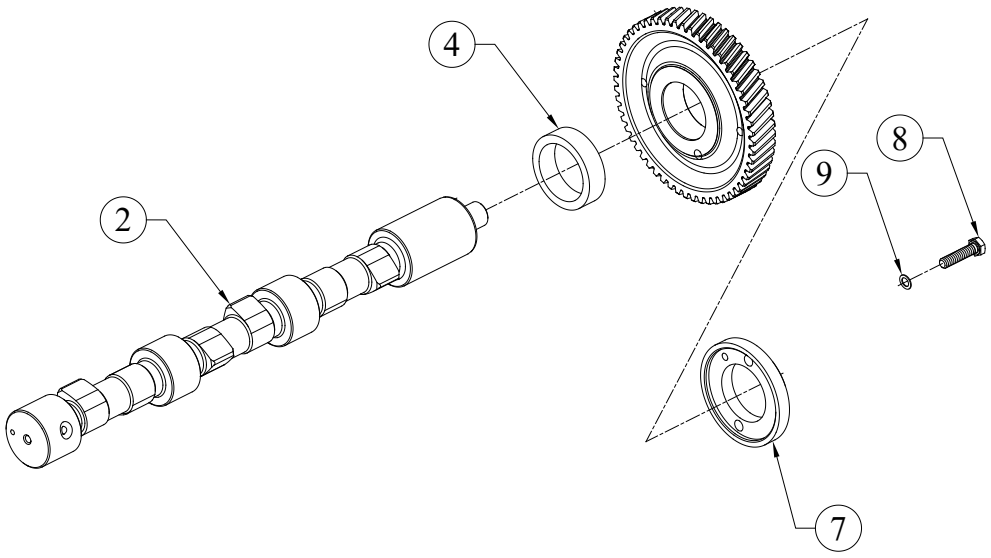
PCV Air Cleaner Rocker Cover			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD50010	RAIN CAP	1
2	HC-48	HOSE CLAMP	1 OR 2
3	KD50009	AIR CLEANER	1
3.5	KD50016	ELEMENT, REPLACEMENT AIR FILTER (NOT SHOWN)	1
4	153789	INDICATOR RESTRICTION (OPTIONAL)	1
5	KCN-1/4X3/8-90	FITTING, BRASS, 1/4 NPT X 3/8 BARB 90	2
6	KD50022	HOSE, FORMED, INTAKE	1
7	41236	CLAMP, HOSE 3.06-4.0	1
8	KCN-1/4X3/8	FITTING, BRASS, 1/4NPT X 3/8 BARB	1
9	M8X95	HEX HEAD SCREW	3
10	M8X70	HEX HEAD SCREW	3
11	M08FW	FLAT WASHER	8
12	WR07000	HOSE CLAMP	4
13	KD09017	VALVE COVER ASSEMBLY	1
14	KD50007	COVER, VENT	1
15	BOLT	STUD M10X1.5X40 TBE	4
16	M10FW	FLATWASHER, ZINC-PLATED	6
17	M10NF	HEX NUT, ZINC-PLATED	4
18	KD05055	GASKET, ROCKER COVER	1
19	KD09014	ROCKER COVER ASSEMBLY	1
20	NOT AVAILABLE	DEFLECTOR PLATE	1
21	NOT AVAILABLE	P K DRIVE SCREW 1/8X3/8 INCH (RIVET)	4
22	NOT AVAILABLE	CLOSING BUTTON	1
23	NOT AVAILABLE	TUBE FOR BREATHER	1
24	NOT AVAILABLE	ADAPTER FOR BREATHER TUBE	1
25	NOT AVAILABLE	PLATE	1
26	SEALANT	GASKET FOR BREATHER	1
27	KD16000	ADAPTOR, MOUNT PCV VALVE	1
28	157497X	O-RING	1
29	WR50011	PCV VALVE	1
30	M8X55	HEX SCREW	2
33	KD08009	AIR CLEANER BRACKET	1
35	M6X14	HEX SCREW	1
36	M06FW	FLATWASHER ZINC-PLATED	1
37	KD08009	BRACKET, AIR CLEANER G-DRIVE	1
38	M10X30	HEX SCREW	1
39	29A-3/816	HEX NUT, FINISHED	2
40	1N-3/8	WASHER, FLAT SAE-PLATED	2
41	7A-3/816X7/8	CAP SCREW, HEX HEAD	2
42		COVER PLATE (NOT SHOWN)	1

Air Inlet Manifold



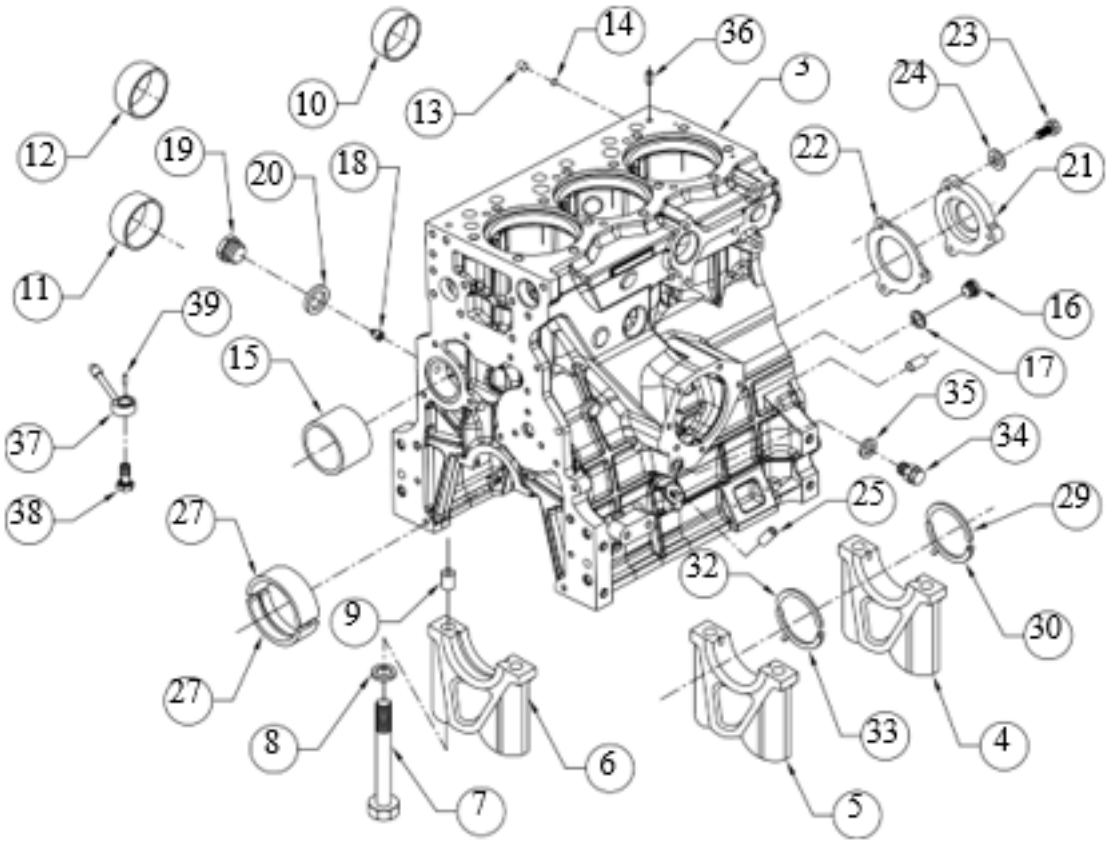
Air Inlet Manifold			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09011	INTAKE MANIFOLD	1
2	M08FW	PLAIN MACHINED WASHER - M8	6
3	KB00007	BOLT, COIL BRACKET M8 1.2 5X 130 (8.8)	3
4	M8X30	M8X30 HEX HEAD CAP SCREW	2
5	M8X90	M8X90 HEX HEAD CAP SCREW	1
6	KD05060	GASKET, INTAKE MANIFOLD	1
7	WD06005	SENSOR MANIFOLD PRESSURE - SEE SENSOR PAGE	1

Camshaft, Gas Engine



Camshaft, Gas Engine			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
2	KD09010	CAMSHAFT ASSEMBLY WITH CAM GEAR	1
4	KD05069	THRUST WASHER (FOR CAM SHAFT)	1
7	KD16008	CAMTONE SPACER	1
8	M8X1.25X35-8.8	SCREW - M8X1.25X35 - 8.8	2
9	M8	PLAIN MACHINED WASHER - M8	2
NOT SHOWN	KD09000	RELUCTOR WHEEL (NOT SHOWN)	1

Crankcase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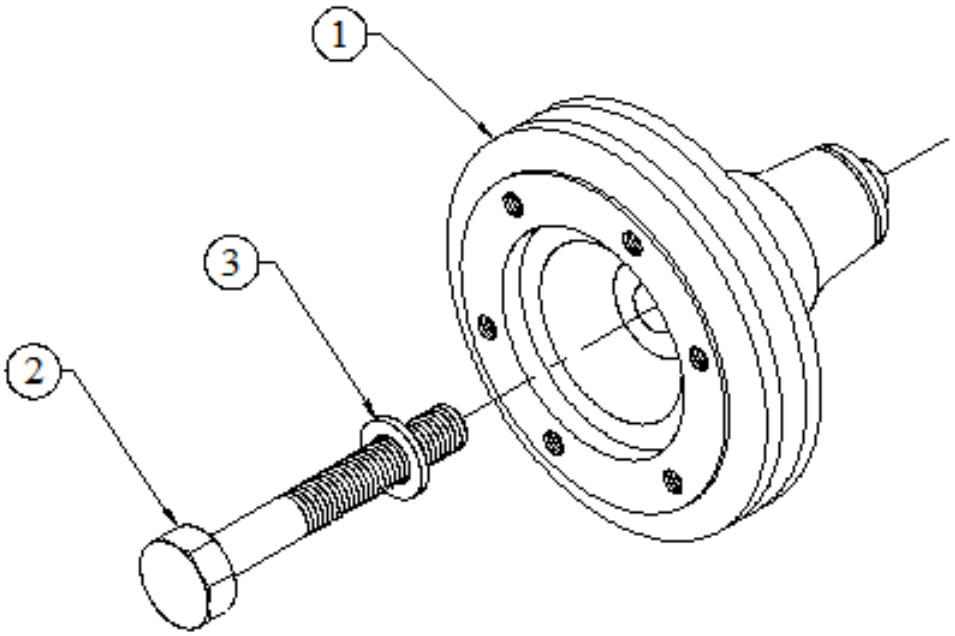
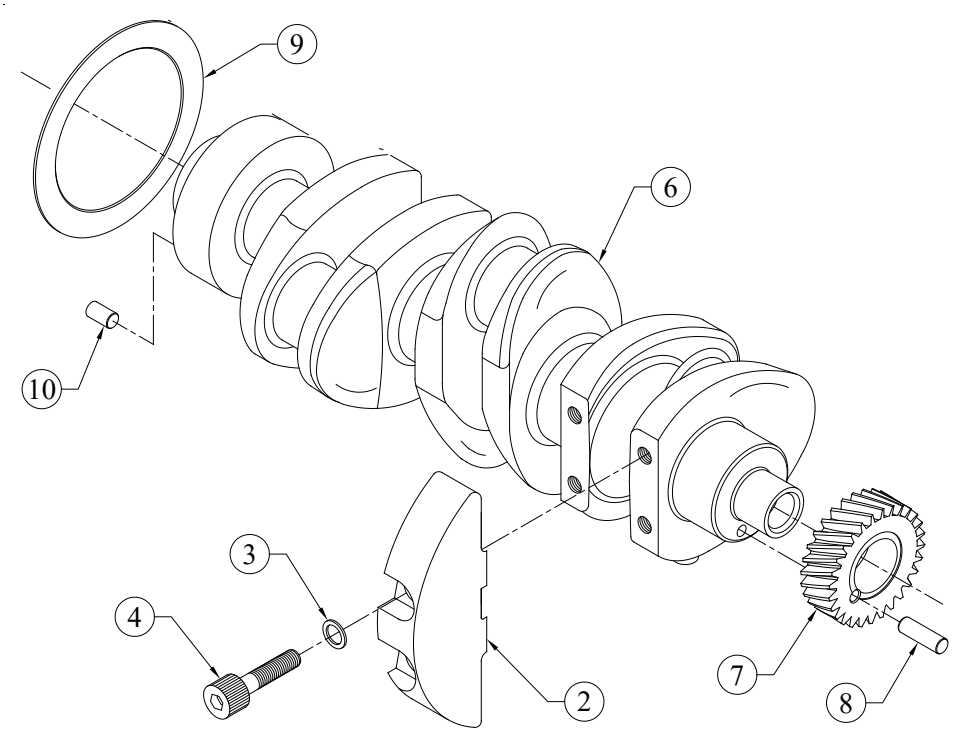
Crankcase			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09018	CRANKCASE ASSEMBLY WITHOUT BEARINGS, CONSISTS OF NOS. 2 AND 15-25	1
7	M14X2X128	BOLT FOR MAIN BEARING CAP (HEX HEAD) M14X2X128	8
8	M14	SPECIAL WASHER FOR M14 BOLT	8
9	NOT AVAILABLE	HOLLOW DOWEL (MAIN BEARING CAP)	8
10	KA17006	SEALING CAP, 32 MM SHALLOW	5
11	KB17004	SEALING CAP (40 DIN 443)	2
12	NOT AVAILABLE	SEALING CAP	2
13	NOT AVAILABLE	CRANK SHAFT PLUG - ALUMINIUM	2
14	NOT AVAILABLE	WASHER FOR ALUMINUM PLUG	2
15	KD05013	CAM BUSHING	1
16	NOT AVAILABLE	PRECOATED SCREW PLUG	1
17	KD05065	COPPER WASHER (20X26)	1
18	NOT AVAILABLE	SLOTTED PIN	5
19	NOT AVAILABLE	PRECOATED PLUG	4
20	KD05066	COPPER WASHER (12X18)	5
21	NOT AVAILABLE	COVER PLATE FOR CAM BORE	1
22	KD05046	GASKET FOR CAM BORE COVER PLATE	1
23	M8X1.25X25	SCREW - 8.8	3
24	M8	PLAIN MACHINED WASHER	3
25	NOT AVAILABLE	DIPSTICK GUIDE	1
26	KD09001	MAIN BEARING TOP AND BOTTOM, CONSISTS OF NO. 27	4
28	KD05014	THRUST RING PAIR - DRIVE END	1
29	KD05015	THRUST WASHER - DRIVE END, TOP	1
30	KD05016	THRUST WASHER - DRIVE END, BOTTOM	1
31	KD05017	THRUST RING PAIR - GEAR END	1
32	KD05018	THRUST RING HALF - GEAR END, TOP	1
33	KD05019	THRUST RING HALF - GEAR END, BOTTOM	1
34	M14X1.5	PLUG	1
35	14X20	COPPER WASHER	1
36	NOT AVAILABLE	DOWEL	2
37	KD05020		3
38	KD05021	SPECIAL BANJO BOLT ASSEMBLY (FOR OIL SPRAY NOZZLE)	3
39	NOT AVAILABLE	DOWEL PINS	3

Crank Pulley



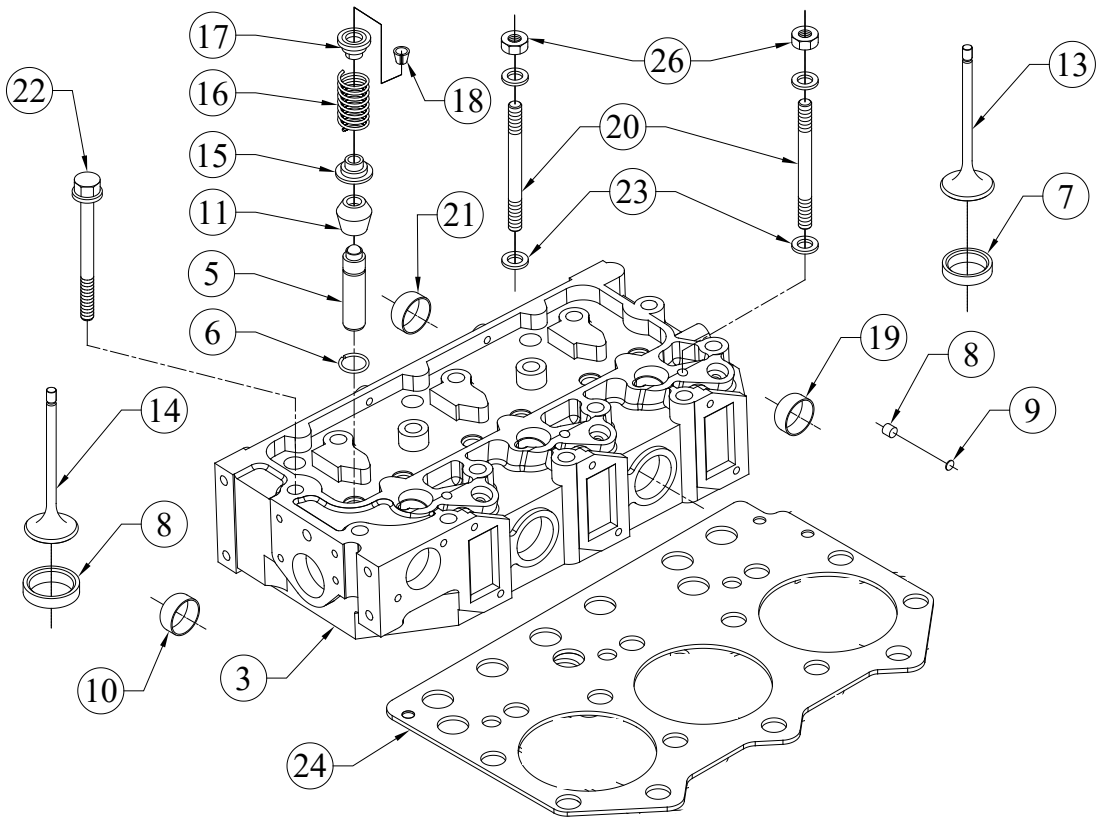
Crank Pulley			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KC50012	CRANK PULLEY (FINISH)	1
2	KD00008	CRANK PULLEY BOLT, UPDATED (110 MM)	1
3	KD19000	WASHER (FOR CRANK PULLEY BOLT), UPDATED	1

Crankshaft



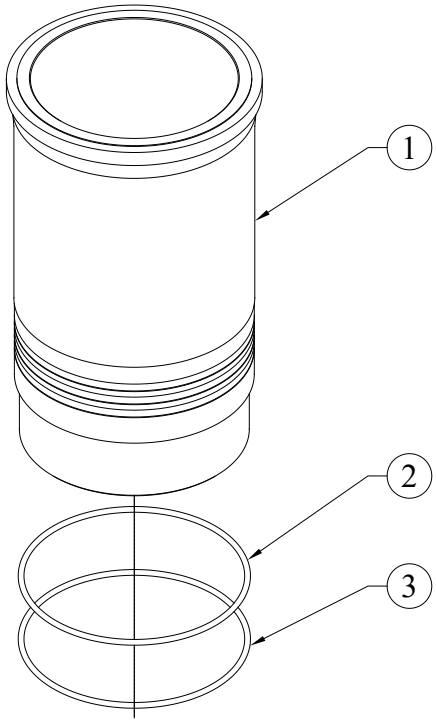
Crankshaft			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09002	CRANKSHAFT ASSEMBLY WITH GEAR	1
3	NOT AVAILABLE	HARD WASHER (13 ID X 21 OD X 1.5 THICK)	8
4	M12X1.75X60	SOCKET HEAD BOLT - M12X1.75X60 - 10.9	8
8	NOT AVAILABLE	DOWEL PIN, 8X60	1
9	KB09036	DEFLECTOR FOR OIL SEAL	1
10	NOT AVAILABLE	SPRING DOWEL	1

Cylinder Head



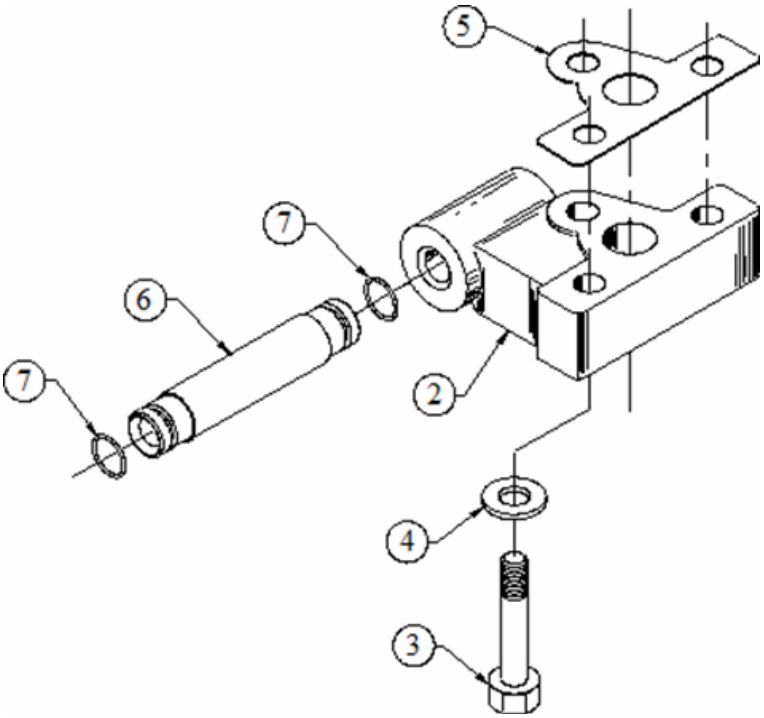
Cylinder Head			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09008	CYLINDER HEAD ASSEMBLY (COMPLETE)	1
5	KB09044 / KD05034	SEMI-FINISHED GUIDE AND SNAP RING ASSEMBLY	1
6	KD050351	WIRE SNAP RING	1
7	KD05036	VALVE SEAT INSERT (INLET) (SEMI-FINISH)	3
8	KD05037	VALVE SEAT INSERT (SEMI-FINISH) (EXHAUST)	3
8	NOT AVAILABLE	CRANKSHAFT PLUG, ALUMINIUM	4
9	NOT AVAILABLE	WASHER (FOR ALUMINUM PLUG)	4
10	KB17004	SEALING CAP (40 DIN 443)	3
11	KD05038	VALVE SEAL	6
13	KD05039	INLET VALVE (STELLITE)	1
14	KD05040	EXHAUST VALVE (STELLITE)	1
15	KB09045	CUP (FOR VALVE SPRING)	6
16	KB09048	VALVE SPRING	6
17	KB09049	VALVE CUP	6
18	KB09046	VALVE COLLET	12
19	KB17004	SEALING CAP (40 DIN 443)	1
21	KB17004	SEALING CAP (40 DIN 443)	1
22	KD05044 / KB09016	BOLT (FOR CYLINDER HEAD)	14
24	KD05045	GASKET (FOR CYLINDER HEAD, 1.22 MM)	1
26	M10X1.5-8	NUT - M10X1.5 - 8	6

Cylinder Liner



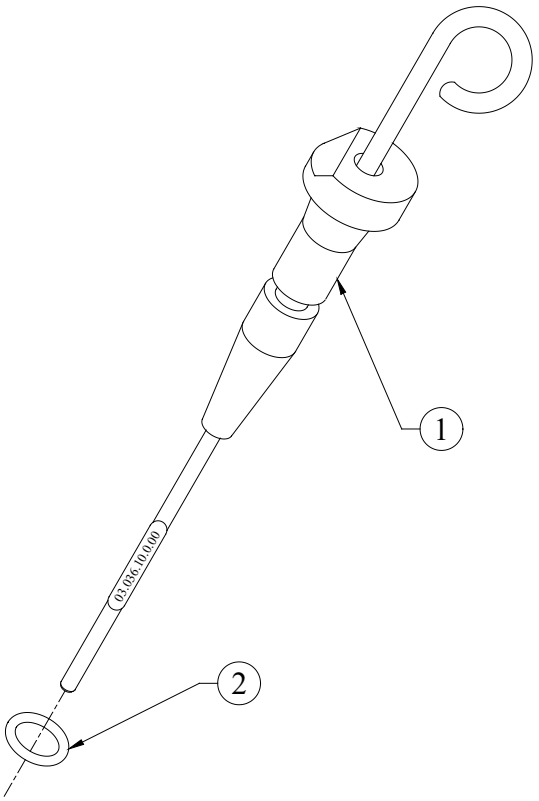
Cylinder Liner			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB09006	CYLINDER WITH O-RINGS	1
2	KB09012	O-RING (FOR CYLINDER LINER, TOP)	2
3	KB09013	O-RING (FOR CYLINDER LINER, VITON MATERIAL, BOTTOM)	1

Delivery Body



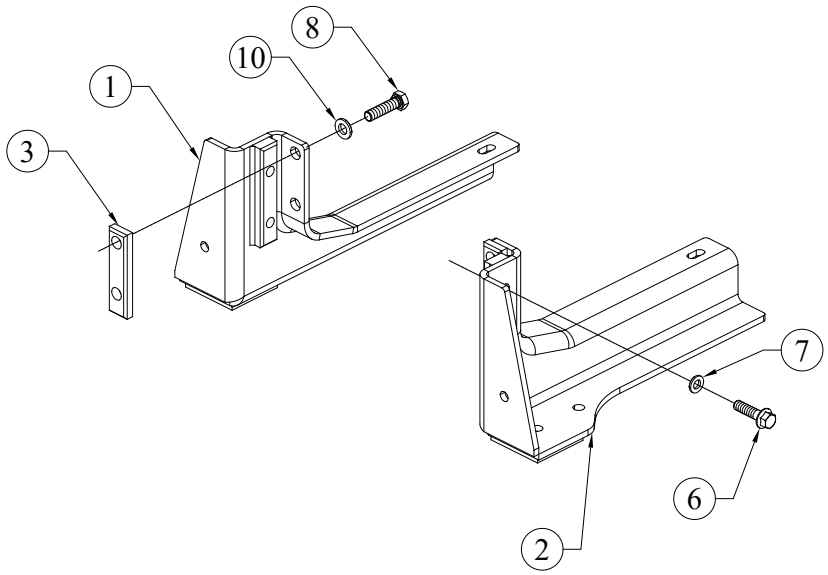
Delivery Body			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
2	KB50014	DELIVERY BODY ASSEMBLY	1
3	M8X1.25X45-8.8	BOLT - M8X1.25X45 - 8.8	3
4	PLAIN MACHINED WASHER - M8	PLAIN MACHINED WASHER - M8	3
5	KB03014 / KD05048	GASKET, DELIVERY BODY	1
6	KB50015	DELIVERY TUBE	1
7	KB03015 / KD05062	O-RING (FOR DELIVERY TUBE)	2

Dipstick



Dipstick			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD50029	DIPSTICK KP3	1
2	KD05063	O-RING - DIPSTICK	1

Engine Mounting Foot



Engine Mounting Foot			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD50037	ENGINE MOUNTING FOOT (LEFT SIDE FROM FLYWHEEL END)	1
2	KD50038	ENGINE MOUNTING FOOT (RIGHT SIDE FROM FLYWHEEL END)	1
3	KD16013	PLATE (ON CRANKCASE SIDE)	2
6	M12X1.75X50	SCREW - 8.8	4
7	M12	SPECIAL PLAIN WASHER - M12	4
8	M14X2X50	SCREW - M14X2X50 - 8.8	4
10	M14	SPECIAL PLAIN WASHER - M14	4

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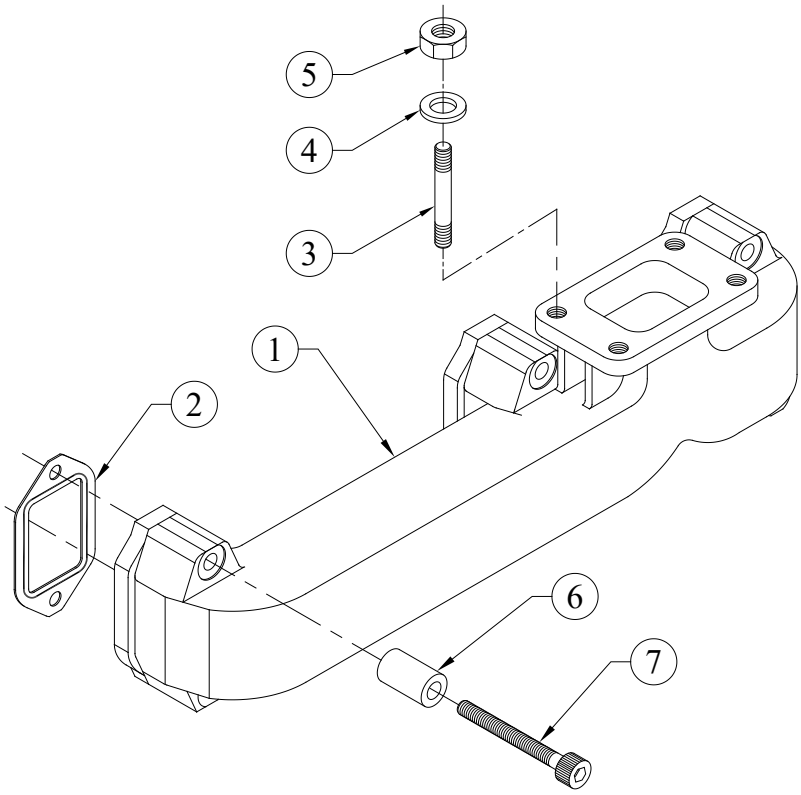
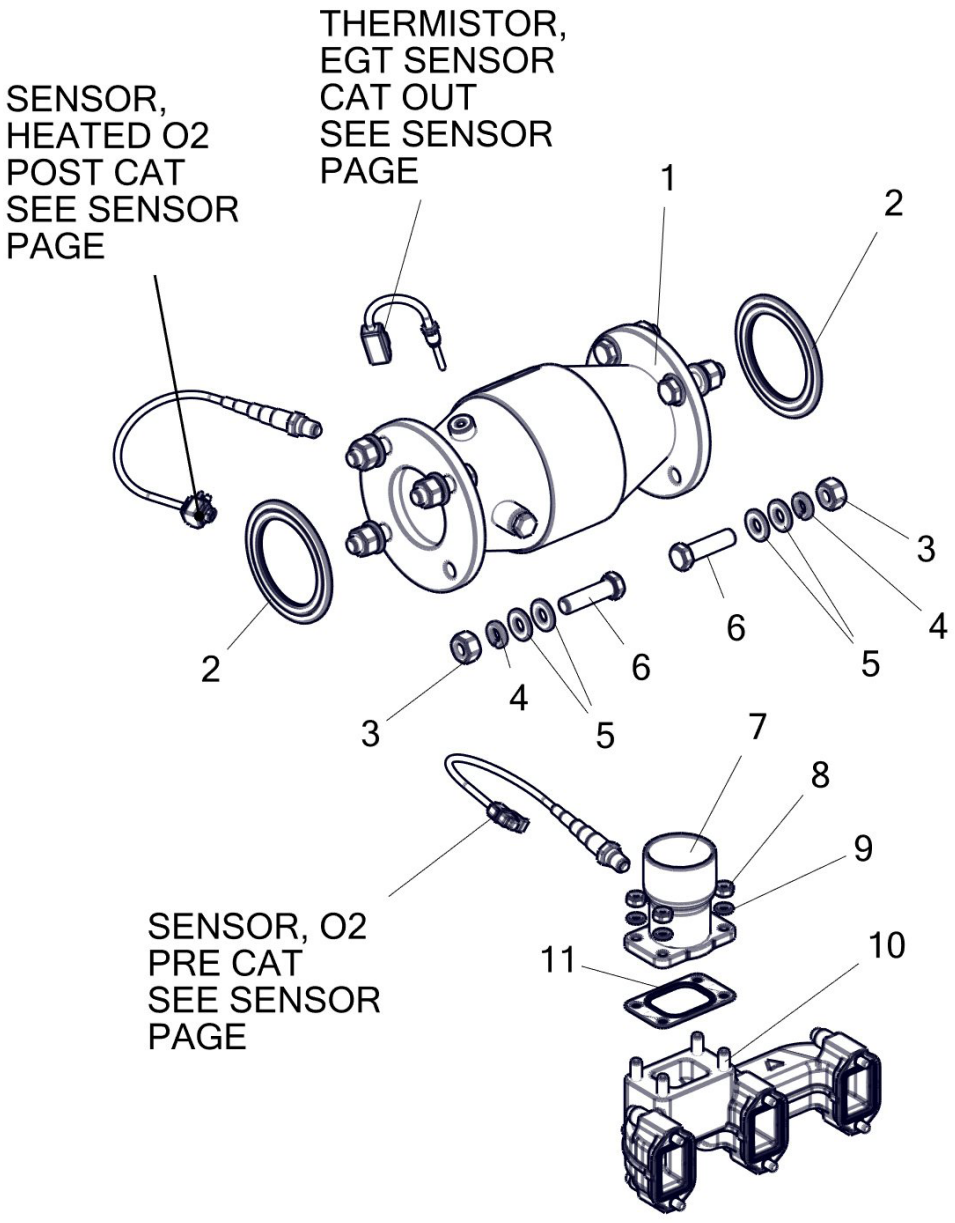
Exhaust Manifold with Adapter



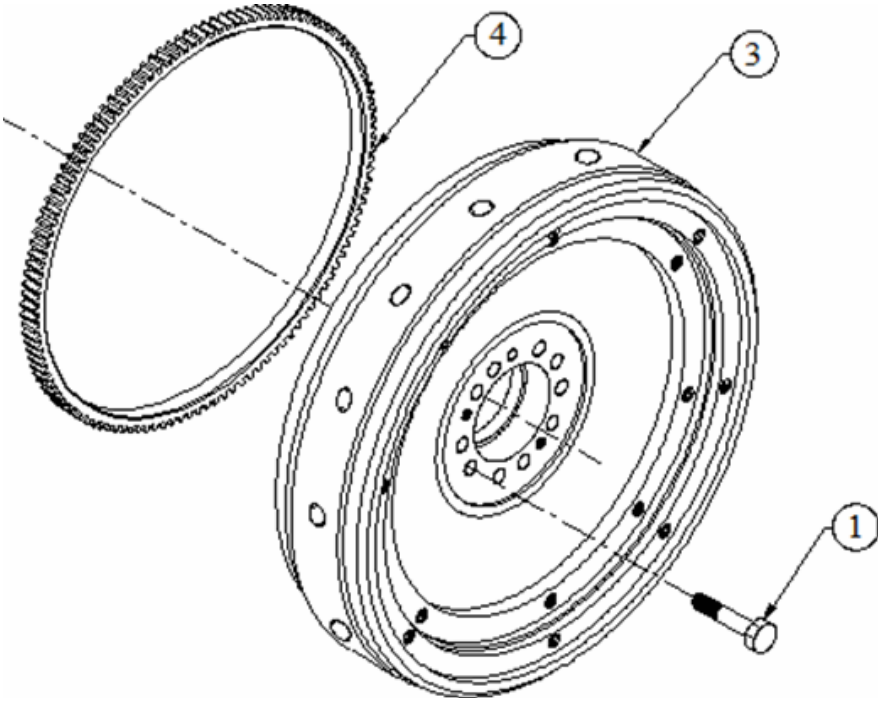
Exhaust Manifold with Adapter			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09004	EXHAUST MANIFOLD	1
2	KB03004	SS GASKET (FOR EXHAUST MANIFOLD TO HEAD)	3
3	M10X1.5X30-8.8	STUD - M10X1.5X30 - 8.8	4
4	M10	PLAIN MACHINED WASHER - M10	4
5	M10-AISI-304	STAINLESS-STEEL NUT M10-AISI-304	4
6	KB16001	SPACER (FOR EXHAUST MANIFOLD)	6
7	M8X1.25X75-8.8	SOCKET HEAD SCREW	6

Exhaust System



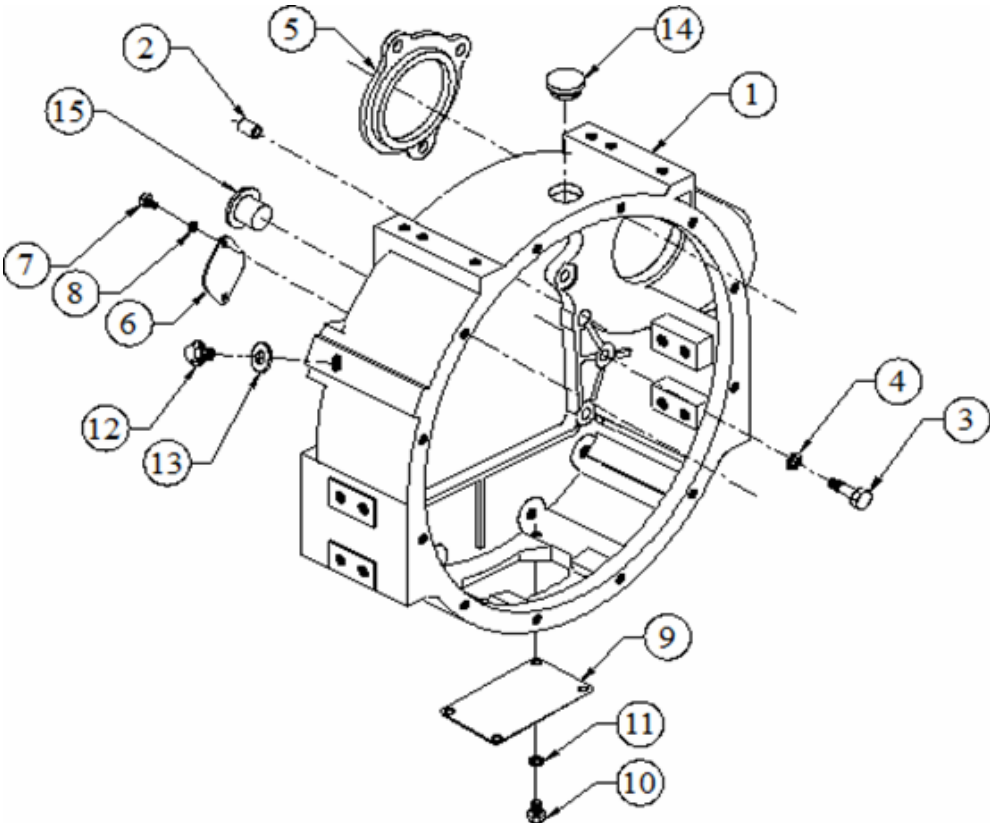
Exhaust System			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	DDC70031	CATALYST, INTEGRAL, 7.0-INCH SINGLE	1
2	AFR-GASKET	FLANGE GASKET/CATALYST	2
3	25A-5/8-11	NUT, HEX HEAVY	8
4	1A-5/8	LOCK WASHER, PLATED	8
5	1N-5/8	WASHER, FLAT, SAE-PLATED	16
6	7A-5/811X21/2	CAP SCREW, HEX HEAD	8
7	KD50003	STUB PIPE FOR G-DRIVE	1
8	M10NF	HEX NUT, 10 MM, ZINC-PLATED	4
9	M10FW	WASHER, PLAIN	4
10	M10X1.5X30	STUD, METRIC	4
11	KC03000	GASKET, EXHAUST MANIFOLD OUTLET FLANGE, SS	1

Flywheel



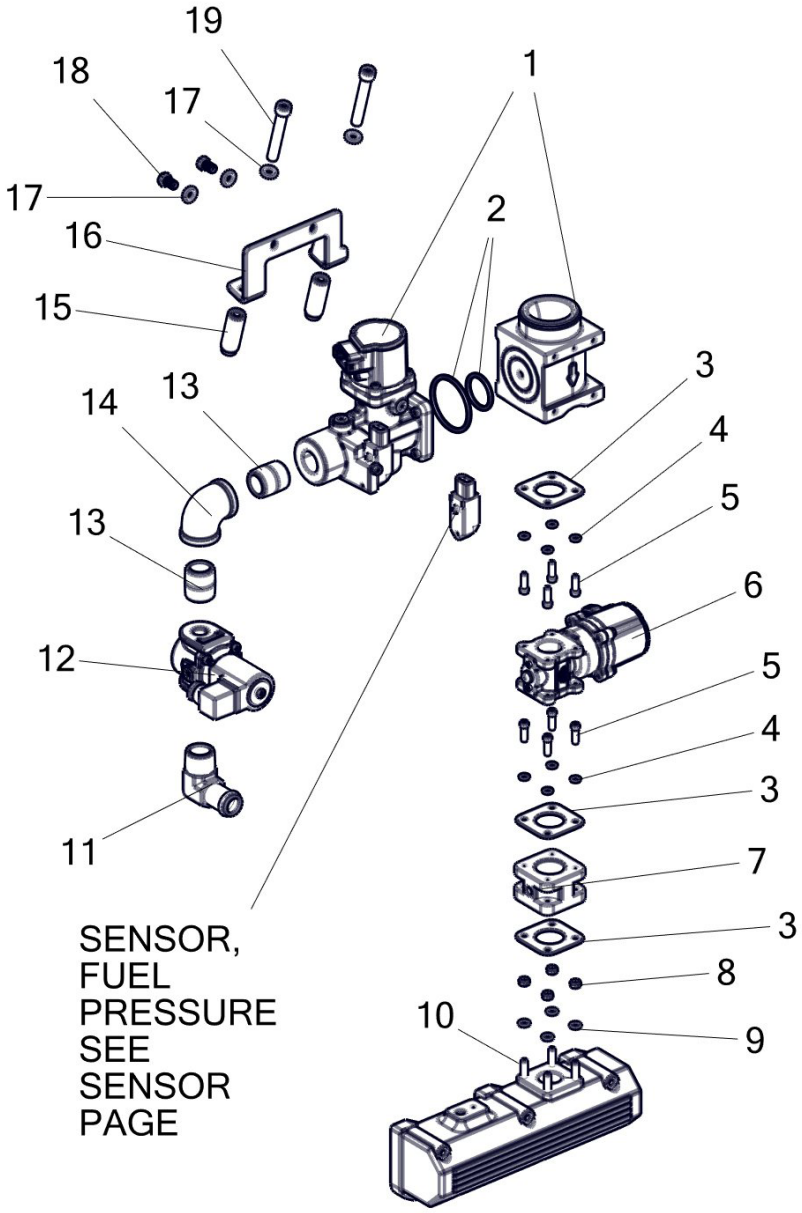
Flywheel			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB09008	FLYWHEEL BOLT (M10 X 35)	10
3,4	KB09009 3+1	FLYWHEEL ASSEMBLY, 3+1, 121 TEETH	1

Flywheel Housing



Flywheel Housing			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB09033	FLYWHEEL HOUSING (SAE 3)	1
2		HOLLOW DOWEL (16 DIA.)	2
3	M10X30-10.9	BOLT-M10X30-10.9	10
4		WASHER M10	10
5	KB09070	FLANGE (FOR STARTER)	1
6		BLANKING PLATE (FOR FLYWHEEL HOUSING)	1
7	M6X1X12-8.8	SCREW - M6X1X12 - 8.8	2
8	M6	PLAIN MACHINED WASHER - M6	2
9		COVER (FOR FLYWHEEL HOUSING)	1
10	M8X1.25X16-8.8	SCREW - M8X1.25X16 - 8.8	4
11	M8	PLAIN MACHINED WASHER - M8	4
12	16X1.5	CORE PLUG 16X1.5	1
13	17X23	COPPER WASHER (17X23)	1
14		RUBBER CAP	1

Fuel System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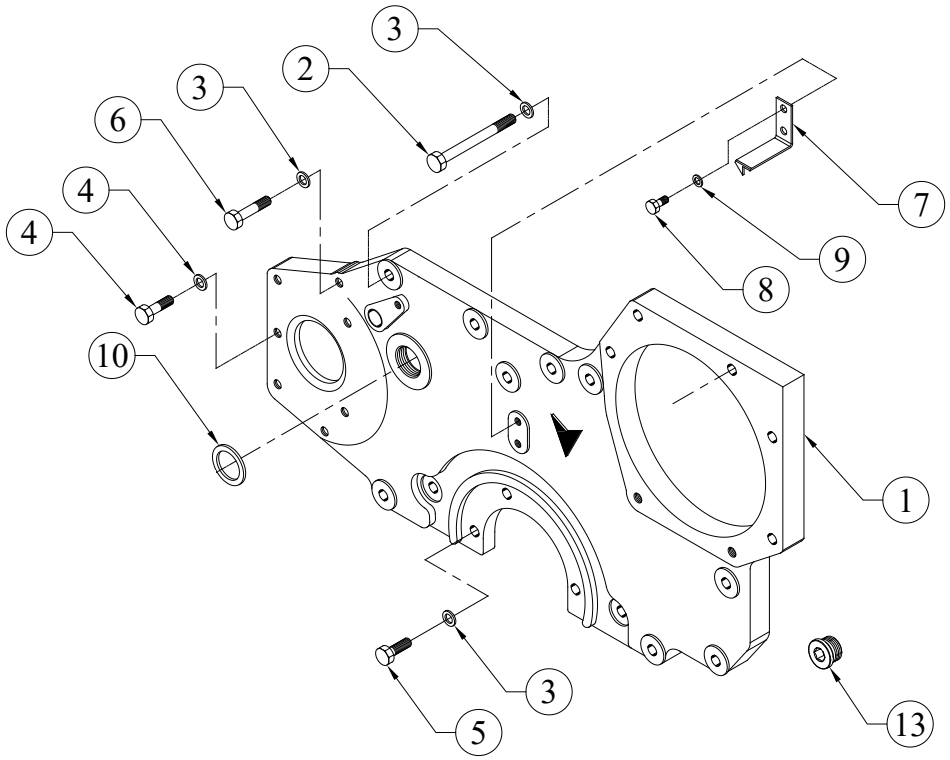
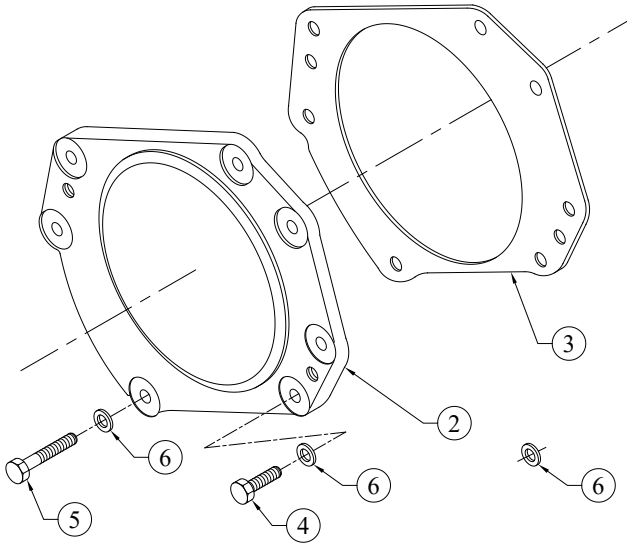
Fuel System			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	WD06011	VALVE, 16 MM-180 EFR /70 MM MIXER KP3NA	1
2	WD06008	KIT, PRESSURE SENSOR WITH O-RINGS FOR PG+EFR	1
3	KD03000	GASKET, THROTTLE BODY 25-36 MM	3
4	M5WASH	WASHER, 5 MM	8
5	KD00001	SCREW, SOCKET HEAD (M5 X 20 MM) (1.0)	8
6	WD06010	THROTTLE BODY, 30 MM WOODWARD	1
7	KD16006	ADAPTOR, INTAKE TO THROTTLE WITH PCV PORT	1
8	M06NF	METRIC NUT	4
9	M06FW	FLAT WASHER, 6 MM, ZINC-PLATED	4
10	KD01000	STUD, M6X1 MM 30 MM LONG ZING	4
11	WR18001	FITTING, 90-DEGREE 1" NPT MALE X 1" HOSE BARB	1
12	KB14000	LOCK-OFF VALVE, NG 12V (ODE)	1
13	PF2-1	PIPE NIPPLE	2
14	PF10-1	ELBOW, DMI 90-DEGREE	1
15	KD16007	SPACER, EFR SUPPORT BRACKET	2
16	KD08007	BRACKET, EFR SUPPORT	1
17	M08FW	WASHER, 8 MM	4
18	M8X16	CAP SCREW, HEX HEAD, GRADE 8.8-PLATED	2
19	KD00009	SCREW, (M10 X 75) (1.5) 8.8 SOCKET HEAD	2

Front Cover



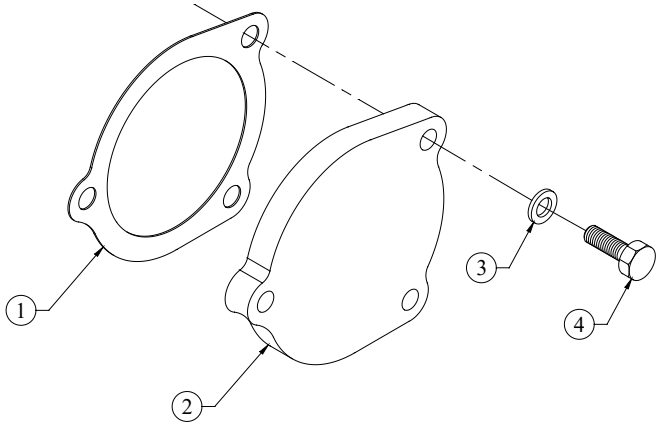
Front Cover			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09005	GEAR COVER	1
2	M8X1.25X100-8.8	BOLT - M8X1.25X100 - 8.8	4
3	M8	PLAIN MACHINED WASHER - M8	17
4	M8X1.25X30-8.8	BOLT - M8X1.25X30 - 8.8	5
5	M8X1.25X25-8.8	SCREW - M8X1.25X25 - 8.8	5
6	M8X1.25X35-8.8	BOLT - M8X1.25X35 - 8.8	5
7	NOT AVAILABLE	TIMING POINTER	1
8	M6X1X12-8.8	SCREW - M6X1X12 - 8.8	2
9	M6	PLAIN MACHINED WASHER - M6	2
10	KD05071	COPPER WASHER (24X29)	1
11	KC50014	CAM RETAINER SCREW (24MM X 2) (NOT SHOWN)	1
12	KC02000	NUT (24MM X 2) (NOT SHOWN)	1
13	KC50015	CAP NUT, KC50015 (NOT SHOWN)	1

Cover, Plate



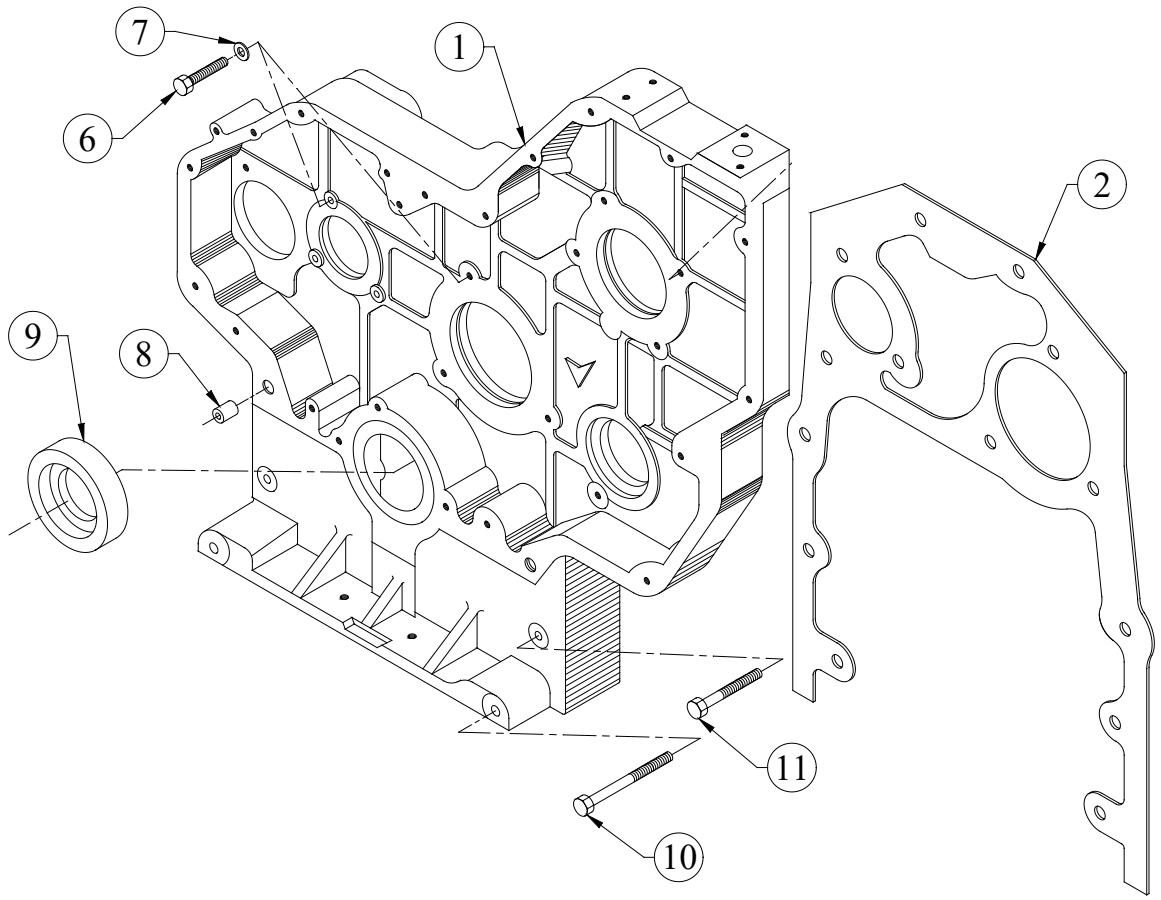
Cover, Plate			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
2	NOT AVAILABLE	COVER	1
3	KD05053	GASKET, COVER (FOR FUEL PUMP GEAR)	1
4	M8X1.25X20-8.8	SCREW - M8X1.25X20 - 8.8	2
5	M8X1.25X45-8.8	BOLT - M8X1.25X45 - 8.8	5
6	M8	PLAIN MACHINED WASHER - M8	7

Cover, Plate



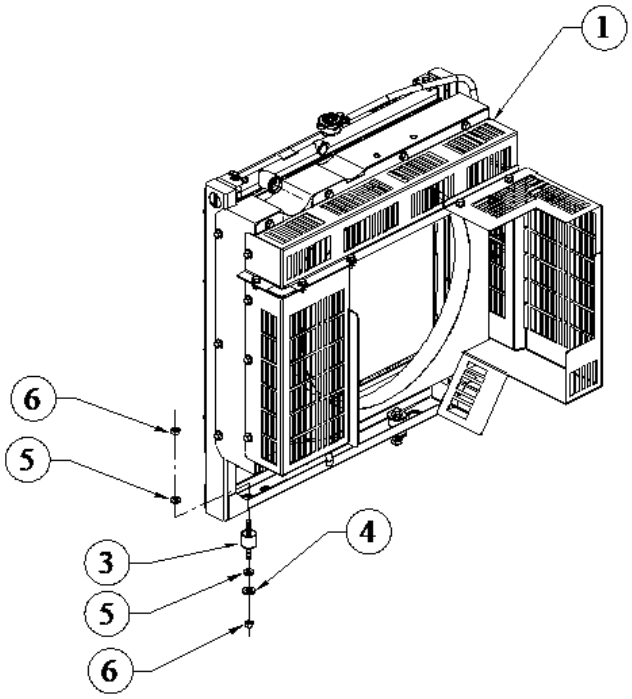
Cover, Plate			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD05054	GASKET (COVER)	1
2	NOT AVAILABLE	COVER	1
3	M8	PLAIN MACHINED WASHER - M8	3
4	M8X1.25X25-8.8	SCREW - M8X1.25X25 - 8.8	3

Gear Casing



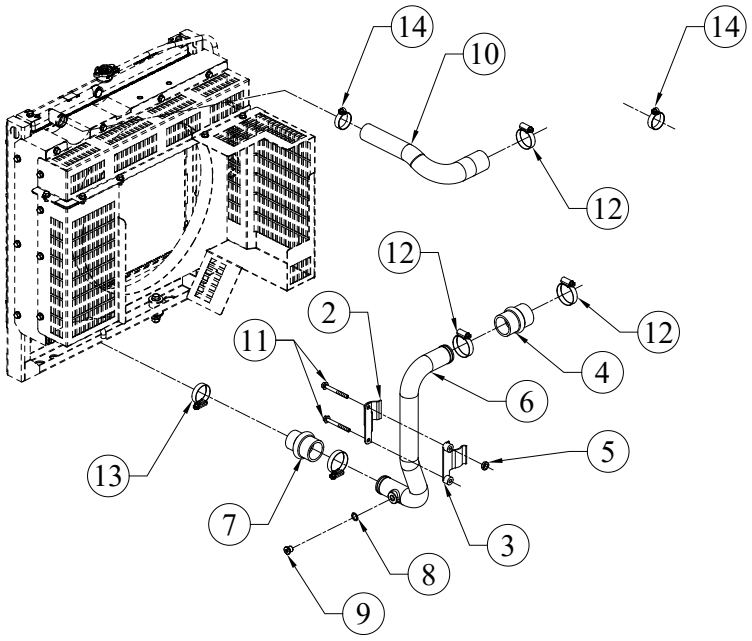
Gear Casing			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09006	GEAR CASING	1
2	KD05047	GASKET (FOR GEAR COVER)	1
6	M8X1.25X25-8.8	SCREW - M8X1.25X25 - 8.8	7
7	M8	PLAIN MACHINED WASHER - M8	11
8	NOT AVAILABLE	DOWEL (FOR GEAR CASING)	2
9	KD05025	OIL SEAL (65X85X13)	1
10	M8X1.25X110-8.8	BOLT - M8X1.25X110 - 8.8	2
11	M8X1.25X80-8.8	BOLT - M8X1.25X80 - 8.8	2

Radiator and Mounting Assembly



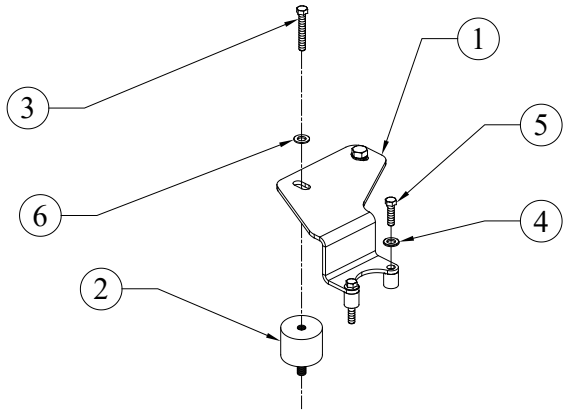
Radiator			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD50035	ALUMINIUM RADIATOR ASSEMBLY	1
3	KD50036	MOUNT, LOWER RADIATOR	2
4	KD19001	SPECIAL WASHER (FOR RADIATOR MOUNTING)	2
5	M10	PLAIN WASHER	4
6	M10X1.5	NUT - GRADE 8	4

Water Connection Assembly



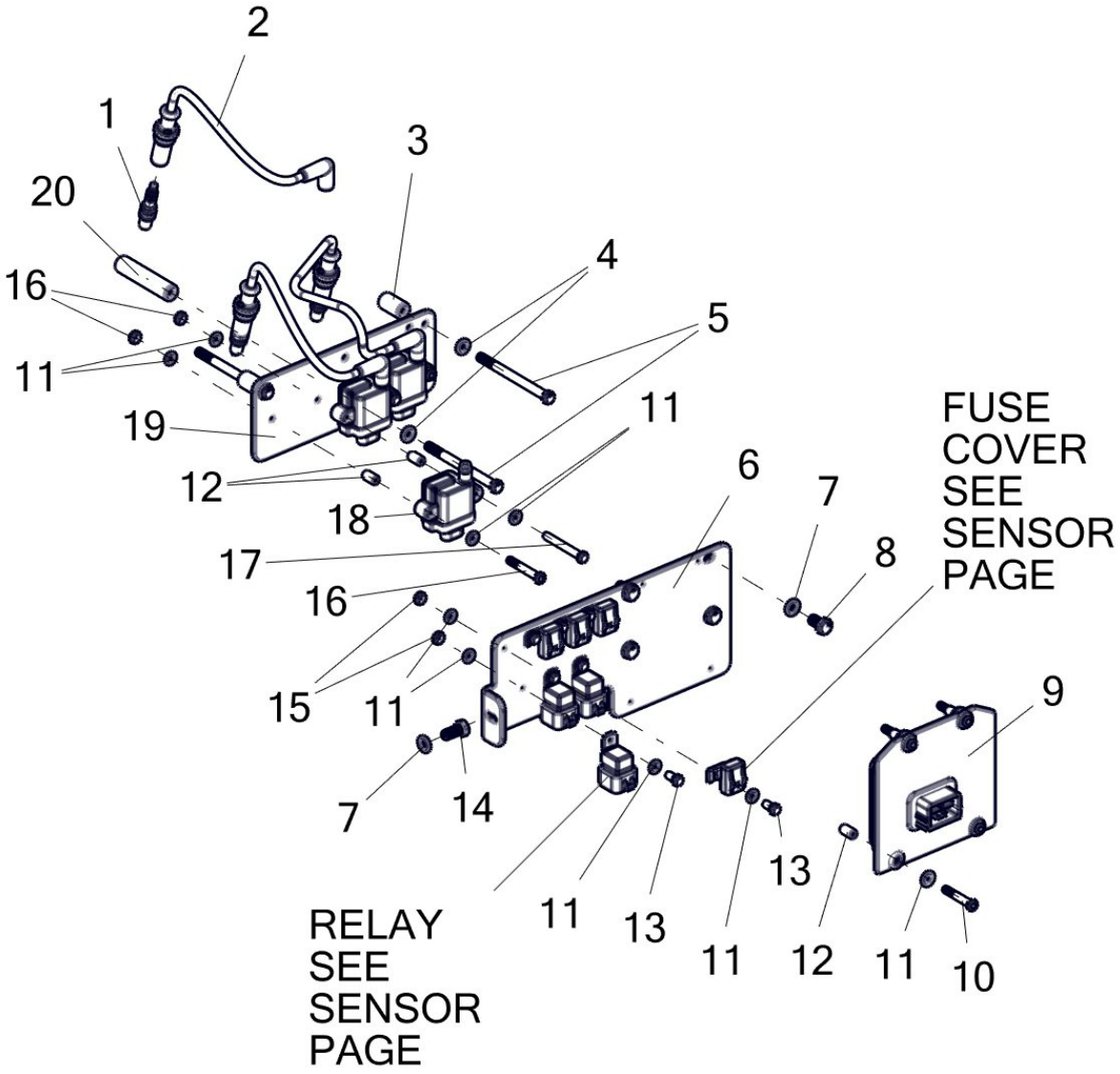
Water Connection Assembly			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD08011	BRACKET, LOWER PIPE SUPPORT ASSEMBLY, CONSISTS OF NOS. 2 AND 3	1
2	NOT AVAILABLE	UPPER CLAMP FOR PIPE	1
3	NOT AVAILABLE	LOWER CLAMP FOR PIPE	1
4	KD05077	HOSE, PIPE TO WATER PUMP	1
5	KD16014	SPACER, WATER PIPE RETAINER BRACKET	1
6	KD05078	PIPE FROM RADIATOR TO PUMP INLET	1
7	KD05079	HOSE, WATER PUMP INLET TO RADIATOR OUTLET	1
8	13023358	COPPER WASHER (14X20)	1
9	01118952	PLUG - HEXAGONAL SOCKET HEAD	1
10	KD05080	HOSE, THERMOSTAT TO RADIATOR	1
11	M8X1.25X45	BOLT - 8.8	1
12	45-61 MM	STAINLESS-STEEL HOSE CLAMP, HOSE OUTER DIAMETER	4
13	45 MM	WORM DRIVE HOSE CLAMP	1
14	55 MM	WORM DRIVE HOSE CLAMP	2

Top Radiator Mount



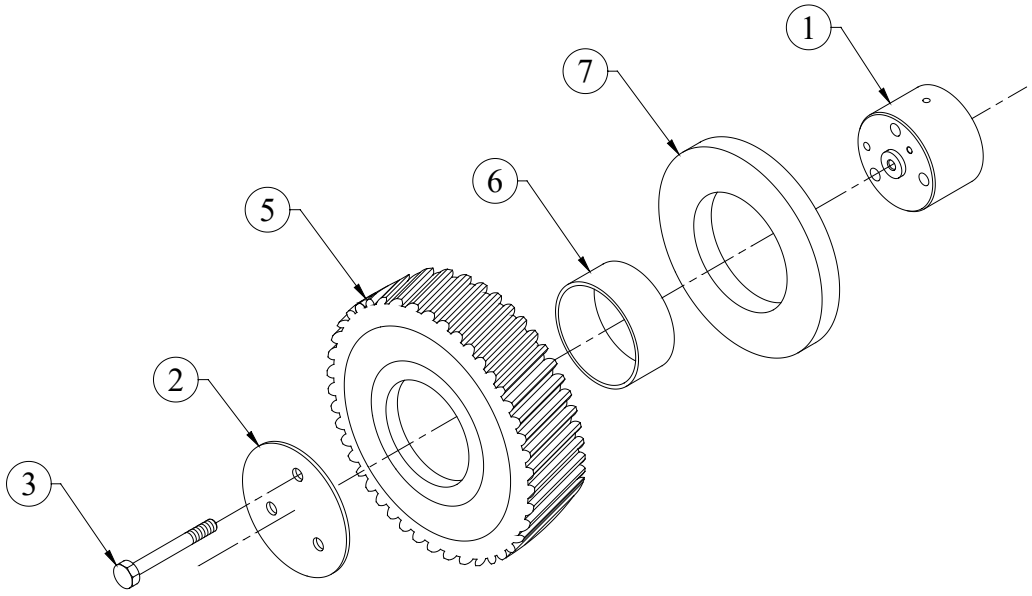
Top Radiator Mount			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD08010	BRACKET, TOP RADIATOR MOUNT	1
2	KD50034	ANTIVIBRATION MOUNTS	2
3	M8X1.25X60	SCREW - M8X1.25X60 - 8.8	2
4	M10	WASHER - M10	2
5	M10X1.5X20	SCREW - M10X1.5X20 - 8.8	2
6	M8	MACHINED WASHER - M8	2

Coil Bracket Assembly



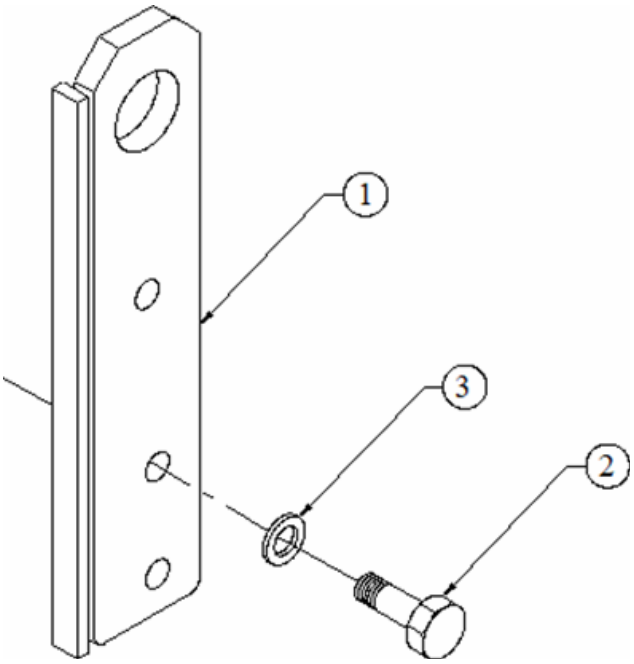
Coil Bracket Assembly			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	330-18-A42	SPARK PLUG	3
2	69462A-01	WIRE SPARK PLUG	3
3	KB16004	SPACER, COIL BRACKET, SHORT	2
4	M08FW	PLAIN WASHER, METRIC	3
5	KB00007	BOLT, COIL BRACKET M8 1.25X 130 (8.8)	3
6	KD08000	BRACKET, ECM / FUSES / RELAYS	1
7	M10FW	FLAT WASHER, 10 MM, ZINC-PLATED	5
8	M10X20	CAP SCREW, HEX HEAD	4
9	WD06002	ECM, SECM 70	1
10	21291	CAP SCREW, HEX HEAD, 7A-1/420X2 NC	4
11	1N-1/4	WASHER, FLAT, SAE-PLATED	26
12	SPACER-EMC-COIL	SPACER FOR ECS UNIT	8
13	7A-1/420X1/2	CAP SCREW, HEX HEAD	7
14	M10X1.5X25	BOLT	1
16	M6X50	CAP SCREW, HEX HEAD	2
17	M6X70	CAP SCREW, HEX HEAD	2
18	WD06000	COIL IGNITION, 12V SMART	3
19	KB08000	BRACKET, COIL	1
20	KB16003	SPACER, COIL BRACKET, LONG	1

Intermediate Gear and Support



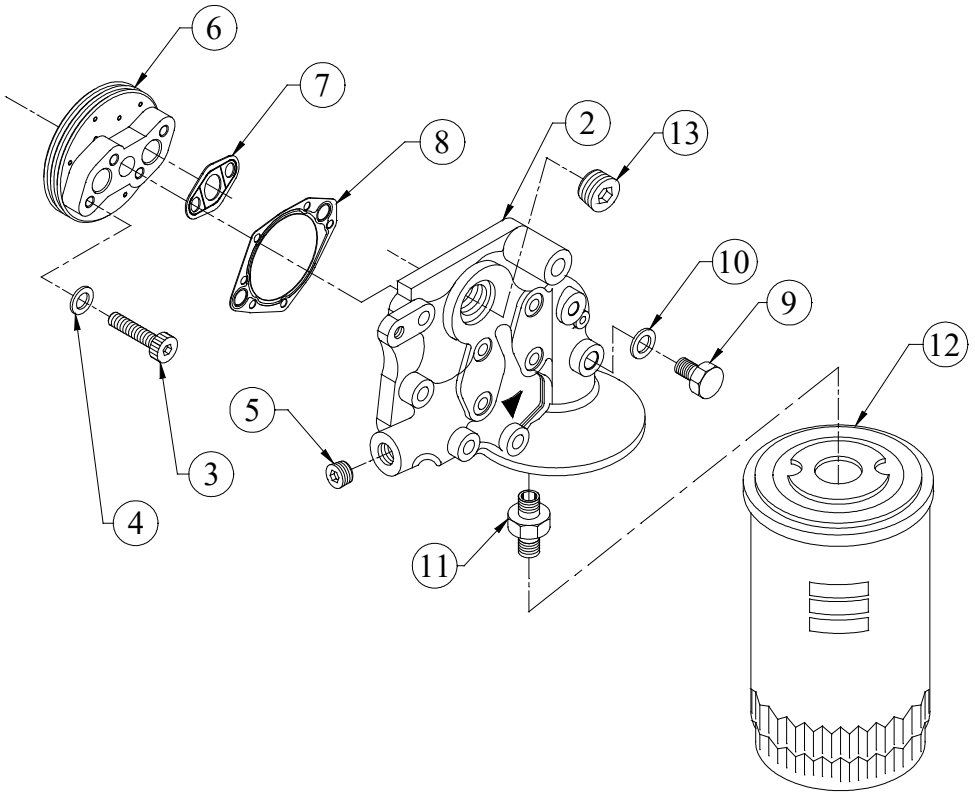
Intermediate Gear and Support			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB09062	SUPPORT, INTERMEDIATE GEAR	1
2	KB09060	RETAINING PLATE (FOR INTERMEDIATE GEAR)	1
3	M8X1.25X70-8.8	BOLT - M8X1.25X70 - 8.8	3
4	KD09007	INTERMEDIATE GEAR ASSEMBLY	1
7	KD05029	THRUST WASHER INTERMEDIATE CAM GEAR	1

Lifting Hook



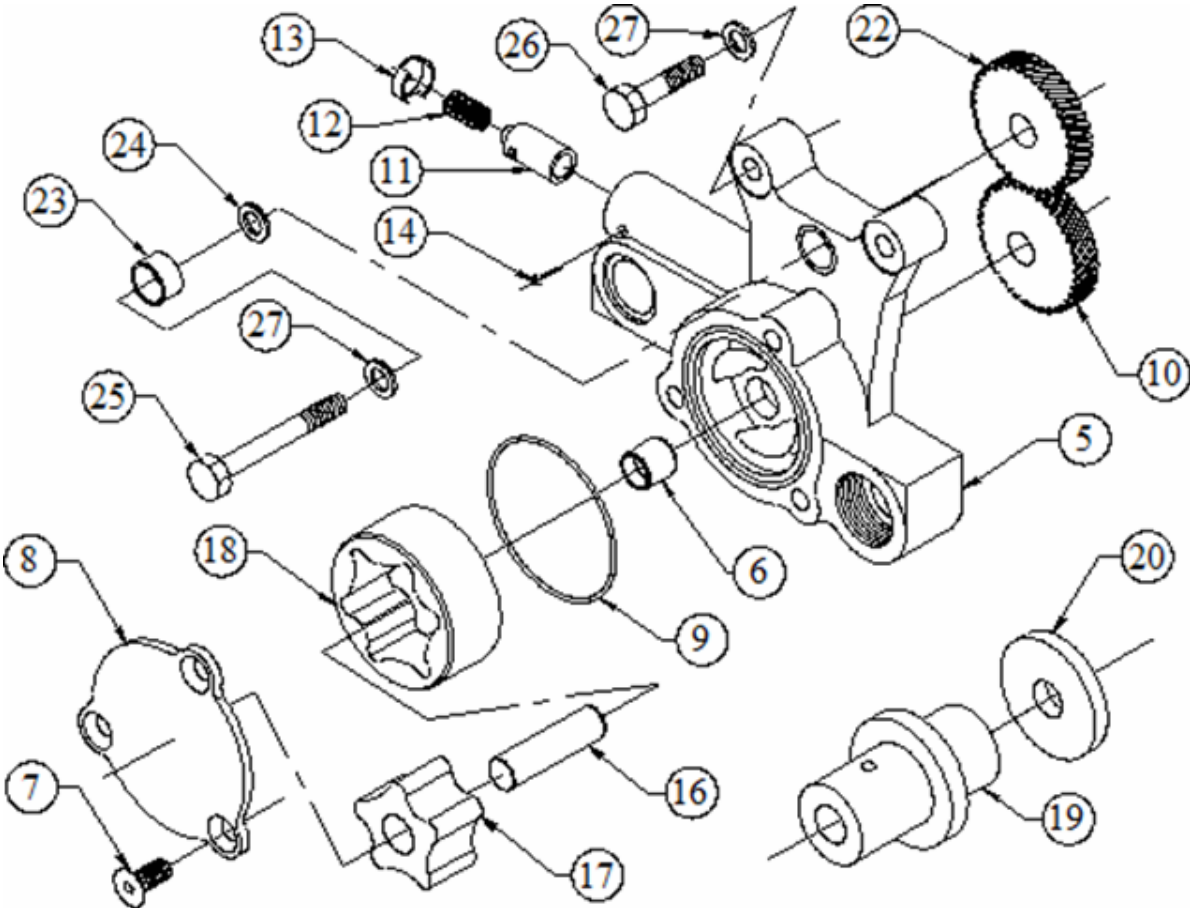
Lifting Hook			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB08001	LIFTING HOOK	2
2	M10X1.5X30-8.8	BOLT - M10X1.5X30 - 8.8	2
3	M10	PLAIN MACHINED WASHER - M10	2

Oil Cooler, Spin-on Filter



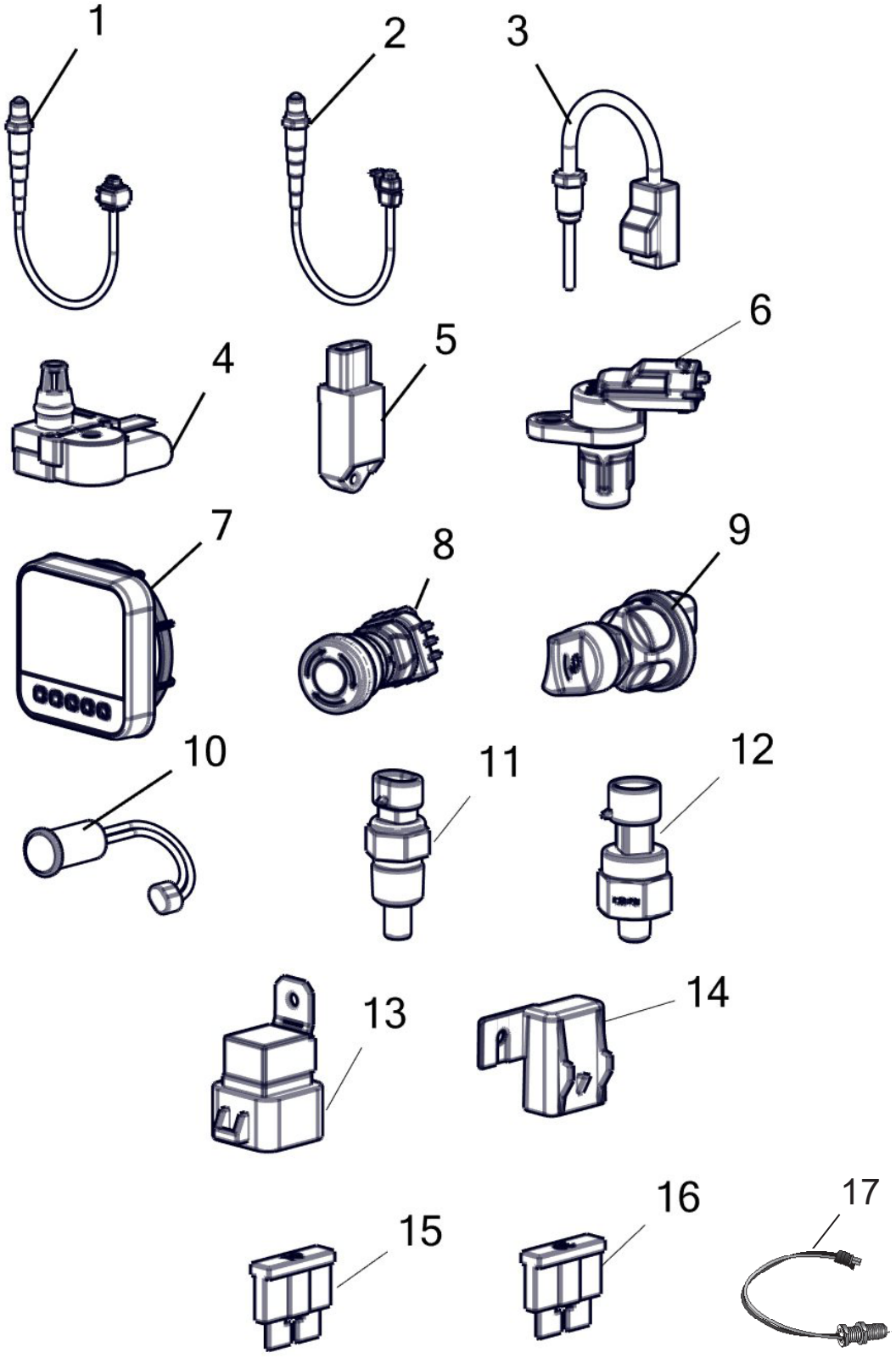
Oil Cooler, Spin-on Filter, S/F Heater			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD50039	OIL HEADER SUBASSEMBLY	1
2	NOT AVAILABLE	HEADER (FOR OIL COOLER AND FILTER)	1
3	M8X1.25X40-8.8	SOCKET HEAD SCREW - M8X1.25X40 - 8.8	4
4	M8	PLAIN MACHINED WASHER - M8	6
5	NOT AVAILABLE	PIPE PLUG, 1/2 INCH-14 NPTF	2
6	KD09003	OIL COOLER (3-PLATE)	1
7	KD05050	GASKET (FOR OIL COOLER)	2
8	KD05051	GASKET (FOR HEADER)	1
9	NOT AVAILABLE	PRECOATED PLUG (FOR OIL GALLERY)	1
10	KD5064	COPPER WASHER (10X14)	2
11	KD16009	ADAPTER (FOR SPIN-ON FILTER)	1
12	KA50060	SPIN-ON FILTER (FOR LUBRICATING OIL)	1
13	NOT AVAILABLE	PIPE PLUG (NPTF 14-3/4-INCH)	1

Oil Pump



Oil Pump			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD05026	OIL PUMP ASSEMBLY WITH INTERMEDIATE GEAR	1
19	KB09052	SUBASSEMBLY OF OIL PUMP INTERMEDIATE GEAR AND BUSHING	1

Sensors



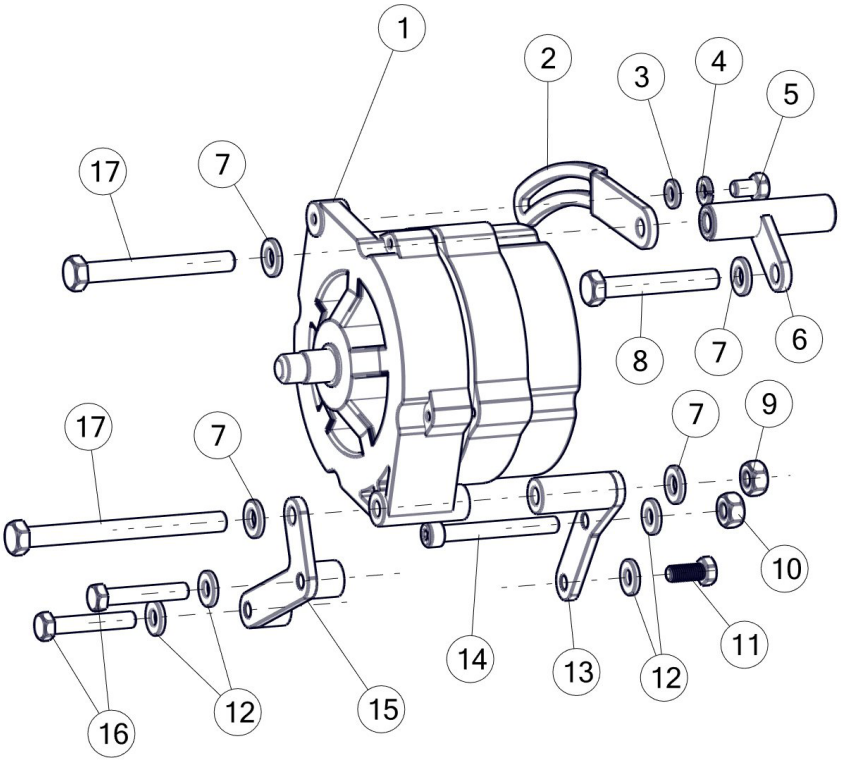
Sensors			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	WD06003	SENSOR, O_2 POST CAT	1
2	WD06004	SENSOR, O_2 PRE CAT	1
3	WR06000	SENSOR, EXHAUST TEMPERATURE	1
4	WD06005	SENSOR, MANIFOLD PRESSURE	1
5	WD06007	KIT, ELECTRONIC FUEL REGULATOR	1
6	KB06001	SENSOR, CAM, HALL EFFECT	1
7	WR50025	PANEL, CONTROL	1
8	WR06003	E-STOP SWITCH	1
9	WR06004	SWITCH, POWER	1
10	WR06007	LIGHT, MALFUNCTION INDICATOR LAMP (MIL)	1
11	TEMP-SENSOR	SENSOR, TEMPERATURE	1
12	OP-SENSOR	SENSOR, OIL PRESSURE	1
13	RELAY-START	RELAY	3
14		FUSE COVER	4
15	FUSE	FUSE 20 AMP	1
16	FUSE	FUSE 10 AMP	3
17	7910151	IGNITION PICKUP	1
	KB15100	ENGINE/WIRE HARNESS (NOT SHOWN)	1

ENGINE / WIRE HARNESS

Printed version of schematic
is available on foldout page
at back of this manual.

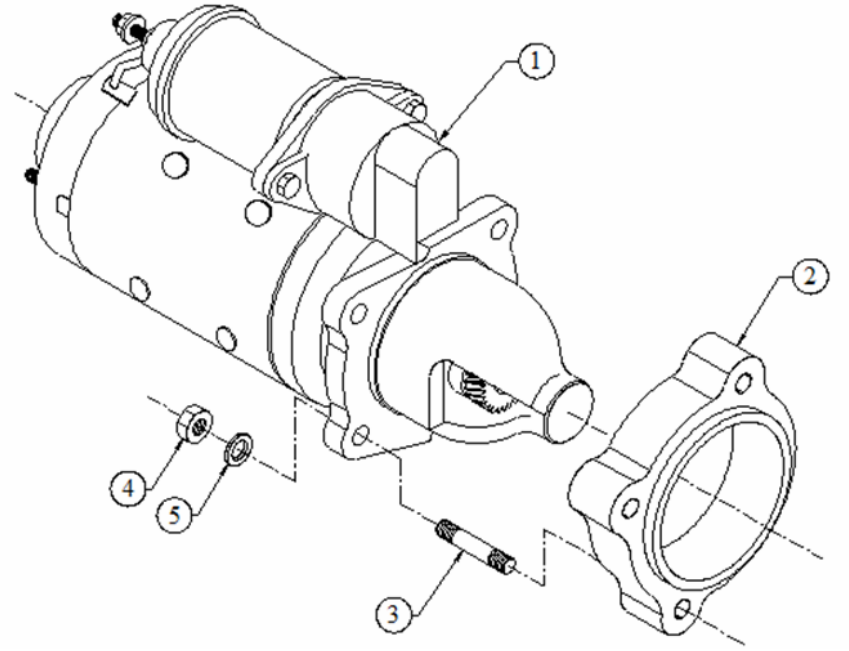
Digital version of schematic
is available as a PDF file.

Alternator, 13.2V



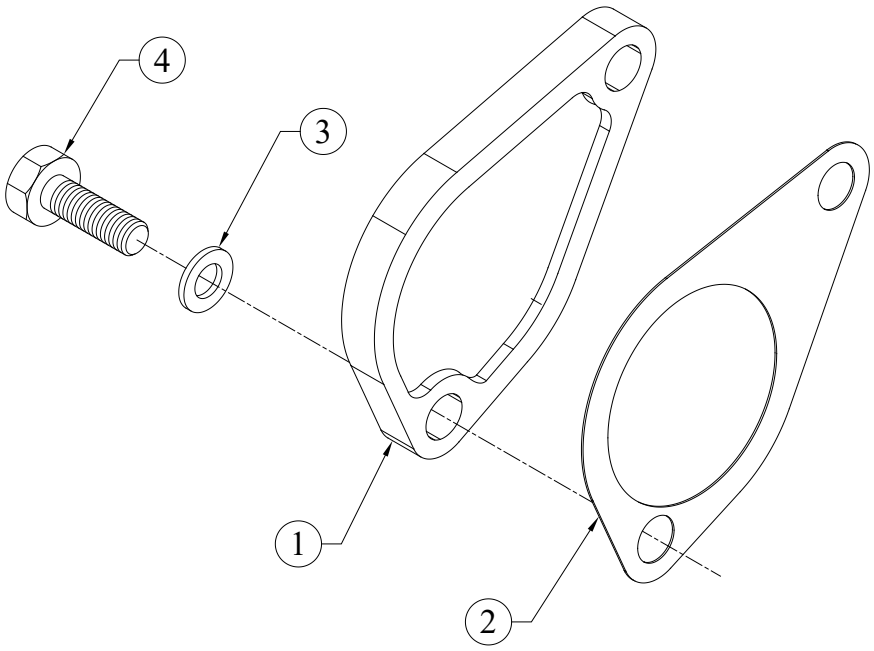
Alternator			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	69753LV	ALTERNATOR, 12-VOLT	1
2	199094D	STRAP, ALTERNATOR, ADJUSTABLE	1
3	1N-5/16	WASHER, FLAT, SAE-PLATED	1
4	1A-5/16	LOCK WASHER, PLATED	1
5	7A-5/1618X1/2	CAP SCREW, HEX HEAD	1
6	KD08014	BRACKET, UPPER, ALTERNATOR	1
7	M10FW	FLAT WASHER, 10 MM, ZINC-PLATED	4
8	M10X70	BOLT, HEX HEAD	1
9	M10NF	HEX NUT, 10 MM, ZINC-PLATED	1
10	M08NF	METRIC NUT	1
11	M8X20	CAP SCREW, HEX HEAD, GRADE 8.8, PLATED	1
12	M08FW	FLAT WASHER, 8 MM, ZINC-PLATED	4
13	KD08006	BRACKET, ALTERNATOR, LOWER SUPPORT	1
14	KD00006	BOLT, SOCKET HEAD (M8 X 70 MM)	1
15	KD08005	BRACKET, ALTERNATOR, LOWER	1
16	KD00007	BOLT, HEX HEAD (M8 X 50 MM)	2
17	KD00005	BOLT, HEX HEAD (M10 X 120 MM)	2

Starter, 12V



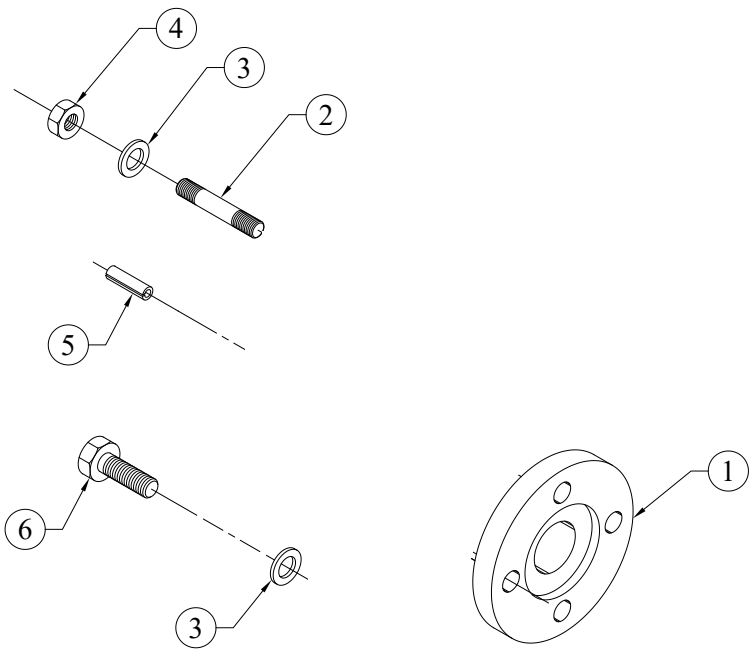
Starter, 12V			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB10000	STARTER (12V)	1
2	NOT AVAILABLE	STARTER (24V)	
3	KB09070	FLANGE, STARTER (12V)	1
4	M10X1.5X45-8.8	STUD - M10X1.5X45 - 8.8	3
5	M10X1.5-8	NUT - M10X1.5 - GRADE 8	3
6	M10	PLAIN MACHINED WASHER - M10	3

Plate, Gas Engine



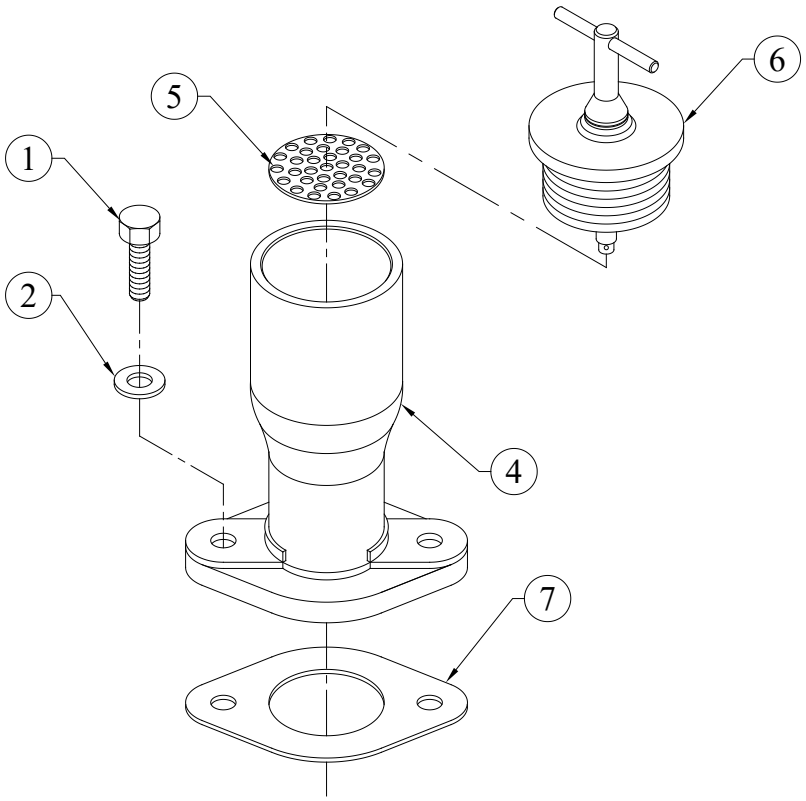
Plate, Gas Engine			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	NOT AVAILABLE	BLOCK-OFF PLATE	1
2	KD03001	GASKET	1
3	M10	PLAIN MACHINED WASHER - M10	2
4	M10X1.5X25-8.8	SCREW - M10X1.5X25 - 8.8	2

Mounting, Radiator Fan



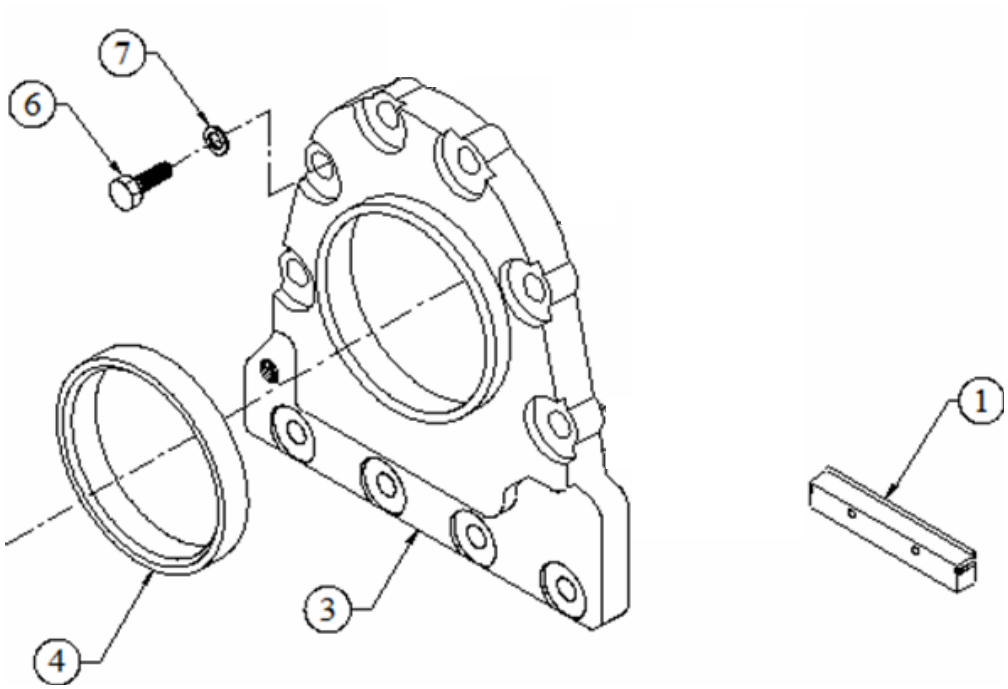
Mounting, Radiator Fan			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD16012	SPACER (FOR FAN), G-DRIVE	1
2	M8X1.25X35-8.8	STUD - M8X1.25X35 - 8.8	4
3	M8	PLAIN MACHINED WASHER - M8	8
4	M8X1.25-8	NUT- M8X1.25 - 8	4
5	NOT AVAILABLE	SPRING DOWEL PIN	1
6	M8X1.25X25-8.8	SCREW - M8X1.25X25 - 8.8	4

Oil Fill



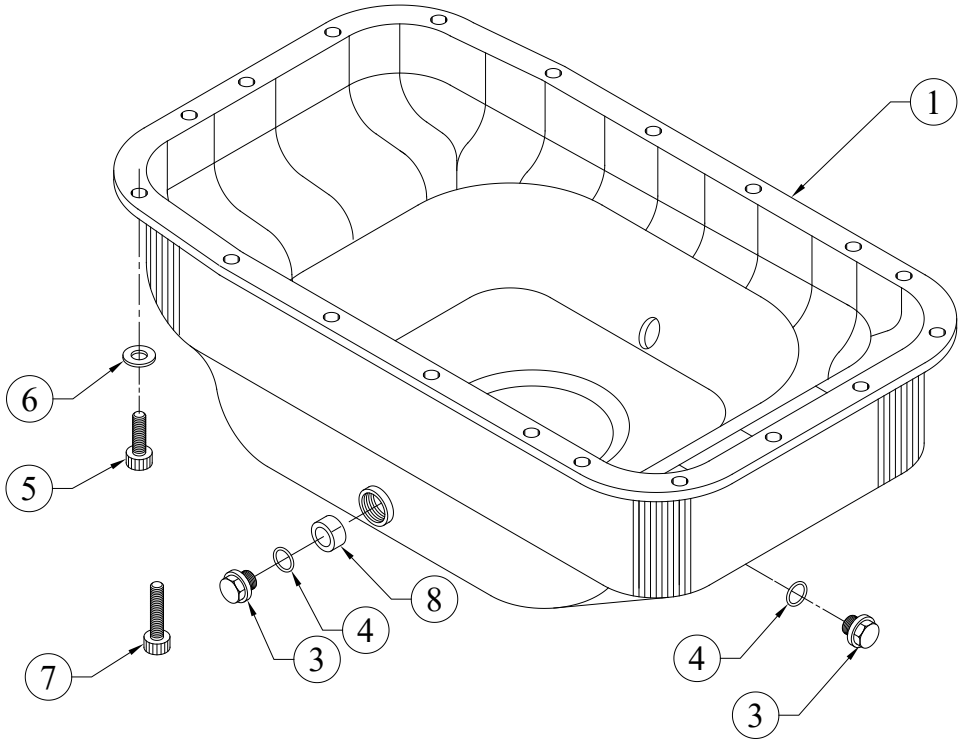
Oil Fill			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	M8X1.25X25-8.8	SCREW - M8X1.25X25 - 8.8	2
2	M8	PLAIN MACHINED WASHER - M8	2
3	NOT AVAILABLE	OIL FILLING BODY SUBASSEMBLY	1
4	NOT AVAILABLE	OIL FILLING BODY	1
5	NOT AVAILABLE	PERFORATED DISC	1
6	KB17001	CAP ASSEMBLY	1
7	KD05056	GASKET (FOR OIL FILLING BODY)	1

Oil Seal Housing



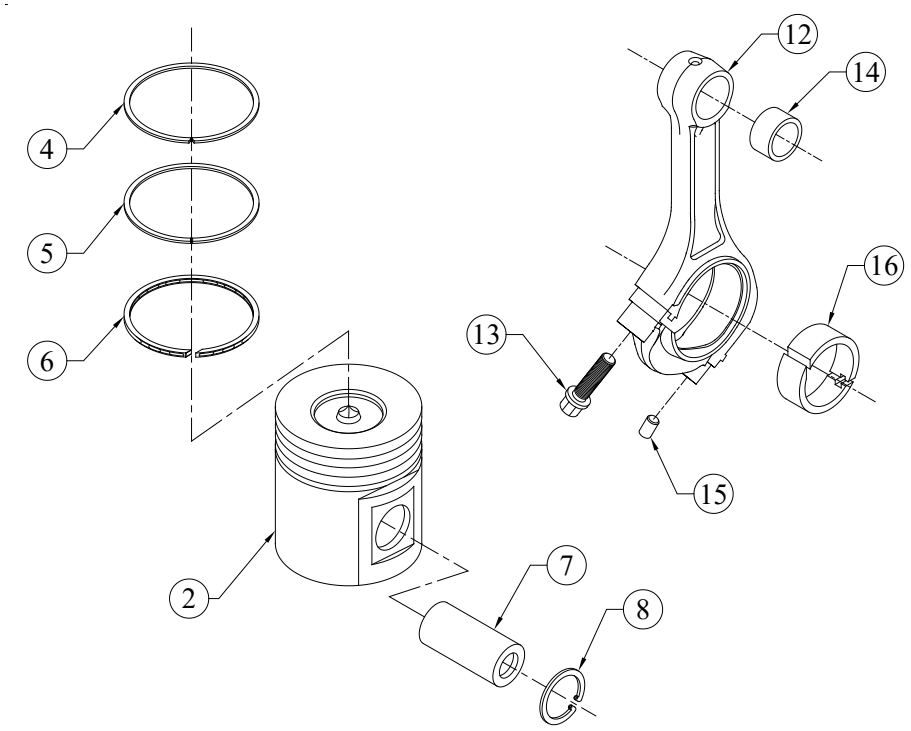
Oil Seal Housing			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB50016	PLATE WITH RUBBER MOLDING	1
3	KB50008	OIL SEAL HOUSING REAR (CRANKSHAFT)	1
4	KB09040	OIL SEAL (115X140X16)	1
6	M8X1.25X20-8.8	SCREW - M8X1.25X20 - 8.8	10
7	M8	PLAIN MACHINED WASHER - M8	10

Oil Pan



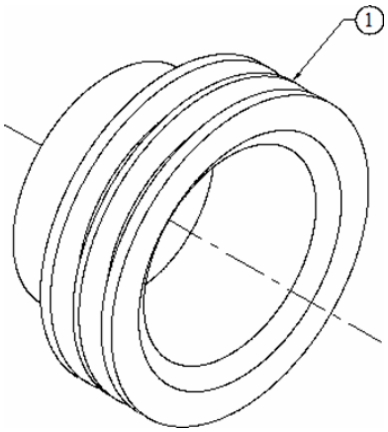
Oil Pan			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09012	OIL PAN (FLAT FACE)	1
3	KD05032	DRAIN PLUG ASSEMBLY	1
5	M8X16-12.9	SOCKET HEAD CAP SCREW-M8X16-12.9	18
6	M8	WASHER	19
7	M8X1.25X25-8.8	SOCKET HEAD SCREW - M8X1.25X25 - 8.8	1
8	NOT AVAILABLE	BUSHING (KHD NO. 0121 6151)	1

Piston and Connecting Rod Assembly



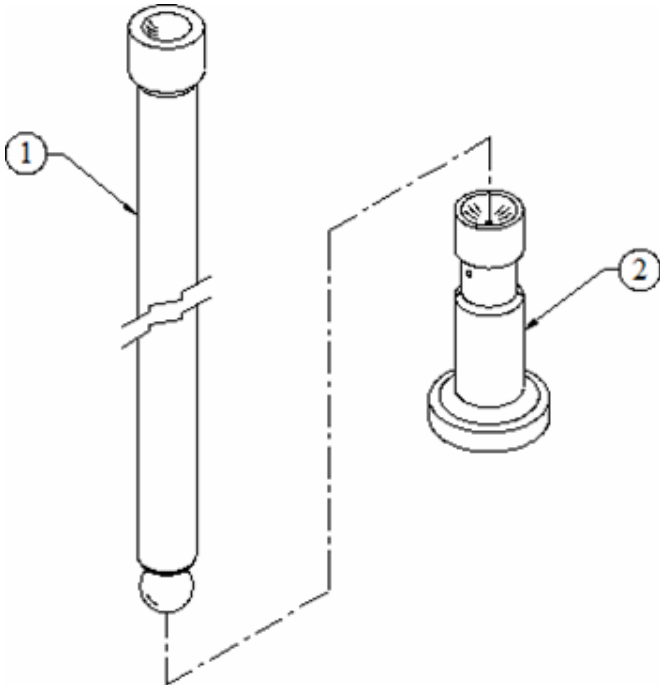
Piston and Connecting Rod Assembly			
ITEM NO.	**PART NO. / REFERENCE**	**DESCRIPTION**	**QTY.**
2	KD05005	PISTON, GAS ENGINE	1
3	KD05006	PISTON RING SET	1
7	KD05007	PISTON PIN	1
8	KD05008	CIRCLIP (INTERNAL), 35 MM	2
11	KD05009	CONNECTING ROD ASSEMBLY (WITHOUT BEARING)	1
13	KB09021	CONNECTING ROD BOLT	2
14	KD09013	SMALL END BUSHING (S/F)	1
15	NOT AVAILABLE	D0WEL PIN	2
16	KD05010	CONNECTING ROD BIG END BEARING	2

Pulley for Water Pump



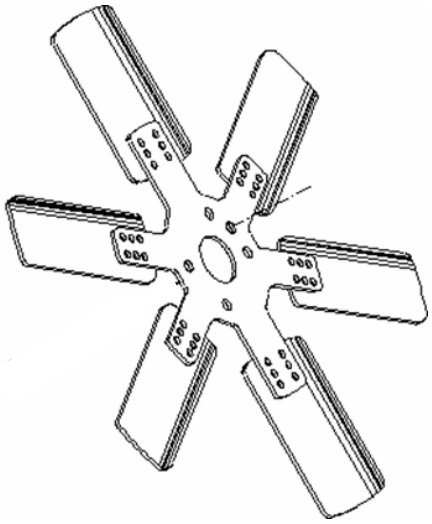
Pulley for Water Pump			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB50013	WATER PUMP PULLEY	1

Pushrod and Lifter



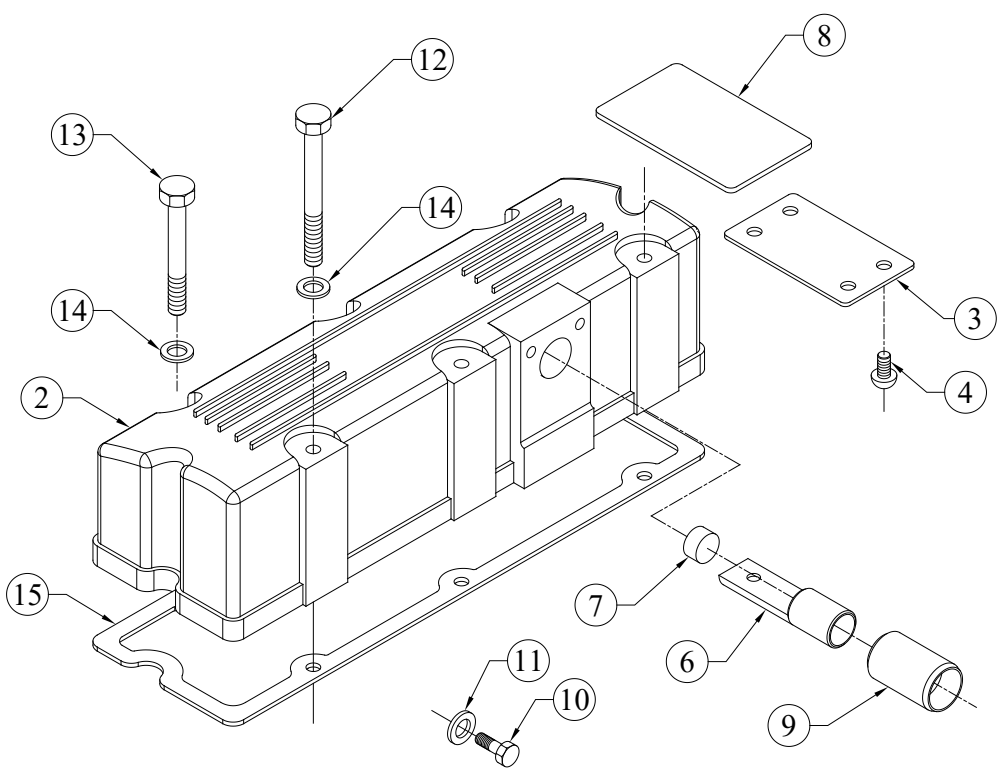
Pushrod and Lifter			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB09031	PUSH ROD	6
2	KB09032	VALVE LIFTER	6

Radiator Fan, GKP3 NA



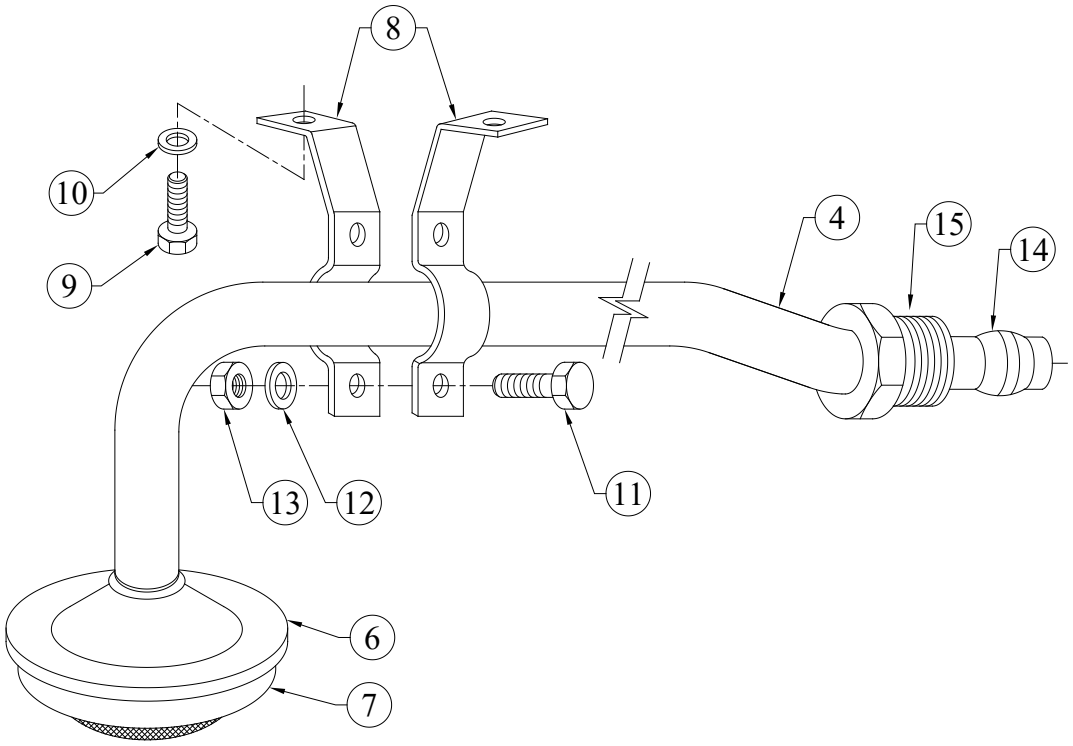
Radiator Fan			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
3	KD13000	FAN, 17-INCH PUSHER / G-DRIVE	1

Valve Cover



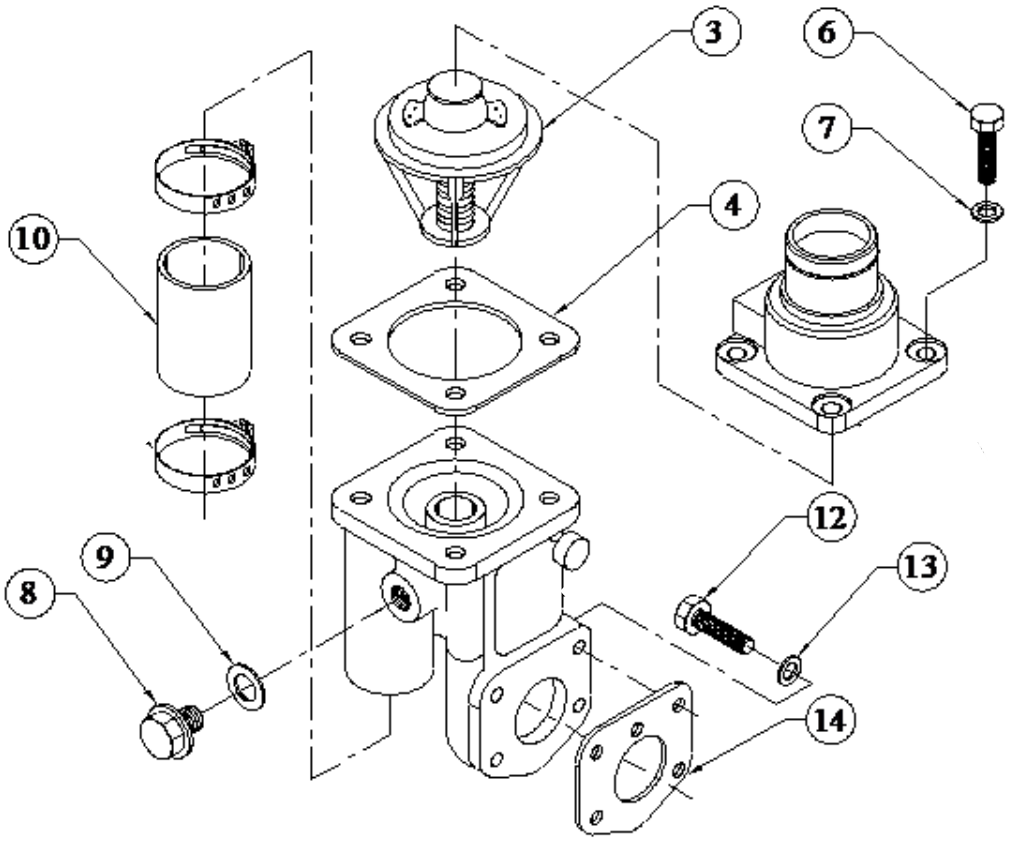
Valve Cover			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
2	KD09014	VALVE COVER ASSEMBLY	1
3	NOT AVAILABLE	DEFLECTOR PLATE	1
4	1/8X3/8-IN	P K DRIVE SCREW 1/8X3/8-INCH (RIVET)	4
5	KD50040	BREATHER TUBE ASSEMBLY, CONSISTS OF NOS. 6 TO 9	1
6	NOT AVAILABLE	TUBE (FOR BREATHER)	1
7	NOT AVAILABLE	CLOSING BUTTON, NOT SUPPLIED LOOSE	1
8	NOT AVAILABLE	PLATE, NOT SUPPLIED LOOSE	1
9	NOT AVAILABLE	ADAPTER (FOR BREATHER TUBE), NOT SUPPLIED LOOSE	1
10	M8X1.25X16-8.8	BOLT - M8X1.25X16 - 8.8	2
11	M8	PLAIN MACHINED WASHER - M8	2
12	M8X1.25X95-8.8	BOLT - M8X1.25X95 - 8.8	3
13	M8X1.25X70-8.8	BOLT - M8X1.25X70 - 8.8	3
14	M8	PLAIN MACHINED WASHER - M8	6
15	KD05055	GASKET (VALVE COVER)	1

Oil Pump Suction Tube



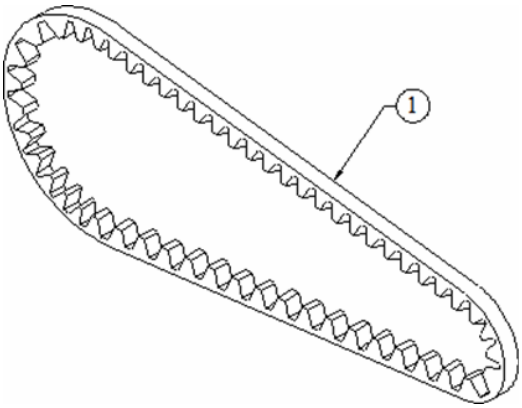
Oil Pump Suction Tube			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09015	SUCTION TUBE, CONSISTS OF NO. 2 ASSEMBLY	1
2	NSS	ASSEMBLY OF SUCTION TUBE, CONSISTS OF NOS. 3, 8 TO 15 (NOT SOLD SEPARATELY)	1
3	NSS	SUCTION TUBE, CONSISTS OF NOS. 4, 5 (NOT SOLD SEPARATELY)	1
4	NSS	PIPE (FOR SUCTION TUBE) (NOT SOLD SEPARATELY)	1
5	NSS	Oil STRAINER ASSEMBLY, CONSISTS OF NOS. 6, 7 (NOT SOLD SEPARATELY)	1
6	NSS	BOTTOM PLATE (NOT SOLD SEPARATELY)	1
7	NSS	STRAINER BASKET (NOT SOLD SEPARATELY)	1
8	NSS	CLIP (FOR PIPE) (NOT SOLD SEPARATELY)	2
9	M8X1.25X16-8.8	SCREW - M8X1.25X16 - 8.8	2
10	M8	PLAIN MACHINED WASHER - M8	2
11	M6X1X12-8.8	SCREW - M6X1X12 - 8.8	2
12	M6	PLAIN MACHINED WASHER - M6	4
13	M6X1-8	NUT - M6X1 - 8	2
14	NOT AVAILABLE	UNION SCREW	1
15	NOT AVAILABLE	DOUBLE CONE RING	1

Thermostat and Housing



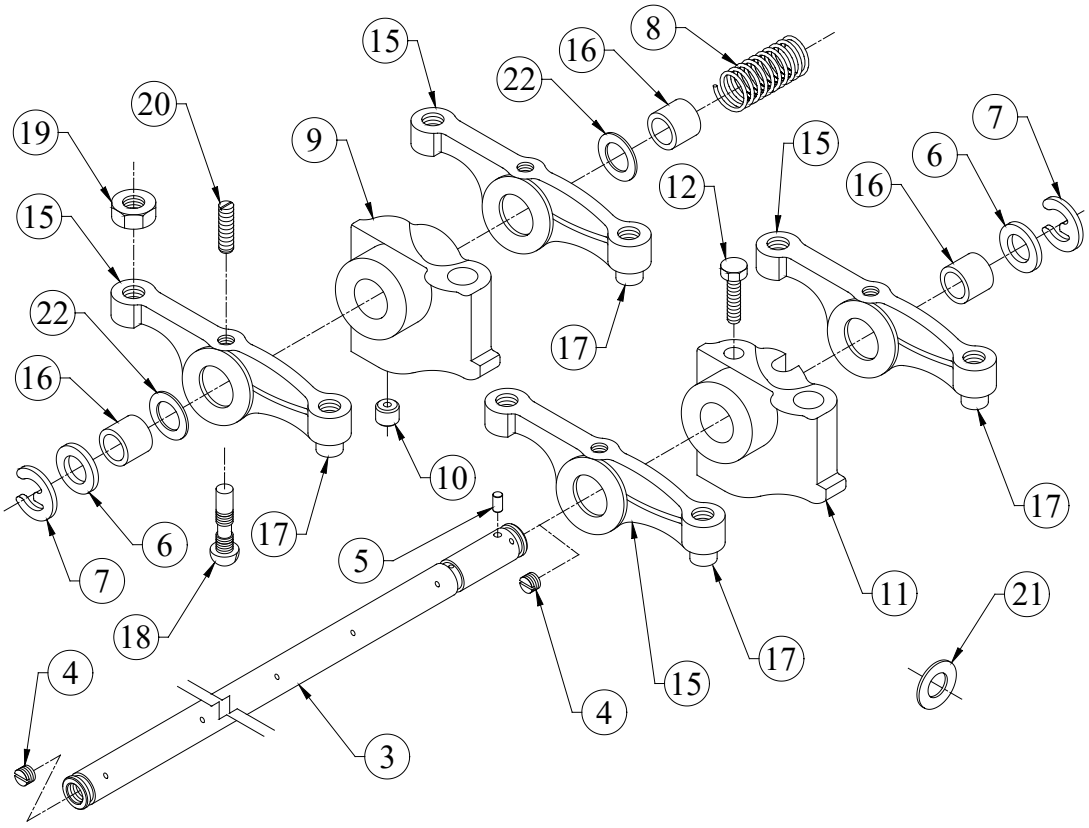
Thermostat and Housing			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09016	THERMOSTAT AND HOUSING ASSEMBLY	1
3	KB09025	THERMOSTAT ELEMENT (74 DEG)	1
4	KB03000	GASKET, THERMOSTAT HOUSING	1
6	M8X1.25X25-8.8	SCREW - M8X1.25X25 - 8.8	4
7	M8	PLAIN MACHINED WASHER - M8	4
8	M14X1.5	PLUG (M14X1.5)	1
9	14X20	COPPER WASHER (14X20)	1
10	KB05000	THERMOSTAT BYPASS HOSE	1
12	M8X1.25X35-8.8	SCREW - M8X1.25X35 - 8.8	4
13	M8	PLAIN MACHINED WASHER - M8	4
14	KB03007	GASKET, THERMOSTAT HOUSING TO HEAD	1

Alternator V-belt



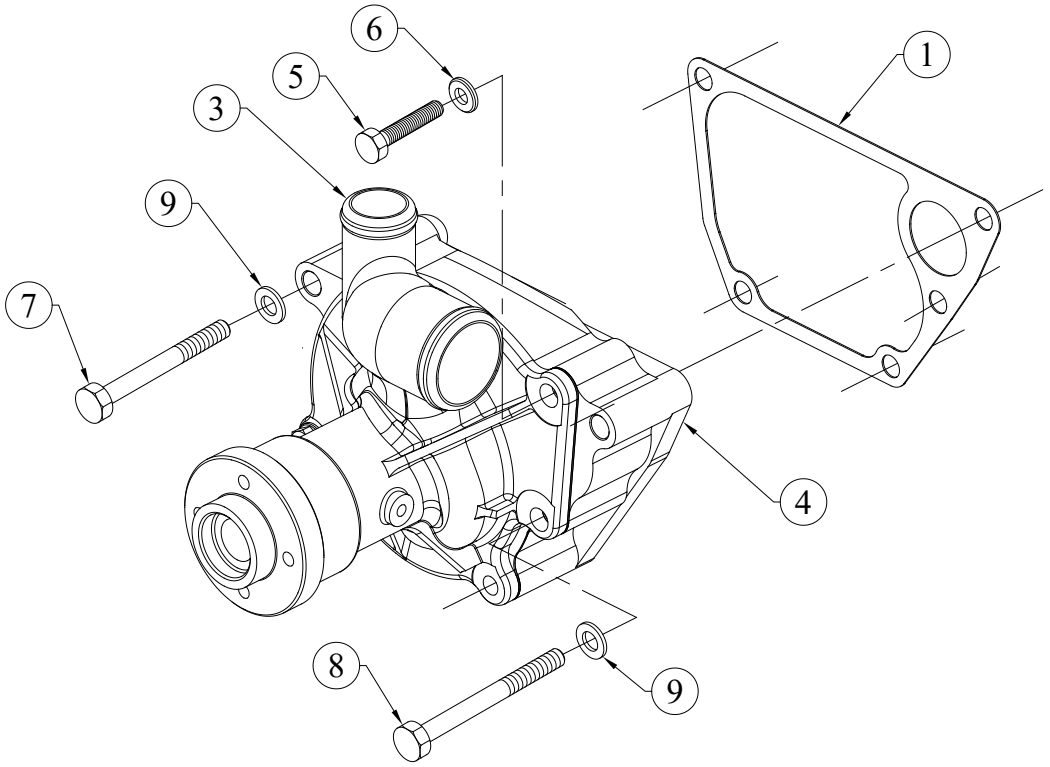
V-belt Xpa1280			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD04000	ALTERNATOR V-BELT (PAIR)	1

Valve Rocker Assembly



Valve Rocker Assembly			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KD09017	VALVE ROCKER ASSEMBLY (COMPLETE), CONSISTS OF NOS. 2, 6 TO 13; AND 21, 22	1
2	NOT SOLD SEPARATELY	VALVE ROCKER SHAFT SUBASSEMBLY, CONSISTS OF NOS. 3 TO 5	1
3	NOT SOLD SEPARATELY	ROCKER SHAFT	1
4	M12X10	SOCKET HEAD SCREW - M12X10	2
5	NOT SOLD SEPARATELY	GROOVED SOCKET PIN	1
6	NOT SOLD SEPARATELY	WASHER (FOR ROCKER ARM)	2
7	NOT SOLD SEPARATELY	E-TYPE CIRCLIP-EXTERNAL (15 DIA.)	2
8	NOT SOLD SEPARATELY	SPRING (FOR ROCKER SHAFT)	2
9	NOT SOLD SEPARATELY	ROCKER SUPPORT (FINISH) (FLYWHEEL END)	1
10	NOT SOLD SEPARATELY	OIL METERING ORIFICE	1
11	NOT SOLD SEPARATELY	ROCKER SUPPORT (FINISH)	2
12	M8X1.25X30-8.8	SCREW - M8X1.25X30 - 8.8	2
13	NOT SOLD SEPARATELY	VALVE ROCKER ASSEMBLY	6
14	NOT SOLD SEPARATELY	ROCKER ARM SUBASSEMBLY (WITH VALVE ROCKER BUSH)	1
15	NOT SOLD SEPARATELY	ROCKER ARM	1
16	NOT SOLD SEPARATELY	VALVE ROCKER BUSHING (SEMI-FINISH)	1
17	NOT SOLD SEPARATELY	VALVE ROCKER TOE	1
18	NOT SOLD SEPARATELY	ROCKER-ARM ADJUSTABLE SCREW	1
19	NOT SOLD SEPARATELY	NUT (FOR ROCKER ADJUSTABLE SCREW)	1
20	NOT SOLD SEPARATELY	OIL METERING SCREW	1
21	NOT SOLD SEPARATELY	WASHER (FOR ROCKER ARM)	6
22	NOT SOLD SEPARATELY	WASHER	3

Water Pump



Water Pump			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	KB03003	GASKET, WATER PUMP	1
2	KB09022	WATER PUMP SUBASSEMBLY	1
5	M8X1.25X25-8.8	SCREW - M8X1.25X25 - 8.8	3
6	10.020.03.0.00	HARD WASHER (F)	3
7	M10X1.5X60-8.8	BOLT - M10X1.5X60 - 8.8	3
8	M10X1.5X70-8.8	BOLT - M10X1.5X70 - 8.8	2
9	M10	PLAIN MACHINED WASHER - M10	5

Set of Gaskets, Copper Washers, O-rings

Set of Gaskets, Copper Washers, O-rings			
ITEM NO.	**PART NO.**	**DESCRIPTION**	**QTY.**
1	SKD03005	GASKET SET	1
3		GASKET FOR COVER FOR FUEL PUMP GEAR	1
4		GASKET FOR FRONT COVER	1
5		GASKET FOR FUEL PUMP COVER PLATE	1
6		GASKET FOR FLANGE/FUEL SPOUT	1
7	KB03000	GASKET FOR THERMOSTAT COVER	1
8		GASKET FOR OIL FILLER BODY	1
9		GASKET	3
10	KB03004	GASKET FOR EXHAUST MANIFOLD TO HEAD	6
11	KB03003	GASKET FOR WATER PUMP	1
12		GASKET FOR BEARING HOUSING (282.5 CRS)	1
13		GASKET FOR ADAPTER (CRANKCASE SIDE)	1
14		GASKET FOR ROCKER COVER	1
15		GASKET FOR HEADER	1
16		GASKET BETWEEN CRANKCASE AND GEAR COVER	1
18		GASKET FOR OIL SEAL HOUSING	1
19		GASKET FOR GLACIER FILTER (0.3 L)	1
20		GASKET FOR OIL COOLER	1
21		SS GASKET (4-INCH)	3
22	SKD19002	SET OF COPPER WASHERS	1
23	8X12	COPPER WASHER (8X12)	12
24	KD05064	COPPER WASHER (10X14)	4
25	KD05068	COPPER WASHER (10X16)	1
26	12X16	COPPER WASHER (12X16)	4
27	KD05047	COPPER WASHER (14X18)	8
28	14X20	COPPER WASHER (14X20)	15
29	KD05076	COPPER WASHER (16X22)	2
30	17X23	COPPER WASHER (17X23)	1
31	18X22	COPPER WASHER (18X22)	1
32	20X24	COPPER WASHER (20X24)	2
33	KD05065	COPPER WASHER (20X26)	1
34	KD05071	COPPER WASHER (24X29), CAM RETAINER WASHER	1
35		SET OF O-RINGS	1
36		O-RING - DIPSTICK (2X5, 21515 OR 21511)	3
37		O-RING FOR DELIVERY TUBE	2
38		O-RING FOR NOZZLE	6
39		O-RING	1

Set of Bearings

Set of Bearings				
ITEM NO.	PART NO.	DESCRIPTION	REMARKS	QTY.
SET OF MAIN BEARINGS				
1	G-918-KP3	MAIN BEARING	(7 PAIRS) STD.	1
2		MAIN BEARING HA6 AND TC	0.25 MM U/S	1
3		MAIN BEARING HA6 AND TC	0.50 MM U/S	1
4		MAIN BEARING HA6 AND TC	0.75 MM U/S	1
5		MAIN BEARING HA6 AND TC	1.00 MM U/S	1
6		MAIN BEARING HA6 AND TC	1.25 MM U/S	1
7		MAIN BEARING HA6 AND TC	1.50 MM U/S	1
SET OF CONNECTING ROD BEARINGS				
8		CON. ROD BEARING HA6 AND TC	(6 PAIRS) STD.	1
9		CON. ROD BEARING HA6 AND TC	0.25 MM U/S	1
10		CON. ROD BEARING HA6 AND TC	0.50 MM U/S	1
11		CON. ROD BEARING HA6 AND TC	0.75 MM U/S	1
12		CON. ROD BEARING HA6 AND TC	1.00 MM U/S	1
13		CON. ROD BEARING HA6 AND TC	1.25 MM U/S	1
14		CON. ROD BEARING HA6 AND TC	1.50 MM U/S	1
SET OF THRUST WASHERS				
15		THRUST WASHER SET OF INNER AND OUTER	ONE SET	1
16	G-927-KP3	SET OF CAM BEARINGS	ONE SET (STD.)	

Sleeve Kit

Sleeve Kit			
ITEM NO.	PART NO.	DESCRIPTION	QTY.
1	G-907-KP3	PISTON, PIN, CIRCLIP, RINGS	1
2	KB09006	LINER, CYLINDER WITH O-RINGS	1

OPERATION AND SERVICE

INTRODUCTION TO KP3

The KP3 engine is specially designed for heavy-duty industrial use and is not derived from light automotive engines. The crankcase is integral with rigid structure at bottom and top ends with stiffening provided by specially designed beam structure. This rigid structure also ensures minimum cylinder bore distortion, low oil consumption, extended life of oil, and reduced emissions.

The rigid and integral cylinder head is equipped with replaceable Stellite valves, seats, and guides. The heads are provided with six bolts per cylinder to ensure uniform clamping. Steel backbone cylinder head gasket ensures proper sealing.

The combustion system is designed to ensure low exhaust emissions. The entire oil circuit is built into the crankcase with external piping on the engine, which prevents leaks. The oil cooler has a modern plate-type design, which is compact and efficient. Crankshaft is made of forged alloy steel with hardened journals and pins.

Serviceability
All service points such as dipstick, oil filling, and oil filter are located on the cooler side, for easy access. Wet liners ensure low cost of maintenance as compared to engines with dry liners. Wet liners are easy to replace at site without any special tooling.

Silent Operation
Rigid engine structure and crowned gears in gear train substantially reduce the engine noise.

Low Operating Cost
Low oil consumption and extended oil change intervals of 750 hours (with recommended oil grade) reduce the operating cost. Oil consumption is less than 0.3 % of fuel consumption.

Overhaul instructions are not included, except where certain special procedures are required. Specifications information, discussed in the Repair and Replacement section of this manual, will allow a competent mechanic to determine when parts are no longer usable.

All data and recommendations contained in this manual represent the latest information available at the time of printing and are subject to change.

Symbols are incorporated throughout this manual to emphasize important information. These symbols and their meanings are as follows:

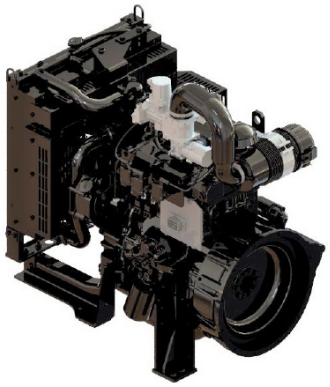
WARNING This symbol denotes information which, if disregarded, may result in injury or death of the user of the engine (or others).

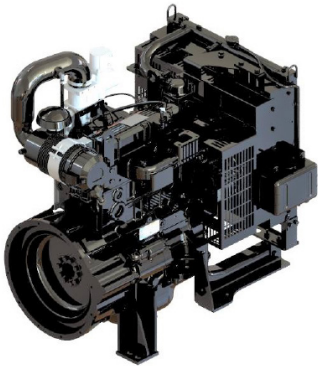
CAUTION This symbol denotes information which, if disregarded, may result in damage to the engine.

NOTE This symbol denotes information which is vital to the operation or maintenance of the engine.

Features

- EPA-certified stationary/nonroad mobile and emergency standby
- Prime certified operating fuels – pipeline NG, LPG/VPG, and wellhead NG (700–1,600 BTU/ft^3)
- Standby certified operating fuels – pipeline NG, LPG/VPG
- Single-piece cylinder head
- Stellite valves and hardened seats
- Two valves per cylinder
- Integral oil cooler with filter
- Cast-iron block
- Forged steel, dynamically balanced and counterweighted crankshaft with hardened journals
- Woodward PG+ engine control system
- Standard canbus interface (SAE J1939)
- Telematics compatible
- Bi-fuel auto switching capable





ENGINE SPECIFICATIONS	
Configuration	Vertical in-line 3-cylinder
Induction system	Naturally aspirated
Combustion system	Spark-ignited
Cooling system	Water-cooled
Displacement	3.12 L (190 cubic inches)
Compression ratio	9:1
Bore x stroke	4.1 x 4.7 inches (105 x 120 mm)
Direction of rotation	Counterclockwise
Approximate wet weight	1,025 lbs. (464.9 kg)
Length	41.0 inches (104.1 cm)
Width	28.8 inches (73.2 cm)
Height	40.8 inches (103.6 cm)
Fuel type	NG/ wellhead/ VPG/ LPG

Weight and physical dimensions are for reference only.
Final product data may differ slightly.

NOTE: kWe calculated using 90 percent alternator efficiency at 0.8 power factor.

ENGINE SPECIFICATIONS		
	Dmensions, mm	**Max. Limit**
CYLINDER HEAD		
Valve guide outside diameter	15 + 0.056 / + 0.045	
Valve guide bore in cylinder head	15 + 0.018 / + 0.000	
Valve guide inside diameter (pressed in)	8 + 0.015	
Valve stem diameter		
Inlet	7.96 - 0.02	
Exhaust	7.94 - 0.02	
Valve stem clearance in guide, normal		
Inlet	0.04 to 0.075	
Limit value		0.2
Valve stem clearance, normal		
Exhaust	0.06 to 0.95	
Limit value		0.3
Valve seat insert (in head)		
Inlet valve seat outer diameter	48.5 + 0.070 / + 0.054	
Counter bore inner diameter in cylinder head	48.5 + 0.025 / + 0.000	
Exhaust valve seat outer diameter	44.2 + 0.070 / + 0.054	
Counter bore in cylinder head	44.2 + 0.025 / + 0.000	
Valve insert seat angle	45 +/- 0.17 degrees	
Valve seat sealing width		
Inlet	2.45 + 0.5	
Exhaust	2.06 + 0.5	
Valve bore diameter in cylinder head		
Inlet	44.5 +/- 0.1	
Exhaust	42.2 +/- 0.1	
Seat angle	45.33 +/- 0.17 degrees	
Rim thickness		
Inlet	1.2 - 0.2	
Exhaust	1.5 - 0.2	0.3
Wear limit		
Valve recess (distance between cylinder head face and valve face)	0.6 + 0.1	
Limit value		0.8
Valve spring total coils	7	
Free length	59 +/- 1.9	
Free length limit value (fatigue limit)		56

ENGINE SPECIFICATIONS		
	Dmensions, mm	**Max. Limit**
Nominal length of cylinder head bolt	145 + 0.8	
Limit value	146.5 + 0.5	
Valve rocker bush inner diameter (pressed in lever)	18.014 + 0.049	
Steel back outside diameter	18.0 - 0.006 / - 0.017	
Clearance, normal	0.02 - 0.08	
Limit value		0.2
Cylinder head surface flatness	0.05	
Limit value		0.06
CYLINDER LINER		
Bore (normal)	105 + 0.035 / + 0.000	
Wear limit		0.2
Permissible ovality		0.2
Liner projection above block	0.03 - 0.08	
PISTON		
Normal diameter (as punched on crown)	105	
Piston diameter	104.76 +/- 0.009	
At top of skirts	104.44 +/- 0.039	
Along piston pin axis	104.67 +/- 0.009	
Across piston pin axis	104.22 +/- 0.039	
Piston pin bore	35 + 0.009/ + 0.003	
Piston pin outer diameter	35 - 0.011	
Piston ring groove width		
1st groove	2.67 - 0.25	
2nd groove	2 + 0.040 / + 0.060	
Oil control ring groove	2+ 0.030 / + 0.060	
PISTON RINGS		
Land side clearance		
1st compression ring	0.075 to 0.100	
Limit value		0.30
2nd compression ring	0.050 to 0.090	
Limit value		0.30
Oil control ring	0.040 to 0.110	
Limit value		0.15
Butt gaps (as measured in liner bore)		
1st compression ring	0.30 to 0.50	

ENGINE SPECIFICATIONS		
	Dmensions, mm	**Max. Limit**
Gap limit value		1.5
2nd compression ring	0.25 to 0.50	
Gap limit value		1.5
Oil control ring	0.25 to 0.55	
Gap limit value		1.5
CONNECTING ROD		
LE bearing bore	64 + 0. 019	
Bearing inner diameter	60 + 0.039	
Number of undersizes	4 in steps of 0.25	
Minimum inner diameter	59.5 + 0.039	
Limit value		0.3
Width of bearing	25.0 - 0.2	
Connecting rod width	33.6 - 0.082 /0.140	
Side clearance – normal	0.3 to 0.4	
Limit value		0.48–0.581
Connecting rod S/E bush inner diameter (pressed in)	35.04 + 0.046	
Clearance - bush and piston pin, normal	0.04 to 0.091	
Limit value		0.25
INTERMEDIATE GEAR AND SUPPORT		
Bearing inside diameter	75 + 0.060 + 0.030	
Journal diameter	75 - 0.029 - 0.010	
Bearing clearance – normal	0.04 - 0.089	
Limit value		0.1
End play	0.10 to 0.30	
Limit value		0.40
CAM SHAFT		
Camshaft end play	0.2 to 0.3	
Radial clearance	0.03 to 0.100	
Limit value		0.2
Bush bearing inside diameter	47.980 + 0.054	
Journal outer diameter	47.950 - 0.03 - 0.05	
CRANKSHAFT		
Crank pin diameter	59.97 - 0.010 - 0.029	
Limit value		58.97
Ovality wear limit		0.02

ENGINE SPECIFICATIONS		
	Dmensions, mm	**Max. Limit**
Number of undersizes	4 in steps of 0.25 mm	
Nominal hardness	58. 3 RC	
Limit value		50 RC
Journal diameter	70.0 - 010 - 0.029	
Limit value		69
Ovality wear limit	0.02	
Number of undersizes	4 in steps of 0.25 mm each	
Nominal hardness	58 +/- 3 RC	
Limit value		50 RC
Length of journal	37 + 0.039	
Main bearing bore inner diameter	74.5 + 0.019	
Main bearing inner diameter	70.042 + 0.039	
Number of undersizes	4 in steps of 0.25 mm each	
Radial clearance in main bearing – normal	0.052 to 0.110	
Limit value		0.3
Parallelism between all pin with respect to end journals	0.02	
Concentricity between all intermediate journals with respect to end journals	0.06	
Filet radius	4.5 R	
Thrust ring thickness	2.985 - 0.05	
Limit value		2.621
Number of oversizes available	0.25 and 0.50 mm	
Crankshaft end play – normal	0.15 to 0.314	
Limit value		0.8
OIL PUMP		
Pump speed rpm	Corresponding to engine speed	
Delivery at 4.0 kg/cm^2 (LPM) / GPM	39 / 10.3	
End float of rotor pair in pump – normal	0.026 - 0.063	
Limit		0.1
Limit value for radial clearance	0.25	
Backlash between oil pump driving gear and intermediate gear	0.100 - 0.275	
Backlash between intermediate gear and crankshaft gear	0.05 - 0.27	
Relief valve on pump opens at	5 to 6 kg/cm^2	
Grade of oil to be used	SAE 30	

General Guidelines

Your engine needs the following:

- Clean pipeline-quality natural gas or propane (commercial grade HD-10 or better)
- Lubricating oil of specified quality and viscosity grade
- Fresh air for combustion of fuel, and cooling of engine
- Proper ventilation of engine compartment to avoid recirculation of hot air
- Genuine spare parts for its maintenance

Service and Maintenance

- Sound service and maintenance practices will ensure that the engine continues to meet your requirements. Recommended service intervals must be observed. The service and maintenance work should be performed carefully.
- Special care should be taken in highly demanding operating conditions.

Maintenance and Repairs

1. Shut down the engine before performing maintenance or repair work.
2. When the work is complete, be sure to install safety devices that may have been removed.
3. If you must work on a running engine, ensure that all clothing is tight-fitting and cannot catch the moving parts.
4. Observe all industrial safety regulations when operating engines in enclosed spaces or underground.
5. Contact distributor for spare parts inquiries. Use only genuine spare parts.

Safety Symbols

Symbols are incorporated throughout this manual to stress important information. These symbols and their meanings are as follows:

WARNING This symbol precedes information which, if disregarded, may result in injury or death of the user (or others) of the engine.

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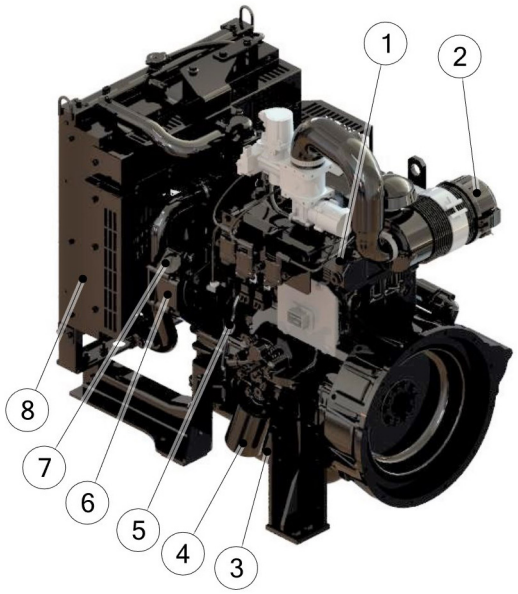
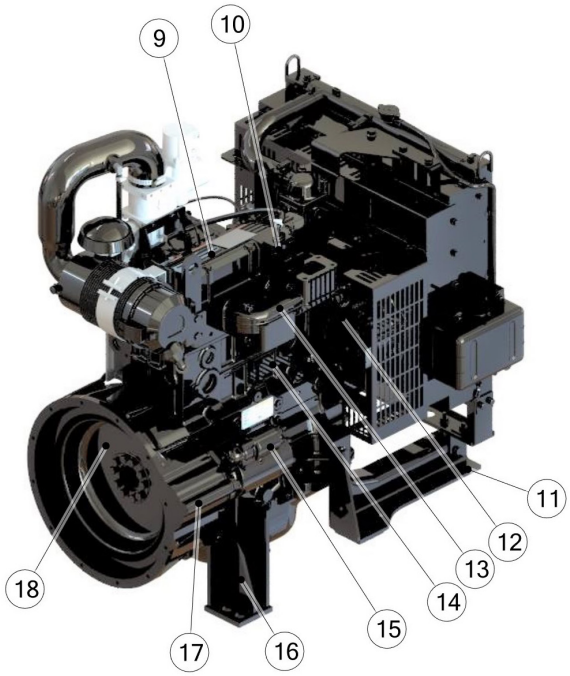
NOTE This symbol precedes information which is vital to the operation or maintenance of the engine.

Engine Illustrations



Intake Manifold Side



Exhaust Manifold Side

1. Air intake manifold
2. Air cleaner
3. Oil pan with drain plug
4. Spin-on oil filter
5. Dipstick
6. Gear casing
7. Oil filling body
8. Radiator
9. Rocker cover
10. Breather (positive crankcase ventilation)
11. Engine mounting foot (gear-end side)
12. Alternator (for battery charging)
13. Exhaust manifold
14. Crankcase
15. Starter
16. Engine mounting foot (flywheel-end side)
17. Flywheel housing
18. Flywheel

Figure 1

Engine-lifting Device

For bare KP3 engine

Before lifting, attach the lifting hooks onto the engine and lift (Figure 2). The lifting hooks provided on the engine are meant for lifting bare engine only. Avoid the use of engine-lifting hooks for lifting of generating set because it can damage the engine or generating set in the event of breakage.

Figure 2

Use proper sling or tackle arrangement for lifting.

Oil System

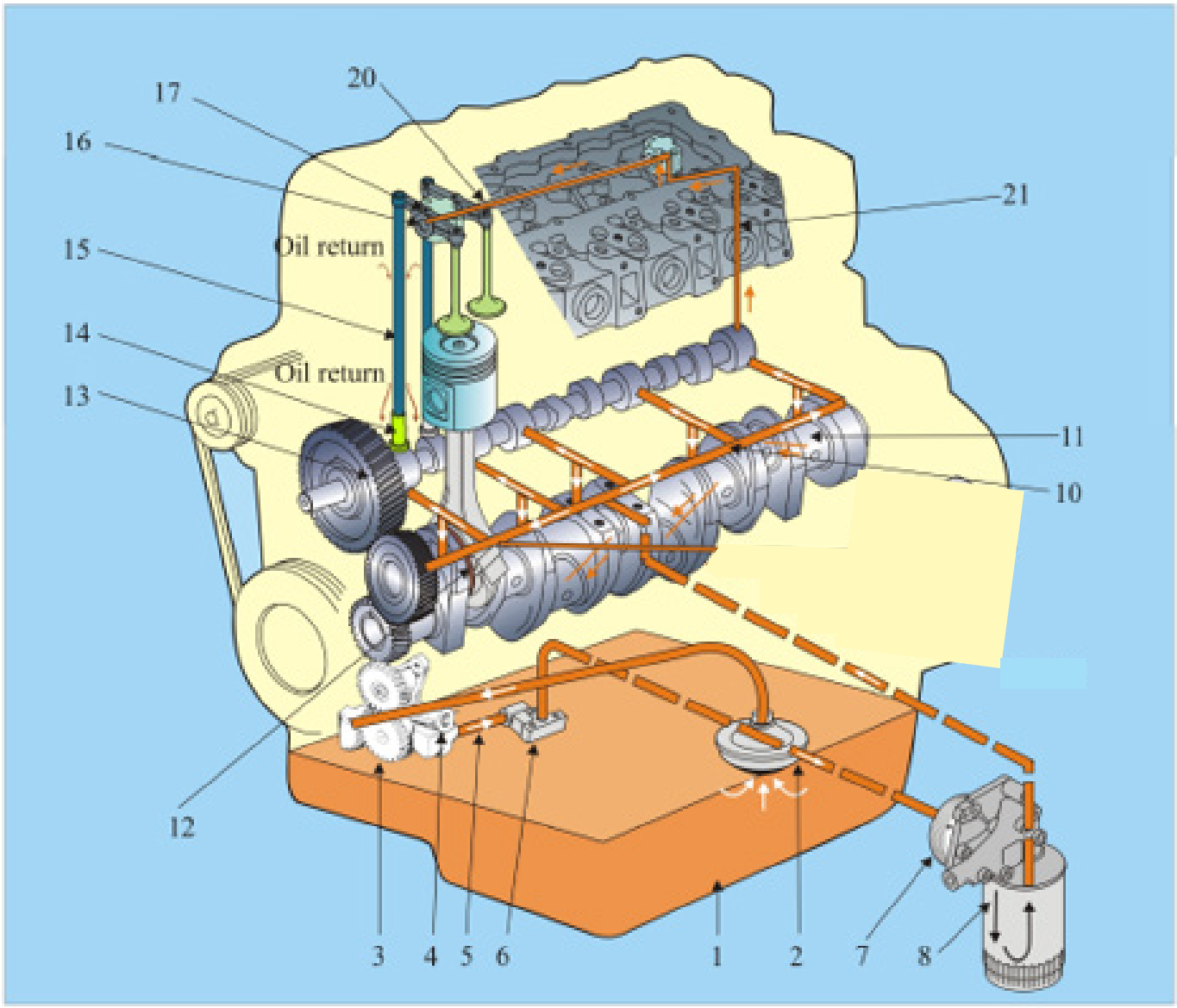
Oil Circuit

Force-feed lubrication is provided by a G rotor-type pump to main bearings, large end bearings, camshaft journals, and to the valve gear. Other components like connecting rod small end bushings, cylinder liners, and gear train are splash lubricated. Piston cooling nozzles are provided for piston cooling. Oil supply to valve gear is achieved through rocker shaft core hole; the oil supply is controlled to the valves and rocker arm by oil metering screw, which results in lower oil consumption and lower carbon deposition.

The system includes adequate filtering by a replaceable spin-on filter cartridge. The water-cooled oil cooler is provided to maintain the oil temperature within limits. A relief valve controls the maximum oil pressure, which is provided on delivery side of the oil pump.

Lubrication System for Arrow Engine KP-Series Water-cooled Engines

Illustration below shows the lubrication oil circuit of a typical KP-Series water-cooled engine. These parts are arranged in typical oil flow as observed in KP-Series engine oil circuit.



1 Lube oil sump
2 Suction tube
3 Lube oil pump
4 Pressure Relief valve
5 Delivery pipe
6 Delivery body
7 Plate type oil cooler
8 Lube oil filter
9 Safety valve (not shown) (In -built in Lube oil filter)
10 Oil gallery (Main)
11 Main bearing
12 Large end bearing
13 Camshaft bearing
14 Tappet with grooves for pulse fed rocker arm lubrication
15 Push rod (hollow, supplying oil to rocker arms)
16 Rocker arm bearing
17 Metering plug (not shown)
18 Oil spray nozzle for piston cooling (Not shown) (Used on Turbo charged & Turbo charged aftercooled engines only.)
20 Rocker Shaft
21 Oil passage in cylinder head

Oil pressure:

At low idle speed	minimum 21 PSI
In normal working condition when engine is warm	70 to 80 PSI
At loaded condition in operating range	36 to 78 PSI

Oil viscosity selection:

The operating temperature of the oil in the sump is the best guide for selecting the proper SAE grade of oil. When the oil temperature of KP Series engines is unknown, add 120°F to the ambient temperature to obtain the estimated sump oil temperature.

For example: at an air temperature of 70°F, estimated oil pan operating temperature would be 190°F. Use SAE 30 as indicated in the table below.

KP ENGINES	
SUMP TEMPERATURE	**SAE No.**
210–250ºF (99–121ºC)	40
160–210ºF (71–99ºC)	30
130–160ºF (55–71ºC)	20

Oil consumption:

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

LBS/HP-HR = 1.82 X quarts of oil used/operating HP X total hours of operation

NOTE: Prime applications

1. During the run-in period of first 50 hours, never exceed full load even for a short duration; this applies to stationary applications like power-generation application.
2. During the run-in period, the oil consumption is slightly more than the amount mentioned above.
3. The oil consumption varies according to engine operating conditions. The value mentioned above is for the normal engine operating condition.

Oil pan capacity and oil change intervals:

The oil pan capacities and oil change intervals of KP-Series engines are presented in the following table. These capacities are for the standard cast-iron and standard sheet metal sumps.

ENGINE TYPE	KP3
Oil pan	Standard
Initial fill	4 quarts (3.8 liters)
Refill	4 quarts (3.8 liters)
Oil specifications SAE-30 (low ash), see assembly	Oil change interval: 750 hours

Cooling System

Radiator-type cooling system

The typical water circuit with radiator-type cooling system is shown in Figure 3.

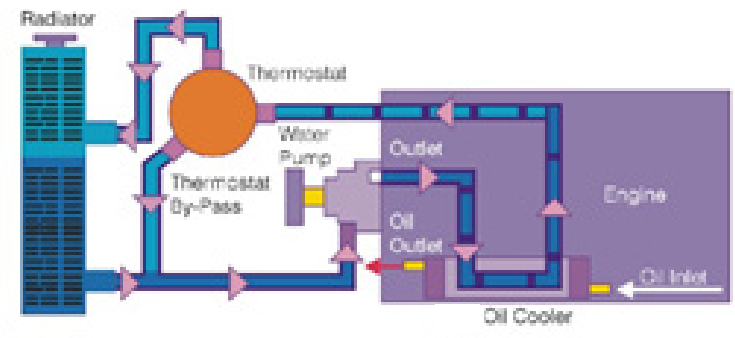


Figure 3

CAUTION

- *To achieve the efficient cooling and optimum performance of the engine, use the radiator supplied by Arrow Engine.*
- *It is necessary to ensure proper ventilation to avoid hot air recirculation into the cooling system.*

Coolant

In summer, use fresh water with anticorrosion additive for engine cooling to avoid rust formation. Water should be clear and free of any corrosive chemicals such as chloride, sulfates, and acids.

We recommend to use coolant blend of soft water and a rust-preventive compound.

In winter, use ethylene glycol antifreeze diluted with coolant blend as mentioned above in the proportion in the cooling system as listed in the following table:

AMBIENT TEMPERATURE RANGE	RATIO BY VOLUME OF ANTIFREEZE TO COOLING WINTER BLEND
+23°F to +41°F (-5°C to +5°C)	20:80
+5°F to +21°F (-15°C to -6°C)	33:67
-13°F to +3°F (-25°C to -16°C)	40:60
Below -25°F (-32°C)	50:50 (maximum permissible ratio)

- Commercially available ready-mixed coolants can also be used with antifreeze and anticorrosion additives after determining suitability for low ambient temperature.
- Storage of engine with only fresh water in engine-cooling system should be avoided at ambient temperature below 32°F (0°C). This may cause cracks in the engine components.
- If the engine is to be transported from normal ambient areas to low ambient areas below 41°F (5°C), drain the complete cooling system and refill with antifreeze and water mixture as mentioned above.

Electrical System

Electrical equipment

Standard engines are equipped with 12V, negative-ground electrical starting system without battery and leads.

12V electrical system — for both alternator and starter

MANUFACTURER	SPECIFICATION	REMARKS
Arrow Engine	12V	Common for 3- to 6-cylinder engines

Battery and Cables

- Minimum 750 CCA battery required
- Recommended battery cable size of 1/0

Engine Operation

Commissioning

Before you start a new or overhauled engine, follow the instructions below.

Oil

Fill the engine with oil through oil-filling neck (Figure 4). For oil quantity, grade, and viscosity, see previous sections discussing oil pan capacity.

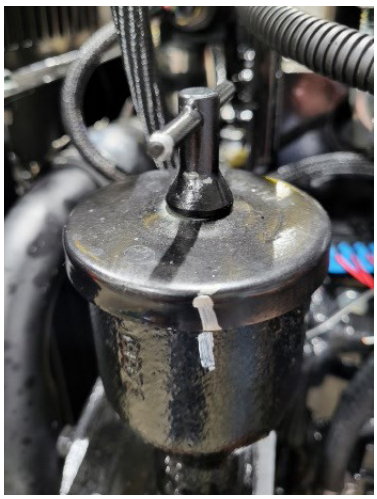


Figure 4

Cooling system

Do not open the radiator cap while engine is running or hot. The cooling system is under pressure, and therefore poses a danger of burning skin.

Add coolant when the coolant system is cold. The temperature difference between the coolant in the engine and the coolant being added must not exceed 122°F (50°C).

Belts

Check for correct belt position and belt tension. If the belt tension is not correct, adjust the same as described in the Belt Drives section of this manual.

Valve clearance

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

On the other hand, when the clearances are too tight, the possibility of burned valves increases.

It is not necessary to check or adjust the valve clearance on new engines because it is already adjusted at its required value. After the first 50 hours of operation, however, it is recommended to recheck and adjust the valve clearance. See Checking Valve Clearance section in this manual.

Other preparations

Check battery and lead connections. Also check cable connections at the starter and alternator. Loose connections lead to improper contact and damage to the terminals.

1. For trial run starting instructions, see section on Engine Starting.
2. After completing the preparations, run the engine for 10 minutes without load.
3. Check engine for oil and water leakages; fix as necessary.
4. Stop engine after trial run. With engine stationary, check the oil level. Top off oil if necessary.
5. Check V-belts; see section on Belt Drives.

Engine Starting

Before starting, make sure no one is standing in close proximity to the engine-driven machine.

After repairs
1. Make certain that all safety guards are returned to their original position.
2. Ensure all tools are removed from the engine and the driven machine.

Engine Stopping

Never stop the engine suddenly when running on load. First, allow the engine to run on no-load for 5 minutes, then stop the engine.

To stop the engine, follow these instructions:

1. Press the stop push button until the engine is completely stopped.
2. Turn the key counterclockwise to OFF position.
3. After stopping the engine, close any manual fuel valves.

Operating Conditions

Operation in winter — oil viscosity

Select specified viscosity grade to meet the performance level for the ambient temperature prevailing at the time of starting the engine.

Note shorter periods between oil changes when operating below 14°F (-10°C).

Battery

Cold starting requires a good battery charge. Lowering the starting limit temperature by 39°F to 41°F (4°C to 5°C) is possible by increasing the battery temperature to approximately 68°F (+20°C). Remove the battery and store it in a warm room or use battery-preheating pads to achieve this.

Engine coolant

Use coolant blend with antifreeze ethylene glycol for operations below 41°F (+5°C). The percentage of mixing the antifreeze into water according to ambient temperatures is given in the Coolant section.

High ambient temperature and/or high altitude

With increasing altitude or ambient temperature, the air density decreases, which affects the following conditions:

1. Maximum power output of the engine
2. Exhaust gas temperature
3. In extreme cases, the starting behavior

Service and Maintenance

Maintenance of Lubrication System

Checking oil level

1. Stop the engine and wait until oil level in the sump is settled. Ensure that engine is in horizontal position.
2. Pull out dipstick and wipe it with a clean rag. Push it in as far as it will go, then withdraw again (Figure 5).

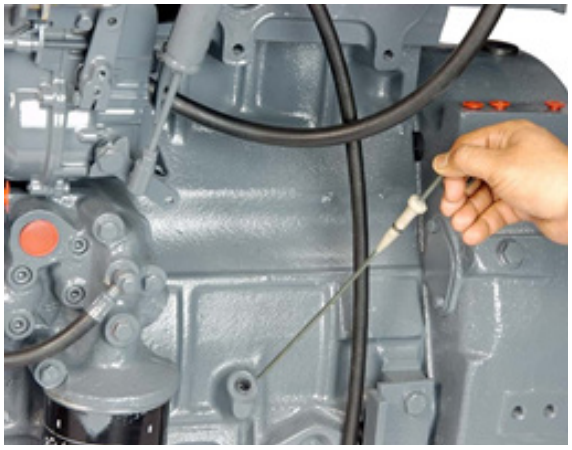


Figure 5

3. The oil that appears on the dipstick should extend to the upper (maximum) mark. If the level reaches only the lower mark, the oil should be topped off.

CAUTION

Failure to top off oil may result in serious damage to the engine, causing piston and bearing seizure.

Changing engine oil

1. Change engine oil at recommended intervals.
2. Run engine until warm (oil temperature approximately 176°F (80°C)).
3. Stop the engine (Figure 6).

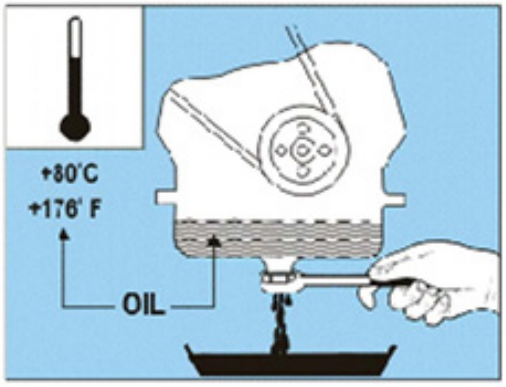


Figure 6

4. Place oil tray under drain pipe.
5. Unscrew oil drain plug on the end of drain pipe and drain oil completely (Figure 7).

Figure 7

6. Collect used oil in receptacle suitable for proper disposal to prevent environmental pollution.
7. Reinstall oil drain plug with new gasket and tighten.
8. Fill with fresh oil.

· For oil pan capacity, see section on Oil Consumption.

WARNING

Be careful when draining hot oil. There is danger of severely burning skin!

Oil filter

Replace spin-on oil filter cartridge during every oil change.

1. Remove oil filter cartridge with special tool and spin off (Figure 8).

Figure 8

2. Clean sealing surface of filter carrier (Figure 9).

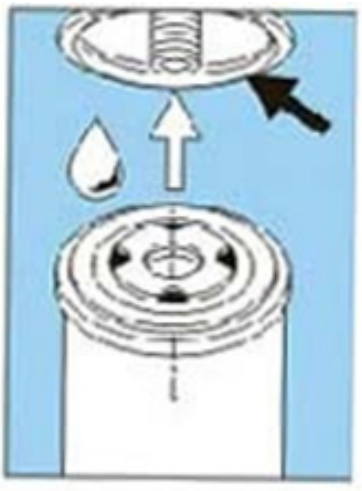


Figure 9

3. Fill the new cartridge with oil before assembly.
4. Apply light film of oil to rubber seal of new cartridge.
5. Screw cartridge into place by hand until seal is evenly seated.
6. Tighten oil filter cartridge firmly by giving a final half turn (Figure 10).
7. Check oil level and oil pressure.
8. Check seal of oil filter cartridge for leaks.

Figure 10

Belt Drives

KP3 engines provide a dual belt drive for engine water pump, radiator fan, and charging alternator (Figure 11).

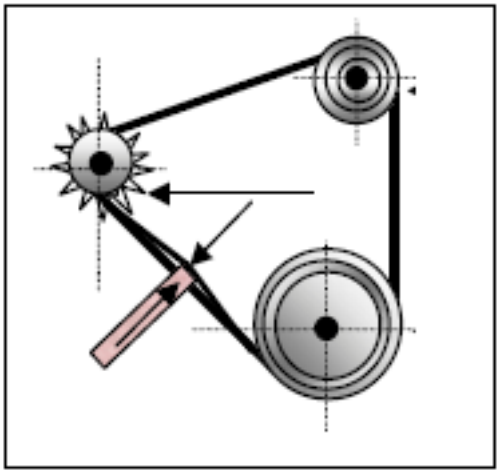


Figure 11

Check belt tension for the fan drive in a similar process. If necessary, adjust the fan belt tension with the alternator adjustment bracket.

Adjustments

Checking and adjusting valve clearance

The valve clearance is the necessary gap between the rocker arm toe and valve stem end (Figure 12). Engine performance and power output depend on its correct setting, which can be performed by a skilled mechanic according to the following instructions:

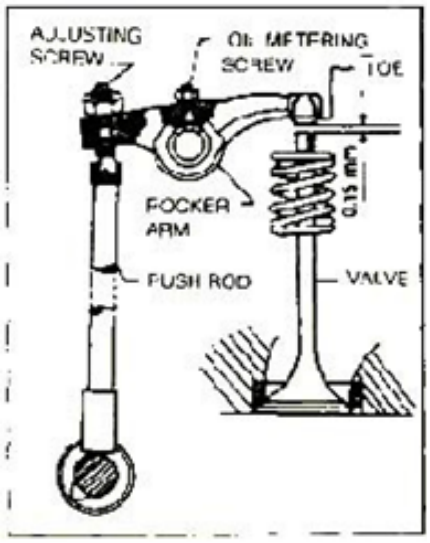


Figure 12

Checking valve clearance

1. Check clearance when engine is cold (at room temperature).
2. Remove the rocker cover.
3. Turn crankshaft until the valves of the cylinder (on which the clearance is being checked) are overlapping (exhaust valve about to close, intake valve about to open).
4. Continue turning the crankshaft through 360 degrees (one complete revolution). At this position, both valves are closed.
5. Insert a feeler gauge of 0.010 inch in the gap between rocker arm toe and valve for all intakes. The valve clearance is correct when the filler gauge can be inserted with a slight drag. If this fails, the valve clearance must be readjusted as follows:

Adjusting valve clearance

1. Loosen the lock nut of adjusting screw with one or two turns. Adjust the screw with screwdriver so that when locknut is retightened, the feeler gauge of 0.010 inch can be inserted and withdrawn with slight drag (Figure 13).

Figure 13

2. Similarly, check the valve clearance of exhaust valve with a 0.012-inch feeler gauge. Readjust if necessary.

3. Check the valve clearances of each of the remaining cylinders and readjust, if necessary.

4. Do not change the setting of the oil metering screw unless required. With hot engine running at idle, an oil flow to pad at rocker arm must be noticeable. An excess oil flow can lead to higher oil consumption.

Settings

Lifter clearance (in cold condition only)
Inlet = 0.25 mm (0.010 inch)
Exhaust = 0.30 mm (0.12 inch)

Tightening Torque

Tightening high-tensile fasteners by angular method

The angular tightening procedure differs from the one usually applied. The tightening angle is particularly important. The clock (Figure 14) indicates how the various angles can be readily obtained by comparison of the clock face.

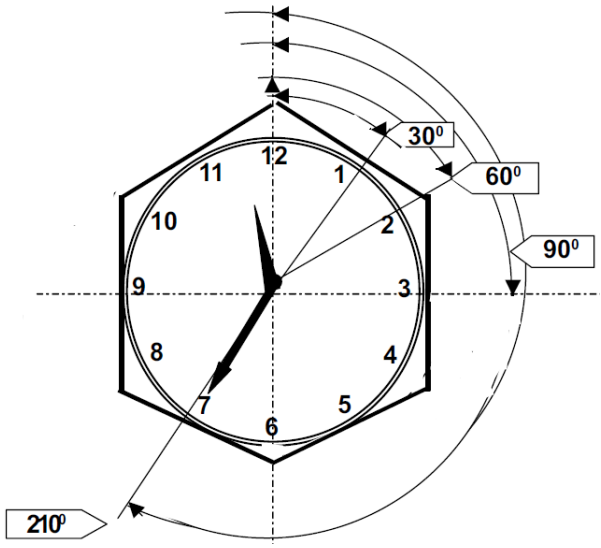


Figure 14

CAUTION

To avoid faulty assembly, perform the following procedure regarding the angular tightening of high-tensile fasteners.

1. Clamp a tommy bar extension in the slot of the angular tool. A specified angle can be turned with reference to the graduation stamped on the outer dial of the angular tool or in relation to the hex head of the bolt which can also be used as a reference.

2. Before fitting the bolt, lightly lubricate the threads and the seating face of the bolt head with fresh engine oil.

3. Hand-tighten the bolt until it rests on the seating face of the bolt head.

4. Apply the initial torque as shown in the tightening table.

5. Tighten the bolt by angular torque, as required in stages shown in the tightening table.

ITEM NO.	DESCRIPTION	INITIAL TORQUE FT.-LBS.	TIGHTENING METHOD ANGLE / FT.-LBS.			TOTAL ANGLE TORQUE
			Stage 1	Stage 2	Stage 3	
1	Bolt for balance weight (M12 X 1.75 X 60 mm long 10.9)	22	30 degrees	30 degrees	-	60 degrees
2	Bolt for main bearing cap (M14 X 2 X 128 mm long 10.9)	22	60 degrees	45 degrees	-	105 degrees
3	Bolt for connecting rod (M12 X 1.5 X 55 mm long 10.9)	22	30 degrees	60 degrees	-	90 degrees
4	Bolt for crank pulley (M24 X 2 X 100 mm long 10.9) without power takeoff	36	25 degrees	48 degrees	-	48 degrees
5	Bolt for flywheel (M10 X 1 X 45 mm long 10.9)	22	30 degrees	60 degrees	-	90 degrees
6	Bolt for flywheel housing (M10 X 1.5 X 40 mm long 10.9)	36	-	-	-	36 ft.-lbs.
7	Bolt for cylinder head (M12 X 1.75)	22	43 ft.-lbs.	0 ft.-lbs.	87 ft.-lbs.	87 ft.-lbs.
8	All M8 X 1.25 screws and bolts 8.8	18	-	-	-	8 ft.-lbs.
9	All M10 X 1.5 screws and bolts 8.8	25	-	-	-	25 ft.-lbs.

Table: Tightening torque for fasteners

The tightening torque sequence for cylinder head bolts for KP3 engines is shown in Figure 15.

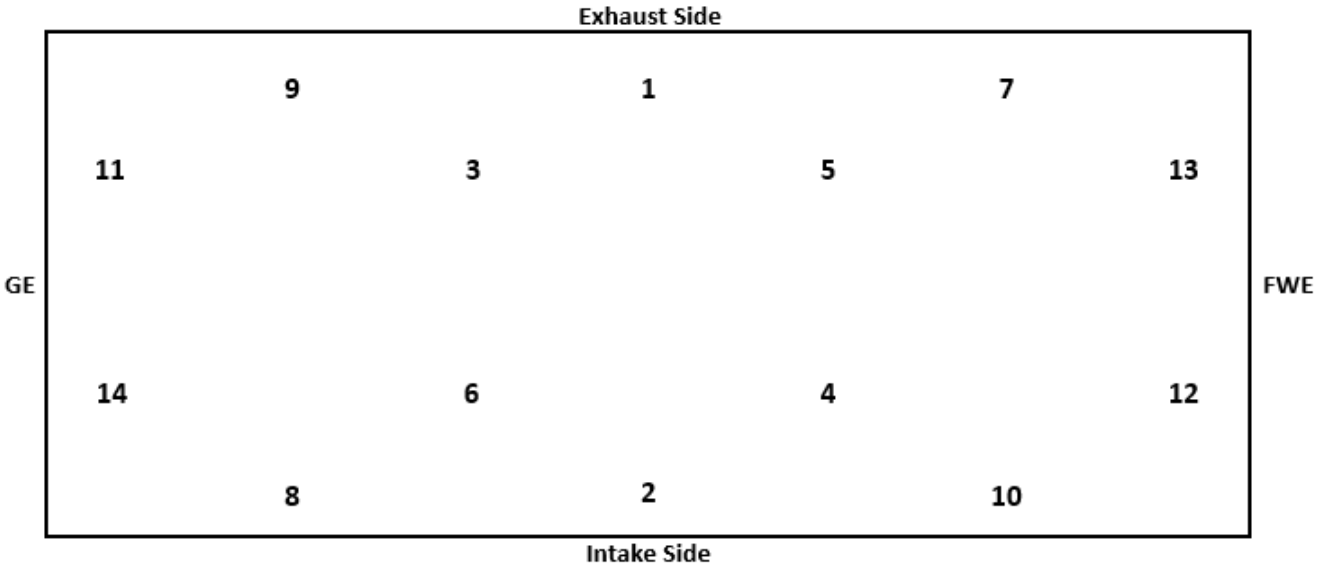


Figure 15. Cylinder Head Torquing Sequence – KP3 Engine

Checking Flatness Method

- Place the straight edge on the polished surface of the head.
- Pass a feeler gauge between the straight edge and the head (not under valve cavities).
- If a feeler gauge thicker than specified passes through the gap (refer to specification data), the face of the head must be refaced.
- Correct the flatness by refacing the head.
- Using a large thick-plate glass, smear emery paste over the glass surface. Sprinkle diesel on the paste so that it spreads evenly when refacing. Place the head, face toward the plate, and lap. Lap it with a even pressure and lengthwise, until the high spots are removed. If this failsl to reduce the gap, replace the cylinder head.
- This task can also be performed in a well-equipped machine shop.
- On turbocharged engines, also check exhaust and intake manifold seating faces for flatness.

Inspecting Valve Recess in Cylinder Head

Before dismantling the valves, check the valve recess. The valve recess is the distance between the valve face and the cylinder head face. This can be checked with the use of a straight edge and a feeler gauge. Insert the feeler gauge between the valve face and the straight edge. If the gauge passes through the gap effortlessly, the gap is more than specified (refer to specification data). In such case, the valve — possibly the valve seat insert or even both the valve and valve seat insert — must be replaced.

Replacing Valve Guides

- Punch out the old valve guide from the valve cavity side of the head.
- Clean the guide bores with a cloth.
- Check bores for scoring or other damage.
- Insert the wire snap ring onto the machined guide.
- Press the valve guide from cylinder head top until the wire snap ring rests on the cylinder head.
- Press new stem seals onto the guide.
- If the guide bore in the head is damaged and must be oversized, semi-finished valve guides are available for this purpose.

NOTE: It is recommended that all bores should be oversized together to the same diameter, even if only one or two guide bores are damaged.

Replacing Valve Seat Inserts

- Remove the valve seat inserts with a chisel. Take care not to damage the insert bore in the cylinder head.
- Alternatively, insert can be removed by cutting on an appropriate lathe in machine shop.
- Remove old valve guides.
- Clean and remove all burr particles from the bore.

NOTE: Inlet valve seat insert and exhaust valve seat insert diameters are different.

- Fit new valve guides.
- Cool the valve seat inserts in dry ice for approximately 20–30 minutes or cool in liquid nitrogen for 5–6 minutes. Fit in the head bore and press immediately.

CAUTION

When using liquid nitrogen, avoid direct contact with this coolant to prevent injury to the body due to its subzero cooling effect. It is recommended to wear gloves when working.

- Fit intake valve seat insert.
- Fit exhaust valve seat insert.
- Ensure the seats are fitted squarely and completely in the bore.

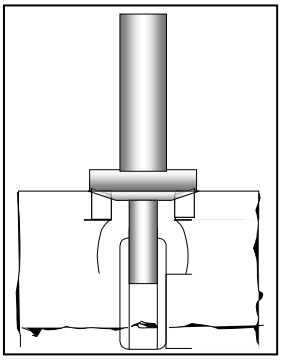


Figure 16

Assembly of Piston and Connecting Rod

- Apply oil to the piston pin and connecting rod S.E. bushing.
- Install a circlip in one end of the piston pin cavity.
- Assemble the connecting rod to the piston. Ensure the “AC” mark punched on the piston crown is on the opposite side of the connecting rod cap.
- Press the pin into the assembly. Piston pin is clearance-fit and should be fitted by pushing with the thumb, not driving with a hammer.
- Fit the second circlip in place.

Checking Piston Ring Butt Clearance

- Butt clearance (end clearance) is the gap between piston ring ends. This gap is crucial and should be maintained as specified in the manual. Check butt clearance with new rings.

Method:

- Insert one piston ring at a time in the liner. To set the ring squarely inside the liner, push it down of liner with a piston (Figure 17).
- Measure gap between ring openings with a feeler gauge.
- Keep the checked rings in the respective liner.
- Follow this procedure with the next set of rings in another liner.
- Repeat the procedure with the remaining rings of the set.
- This way, rings checked in a liner should be installed in that respective liner only.

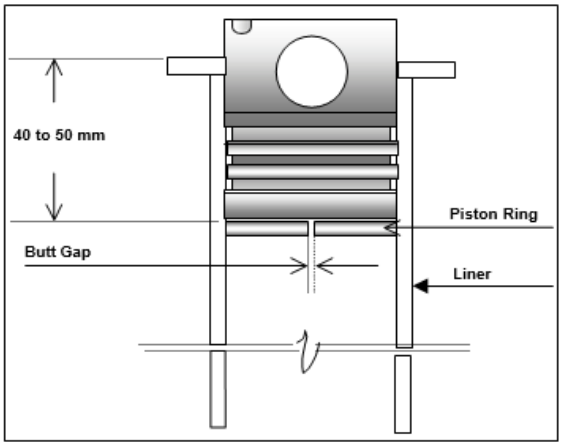


Figure 17

Checking Internal Diameter of Main and Connecting Rod Bearing Shells

- Main bearings are available in two halves, in finished condition, and available in four undersize. Because these are thin-walled bearings, they should be pre-loaded in the main bores.
- During fitting, the bearing shells should not be scraped, touched, or polished. The bearing shells should be cleaned only in clean fuel oil and fitted. Under no circumstance should bearings be wiped after cleaning.
- Set dial gauge to the correct size (standard or oversize). Measure the bearing ID at two planes and at as near the bearing parting line and at vertical.
- Record the values and check these with the specification data.

Fitting of Piston Rings on Piston

- Before fitting the piston rings in the piston ring groove, ensure the following:
- When installing piston rings, the manufacturer's name or "TOP" stamp should be facing the piston crown.
- Install correct rings in their proper sequence (Figure 18).
- Piston rings should be installed with a ring expander to avoid premature failure.

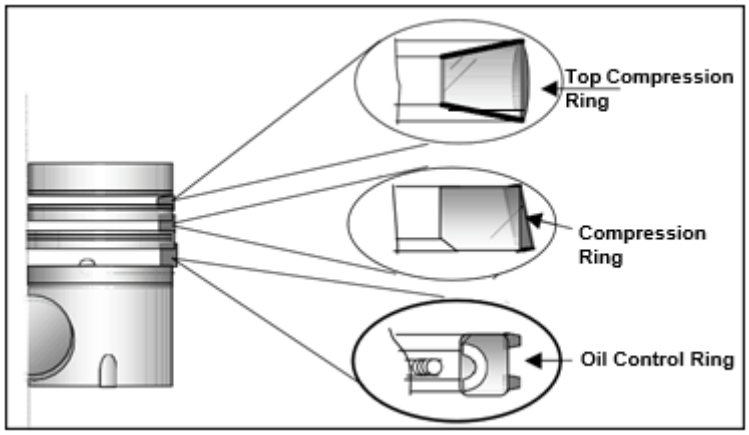


Figure 18

- Ring gaps are to be spaced at 120 degrees. Gaps should not be set along the axis of the piston pin (Figure 19).

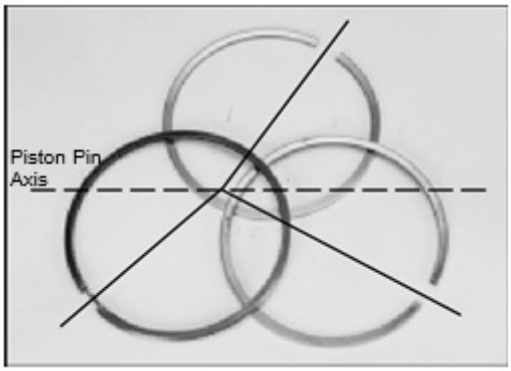


Figure 19

Fitting Crankshaft in Crankcase

- Wipe clean the crankcase main bearing bores and caps where the bearings sit.
- Fit the bearing shell halves in the crankcase bearing cavity and the bearing caps without applying any oil to the bearing back.
- Make sure bearing shells are fitted correctly and are engaged properly in the locating notches.
- Fit the correct-thickness thrust washer in their respective slots provided in the locating bearing bore and cap (nearest to the flywheel).
- Wipe the crankshaft journals.
- Lightly wipe the bearings in the crankcase. Apply fresh lubricating oil with a brush to the journals, bearings, and the thrust washers.
- Lower the crankshaft in the crankcase.
- Rotate the crankshaft and ensure that it is free.
- Check the cap numbers, apply oil, and fit the caps with dowels.
- While fitting the caps, ensure the following:

a. Serial number on crankcase and main bearing caps are the same.
b. Caps are fitted sequentially in ascending order (1, 2, 3, 4) starting from the flywheel side.
c. The bearing locating notches on the crankcase and bearing caps are on the same side.

- Tighten the main bearing caps as follows:

a. Lubricate the bolt threads with engine oil.
b. Apply initial torque with torque wrench. (See Table regarding tightening torque.)
c. Torque the caps starting from center going outward.
d. Finally tighten by angular method in steps, tightening from the center cap and going outward. (See Torque table.)
e. Rotate the crankshaft hand and check that it is free and smooth.
f. Check the crankshaft end play (Figure 20).

Checking Crankshaft End Play

- Crankshaft end play can be checked with either a feeler gauge or a dial gauge. For accurate reading, the dial gauge is preferred.

With Feeler Gauge:

- To check end play, shift the crankshaft with a lever toward the flywheel end side. Insert the feeler gauge in the gap at the flywheel end side between the thrust washer and the crankshaft locating journal face, then check the clearance with dial gauge.
- Fit a dial gauge with a magnetic base on the crankcase either on the gear side or the flywheel end side (Figure 20). Push the crankshaft away from the dial gauge with a lever. Set the dial at zero (0). Again, move the crankshaft toward the dial gauge and take the reading.

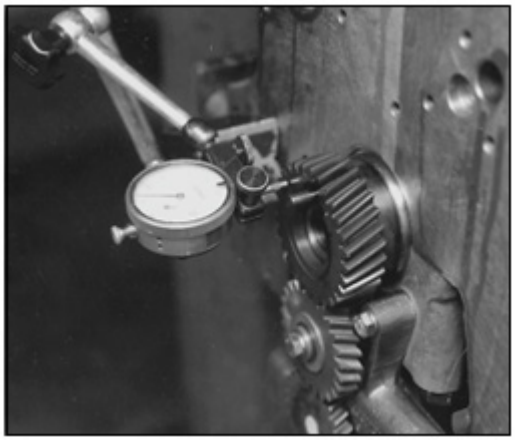


Figure 20

Fitting Piston and Connecting Rod Assembly in Liner

- Select the assembled piston and connecting rod assembly. Check the cylinder number punched or etched on it.
- Set the piston rings gaps at 120-degree intervals. Ensure ring gaps are not in line with axis of the piston pin.
- Lightly lubricate piston rings with fresh engine oil.
- Set the ring-inserting guide tool onto the piston with rings.
- Remove the connecting rod cap from the connecting rod, keeping the bearing halves in place.
- Wipe the crank pin and cylinder liner. With a brush, apply fresh engine oil to the crank pin and cylinder liner.
- Turn the crankshaft and bring the respective cylinder crank pin to top dead center (TDC).
- Insert the connecting rod from the top of the liner, ensuring the “AC” mark on the piston crown is toward the camshaft or lifter side.
- Tap the piston into the liner with a wooden handle. At the same time, guide the connecting-rod large-end bore toward the crank pin until it snugly fits onto it.
- Recheck fitting of the connecting rod onto the crank pin.
- Lubricate bearing shell in the cap. Fit the cap, ensuring that both bearing notches are on the same side.
- Tighten the connecting rod bolts firmly and evenly.
- Follow the same procedure with the other piston and connecting rod assemblies.
- After all connecting rods are fitted and tightened, torque the bolts according to specification. (See Torque table.)
- Check that connecting rod is free in its end play.

Valve Lapping

Before proceeding with valve lapping:

- Check that the valve recess is within the prescribed limit (refer to specification data). If not, replace the valve and/or the valve seat.
- Check condition of both the valve face and the valve seats in the head.
- If the valve face is in relatively good condition, only light lapping with a fine lapping paste will be required to ensure a good seating.
- If valve face is damaged, the face must be refaced to the correct angle without reducing the rim thickness.
- If the valve rim thickness is already reduced, replace the valve.
- Check the valve stem diameter for wear and tear. Replace valve if required.
- Similarly, if the seat in the head must be refaced, the refacing will be accomplished with a seat-grooming tool to the required angle. It is recommended to fit new valve guides before recutting or fitting new valve seats.
- Replace valve seat if damaged beyond repair.

Valve lapping:

- Thoroughly de-carbonize and clean the valve and cylinder head before proceeding with valve lapping.
- Apply a small quantity of coarse lapping compound all around the valve seat.
- Dip the valve stem in fresh clean oil. Insert the numbered valve into the respective valve guide.
- Lap the valve and seat by rotating the valve back and forth in a half turn with a gentle but firm pressure by means of a cupped valve-grinding tool.
- After every few turns, lift the valve off slightly from the seat and give it a half turn, then tap. This is essential to uniformly spread the grinding paste.

- Keep grinding until the rough gritty feeling of the coarse compound turns relatively smooth.
- Remove the valve, wipe the compound from the valve and seat, and check for a contact pattern. When a relatively good flawless pattern is achieved, proceed with the next step and lap the valve again with the fine lapping compound.
- After lapping, visually inspect both valve face and seat. The finished contact pattern on both should be even, without flaws, breaks, scratches, or depression marks (Figure 21).

Figure 21

NOTE: If a shining line or scratches are visible on the seats after lapping, it is possible that the lapping was performed with a heavy hand. Such valves must be lightly relapped again with the fine compound.

- Wash the valves and cylinder head with clean fuel to remove all traces of the harmful abrasive material and dry with compressed air.
- Before assembling the lapped valve assembly, confirm seating is good. This can be determined by a "pencil erase test."
- Wipe and lightly lubricate the valve stem. Assemble valve in its original seat with valve spring and new stem seal, then lock it in position (Figure 22).

Figure 22. Fitting Sequence of Valve Assembly

- After locking valve, check sealing of the seats by performing the "fuel leakage test."

Valve Checking with Pencil Erase Test

The pencil erase test is a simple test and should be performed before the valve is assembled and locked. This test ensures that the valve seat is properly lapped and the sealing is good.

Method:

- Draw a zigzag line on the lapped surface of the valve seat with a soft lead pencil (Figure 23).

Figure 23

Figure 24

- Fit the valve in its seat in the head. With a slight but firm pressure, turn the valve once to 90 degrees or one-quarter turn.
- Remove the valve from the cylinder head and inspect pencil line. The line over the seat should be completely erased (Figure 24). This demonstrates a proper seating and a good sealing.

Valve Checking with Fuel Leakage Test

- After assembling the lapped valves, lock the collar, spring, and cone in position with the valve collets. Pour clean fuel oil into the air intake and subsequently exhaust gas ports.
- Check if the liquid leaks out between the valve face and seat (Figure 25).
- No fuel oil will leak out between the seats if sealing is effective.
- If sealing is ineffective, fuel will leak out between a valve and seat. This oil leak may be due to dirt on the valve seat. Tap the valve lightly on the stem with a hammer to remove the leak.

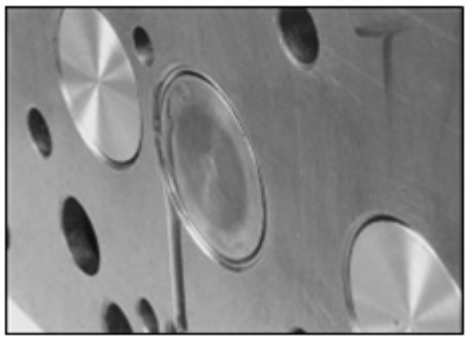


Figure 25

Inspection and Servicing of Oil Spray Nozzles

- Check the oil spray nozzle before reattaching to engine. Old, unserviceable oil spray nozzles should be replaced with new ones.
- The criteria to keep the old nozzles are as follows:

a. Minimum actuating pressure: 0.4 kg/cm^2 (minimum)
b. Minimum spray length: 40 mm (minimum)
c. Spray angle: 5 degrees at 40 mm length (radius of 25 mm)

Measurements above can be checked by using a cardboard disc.

- Old spray nozzles left unchecked can lead to piston damage.

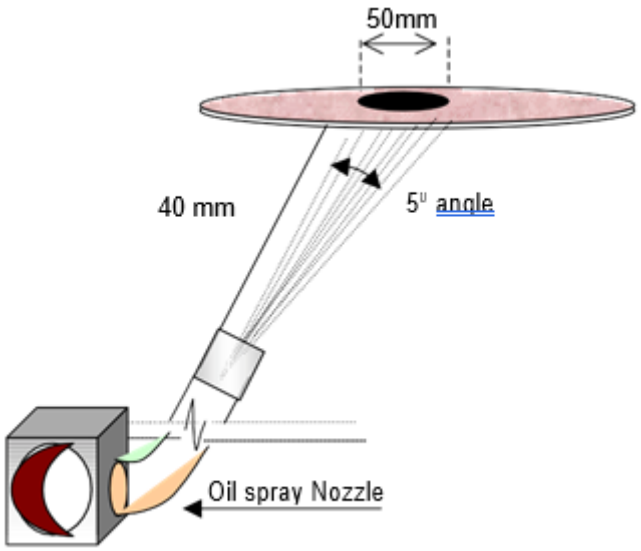


Figure 26

Checking Gear Backlash

- Backlash is the gap between gear teeth.
- To check gear backlash, fit a magnetic base dial gauge on the crankcase face.
- Set dial gauge pointer on a tooth of the gear required to be checked (Figure 27).
- Engage the gear to one side and set the dial to zero (0).
- Oscillate the gear back and forth within its free movement.
- Check the reading on dial gauge.
- Repeat this procedure at four places at right angles.

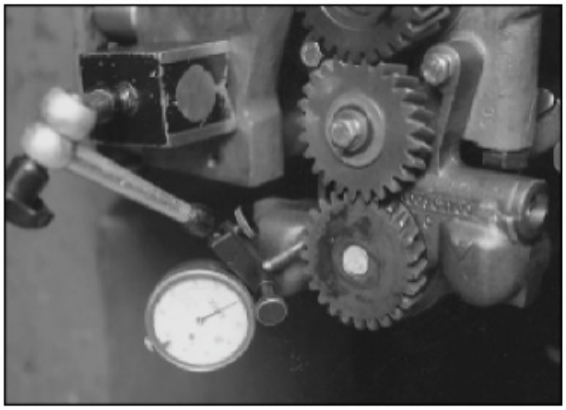


Figure 27

Recommended Gear Backlash

a.	Intermediate gear – crank gear	0.02 – 0.26 mm
b.	Oil pump idler gear – crank gear	0.05 – 0.27 mm
c.	Oil pump driving gear – idler gear	0.098 – 0.35 mm
d.	Cam gear – intermediate gear	0.02 – 0.26 mm

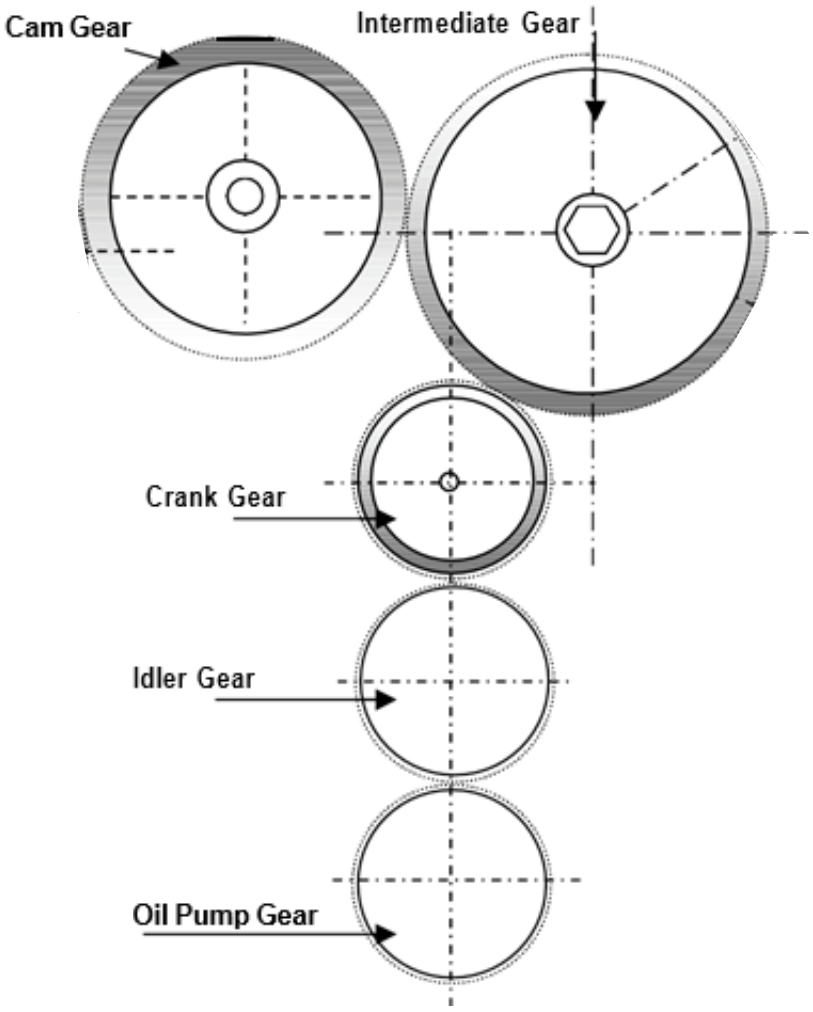


Figure 28. Gear Train

Valve Lifter Setting

Firing Order:

1.	3-cylinder engine	1-3-2	Each cylinder will come to top dead center at 240 degrees
2.	4-cylinder engine	1-3-4-2	Each cylinder will come to top dead center at 180 degrees
3.	6-cylinder engine	1-5-3-6-2-4	

Setting Process

- Bring the first cylinder (flywheel-end side) to top dead center (TDC) compression stroke. The "T" mark on the crank pulley will coincide with the pointer. Check that both intake and exhaust valves are free; if free, do not move when the crankshaft is rocked back and forth. If valves are not free, rotate the crankshaft a full 360 degrees.
- Tools required: 6-inch screwdriver, a correct-size ring spanner, and a correct-thickness feeler gauge.
- Set the gaps on both the intake and the exhaust lifters of the cylinder as specified (see specification data). The feeler gauge should slide firmly but freely in the gap.
- Turn the pulley clockwise until the next cylinder in firing order comes to TDC compression stroke. Continue with the process until all the cylinders are covered and all lifters are set (Figure 29).

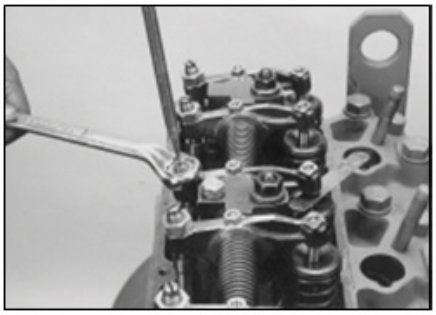


Figure 29

Servicing Spin-on Lubricating Oil Filter

- The spin-on filter should be replaced at every oil change, or whenever the oil is changed for any reason.
- Unscrew the filter cartridge counterclockwise, using a strap tool (commercially available).
- Remove the cartridge and dispose of properly.
- Clean the sealing surface of the filter carrier with a dry cloth.
- Apply a light film of oil with a brush to rubber seal of new cartridge.
- Screw cartridge into place by hand until the seal is evenly seated.
- Tighten the cartridge firmly by giving half a turn.

Inspection and Servicing Oil Cooler

The oil cooler is a stainless-steel disc-type plate cooler. It is located in a cavity provided in the lubricating filter header. In normal conditions, servicing for the plate-type oil cooler is not required, but if the cooler is removed for any reason then it must be serviced. To reach the cooler, you must dismantle and remove the filter header.

Servicing:

- Remove the cooler from the header by removing the BOLT and special washer (Figure 30).

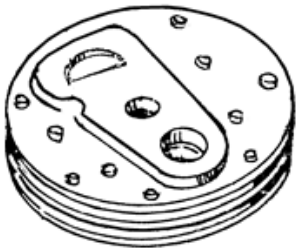


Figure 30

- Plug oil intake and outlet openings of the coolers.
- Clean exterior surfaces of the cooler with soap and water. Use gasoline to remove rust or similar coatings.

CAUTION

Do not use acid-based or alkaline-based cleaners.
Avoid using sharp instruments because this may damage the cooler.

- In a container of clean solvent, dip the cooler element after removing the plugs. Clean the oil side of the cooler by vigorously shaking the element in the solvent. With the cooler still dipped in solvent, direct the compressed air slowly from the oil outlet to clean the inside of the cooler by agitation method. Rinse it twice in clean solvent and flush it with fresh lubricating oil.
- Install the cooler back in the header with new gasket, and torque as specified.

SAFETY PRECAUTIONS

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

These safety precautions 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 U.S. Federal Occupational Safety and Health Administration Act must be met when Arrow engines are operated in areas that are under the jurisdiction of that U.S. 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.

Bodily Protection

Wear OSHA-approved protection for body, sight, hearing, and respiratory system. Never wear loose clothing, jewelry, or long hair around an engine.

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.

Engine Fuels

Natural gas is highly combustible and may ignite or explode. Fuels must be connected to the engine with proper piping, free from leaks, and designed to resist breakage from vibration. When servicing engine, never smoke or use open flame in the immediate area. Fuel tanks should be grounded to prevent buildup of static electricity. If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition. Then crank the engine to purge the cylinders and exhaust system of accumulated, unburned gas. If you fail to do this, a spark plug could ignite the gas and cause an explosion. See the Fuels section of this manual for more information.

Positive Fuel Shutoff

Use of positive fuel shutoff shall be provided. Pressurized fuels (such as natural gas, liquefied petroleum gas, vapor petroleum gas) must have an automatic positive shutoff valve. Gas mixer does not provide gas shutoff protection. It is the final responsibility of the engine owner to ensure that an electric lock-off valve was installed and is free from fuel leakage, and that the installation meets all applicable codes. See Fuels section for more information.

Safety Guards

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

Ignition Systems

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

WARNING

If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition. Then crank the engine to purge the cylinders and exhaust system of accumulated, unburned gas. If you fail to do this, a spark plug could ignite the gas and cause an explosion.

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 coolants have cooled before removing the radiator or surge tank caps. Always replace worn hoses, lines, and fittings.

Generator Sets

The voltage produced by generator sets is dangerous. Severe, possibly fatal shock may result from contact. Make sure the generator set is grounded before operation. Be 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 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 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 victim is unconscious, perform cardiopulmonary resuscitation (CPR) and seek medical help.

Do not operate the generator 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.

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

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 is bent, mutilated, modified, or damaged in any way.
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. Replace fan if damaged.
4. Ensure that all bolts attaching the fan are securely installed to the proper torque.
5. Perform all required maintenance on the subassembly to which the fan is attached (water pump, fan drive, etc.). See operation and service section of manual.
6. 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.
7. Replace the fan if signs of excessive corrosion or erosion appear on the fan.
8. 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, causing potential unbalance of the fan.
9. Be sure all fans, fan drives, and belts are properly shielded.

Oil Change Procedure

1. Start engine and run until reaching operating temperature.
2. Place an oil pan under the engine.
3. Remove the drain plug (1), paying attention to the seal ring on the plug (if applicable).
4. Drain the oil.
5. Replace the drain plug (1) with seal ring (if applicable).
6. Replace the oil filter elements.

- Remove the oil filter (2).
- Apply oil on the filter seal rings (3) and tighten the new filter by hand.

7. Fill with clean oil up to the full mark on the dipstick.
8. Operate the engine for a few minutes to circulate the oil throughout the system. Check tightness of the new oil filter while the engine is running.
9. Stop the engine and check to see if any additional oil is required. Top off the oil level 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 its performance level while in service. Trial periods of 10 hours are suggested. At the end of such periods, carefully inspect the oil depth gauge for sludging, frothing, and emulsification. These conditions call for more frequent changes or a different oil. In cold weather operation, low oil temperatures – below 160°F (71.1°C) – are likely to cause sludge formation. Temperature control devices such as curtains or shutters should be used if needed to maintain the oil temperature around 180°F (82.2°C).

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. Therefore, it is important when changing oil to also change the filter and wash the filter parts thoroughly to prevent clogging or blocking of the oil flow to the engine. At the same time, examine the bypass valve for proper operation. To ensure a clean job without leaks, handle the filter seal gasket carefully and replace it at the same time as the filter.

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 skin, 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 remove the labels on the containers.

Generally, heating of preservative compounds is limited to 200°F (93°C) or less. These temperatures are easily reached by placing the preservative container in heated water. If this is performed, the container must be vented or opened to reduce the danger of explosion. Direct heating presents a dangerous and unnecessary fire hazard.

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.

Cleaning Solvents

Use approved cleaning solvents in a well-ventilated area. Avoid breathing fumes because some vapors can be fatal. Keep away from open flames or sparks. Do not use gasoline or paint thinners or other highly volatile fluids for cleaning. Always read and observe the CAUTION labels on containers. Do not remove the labels on the containers. Cleaning solvents can cause various types of skin irritations.

Welding Equipment

Welding gas cylinders can explode if damaged. Cylinders must be stored in accordance with manufacturer's specifications and applicable safety requirements.

When using acetylene, install check valves between the regulators and hoses to prevent flashback into the regulators and supply tanks. Flashback could cause the regulators and supply tanks to explode.

Oily and greasy materials must be kept away from oxygen valves, hoses, etc. Oxygen may combine with such materials and cause an explosive reaction.

Always wear protective eye shields when welding, cutting, or watching a welding operation. Protective clothing and face shields must be worn to prevent injury. Do not weld or cut near combustible materials.

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.

Electric Power Tools

Be certain the electric tool is properly grounded. Wear proper eye protection. Do not work in wet or damp conditions. Be sure the tool is in good condition and safety guards are in position. An electric trouble light must also be grounded. Do not carry electric power tools by the cord. Do not yank the cord when removing from and outlet; instead, grasp the plug to remove it from the outlet.

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 from accidentally 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.

Precautions When Using Booster Batteries and Cables

Do not attempt to jump start an engine with a frozen battery. The battery may rupture or explode. Before starting, examine all fill vents on the battery. If ice is visible, or if you cannot see the electrolyte fluid, do not attempt to start with jumper cables.

Treat batteries carefully when using jumper cables. The following procedures assist in reducing sparks and explosion hazards 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 walls 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 is gray.

Negative-grounded Battery

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 series 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.

Compressed Air

Compressed air or gases should never be used to clean clothing or the body. Compressed air can pierce the skin and cause severe and painful injury. Never use your hand to check air, gas, or liquid flow rates. Do not engage in horseplay with air, gas, or liquid hoses. Observe all applicable regulations as related to compressed gases.

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 is required, do not exert undue force at the grinding wheel because 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. Treat affected areas of the body as a burn and seek medical attention.

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 because these materials react violently with hot sodium. The smoke and fumes are irritating. Provide adequate ventilation and inhalation and avoid contact with smoke and fumes.

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.

Drugs and Alcohol

Workers under the influence of drugs and/or alcohol are unsafe workers and are a hazard to themselves and other employees.

Safety Practices for Handling Acids

Throughout this manual, acid cleaning procedures are recommended for certain castings or pieces of equipment.

WARNING

Always add the acid to the water. Never add water to acid when mixing solution.

1. Keep acids off of concrete floors because acid attacks lime in the concrete. If solution does get on concrete surfaces, apply an alkaline solution to neutralize.
2. Acids can react with metals to form various gases. Generally, acid solutions on lime scale and rust form harmless carbon dioxide. However, when acids contact aluminum, zinc, cadmium, tin, sulfides, arsenic, and cyanides, poisonous and explosive gases may be generated. When descaling is performed in closed equipment, install proper ventilation to carry the gases away. When using an open tank or crock, dilute gases by ensuring adequate airflow above the open tank.
3. Always fill closed vessels from bottom upward.
4. Be sure that there are no leaks in the vessel being descaled which will permit solution to leak into opposite side or equipment. The recommended practice is to fill the opposite side of the equipment being descaled with water to a level higher than the acid solution.
5. Use an acid-proof pump, or an inexpensive, expendable one.
6. When mixing with water, pour acid into the water. Do not pour water in concentrated acid.

Engine Storage

Preservation of engines and generators in storage involves several basic requirements. Storage of new engines and generators includes the following steps:

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

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

3. Protect accessory equipment, including fuel system, gas regulators, starters, generators, and fan belts from corrosion, dirt, moisture saturation, and deterioration.

4. Protect the cooling system and LPG vaporizers from freezing, rusting, or seizure.

5. Protect engine from rain, snow, and extreme temperatures.

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

7. Protect the generator or alternator by covering all openings to prevent the entry of dust, moisture, dirt, and rodents. A heavy craft paper will serve this purpose. Place the protective paper over the openings, behind movable parts such as screened or louvered guards or covered plates. If this is not possible, use a pressure-sensitive tape to hold the paper in position.

8. Do not use masking tape. It is not suitable for this type of service and will be difficult to remove after extended use. Apply protective paper on both the inside and outside of large, fixed, louvered surfaces. Large open areas should have a corrugated cardboard backing for paper.

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

9. Protect interior engine parts, particularly bearings, cylinder walls, and valves, against (1) corrosion by the products of combustion combined with atmospheric moisture, and (2) corrosion by lubricating oil contaminants.

The level of attention given to each of the preceding points of possible damage depends on the judgment of the person in charge of the equipment. Consider the following factors before deciding how much preservation is required:

1. Period of time the equipment is likely to be inoperative.

2. Severity of the weather and atmospheric conditions at the point of storage. The problems of storing equipment in a tidewater warehouse, for example, differ greatly from storage problems in a location where the air is dry and dusty.

3. 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.

CONVENTIONAL STORAGE

Storing New Engines

All KP-Series engines shipped by Arrow Engine Company will be shipped with oil. Engines stored outdoors or in a humid environment may require additional preservation methods. For recommendations, contact the factory.

NOTE: Remove emissions components such as catalyst and O_2 sensors before treatment and at restart. Start and burn out storage oils before reinstalling catalyst and O_2 sensors.

1. Engines in operable condition:

A. Mix an inhibitive-type preservative oil with the engine lubricating oil in the proportions recommended by the manufacturer of the preservative oil. (With some products, no mixing may be necessary). Operate the engine until the oil is hot. Cooling water used in this run should have an inhibitor, as explained in the cooling system section of this manual.

B. Remove air cleaner from gas engines. With a manually operated sprayer, squirt can, or other means, inject preservative oil into the air intake while engine is running. Approximately one minute should be long enough.

If possible, stop the engine by slugging enough oil through the air intake to make it stall. Continue injecting oil until the engine stops turning.

C. Drain oil and water while hot. If extra protection is desired, remove rocker arm covers and pour preservative oil over the rocker arm and valve mechanisms. Replace the rocker arm cover and tighten to seal the vapor inside the cover.

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

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

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

G. Apply a coating of a heavy preservative compound with a 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.

H. If possible, crank the engine by hand for one or two turns approximately once a month. This helps prevent seizure of water pump seals. If this is performed, it is recommended 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 oil used.

2. When the engine is not operable:

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

B. Remove the spark plugs and pour or squirt a teaspoon (5 cm^3) of preservative oil into each cylinder.

C. Inject preservative oil into each cylinder by hand or with mechanically operated atomizing spray. Do not use ordinary compressed air.

Crank the engine in the normal direction approximately one-quarter turn and spray each cylinder again. Do this eight times, or until the 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.

D. The remaining steps are the same as steps E through H for an operable engine.

Storing Engines That Have Been in Service

In the course of normal engine operation, residues of various combustion products such as lead and sulfur accumulate in the combustion area and in the lubricating oil. Portions of these residues combine with atmospheric moisture to from corrosive compounds. The following treatment will help reduce damage from this source:

NOTE: Remove emissions components such as catalyst and O_2 sensors before treatment and at restart. Start and burn out storage oils before reinstalling catalyst and O_2 sensors.

1. Engines in operable condition:

A. Run engine until the original oil is hot, then drain.

B. If practical, run engine with a good flushing oil in the crankcase and drain the oil and water while still hot.

C. Refill the crankcase with preservative oil, or with the proper grade of oil to which an inhibitive-type preservative oil has been added (in recommended proportion).

D. Follow instructions D through H in the previous section “Storing New Engines” as needed.

2. When the engine is not operable:

A. If storage conditions warrant, disassemble the engine, clean thoroughly, and reassemble for treatment as a new engine.

Generally, this procedure is unnecessary except when using fuels containing considerable amounts of sulfur or in poor climatic conditions.

PRESERVATION EQUIPMENT AND MATERIAL

Sprays and Atomizers

It is often necessary to apply a protective compound in applications with challenging field conditions. Several simple tools can be used to atomize preservative oil and force it into the manifolds and combustion chambers. A manually operated atomizing gun can be used to lubricate inaccessible points on car and truck chassis. A hand-pump sprayer with a pointed discharge nozzle (commonly used with insecticides) can also be used effectively. Small oil pumps can be rigged with a motor drive to make a convenient, pressure-spray unit. In almost all cases, the air available from shop compressor lines carries too much moisture to be safe for this purpose. Do not use high-pressure air from this source.

Heating of Preservative Compounds

Many preservative compounds are most effective when heated before application. If possible, warm up the engine prior to applying preservatives. Heating preservative oils reduces their viscosity, gaining penetration into accessible areas. In addition, the hot compound reduces the moisture film at the metal surface and thus avoids trapping moisture under the preservative layer.

WARNING

Generally speaking, such heating is confined to 200°F (93°C) or less. These temperatures are easily reached by placing the preservative container in heated water. Direct heating presents a dangerous and unnecessary fire hazard.

PREPARING ENGINE FOR OPERATION AFTER STORAGE

The steps to return an engine to active service after storage are similar to the steps performed on any new engine. These include inspection; checking for free rotation, adequate cooling water, or antifreeze; adding lubricating oil of the correct type and viscosity; and adjusting properly.

Wipe down or wash away accumulated dust and dirt from the exterior before removing the covers over the engine openings.

Remove installed protection upon normal inspection of the engine, generator, and switchgear interiors prior to start-up. Partial removal may be necessary during installation, but this should be kept to 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 they are run. Investigate any resistance to free cranking; rust and corrosion can cause severe seizure that cannot be forced clear without engine damage.

CAUTION

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 could lead to a possible hydraulic lock if an attempt is made to operate the engine. Continue to crank the engine with the starter or by hand until liquid is no longer ejected from any openings. Inspect intake passages and manifolds for thickened preservative oil. Oil accumulated in this condition may melt when the engine warms up and cause a leak or spill.

TROUBLESHOOTING

A well-planned troubleshooting program can help determine the cause(s) of unsatisfactory engine operation and the action needed to correct the problem. A working knowledge of how engine systems work — combined with the troubleshooting chart in this manual and current indications from the engine instrument panel — provides the best background for effective troubleshooting.

OPERATING CONTROLS

Electrical System

The engine electrical system consists of a main engine harness, engine control module, sensors, relays, fuses, heavy-duty starter, alternator, and other devices similar to automotive installations. The engine is started by closing a circuit from the battery to the starter. The starting motor solenoid provides positive engagement of the pinion before cranking. After cranking is completed and the engine starts, the solenoid disengages. The alternator recharges the battery. Regulators control the alternator's output and protect the system from reverse currents and excessive charging.

Arrow Engine Company supplies engines with negatively grounded electrical equipment only. This standardization of electrical system polarity is common for most equipment manufacturers, and this increases compatibility between supplied electrical equipment and that which is supplied by the equipment builder.

Cooling System

A pressure-circulating cooling system is used on the KP-Series engines. The water enters the water pump intake on the left side of the engine. The centrifugal pump pulls this supply of cool water through the pump body and forces it into a passage leading directly into the engine cylinder jacket. The water enters the engine just above the lower end of the cylinder sleeves.

From here, the water flow is directed around the cylinder sleeves until it passes upward from the crankcase and into the passages in the cylinder heads. These passages are carefully designed to allow the cooling water to have access to the areas around the valve seats and valve guides. Water is collected from the cylinder head and enters the thermostat housing at the forward end.

The thermostat regulates the engine temperature by automatically controlling the amount of coolant passing through the cooler or radiator core. Back pressure at the water outlet must not exceed 5 PSI (.35 kg/cm^2).

Fuel System

KP-Series engines are equipped with a Woodward PG+ fuel system comprised of an electronic flow regulator (EFR), fuel/air mixer, and electronic throttle body. The system is designed to operate with pipeline-quality natural gas, wellhead natural gas (700–1,600 Btu) or commercial-grade propane (VPG or LPG). Note that an electronic, automatic positive shutoff valve is required for proper and safe operation of the engine. The EFR does not provide any positive sealing of the fuel source. In bi-fuel applications in which both fuel sources are connected at the same time, two electronic lock-off valves are required (one for both fuel sources). The engine control module (ECM) controls the operation of each lock-off valve.

Air Intake System

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

Even though the dust particles are small, they can cause great damage. It is mandatory that air intake connections be kept tight to avoid taking in unfiltered air beyond the air cleaner.

The purpose of all air cleaners is to trap dirt and grit. The filter must be cleared or changed as dirt accumulates. Do this several times daily if conditions are especially dirty.

Exhaust System

Efficient removal of engine exhaust is important. An engine consumes an incredible amount of air.

After combustion takes place, the products of combustion must be pushed out of the cylinders, manifolds, and exhaust piping. Every possible provision must be made to minimize the restriction or back pressure in an exhaust system.

NOTE: KP-Series engines require exhaust back pressure less than 20 in H_20.

Ignition System

Proper combustion requires fuel ignition within the cylinders at finely defined intervals. KP-Series engines are equipped with an advanced Woodward ignition system.

Lubrication System

The lubrication system on every KP-Series engine uses a gear-type oil pump and a full-flow filter. The oil cooler is standard on all engines.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
CRANKSHAFT CANNOT BE BARRED OVER **CAUTION:** DO NOT attempt to rotate crankshaft with starter.	Seized piston.	Replace piston assembly and possibly sleeve. Determine cause of seizure-insufficient ring gap, insufficient lubrication, inadequate cooling, or overload.
	Coolant or obstruction in cylinder.	**CAUTION:** 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 TOO TIGHT	
	High spots on bearings.	Replace bearings.
	Incorrect torque.	Loosen bearing cap and re-torque.
	Main bearing caps installed out of location.	Check each bearing cap. Place in proper location.
	Load not disengaged from engine.	Disengage load.

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE CRANKS BUT DOES NOT START	A. Fuse/harness connected. B. Mag pickup issue.	A. Repair or replace faulty component related to power supply. B. Replace/reset sensor.
	INSUFFICIENT CRANKING SPEED	
	A. Run-down battery or electric starter system malfunction. B. Oil viscosity too high.	A. Charge or replace battery; check starter system. B. Change to lower viscosity as recommended in PREVENTIVE MAINTENANCE.
	POOR COMPRESSION	
	A. Worn rings. B. Leaking valves. C. Leaking head gasket.	A. Replace rings. B. Recondition head and valves. C. Replace head gasket.
	FUEL SYSTEM INOPERATIVE	
	A. Water in fuel. B. Insufficient fuel supply. C. Bent gas pressure regulator control rod. D. Wrong type of fuel selected. E. Lock-off not working.	A. Drain water at strainers and tank. B. Check gas pressure. C. Replace control rod.
	Clogged air cleaner element.	Remove and replace element.
	Safety shutdown control not reset.	Key cycle.
	E-stop malfunctions.	Reset E-stop.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE STOPS SUDDENLY	**FUEL**	
	A. Water in fuel. B. Insufficient fuel supply. C. Clogged fuel supply line. D. Check lock-off.	A. Drain water at tank. B. Check gas pressure. C. Replace line and fuel filter. D. Check power and operation.
	Obstructed exhaust manifold.	Determine and correct cause of obstruction.
	Faulty ignition system.	Repair or replace components as required.
	Clogged air cleaner element.	Remove and replace.
	Engine overspeed causes safety control to shut down engine.	Determine and correct cause of overspeed.
	Auxiliary shutdown device.	Determine and correct cause of shutdown.
	Excessive load causes engine to stall.	Determine and correct cause of overload.
	PISTON SEIZURE	
	A. Insufficient ring gap (applicable only immediately after overhaul). B. Insufficient lubrication. C. Insufficient cooling.	A. Replace scored piston, sleeve, rings. Adjust ring gap. B. Replace scored piston, sleeve, rings. Clean oil passages and/or determine cause of lack of lubrication. C. Replace scored piston, sleeve, rings. D. Clean and/or fill cooling system.
	Bearing seizure: Main, connecting rod, piston pin, or camshaft bearings.	Replace bearings. Clean or replace crankshaft, camshaft, or piston pin as required.
	Lack of lubrication.	Check oil system. Correct cause.
	Dirt in oil.	Check oil filter, replace if needed.
	Obstruction in cylinder.	Replace all parts that failed.
	Low oil pressure causes safety control to shut down.	Inspect lubricating oil system and components. Correct cause.
	High coolant temperature causes safety control to shut down engine.	Inspect cooling system and components. Correct cause.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE POWER LOSS	**LOW COMPRESSION PRESSURE**	
	A. Leaking head gasket.	A. Replace head gasket; inspect for warped cylinder head and/or crankcase. Replace if necessary.
	B. Leaking exhaust, intake valves.	B. Recondition head and valves.
	C. Worn rings (excessive blow-by).	C. Replace rings.
	D. Worn piston sleeves.	D. Replace if necessary.
	E. Cracked piston.	E. Replace.
	F. Cracked cylinder head.	F. Replace.
	G. Misadjusted intake and exhaust valve (if recently overhauled).	G. Adjust valves.
	H. Dirty air cleaner element.	H. Clean or replace.
	I. Restriction in intake and/or exhaust system.	I. Check for obstruction.
	INSUFFICIENT FUEL	
	A. Cracked fuel lines/filters. B. Low gas pressure. C. Poor fuel quality (low Btus).	A. Replace cracked lines and damaged filters. B. Check gas fuel system. C. Perform fuel analysis; requires at least 70% methane.
	Excessive exhaust system back pressure.	Correct as required.
	Dirty air cleaner element.	Remove and clean or replace.
	Ignition timing incorrect.	Check pickup/sensors.

TROUBLESHOOTING

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 sensor.
	Engine operated at angles in excess of maximum safe tilt angles.	Operate within maximum safe tilt angles.
	Oil filter plugged.	Change oil filter.
	Worn lubricating oil pump.	Repair or replace pump.
	Worn bearings (connecting rod, main, camshaft).	Replace worn bearings.
	Cracked or leaking lubricating oil piping.	Repair or replace piping.
	Lubricating oil of low viscosity.	Change to higher viscosity oil, as recommended in PREVENTIVE MAINTENANCE.
	Lubricating oil foaming.	Use oil grade recommended in PREVENTIVE MAINTENANCE. Check for water leaks into oil.
	Clogged oil pickup tube.	Remove and clean oil pickup tube.
	Clogged or corroded oil cooler.	Inspect and clean cooler.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE WILL NOT REACH RATED SPEED	Ignition component issue.	Check ignition components.
	Engine overloaded.	Determine and correct cause of overload.
	Tachometer inaccurate.	Check pickup sensor.
	Insufficient fuel supply.	Check fuel supply system.
	Restricted air intake.	Correct cause.
	Low fuel supply.	Check pressures and regulators.
	Control panel not sending speed request over CANbus.	Verify target speed changes when buttons are pressed. If it does not, contact factory.
	CANbus issue.	Check CANbus wiring.

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE HUNTS OR SURGES	Fuel supply.	Adjust to correct pressure.
	Intake air restriction.	Replace filter.
	Erratic load on engine.	Check connected load. Observe manifold pressure readings.

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH PRESSURE – LUBRICATING OIL	Gauge inaccurate Compare to master gauge. Lubricating oil temperature too low.	Replace sensor, increase temperature.
	Oil pressure regulating valve stuck in closed position.	Replace pump.
	Lubricating oil of high viscosity.	Change to lower viscosity oil as recommended in PREVENTIVE MAINTENANCE.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
LOW TEMPERATURE – COOLING WATER	Sensor inaccurate.	Compare to master gauge. Replace sensor, check wires.
	Inoperative thermostat.	Replace thermostat.
	Thermostat seal missing or leaking.	Replace thermostat seal.

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH TEMPERATURE – COOLING WATER **CAUTION:** Cool engine slowly.	Gauge inaccurate.	Compare to master gauge. Check sensor and wires.
	Cooling system is air bound.	Purge air from cooling system.
	Low coolant level.	Fill cooling system.
	Worn water pump.	Replace or overhaul pump.
	Frozen coolant.	Completely thaw cooling system before restarting engine.
	Engine overloaded.	Determine and correct cause of overload.
	Poor coolant circulation.	Check entire cooling system.
	Blown head gasket.	Replace head gasket.
	Insufficient circulation of air (radiator cooling).	Correct as required.
	Cracked head.	Replace head.
	Loose water pump or fan drive belts.	Tighten or replace drive belts.
	Cracked sleeve.	Replace sleeve.
	Inoperative thermostat.	Replace thermostat.
	Late ignition.	Check ignition system.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH CONSUMPTION – LUBRICATING OIL	Oil leaks in lubricating oil system.	Find and repair leaks.
	Oil of low viscosity.	Change to recommended viscosity for operating temperatures in PREVENTIVE MAINTENANCE
	Leaking oil seal(s): rear and/or front.	Change seal(s).
	Worn intake valve guides.	Change head; renew guides, or valve stem seals.
	Stuck/worn piston ring.	Replace rings.
	One or more pistons with rings upside down (if recently over-hauled).	Remove piston; correct position of rings.
	Excessive connecting rod bearing running clearance.	Replace bearings.
	Crankcase breather plugged.	Replace PCV valve/clean breather system.

SYMPTOM	PROBABLE CAUSE	REMEDY
LUBRICATING OIL CONTAMINATED **CAUTION:** Change oil.	**LUBRICATING OIL CONTAMINATED WITH WATER**	
	A. Sleeve seals leaking or sleeve cracked. B. Cracked crankcase.	A. Replace sleeve and/or O-rings. B. Replace crankcase.
	LUBRICATING OIL CONTAMINATED WITH DIRT	
	A. Oil filter bypass valve opening because filter is plugged. B. Oil filter punctured. C. Air cleaner punctured.	A. Replace filter. B. Replace filter. C. Replace air cleaner filter.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
EXCESSIVE VIBRATION **CAUTION:** STOP engine immediately and investigate cause.	**FOUNDATION BOLTS**	
	A. Loose. B. Cracked.	A. Torque. B. Replace bolts. Torque all bolts.
	Vibration damper loose or failed.	Replace and re-torque bolts. Replace damper.
	Misfiring ignition system.	Repair or replace components as required.
	CRANKSHAFT	
	A. Cracked. B. Main bearing bolts loose.	A. Conduct a complete investigation of entire engine for any damage. B. Determine reason for loosening. Investigate the entire lower crankcase before torquing and subjecting engine to use. Replace main bearing bolts.
	Loose flywheel.	Replace cap screws and/or torque as required.

SYMPTOM	PROBABLE CAUSE	REMEDY
BLACK EXHAUST	**INSUFFICIENT INTAKE AIR**	
	A. Air cleaner element clogged. B. Engine overloaded.	A. Clean and repair. B. Determine and correct cause of overload.
	LOW COMPRESSION	
	A. Insufficient valve clearance. B. Burned valves. C. Worn/stuck rings and sleeves.	A. Reset valves. B. Replace or overhaul head. C. Overhaul.
	Over-rich fuel/air mixture.	Check fuel system/supply.
	Excessive back pressure.	Reduce back pressure.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH TEMPERATURE – LUBRICATING OIL	Engine overload.	Determine and correct cause of overload.
	High cooling water temperature.	“High Temperature – Cooling Water” chart for causes.
	Low lubricating oil pressure.	See “Low Lubricating Oil Pressure” table for causes.
	Clogged or corroded oil cooler.	Inspect and clean oil cooler.

SYMPTOM	PROBABLE CAUSE	REMEDY
KNOCKING OR UNUSUAL NOISES	Low octane fuel.	Change to higher octane fuel.
	Engine overloaded.	Determine and correct cause of overload.
	Insufficient oil to idler gear.	Clean oil passage by front main bearing cap (see description under “Lubrication System”). End of idler gear spindle must be plugged.
	Overly advanced ignition timing.	Check pickup ignition system.
	Loose piston pins (failed).	Replace piston pins and/or pin bushings as required.
	Damaged or excessively worn accessory drives.	Repair or replace components as required.
	Excessive crankshaft end play.	Replace main thrust bearing.
	Excessive valve clearance.	Readjust valve clearance.
	Sticking valve or rocker arms.	Free up or replace.
	Misfitted or excessively worn timing gears.	Replace.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
EXCESSIVE FUEL CONSUMPTION	Leaks in fuel system.	Repair as required.
	Faulty ignition system.	Repair of replace components as required.
	Engine overload.	Determine and correct cause of overload.
	Poor compression.	Determine cause(s) and repair.
	Incorrect matching or torque converter to engine and load.	Replace torque converter.

SYMPTOM	PROBABLE CAUSE	REMEDY
LOW GAS PRESSURE	Incorrectly adjusted gas regulator.	Readjust.
	Insufficient line pressure.	Increase line pressure.
	Incorrect orifice and/or spring in gas regulator.	Replace orifice and/or spring.
	Undersize gas regulator.	Replace with gas regulator of adequate size.
	Undersized piping.	Replace with piping of adequate size.
	Gas regulator mounted too far from engine.	Remount gas regulator as close to the lock-off valve as possible.
	Lock-off valve failure.	Check lock-off valve for correct operation.

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH GAS PRESSURE	Incorrectly adjusted gas regulator.	Readjust.
	Incorrect spring or orifice in gas regulator.	Replace spring or orifice.
	Excessive line pressure.	Reduce line pressure.

HORSEPOWER DERATES		
Condition	**Continuous Duty**	**Intermittent Duty**
Altitude Naturally Aspirated	Deduct 3% for each 1,000 ft. above 1,500 ft.	Deduct 3% for each 1,000 ft. above 500 ft.
	Deduct 3% for each 305 m above 457 m	Deduct 3% for each 305 m above 152 m
Altitude Turbocharged	Deduct 3% for each 1,000 ft. above 3,000 ft.	Deduct 3% for each 1,000 ft. above 1,500 ft.
	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 and 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 ft. (152 m) altitude, 29.38 Hg (746 mm), and a temperature of 84°F (29°C).

Natural gas ratings are based on the use of 1,000 Btu LHV gas. Propane ratings are based on the use of 2,335 Btu HD-5 propane.

INSTALLATION

Scope

These are general installation requirements. For more specific requirements, contact the Customer Service Department at Arrow Engine Company.

Automatic Starting

We recommend the use of jacket water heaters for installations subjected to unscheduled automatic starts and instantaneous loading.

Space Requirements

To ensure adequate access for engine installation, ventilation, and in-service maintenance, the engine location must be carefully considered.

Cover all engine openings until installation to prevent foreign objects from entering the engine.

STATIONARY INSTALLATIONS

Engine Foundations

Most stationary engine applications require a foundation or mounting base. This base isolates the engine from the surrounding structure and absorbs or inhibits vibrations. A base provides a permanently accurate surface upon which the engine (and the driven equipment) may be mounted and aligned. The foundation must have a suitable size and mass, rest on an adequate soil or bearing surface, be provided with an accurately finished mounting surface for the engine, and be equipped with properly sized retaining bolts in the correct locations to secure the engine firmly in position.

Mounting

No engine will perform properly if incorrectly installed and aligned.

Any misalignment of mountings causes stress on the engine structure with possible damage to flywheel housing, flywheel, crankshaft, and thrust bearings.

Because of the variety of power applications, the KP-Series engines can be mounted in both mobile and stationary applications. In all cases, it is important to select proper mountings for the specific application. If the engine and driven equipment have separate foundations, alignment is critical. To ensure proper alignment, inspect foundations for weld spatter, burrs, foreign matter, or uneven surfaces. It is a waste of time to attempt alignment if the foundation is not level and clean to begin with.

Alignment

It is desirable to have shims under both the engine and driven equipment, so alignment during rebuilding or replacement will not present a problem.

The nature of any shimming procedure is essentially to cut and try. Use easy-to-cut steel or brass shim stock to make up trial shim pads. Remember, the area of the shim pad must be large enough to support the weight of the engine when the bolts are tightened.

After the engine has been leveled and tightened down, the driven equipment can be aligned. Where the driven equipment is mounted permanently, the engine must be aligned relative to the driven equipment.

When the engine and driven equipment are mounted on a common skid base, use shims under both units to compensate for roughness and unevenness of the skid rails. This also provides shims under drive and driven units for final alignment. Generally, the heaviest machine is permanently mounted and the lightest aligned to the heaviest.

The correct aligning procedure may vary slightly with different types of drive equipment. Many manufacturers of driven equipment will specify the preferred method to align their equipment. In general, the object is the same: to make the driven shaft concentric with the driver shaft.

Use steel chocks to fill larger gaps so that only the last few thousandths of an inch must be filled out with thinner shim stock.

Always use shims wide enough to permit the full base mounting area to bear on them. The full width of mounting base must be supported, not just outer edge.

CAUTION

Never attempt to start an engine that has been stored without first Inspecting intake passages and manifolds for thickened preservative oil.

COOLING SYSTEM

Cooling System Design

Premature engine component failures and abnormal engine performance can often be traced to improper design or sizing of radiators or other coolers.

NOTE: Arrow Engine Company will not be responsible for engine or component failure when the following cooling system design and application recommendations are not followed.

Air Intake System

Large quantities of air are required for all internal combustion engines. Exact combustion air requirements for KP-Series engines can be obtained from Arrow Engine Company.

Certain factors must be considered to ensure an adequate supply of clean combustion air. These are as follows:

1. Air requirements for engines installed in heated, air-conditioned buildings may upset heating and ventilating calculations unless combustion air is supplied via an external air intake.

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

3. All ducting and air cleaner to manifold connections must be airtight to avoid drawing in unfiltered air.

4. The restriction through the air intake system must be kept to a minimum. Air duct restriction must never exceed five inches of water column. Restricted intakes, sharp or numerous bends, and undersized ducting will increase restriction unnecessarily.

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

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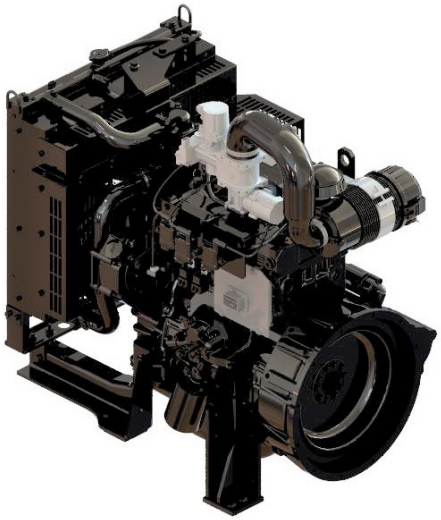
KP3

EMISSIONS-RELATED INSTALLATION MANUAL

2024 Installation Instructions for KP3 Standby Certified Engines



ARROW ENGINE
ENGINES & COMPRESSION

ARROW ENGINE COMPANY
2301 E. Independence St., Tulsa, OK 74110
www.arrowengine.com

KP3-EIM-JAN2024

Table of Contents

IMPORTANT NOTICE

Emissions-related Installation Instructions

These instructions provide the final assembler with the information needed to ensure that the engine, exhaust system, and gaseous fuel system are installed correctly in the engine's certified configuration.

Arrow's certified Large Spark-Ignited (LSI) 3.1L engine, EPA engine family code RARWB03.1SNA, is certified for use as a stationary emergency (standby) engine only. This engine cannot be used in prime applications.

Failure to follow these instructions when installing a certified engine in a piece of non-road equipment violates U.S. federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act.

U.S. EPA Requirements for Stationary Emergency Engines

Per 40 CFR 60.4243(d), you may operate your stationary emergency engine for an unlimited number of hours in emergency situations. You may also operate your engine for up to 50 hours per year in nonemergency situations for maintenance purposes.

To ensure emissions compliance of your stationary engine, the U.S. EPA requires you to perform one of the following two options:

1. Install and operate your engine as specified in these installation instructions.
2. If you do not install and operate your stationary engine as specified in these instructions, your engine will be considered a noncertified engine.

In this case, you must:

- Keep a maintenance plan and records of conducted maintenance.
- To the extent practicable, maintain and operate the engine in a manner consistent with good air pollution control practice for minimizing emissions.

Per section 113 of the U.S. Clean Air Act, failure to abide by these legal requirements can result in fines of the following amounts: up to $49,342 per engine for manufacturers and $49,342 per day for owner-operators.

Safety Symbols

These are the ISO 8999 symbols that may appear in this publication:


Battery


Electrical hazards


Engine coolant fill level


Engine coolant temperature


Engine oil fill level


Engine oil pressure


Hot surface warning


Warning


Read the manual


No Smoking or flame

Operating Speed Ranges

The engine set point for the Arrow KP3 certified engine must stay between 900 and 2,200 rpm. The actual speed may deviate outside of this range for a short period of time.

Exhaust System Application Guidelines

The maximum allowable exhaust back pressure measured between the silencer and exhaust manifold is 20 inches H_2O (5 kPa). Pressures greater than this will cause reduction in available engine power and may cause exhaust leakage at the manifold flange.

Exhaust System Installation Instructions

These installation instructions must be strictly followed and verified on each engine installation. Failure to observe these requirements will void the warranty and may result in EPA fines of the following amounts: up to $49,342 per engine for manufacturers and $49,342 per day for owner-operators.

These instructions are intended to minimize occurrences that may compromise the mechanical durability of the product as a result of the following:

- Engine vibration
- Thermal expansion and contraction of exhaust system
- Shock loads during operation of the equipment

These installation instructions require the following components to be incorporated into the complete assembly to ensure the product meets its design life. Note that some of these instructions represent recommended practices and each exhaust application must be evaluated to meet the specific guidelines regarding temperature and vibration limits.

1. Stainless shim exhaust manifold gaskets are strongly recommended.
2. A 3-inch flexible coupling is recommended between the engine and silencer to protect from the engine's torsional vibration.
3. Band clamps, flanges, or welds are required at all exhaust pipe and silencer-pipe junctions. All junctions must be leak-tight.
4. The pre-cat oxygen sensor must be located per Arrow Engine specification.
5. The EPA requires that (CFR 40 1048.205 (v)) the exhaust pipe be configured so that an 8-inch (20 cm) extension can be easily added to the end of the exhaust pipe for measuring emissions in the field. For example, if a rain cap is used, it must be removable. If it is not feasible to add an extension, add a 1/4-inch sample port to the exhaust pipe at least 8 inches (20 cm) before the end of the pipe.
6. Lightly coat the threads of the pre-cat oxygen sensors with O_2/sensor-safe antiseize compound, if not coated by the sensor manufacturer. Tighten the oxygen sensors to 37 ft.-lbs.
7. A rain cap or 90-degree bend is required if the tail pipe is vertical and can collect water.
8. The entire exhaust system must be checked for leaks by sealing one end of the exhaust pipe and applying 3 psig air pressure to the other end. Apply leak detector or a soapy water mixture to all joints and fittings. There must be no leaks that can be heard or felt. Slow bubble leaks are OK.

Component	Quantity	Approved Part Number Substitutes Must Be Approved by MOR
Exhaust manifold	1	KD09004
Exhaust pipe	—	Ø 3-inch OD x 14 GA (.083-inch wall)
Flex joint	1	10–14 inch OAL SS bellows with 3-inch OD ends

Table 1. Arrow KP3 Exhaust System Components

Engine and Emissions Label

The EPA requires that the label below must be visible.

If you install the engine in a location that makes the engine emissions control information label difficult to read during normal engine maintenance, you must place a duplicate label on the equipment, as described in 40 CFR 1068.105.

1. U.S. EPA emissions label
2. Engine label with engine part number, serial number, and date of manufacture

IMPORTANT ENGINE INFORMATION	EMISSIONS CONTROL INFORMATION
THIS ENGINE COMPLIES WITH U.S. EPA REGULATIONS FOR 2024 STATIONARY EMERGENCY ENGINES. THIS ENGINE IS CERTIFIED TO OPERATE ON COMMERCIAL LPG AND PIPELINE-QUALITY NATURAL GAS. NO ADJUSTMENTS ARE REQUIRED. USE IN CONSTANT-SPEED APPLICATIONS ONLY. Engine Family: RARWB03.1SNA Engine Displacement: 3.1 L Spark Plug Gap: .025 inch (.635 mm)	Stationary Emissions Standards (g/HP-hr) NG: 10 NOx+NMHC, 387 CO LPG: 10 NOx+THC, 387 CO Exhaust Emissions Control: ECM, MIX, HO2S ARROW ENGINE ENGINES & COMPRESSION Part Number: KD50027

Figure 1. Emissions Label, KP3NA Standby

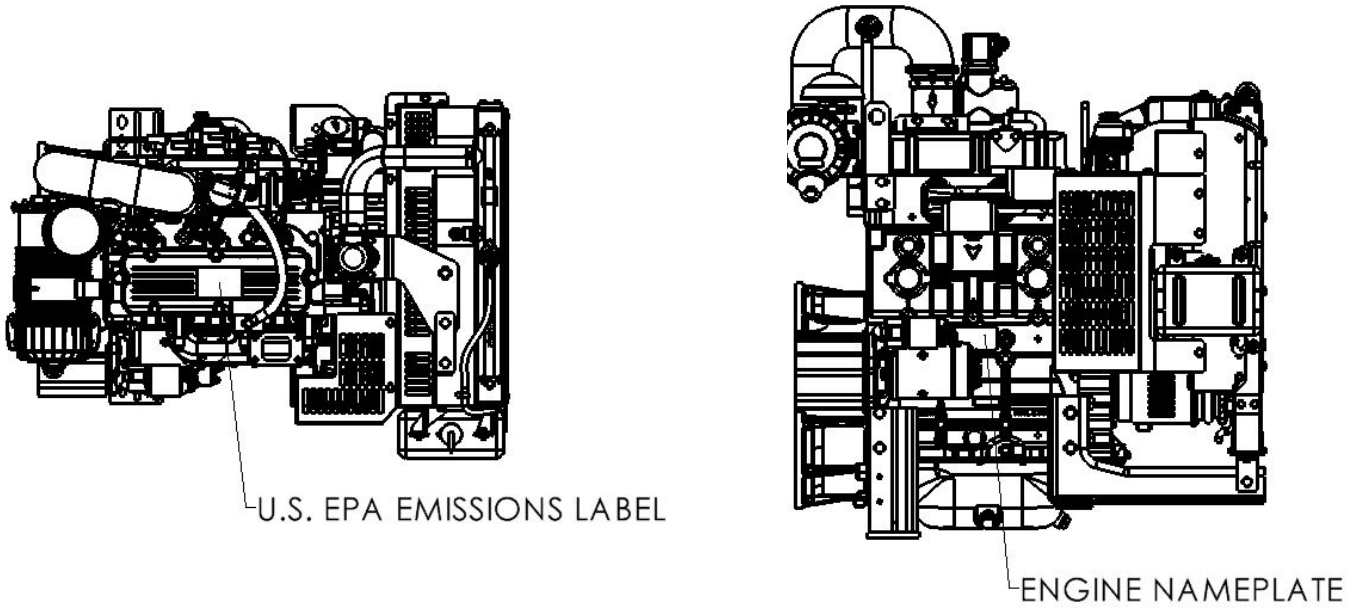


Figure 2

Positive Crankcase Ventilation (PCV) System

The EPA specifies that “Crankcase emissions may not be discharged directly into the ambient atmosphere from any engine throughout its useful life.”

The KP3 engine uses a closed crankcase ventilation system as shown in Figure 3. A manifold vacuum is applied to the PCV valve (Item No. 20) to collect blowby gases and send them back to the intake system. Fresh air is supplied to the crankcase via the crankcase breather (Item No. 13).

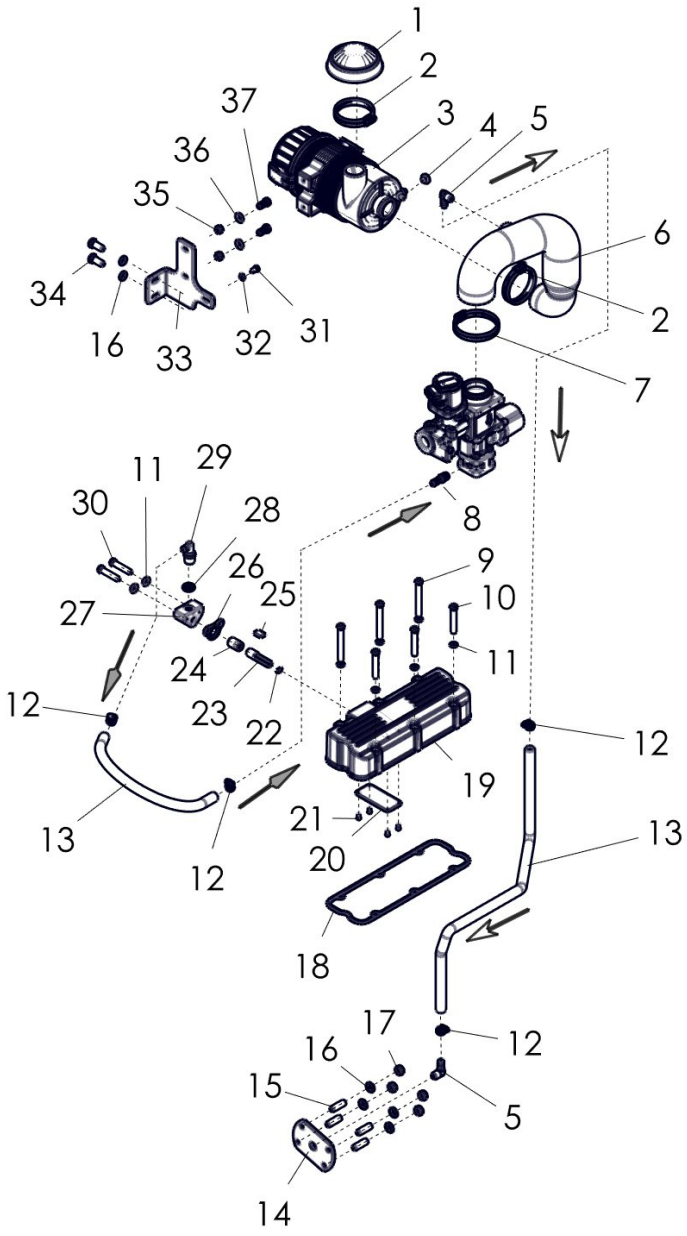


Figure 3

Malfunction Indicator Lamp

EPA Malfunction Indicator Lamp Requirements:

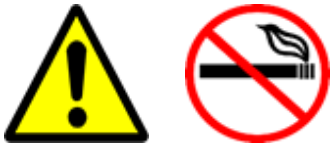
1. Use a malfunction indicator lamp (MIL) (Figure 4).
2. The MIL must be readily visible to the operator; it may be any color except red.
3. When the MIL lights up, it must display “Check Engine” (Figure 5) or “Service Engine Soon” or be appropriately labeled.
4. You may use sound in addition to the light signal.

Figure 4. MIL Bulb

Figure 5. MIL Installed

Air Filter Requirements

1. All engines are required to have an air filter; the engine warranty will be voided without one. The filter should be configured so it does not ingest unnecessarily hot air (greater than 130°F (54.4°C)), rain, or moisture.
2. The air pressure drop across the air filter must not exceed:
   - Clean filter: 5 inches H_2O
   - Dirty filter: 15 inches H_2O
3. The maximum engine air flow for Arrow LSI-certified engines is approximately:
   - 3.1 L – 111 standard cubic feet per minute (SCFM) @ 1,800 RPM



Fuel System Installation Guidelines

Fuels

Natural gas and LPG are combustible gases, and can explode if leaked and contained in a confined area. Keep cigarettes and all other flame sources away from these areas.

Depending on your engine and fuel system configuration, your engine is designed to run on natural gas, liquid propane (LPG), or vapor propane (VPG). The fuel requirements for each are discussed in this section.

Natural Gas

Your engine is certified to run on natural gas of pipeline-quality. Specifically, your engine is certified to run on natural gas provided by a supplier through a pipeline that has at least 70% methane content by volume OR an energy content of 950 to 1,100 Btu per SCF. If your natural gas supply does not meet these specifications, your engine is operating as a noncertified engine. See U.S. EPA Legal Requirements section of this manual.

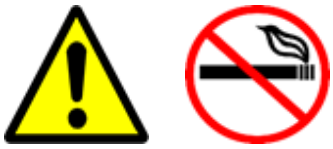
Arrow Engine requires that the natural gas comply with the following specifications; otherwise, the fuel system and engine warranties may be void.

- Hydrogen: < 500 mg/10 kWh
- Chlorine and fluorine compounds (typically chlorofluorocarbons): < 100 mg/10 kWh
- Silicon: < 5 mg/10 kWh
- Ammonia: < 50 mg/10 kWh
- Oil or hydrocarbons in liquid mist form: < 5 mg/10 kWh
- No liquid water is permitted at the intake of the engine-mounted fuel system

Liquefied Petroleum Gas

To maintain emissions compliance and the engine warranty, use commercial-grade HD-10 or better LPG. Liquid propane is drawn off the bottom side of an LPG tank or cylinder and is a liquid until it has passed through the regulator/vaporizer, at which point it is vaporized to a gas. If you connect vapor propane to a liquid propane fuel system, you may starve the engine for fuel, causing it to produce low power and excessive emissions.

Vapor propane is drawn off of the top side of an LPG tank or cylinder. Only a fuel pressure regulator (not a vaporizer) is required for vapor propane. However, the LPG tank/cylinder must have enough internal surface area to vaporize (boil) LPG at the rate required by the engine.



Check for Gas Leaks

If you hear a fuel leak, shut off the fuel supply at the source immediately and fix the leak or have it serviced. Check the entire fuel supply line from the cylinder/tank to the engine for leaks with leak detect or a soapy water bubble mixture anytime the fuel supply line is serviced. Fuel leaks should also be checked as part of the regular engine maintenance.

All fuel hose and connections must be leak-tight! Use fuel hose, connectors, and sealants specified for the fuel type. Use leak detect or a soapy water mixture to check for leaks. All fuel leaks must be eliminated!

Inspection

1. If you hear a fuel leak, shut off the fuel supply at the source immediately and fix the leak or have it serviced.
2. If there are no audible leaks, spray the fuel line up to the lock-off valve with a soapy water mixture. A stream of bubbles indicates leak sources.
3. Tighten fittings and clamps as needed to eliminate slow leaks.
4. Start the engine.
5. Check the fuel supply line from the lock-off valve to the engine with a soapy water mixture.
6. If any fuel line components (hoses, pipe, fittings, etc.) must be replaced, first bleed the fuel out of the line by shutting off the gas supply at the source with the engine running at idle. Wait for the engine to stop before disassembling the fuel line.

Arrow engines are certified to operate on the following fuel types:

- Pipeline-quality natural gas (natural gas from a pipeline having at least 70% methane content or 950–1,100 Btu/ft^3 energy content).
- Commercial LPG and VPG, grade HD-10 or better.

Stationary engines (not constant-speed mobile engines) may be operated on other fuel types, but are considered noncertified engines. See U.S. EPA Requirements for Stationary Engines section of this manual for more information.

Figure 6 shows the fuel system assembly (electronic fuel control valve and air valve carburetor) used on Arrow LSI-certified engines. (See following page.)

Figure 7 is a block diagram of the emissions control system used on Arrow LSI-certified engines.

The requirements for the fuel supply to Arrow LSI-certified engines are as follows:

- Fuel supply pressure to the fuel system intake must be:
  NG – 8–16 inches H_2O (2–4 kPa)
  Propane – 8–16 inches H_2O (2–4 kPa)

- If natural gas and vapor propane supply pressure is higher than 16 inches H_2O (4 kPa), the packager must install a primary pressure regulator upstream of provided fuel system (not provided with system) to meet these pressure requirements.

- A 50-micron fuel filter with 99% efficiency is strongly recommended (not provided with system). Failure to properly filter the fuel may cause damage or plugging to fuel system components and void the warranty.

- The following fuel filters are recommended:

  Raw natural gas: Oxion, Inc. Model M150

  Vapor LPG and pipeline natural gas: Maxitrol Model GF60-1-88

- All low-pressure fuel lines should be 1-inch (2.5 cm) inner diameter (ID) and free from sharp bends or kinks.

- All pipe threads in the fuel system should be sealed with thread sealant specified for the fuel type (NG and/or LPG).

- All fuel system components should be properly supported with brackets and isolated from severe (greater than 5 g) vibration.

- All fuel system components, fuel lines, and electrical wiring should be a minimum of 12 inches (30.5 cm) from exhaust system components and properly shielded from direct radiant heat. The final package should provide air circulation around fuel system components to prevent overheating.

- Installation of a manual shut-off valve at the fuel supply source is strongly recommended to allow the fuel to be shut off when the engine is being serviced.

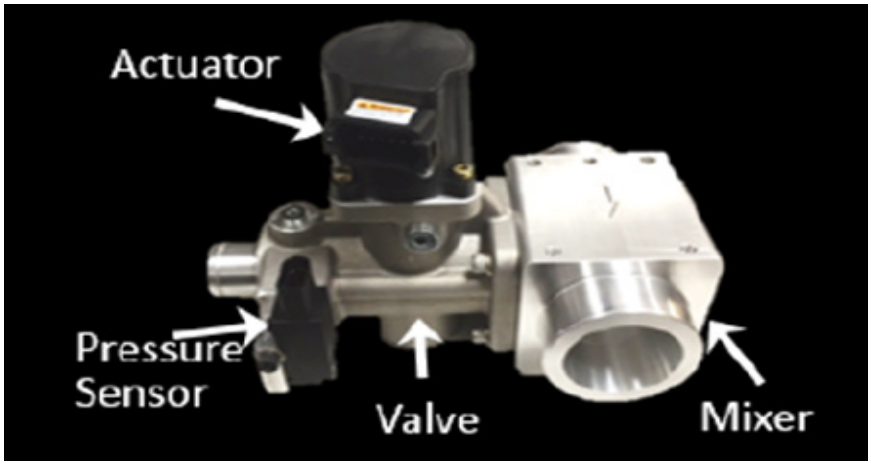


Figure 6. Fuel System Assembly for Arrow LSI Engines

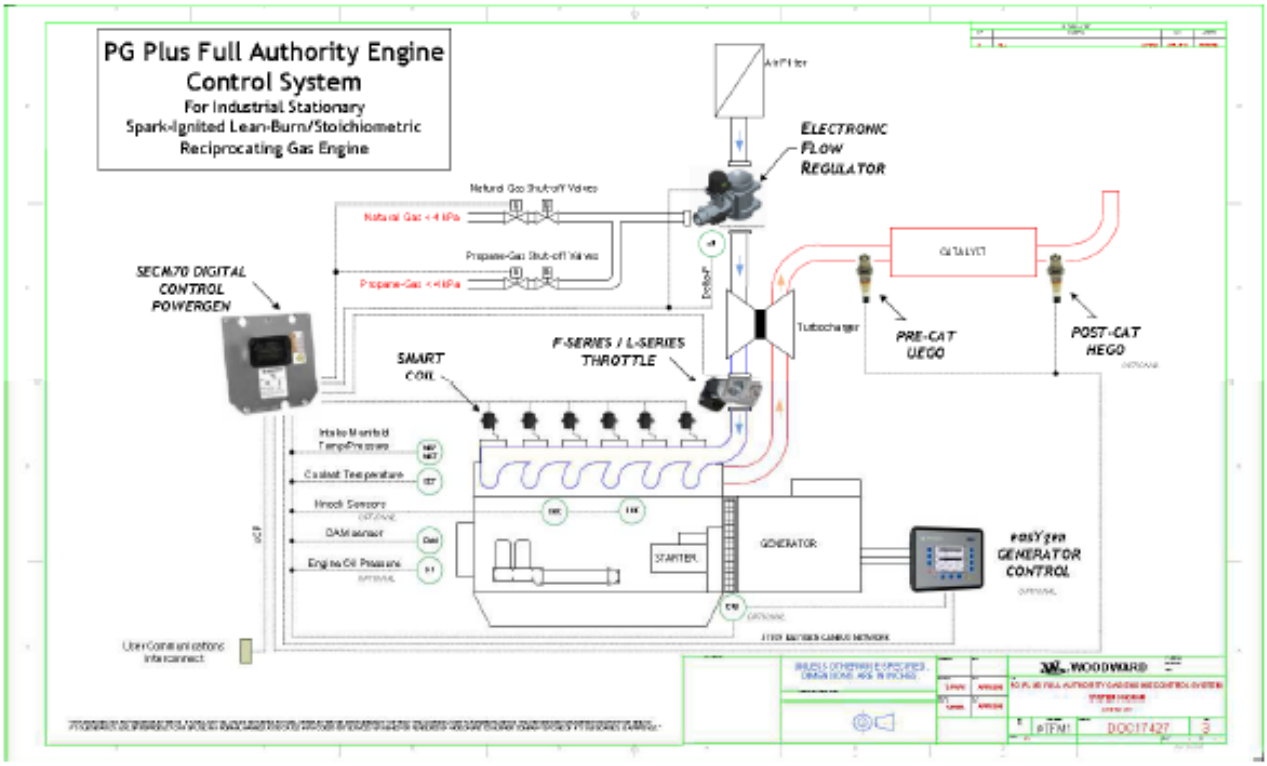


Figure 7. NG/LPG Bi-fuel Engine Control System for Arrow LSI Engines

Spark Plug Gap

Spark plug gap: 0.025 inch (0.635 mm)

Ignition timing is not adjustable.

Emissions-related Installation Checklist

NOTE: The emissions-related installation design is verified during the Application Review.

The Application Review must be completed prior to production release of the application to ensure durability and warranty consideration.

Table 2 is a checklist to use during the package design and final assembly of each production unit. Incorporate this checklist into your design and assembly processes.

	Emissions-related Installation Checklist	Page	Package Designer		Final Assembler	
			Yes	No	Yes	No
1	Engine speed within certified operating range	127				
2	Exhaust back pressure is acceptable (< 20 inches H_2O under all operating conditions)	127				
3	Exhaust band clamps installed and tightened	128				
4	Flexible coupling installed between the engine and silencer	128				
5	Pre-cat oxygen sensor in the top half of horizontal exhaust pipe	128				
6	Rain cap installed	128				
7	Can an 8-inch (20 cm) extension be easily added to the end of the exhaust pipe for in-field emissions testing?	128				
8	Threads of oxygen sensor lightly coated with O_2/sensor-safe antiseize compound (if not coated by sensor manufacturer)	128				
9	Engine and emissions labels installed and visible	130				
10	PCV system plumbed as specified	131				
11	MIL is installed, not red, labeled, and operable	132				
12	Specified air filter is installed	132				
13	Fuel supply configured per guidelines	133				
14	Fuel system is leak-tight	134				
15	Spark plug gap is per specification	136				

Table 2

Maintenance Schedule — Stationary Emergency

Maintenance Item	Weekly	6 months	250 hours or 1 year	2 years
Check air filter restriction indicator (if equipped). Clean filter if red.	X			
Check oil and coolant levels.	X			
Check belts for tension and condition.	X			
Check battery.	X			
Check fuel hoses and fittings for gas leakage.	X			
Inspect/drain volume tank/separator, if applicable.	X			
Clean/inspect/replace air filter.[1]			X	
Check hoses.		X		
Inspect/clean the PCV system.			X	
Check/adjust/replace spark plugs (gap 0.025-inch).			X	
Change oil and oil filter.[2]			X	
Check/adjust valve lash.			X	
Clean oil cooler (if equipped).			X	
Check antifreeze concentration.			X	
Inspect/replace fuel filter.			X	
Inspect NG fuel regulator.			X	
Inspect LPG primary vaporizer/regulator.			X	
Inspect fuel lock-off valve(s).			X	
Replace oxygen sensor.				X
Replace coolant.				X

[1] Perform sooner in dusty or extreme conditions.
[2] Oil sampling program recommended for proper oil change intervals.

DTC Fault Codes

SPN	Description	FMI	Fault	SFC
51	TPS Data Drift High	0	ThrottlePos_IR_Low	558
51	TPS Data Drift Low	1	ThrottlePos_IR_High	559
51	Throttle Fault	5	ThrottleValveDrive_Fault	556
98	Engine Oil Level	1	LowOilLevelFault	573
100	Oil Pressure Low	1	LowOilPressureFault	195
100	Oil Pressure Voltage High	3	OilPRangeHigh	192
100	Oil Pressure Voltage Low	4	OilPRangeLow	191
100	Oil Pressure Fault	15	OilPressureSensorFault	196
102	MAP Sticking	2	MAP_STICKING	345
102	MAP Voltage High	3	MAPRangeHigh	342
102	MAP Voltage Low	4	MAPRangeLow	341
102	MAP Data Drift High	20	MAP_IR_HI	343
102	MAP Data Drift Low	21	MAP_IR_LO	344
105	MAT Higher than Expected	0	MAT_High_Temp	233
105	MAT Voltage High	3	MATRangeHigh	231
105	MAT Voltage Low	4	MATRangeLow	232
110	ECT Over Heat Fault	0	ECTOverHeatFault	265
110	ECT Warmup Slower than Expected	1	ECT_WarmupSlower	266
110	ECT Voltage High	3	ECTRangeHigh	261
110	ECT Voltage Low	4	ECTRangeLow	262
110	ECT Insufficient Activity	10	ECT_IR_Fault	264
110	ECT Over Temp Fault	18	ECTOverTempFault	263
111	Engine Coolant Level	1	LowCoolantLevelFault	572
168	Battery Voltage Higher than Expected	0	SysVoltRangeHigh	165
168	Battery Voltage Lower than Expected	1	SysVoltRangeLow	166
168	DRVP Higher than Expected	20	DRVP_High	169
190	Engine OverSpeed	0	OverSpeed	429
629	CPU Load Higher than Expected	9	CPU_HighLoad	621
629	SRAM Memory Fault	11	SRAMFault	623
629	Flash Memeory Fault	31	FLASHFault	622

DTC Fault Codes

SPN	Description	FMI	Fault	SFC
632	Natural Gas Fuel LockOff Short Open Fault	5	NaturalGasLockOff_Fault	251
632	Low Fuel Pressure	7	LowFuelPressure	476
632	FuelShutOffStuckOpen	12	FuelShutOffStuckOpen	475
636	Crank Sensor Sync Fault	2	CrankSyncFault	423
636	Crank Sensor Other Fault	11	CrankFault	425
637	CAM Sensor Other Fault	11	CamFault	426
854	UEGO Heater Short to Battery Fault	3	UEGO_HtrShortToBattFault	452
854	UEGO Heater Short to GND Fault	4	UEGO_HtrShortToGNDFault	451
854	UEGO Htr Open Fault	5	UEGO_HtrOpenFault	463
854	UEGO Heater Temperature Control	7	UEGO_HtrControl	139
854	UEGO Heater Temperature LTE	16	UEGO_HtrLwrLimit	136
854	UEGO Heater Temperature HTE	18	UEGO_HtrUprLimit	137
970	External Shutdown	1	ExternalShutdownFault	571
1213	MIL Open / Short Fault	5	MIL_Fault	253
1268	Spark 1 Open Primary	5	Ign1OpenPrimary_Fault	842
1269	Spark 2 Open Primary	5	Ign2OpenPrimary_Fault	845
1270	Spark 3 Open Primary	5	Ign3OpenPrimary_Fault	848
1391	delta Pressure - Voltage High	3	deltaPRangeHigh	473
1391	delta Pressure - Voltage Low	4	deltaPRangeLow	474
1391	deltaP Higher than Expected	16	deltaP_HigherThanExpected	477
1391	deltaP Lower than Expected	18	deltaP_LowerThanExpected	478
1391	deltaP Zero Offset Fault	20	deltaP_ZeroOffsetFault	479
1442	EFR Valve Drive Fault	5	EFRValveDrive_Fault	635
1675	Starter Control Relay Fault	5	StarterCtrlRelay_Fault	653
1675	Auto Crank Attempt Failed	11	StarterCtrl_NoCrank_Fault	652
1675	Auto Crank Attempts Exceeded	12	StarterCtrl_NoStart_Fault	651
1695	Adaptive Learn Correction on Hi Limit	16	FuelAdaptRangeHi	471
1695	Adaptive Learn Correction on Lo Limit	18	FuelAdaptRangeLow	472
3056	UEGO IP Fault	0	UEGO_IPDiag	443

DTC Fault Codes

SPN	Description	FMI	Fault	SFC
3056	UEGO SNS Short to BATT Fault	3	UEGO_SNSShortToBattFault	455
3056	UEGO SNS Short to GND Fault	4	UEGO_SNSShortToGNDFault	454
3056	UEGO SNS Open Fault	5	UEGO_SNSOpenFault	453
3056	UEGO O2 Failed on Rich Side	16	UEGOO2FailedRich	466
3056	UEGO O2 Failed on Lean Side	18	UEGOO2FailedLean	465
3217	O2 Closed Loop Correction Fuel Multiplier On High Limit	16	O2CLCorrectionOnHighLimit	142
3217	O2 Closed Loop Correction Fuel Multiplier On Low Limit	18	O2CLCorrectionOnLowLimit	141
3509	XDRP (+5V) Voltage HTE	3	XDRPRangeHigh	161
3509	XDRP (+5V) Voltage LTE	4	XDRPRangeLow	162
516131	Propane Gas Fuel LockOff Short Open Fault	5	PropaneLockOff_Fault	252
520555	UEGO INRC Short to Batt Fault	3	UEGO_INRCShortToBattFault	458
520555	UEGO INRC Short to GND Fault	4	UEGO_INRCShortToGNDFault	457
520555	UEGO INRC Open Fault	5	UEGO_INRCOpenFault	456
520556	UEGO SR Short to BATT Fault	3	UEGO_SRShortToBattFault	462
520556	UEGO SR Short to GND Fault	4	UEGO_SRShortToGNDFault	461
520556	UEGO SR Open Fault	5	UEGO_SROpenFault	459
520700	TSC1 Message Time Out Fault	9	TSC1RxTimeoutFault	662

Engine Identification

Engine Part Number _____

Engine Serial Number _____

Engine Application _____

Purchased From _____

In-service Date _____

Engine Hours at Delivery _____

2024 Stationary Emergency Engine and Emissions Control Warranty Statement

ARROW ENGINE COMPANY U.S. EPA-CERTIFIED STATIONARY EMERGENCY LSI KP-SERIES LIMITED WARRANTY

The U.S. EPA and Arrow Engine Company (Arrow) are pleased to explain the emissions control system warranty on your 2024 Stationary Emergency certified engine. New off-road Large Spark-Ignition (LSI) engines must be designed, built and equipped to meet stringent Federal anti-smog standards. Arrow must warrant the emissions control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emissions control system may include parts such as the fuel mixer, regulator, ignition system, engine control module (ECM), sensors, wires, and air induction system. See below the complete Emissions Warranty Parts List.

STATIONARY EMERGENCY DEFINITION: The highest load and speed which can be applied, subject to Arrow Engine Company's ratings in effect at time of sale.

I. TERMS OF EXPRESS LIMITED WARRANTY

Arrow Engine Company warrants that it will repair or replace, at its election and expense, any part of an engine, or product (hereinafter referred to as "Products") manufactured by Arrow Engine Company, which proves to have had a defect in material or workmanship. There are no other warranties express or implied.

Arrow Engine Company (Arrow) warrants that your U.S. EPA-certified Large Spark-Ignited (LSI) engine, including the emissions control system, meets the following conditions:

1. The engine is designed, built, and equipped so that it conforms with the U.S. EPA emissions requirements for stationary emergency engines at the time of sale to you, the ultimate purchaser.

2. Your engine is free from defects in materials and workmanship that may keep it from meeting the U.S. EPA requirements for stationary emergency engines.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

Base Warranty Period

The engine's base warranty period is:

1. One year after the initial new Products start-up date; or

2. 18 months after the original shipment date of the covered Products by Arrow Engine Company.

General Emissions Warranty Period

The emissions warranty period is 2 years beginning on the date the engine or equipment is sold to the ultimate purchaser. If any emissions-related part on your engine is found to be defective during the warranty period, the part will be repaired or replaced by Arrow.

ARROW ENGINE COMPANY'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Arrow Engine Company shall be responsible for:

A. The repair or replacement, at Arrow Engine Company's election of covered defective parts and all reasonable labor required (at Arrow Engine Company's specified labor rates and repair times) regarding a warranted failure during the express limited warranty and term. All such labor shall be provided by Arrow Engine Company's authorized contractor or distributor.

B. Reasonable and necessary travel (total mileage not to exceed 300 miles) and documented expenses incurred by Arrow Engine Company's authorized contractor or distributor, at its sole discretion. For emissions warranty purposes, if the engine or equipment is located more than 100 mi from an Authorized Dealer or OEM, Arrow Engine Company will facilitate a service technician to come to the engine or equipment to make the warranty repair.

C. Replacement of lubricating oil, coolant, filter elements, or other normal maintenance items for the products that are contaminated and/or damaged as a direct result of a warranted failure.

NOTWITHSTANDING THE FOREGOING, ARROW ENGINE COMPANY SHALL NOT BE RESPONSIBLE FOR ADDITIONAL OR INCIDENTAL LABOR OR OTHER COSTS ASSOCIATED WITH WARRANTY CLAIMS.

III. OWNER/DISTRIBUTOR'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

A. As the certified LSI engine owner, you are responsible for the performance of the required maintenance listed in your Operations Manual. Arrow recommends that you retain all receipts covering maintenance of your certified engine, but Arrow cannot deny warranty solely for the lack of receipts or for failure to ensure the performance of all scheduled maintenance.

B. As the certified LSI engine owner, you should be aware that Arrow may deny your warranty coverage if your certified engine or a part has failed due to abuse, accidents, neglect, misuse, improper service or maintenance, wrong or contaminated fuel, use of any starting aid, improper cooling concentration or unapproved modifications.

C. Arrow engines are designed to operate on commercial grade LPG and pipeline-quality natural gas. Use of any other fuels may result in your engine package no longer operating in compliance with EPA emissions requirements and may void your warranty.

You are responsible for initiating the warranty process. Arrow suggests that you present your certified LSI engine to an Arrow Authorized Dealer or OEM as soon as any problem exists. The warranty repairs should be completed by the Dealer or OEM as expeditiously as possible. You may also contact Arrow Engine Company toll-free at (800) 331-3662 or email info@arrowengine.com to receive information about how to make a warranty claim and how to make arrangements for authorized repairs.

D. The operation and maintenance of the Products within the guidelines established by Arrow Engine Company.

E. Making the Products available to Arrow Engine Company's authorized contractors or distributors for any warranty repair, during normal business hours.

F. All additional costs incurred for premium or overtime labor, should owner request that repairs be made on a premium overtime schedule.

G. All costs incurred as the result of removal or reinstallation of the Products may be required to affect any warranted repair.

H. All administrative costs and expenses resulting from a warranted failure.

I. Any costs of transportation, towing, repair facilities, or associated costs.

J. Loss of revenue and loss of/or damage to real and/or personal property.

K. Compliance with all local, state and federal laws.

L. Warranted repairs not to exceed 50% of the product (Engine) replacement cost without prior approval from Arrow Engine Company. Replacement cost equates to distributor net price from Arrow Engine Company at time of sale.

IV. EMISSIONS-RELATED COMPONENTS LIST

Components covered under the 2-year Emissions Warranty:

- CAM Sensor
- Crank Sensor
- EFR Pressure Sensor
- Engine Coolant Temperature (ECT) Sensor
- Ignition Coil (each)
- Manifold Absolute Pressure/Intake Air Temp (TMAP) Sensor
- Positive Crankcase Ventilation (PCV) Valve
- Wide-range Oxygen Sensor
- Intake Manifold
- Exhaust Manifold
- Wiring Harness
- EFR Valve Assembly
- Electronic Throttle
- Engine Control Module
- Spark Plugs

V. LIMITATION OF ARROW ENGINE COMPANY'S OBLIGATIONS

The obligations of Arrow Engine Company under this express limited warranty shall be waived and voided, and Arrow Engine Company shall not, thereafter, be responsible for the following:

A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, use, installation, application, or maintenance practice not in accordance with guidelines or specifications established by Arrow Engine Company; or

B. Any failure resulting from unauthorized modifications or repairs of the Products; or

C. Any failure resulting from overload, overspeed, overheat, accident, improper storage; or

D. Failure of owner to promptly provide notice of a claimed defect–all warranty claims must be authorized, documented, and submitted within 30 days of the failure date while under the warranty period; or

E. Failure of Products for which Arrow Engine Company did not receive properly completed start-up reports; or

F. Repairs of a covered failure performed with non-genuine Arrow Engine Company parts; or

G. Repairs of a covered failure performed by nonauthorized contractors or distributors; or

H. Failure to make Products available to Arrow Engine Company or its authorized representatives; or

I. Failure to supply documents such as drawing and specifications relating to the specific application of the Products.

VI. APPLICABILITY AND EXPIRATION

The warranties set out above are extended to all owners in the original chain of distribution. The warranties and obligations of Arrow Engine Company shall expire and be of no further effect upon the dates of expiration of the applicable warranty periods.

The foregoing sets forth Arrow Engine Company's only obligations and owners exclusive remedy for breach of warranty, whether such claims are based on breach of contract, tort (including negligence and strict liability), or other theories, and the foregoing is expressly in lieu of other warranties whatsoever expressed, implied, and statutory, including without limitation, the IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Arrow Engine Company be liable for any direct, special, incidental or consequential damages (whether denominated in contract, tort, strict liability, negligence or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based no breach of contract, tort (including negligence and strict liability), or other theories must be commenced within one (1) year after the cause of action accrues or it shall be barred.

Preventive Maintenance Checklist

Engine S/N _____ PM Date _____ ECM Hours _____

PM Type _____ ☐ Hours
_____ ☐ Months/Years

Symbols ☑ PM Complete
☒ Needs Attention

Maintenance Item		Comments
Check air filter restriction indicator (if equipped). Clean filter if red.	☐	
Check oil and coolant levels.	☐	
Check belts for tension and condition.	☐	
Check battery.	☐	
Check fuel hoses and fittings for gas leakage.	☐	
Inspect/drain volume tank/separator.	☐	
Clean/inspect/replace air filter.	☐	
Check hoses.	☐	
Inspect/clean the PCV system.	☐	
Check/adjust/replace spark plugs (gap 0.025-inch).	☐	
Change oil and oil filter.	☐	
Check/adjust valve lash.	☐	
Clean oil cooler (if equipped).	☐	
Check antifreeze concentration.	☐	
Inspect/replace fuel filter.	☐	
Inspect NG fuel regulator (8–16 in H_2O at EFR intake).	☐	
Inspect LPG primary vaporizer/regulator (8–16 in H_2O AT EFR intake).	☐	
Inspect fuel lock-off valve(s).	☐	
Replace oxygen sensor.	☐	
Replace coolant.	☐	

Notes:

Preventive Maintenance Checklist

Engine S/N _____ PM Date _____ ECM Hours _____

PM Type _____ ☐ Hours
_____ ☐ Months/Years

Symbols ☑ PM Complete
☒ Needs Attention

Maintenance Item		Comments
Check air filter restriction indicator (if equipped). Clean filter if red.	☐	
Check oil and coolant levels.	☐	
Check belts for tension and condition.	☐	
Check battery.	☐	
Check fuel hoses and fittings for gas leakage.	☐	
Inspect/drain volume tank/separator.	☐	
Clean/inspect/replace air filter.	☐	
Check hoses.	☐	
Inspect/clean the PCV system.	☐	
Check/adjust/replace spark plugs (gap 0.025-inch).	☐	
Change oil and oil filter.	☐	
Check/adjust valve lash.	☐	
Clean oil cooler (if equipped).	☐	
Check antifreeze concentration.	☐	
Inspect/replace fuel filter.	☐	
Inspect NG fuel regulator (8–16 in H_2O at EFR intake).	☐	
Inspect LPG primary vaporizer/regulator (8–16 in H_2O AT EFR intake).	☐	
Inspect fuel lock-off valve(s).	☐	
Replace oxygen sensor.	☐	
Replace coolant.	☐	

Notes:

Preventive Maintenance Checklist

Engine S/N _____ PM Date _____ ECM Hours _____

PM Type _____ ☐ Hours
_____ ☐ Months/Years

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☒ Needs Attention

Maintenance Item		Comments
Check air filter restriction indicator (if equipped). Clean filter if red.	☐	
Check oil and coolant levels.	☐	
Check belts for tension and condition.	☐	
Check battery.	☐	
Check fuel hoses and fittings for gas leakage.	☐	
Inspect/drain volume tank/separator.	☐	
Clean/inspect/replace air filter.	☐	
Check hoses.	☐	
Inspect/clean the PCV system.	☐	
Check/adjust/replace spark plugs (gap 0.025-inch).	☐	
Change oil and oil filter.	☐	
Check/adjust valve lash.	☐	
Clean oil cooler (if equipped).	☐	
Check antifreeze concentration.	☐	
Inspect/replace fuel filter.	☐	
Inspect NG fuel regulator (8–16 in H_2O at EFR intake).	☐	
Inspect LPG primary vaporizer/regulator (8–16 in H_2O AT EFR intake).	☐	
Inspect fuel lock-off valve(s).	☐	
Replace oxygen sensor.	☐	
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Notes:

Maintenance Log — Stationary Emergency

PM Interval (Hours)	PM Date	ECM Hours	PM Comments	Performed By (Initials)
250				
500				
750				
1,000				
1,250				
1,500				
1,750				
2,000				
2,250				
2,500				
2,750				
3,000				

ENGINE / WIRE HARNESS

PART NUMBER KD15002

ON FOLLOWING PAGE

NOTES:

GENERAL WIRE COLOR FUNCTION
RED = CONSTANT +12 VOLTS
RED W / WHITE = SWITCHED +12 VOLTS
BLACK = 12 VOLT GROUND
ORANGE = SWITCHED +5 VOLTS SENSOR POWER
WHITE W / ORANGE = 5 VOLT SENSOR GROUND
BLACK W / WHITE = EXTERNAL FUNCTIONS

BOTTOM VIEW OF RELAY PLUG
MAIN, COIL, START

CONN DELPHI 12162825
TERM DELPHI 12161184

REAR VIEW ECM PLUG

REV	REVISION DESCRIPTION	BY	DATE	APPD	ECR	MOD	REF		

UNLESS OTHERWISE SPECIFIED
FRACTIONAL ± .015
ANGULAR MACH ± 1/2°
X ± .060
XX ± .030
XXX ± .010
SURFACE FINISH 125 AA
DIMENSIONS ARE IN INCHES
BREAK SHARP CORNERS .010-.030

ARROW ENGINE COMPANY
2301 EAST INDEPENDENCE
TULSA, OKLAHOMA 74110

TITLE: SCHEMATIC, MAIN HARNESS 3 CYL

DRAWN	MM	SCALE	NTS
CHKD	MV	ECR	9659
APPD	MV	DATE	06/16/22

SHEET 1 OF 1
SIZE D
DRAWING NUMBER KD15002

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ENGINES

A-SERIES	A32	A42	A54 A54E	A62 A62 Turbo A62 Genset
C-SERIES	C-46	C-66	C-96	C-106
KP-SERIES	KP3 KP3TA	KP4 KP4TA	KP6 KP6TA	KP8 KP8TA
VRD-SERIES	VRD30	VRD40	VRD60	VRD100

COMPRESSION PRODUCTS

Compressor Frames VRC-2 VRS-2 VRS-4	CNG Compressor Frames and Packages VRC-CNG	Vapor Recovery Units VRU-1 VRU-2	Gas Lift Packages Electric HP Gas Engine (VR, A-Series, CAT)	Custom Compression Packages

GAS PRODUCTS

Coalescers

REPLACEMENT PARTS

Waukesha	145G/F817	140G/F554	F18	H24	WAK/1197

ARROW ENGINE
ENGINES & COMPRESSION

ARROW ENGINE COMPANY
2301 E. Independence St., Tulsa, OK 74110
www.arrowengine.com

KP3-POM-JAN2024