ZENITH
POWER PRODUCTS

NAG416

Operator Manual

and Maintenance Log

Mobile & Stationary Industrial Engines

⚠ WARNING ⚠

This product may contain a chemical known to the state of California to cause cancer, or birth defects, or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

203626 Revision 9
December 21, 2023

⚠ California Prop 65 Warning

Engine exhaust from this product, some of its constituents, along with certain machine components contain or emit chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. In addition, certain fluids contained in the machine and certain products of component wear contain or emit chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

Service Parts

To ensure that your engine continues to run reliably and efficiently for as long as possible, use only genuine Zenith Power Products (ZPP) parts.

For genuine ZPP service parts for your engine, or for technical assistance in servicing your engine, call:

1-715-453-9317

Hours:

Monday - Friday: 8:00 - 4:00 Central Time

Maintenance Providers

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

Operators Manual & Maintenance Log Storage & Use

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

Disclaimer

All information and specifications in this manual are based on the latest data available at the time of the publication. Zenith Power Products reserves the right to make changes or improvements at any time without notice.

For additional information, see:
www.ZenithPP.com

U.S. EPA Legal Requirements

ZPP's NAG416 engine has been certified by the U.S. Environmental Protection Agency (EPA) for constant-speed mobile and stationary applications.

EPA requires that stationary engines remain in one location for one year or more, unless it is a seasonal engine, in which case it must remain in one location for a full season. If an engine does not meet EPA's definition of a stationary engine, it is then considered a mobile engine. As a guideline, engines with wheels under them (vehicles or trailers) are considered mobile engines; engines bolted to the ground are stationary, and engines on skids may be either mobile or stationary.

It is illegal to operate a constant-speed engine in a variable-speed (foot pedal speed control) application.

If your engine is used in a constant-speed mobile application, you must operate and maintain your engine as specified in this Operator's Manual to ensure emissions compliance.

If your engine is used in a constant-speed stationary application, the U.S. EPA requires you to do one of the following two options to ensure emissions compliance:

1. Operate and maintain your engine as specified in this Operator's 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 Operator's Manual, your engine will be considered a non-certified engine.

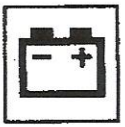
   In this case, you must:
   - Keep a maintenance plan and records of conducted maintenance.
   - To the extent practicable, maintain and operate the engine in a manner consistent with good air pollution control practice for minimizing emissions.

Per section 113 of the U.S. Clean Air Act, failure to abide by these legal requirements can result in fines up to $49,342 per day.

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

SAFETY SYMBOLS

This section identifies the ISO 8999 symbols that may be used in this manual.



Battery

Electrical hazards

Engine coolant fill level

Engine coolant temperature

Engine oil fill level

Engine oil pressure

Hot surface warning

Warning

Read the handbook

No Smoking or Flame

SAFETY PRECAUTIONS – STARTING

WARNING

Starting an engine incorrectly may cause injury to the operator and/or cause damage to the engine. Engine operators must be instructed in the correct procedures before attempting to start any engine.

Before Starting

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- Inspect the engine, intake, exhaust, cooling system, and drivetrain to verify that the engine is fully assembled and not in the process of being serviced.
- Ensure the engine is free to turn without obstruction.
- Check that all safety guards are in their correct position and secure.
- Check that the coolant level in the radiator overflow bottle is between "Add" and "Full".
- Check that the oil level on the dipstick is between "Add" and "Full".
- Check that the fuel supply is connected, shut-off valves are open, and there are no leaks.
- Verify that there is fuel in the gasoline tank or LPG cylinder.
- Check that the battery is connected and charged.
- When possible, disengage any driven equipment while starting.

SAFETY PRECAUTIONS – ELECTRICAL



The battery produces flammable and explosive hydrogen gas. The battery electrolyte contains poisonous and corrosive sulfuric acid. The precautions listed below must be followed to ensure operator safety.

- Do not smoke or allow any flame near the battery.
- With the engine stopped and the ignition switch in the OFF position, disconnect the negative battery cable from the battery before working on the engine.
- Be careful not to short circuit battery positive to ground with tools when working on the engine.
- Avoid getting battery electrolyte in your eyes or on your skin or clothes. If electrolyte gets in your eyes, flush with clean water immediately and get medical help. If electrolyte gets on your skin, wash immediately with soap and water, and get medical help if you feel pain or burning. Remove and wash any clothing that is exposed to electrolyte.
- Never remove any electrical cables while the battery is connected in the circuit.
- Be careful to not short-circuit or cross battery positive and negative.
- Never ‘flash’ any connection to check the current flow.
- The battery and alternator must be disconnected before commencing any electric welding when a pole strap is directly or indirectly connected to the engine.
- When charging the battery, only do a slow charge (5 A or less) and ensure there is good ventilation.

FUELS

Gasoline, Natural Gas and LPG are highly combustible fuels, and can be explosive if leaked and contained in a confined area. Keep cigarettes and all other flame sources away from these areas.

If you can hear or smell 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 a soapy water bubble mixture anytime a cylinder/tank is changed, or the fuel supply line is worked on. Fuel leaks should also be checked as part of the regular engine maintenance.

Depending on your engine and fuel system configuration, your engine is designed to run on natural gas, gasoline, and/or liquid LPG. The fuel requirements for each are discussed below. See the "SPECIFICATIONS" section for the required fuel supply pressures for each fuel.

Gasoline

In order to maintain emissions compliance and the engine warranty, use standard (87 octane) unleaded gasoline.

Natural Gas

Your engine is certified to run on "pipeline-quality natural gas". EPA defines pipeline-quality natural gas as being composed of at least 70% methane by volume or having a heating value of 950-1100 BTUs per cubic foot. In addition, pipeline-quality natural gas must be provided by a supplier through a pipeline. If your natural gas supply does not meet these specifications, your engine is considered to be being operated as a non-certified engine. See "U.S. EPA Legal Requirements" at the front of this manual.

LPG

In order to maintain emissions compliance and your engine warranty, use commercial-grade HD-10 or better LPG.

A liquid withdrawal system is recommended when there is insufficient LPG vapor generated in the storage tank to supply the engine sufficient fuel to maintain maximum power at the ambient temperature the engine is operating in. (see engine data sheet) In a liquid withdrawal system Liquid LPG is drawn off of the bottom side of a LPG tank and it remains a liquid until it has passed through the vaporizer/regulator, at which point it is vaporized to a gas. If you connect vapor LPG to a liquid LPG fuel system, you may starve the engine for fuel, causing it to produce low power and excessive emissions.

In a vapor withdrawal LPG system, LPG is drawn off of the top side of a LPG tank and is a gas from the tank through to the engine intake. If you connect liquid LPG to a vapor LPG fuel system the fuel will not vaporize properly, causing the engine to run rich, produce low power and excessive emissions.

STARTING, RUNNING, & STOPPING THE ENGINE

Observe the safety precautions listed in "SAFETY PRECAUTIONS - STARTING" before starting the engine.

Starting the engine

- Turn the key switch to the ON position and verify that the MIL is illuminated. If not determine why the lamp is not working.
- Turn the key switch to the START position and hold until the engine has started.
- Release the key promptly after the engine starts to avoid grinding the starter.
- Do not crank the engine for more than 15 seconds at a time.
- Allow at least 30 seconds between cranking attempts.
- If the engine does not start after 3 starting attempts, review the "Before Starting" checklist.

Running the engine

- Do not race or fully load the engine during the first 3 minutes of operation.
- Verify that the "CHECK ENGINE" light is off while the engine is running. If it is on, refer to the DIAGNOSTICS section.
- Verify that there are no fuel, coolant, or oil leaks while the engine is running. If there are leaks, stop the engine and fix them or have the engine serviced.
- Listen to the engine. If you hear an abnormal noise while the engine is running, turn it off and correct the problem or have the engine serviced.
- No adjustments are necessary to the fuel or ignition systems.

Stopping the engine

- If the engine has been running under load and is hot, run the engine at no load for 3 minutes to allow the engine to cool before stopping the engine.
- Stop the engine by turning the key switch to the OFF position. The engine may run-on for 1-5 seconds while the fuel is depleted from the carburetor and the air/fuel mixture is depleted from the intake manifold.

ENGINE MAINTENANCE

You should properly maintain your engine for the following reasons.

- You are legally required to maintain your engine as instructed in the Operators Manual to ensure emissions compliance. See "U.S. EPA Legal Requirements" at the front of this manual.

- Your engine warranty will be void if the engine is not properly maintained.

- Keeping your engine properly maintained will ensure the best engine life, power, and fuel economy.

Scheduled Maintenance

A schedule of the required engine maintenance tasks is listed on the following page. The scheduled maintenance should be performed when the engine reaches the specified operating hours or the specified months have elapsed, whichever comes first.

Daily Maintenance

In addition to the scheduled maintenance, daily checks are required to keep your engine running properly. These checks are listed in the "SAFETY PRECAUTIONS - STARTING" and "STARTING, RUNNING, & STOPPING THE ENGINE" sections.

Maintenance Log

Keep a record of your engine's scheduled maintenance in the Maintenance Log at the back of this manual.

WHEN USING THE ENGINE ONLY DURING A PARTICULAR PERIOD OF THE YEAR

When the engine is to be used only in a particular period of the year, such as summer or winter, the service life of the engine will be determined by how it is maintained during the out-of-use period. Follow the procedures below when preparing the engine.

During in-use period

Follow the normal handling procedures during this period.

During out-of-use period

During the out-of-use period, perform the following maintenance procedures for the engine.

1. Perform loaded operation once a month.
    - Run the engine and perform basic engine checks.
    - Apply a load in excess of 50% of the rated load to the engine, and operate it for more than 10 minutes. Make sure that no abnormal noise or vibration is produced.
2. Perform the following inspection and adjustment before placing the engine in use period.
    - Drain sediment from the fuel system (fuel filter and fuel tank).
    - Change engine oil and oil filter element.
    - Check and adjust fan belt tension.
    - Check battery electrolyte level and specific gravity.
    - Change air cleaner element.
    -  Check antifreeze protection and level.

ZPP-416G LSI ENGINE AND EFI

This table lists the periodic maintenance required to ensure quality performance and good

Periodic maintenance should be performed after specified intervals have elapsed in months or hours, whichever comes first	Months Hours	1 250	2 500	3 750	4 1000	5 1250	6 1500
Drive belt tension (A)		I	I	I	I	I	I
Valve Clearance (C)							I
Intake and Exhaust manifold nuts		T					
Radiator Core (D)	(A)			C			C
Engine oil (A)	(A)	R	R	R	R	R	R
Oil Filter (A)	(A)	R	R	R	R	R	R
Engine coolant (A)							
Fuel Filter (If Equipped) (D)					R		
Air cleaner element (D)	(A)	I	I	I	I	I	I
Spark Plugs							
PCV valve	(A)				I		
PCV hoses					I		
Check fuel supply & return lines for leaks (B)				I			I

ADDITIONAL MAINTENANCE

1. Fuel line supply and connectors portion for gas leakage	(B)	I	I	I	I	I	I
2. Fuel line supply and connectors for damage	(B)	I	I	I	I	I	I
3. LPG filter				I/R			I/R
4. Vaporizer/Regulator Plug (oil contamination)				I/D			
5. LPG lock-off				I			

Notes:
A) Under heavy duty operating condition, more frequent maintenance may be necessary
B) At time of LPG cylinder replacement, inspect tank connections for leakage with soapy water.
C) See "Valve Clearance" under Engine Specifications.
D) In certain severe environmental conditions, more frequent maintenance is required

Abbreviations:
I = Inspection
R= Replace
A= Adjust
C= Clean
D= Drain
T= Retighten

*See Valve Clearance Inspection procedure page 53

MAINTENANCE SCHEDULE

mechanical condition of the engine, fuel system, and catalytic converter in your application.

7 1750	8 2000	9 2250	10 2500	11 2750	12 3000	13 3250	14 3500	15 3750	16 4000	17 4250	18 4500	19 4750	20 5000
I	I	I	I	I	I	I	I	I	I	I	I	I	I
					I/A						I/A		
	T								T				
		C			C			C			C		
R	R	R	R	R	R	R	R	R	R	R	R	R	R
R	R	R	R	R	R	R	R	R	R	R	R	R	R
			R										R
	R				R				R				R
I	I	I	I	I	I/R	I	I	I	I	I	I	I	I
			R										R
	I				I				I				I
	I				I				I				I
		I			I			I			I		

REQUIREMENTS FOR LPG FUEL SYSTEM

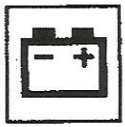
I	I	I	I	I	I	I	I	I	I	I	I	I	I
I	I	I	I	I	I	I	I	I	I	I	I	I	I
		R			I/R			I/R			R		
	I/D				I/D				I/D				
	I/D				I				I				

AIR FILTER

Inspection

1. Remove air filter element from enclosure.
2. Tap filter to knock off loose dirt.
3. Visually check filter.
4. If filter is clean, reinstall old filter.
   If filter is dirty, replace with a new filter.

BATTERY



The battery produces flammable and explosive hydrogen gas. The battery electrolyte contains poisonous and corrosive sulfuric acid. Review the safety precautions in "SAFETY PRECAUTIONS - ELECTRICAL" before working on the battery.

Battery Specifications	
Nominal Voltage:	12 V
Cranking Amps:	675
Cold Cranking Amps:	550
Amp Hours (Ah):	52
Battery voltage during alternator charging:	14.0 -15.0 V
Fully charged battery with key off @ 20 C (68 F):	12.5 -13.0 V
Half charged battery with key off @ 20 C (68 F):	12.0 - 12.5 V
Discharged battery with key off @ 20 C (68 F):	less than 12.0 V

Battery electrolyte inspection

1. Check electrolyte level.
2. If low, top off with distilled water. Do not overfill.

Battery corrosion inspection

Check battery posts and clamps for corrosion.

1. If corroded, remove negative cable first, then positive.
2. Clean both posts and both clamps with a small wire brush.
3. Reconnect cables, positive cable first.

If the engine is cranking slowly or not at all:

1. Remove the battery negative lead from the battery.
2. Remove the positive lead from the battery.
3. Clean the battery posts and cables with a small wire brush.
4. Replace leads, positive lead first.

If the engine is still cranking slowly or not at all:

1. Remove the battery negative leads.
2. Recharge the battery in a well-ventilated area.
3. Reinstall the battery.

If the engine is still cranking slowly or not at all:

Replace the battery.

ENGINE COOLANT, RADIATOR, AND COOLING SYSTEM



To avoid being scalded or burned, never remove the radiator cap unless the engine is off, and coolant has fully cooled. The coolant in the radiator is pressurized when hot and may boil over when the radiator cap is loosened.

When using antifreeze coolant, mix the antifreeze coolant with water, observing instructions attached to antifreeze container. Use only antifreeze approved for aluminum components in a 50/50 mixture ratio.

Clean radiator outside

Clean outside of radiator with dry compressed air.

Inspect cooling system, hoses and connections

Check hoses and fittings for loose connections or for any sign of oil deterioration or soft spots in the hoses. Retighten connections or replace hoses if needed.

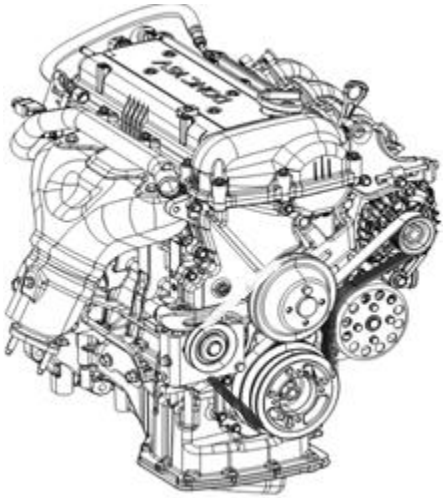
Check coolant level. If low, top off coolant with a premixed 50/50 mixture of antifreeze and water.

Engine Coolant Replacement

1. Open overflow bottle cap.
2. Drain old coolant.
3. Flush system with fresh, clean water.
4. Slowly refill system with premixed 50/50 antifreeze/water mixture.
5. Idle engine with radiator cap off to allow air to escape.
6. Top off coolant in overflow bottle if needed.
7. Stop engine.
8. Replace radiator cap and close overflow bottle cap.

DRIVE BELT

416G Belt P/N: 25212 2B030 (Serpentine)
203600 (V-Belt, if equipped with cooling fan)



Inspection

Check the belt for visible cracks, missing chunks, and fraying. Small cracks on the inside of the belt are OK. Replace the belt if cracks are visible on the outside of the belt, chunks are missing from the inside of the belt, or the belt is frayed.

Belt Tension

Measure the belt tension midway between the alternator and water pump pulley as specified by the arrow in the left figure above. Use a tensioning tool such as the one shown in the right figure above (OTC 6673LG or equivalent).

Deflection:

A second method of measuring belt tension is to apply a force of 98N (10kg, 22lb), and measure the deflection between the alternator and water pump pulley.

DEFLECTION	
New belt:	0.13 in. to 0.15 in.
Used belt	0.17 in. to 0.19 in.

Adjust the belt if tension is not as specified.

DRIVE BELT – CONTINUED

NOTE:
"New belt" *refers to a belt which has been used less than 5 minutes on a running engine.*

"Used belt" *refers to a belt which has been used on a running engine for 5 minutes or more. After installing a belt, check that it fits properly in the ribbed grooves. Check with your hand to confirm that the belt has not slipped out of the groove on the bottom of the pulley. After installing a new belt, run the engine for about 5 minutes and recheck the belt tension.*

Belt Replacement

1. Release all tension from the old belt.
2. Remove the old belt.
3. Install the new belt.
4. Apply tension to the belt as specified in "Belt Tension".
5. Recheck tension after 25-50 hours of operation.

* Consult with ZPP for proper application

ELECTRICAL CONNECTIONS

1. Visually inspect the electrical connections in the wiring harness for loose connections.

2. If you see a loose connection, or suspect a loose connection for other reasons, take the connection apart.

3. Visually inspect the pins in the male connector and the sockets in the female connector.

4. If any pins or sockets are bent, recessed, or corroded, repair the connector.

5. Remake the connection. Verify that the connection is fully made and is snug and secure.

ENGINE OIL AND FILTER REPLACEMENT

Filter:	26300-35503
Oil Grade:	See “SELECTION OF ENGINE OIL”
API Certification:	SJ or later
Oil Capacity (with filter):	3.49 qt (3.3 Liter)

DRAIN THE ENGINE OIL

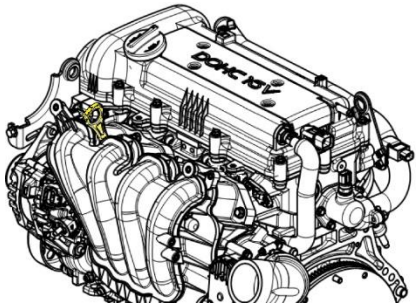
1. Remove the oil filler cap.
2. Remove the oil drain plug and drain the oil into a container.

REPLACE THE OIL FILTER

1. Remove the oil filter.
2. Check and clean the oil filter installation surface.
3. Check that the part number of the new oil filter is correct.
4. Apply clean engine oil to the gasket of the new oil filter and screw on until finger tight.
5. Tighten it an additional ¾ turn.

REFILL WITH ENGINE OIL

1. Clean and install the oil drain plug with a new gasket.
2. Fill with fresh engine oil. Do not overfill.
3. Install the oil filler cap.
4. Start engine and check for oil leaks.
5. Recheck the engine oil level.



Dispose of used oil at your local oil recycling center.

INSPECTION

1. Check the engine oil quality. Check for oil deterioration, entry of water, discoloring or thinning. If the quality is visibly poor, replace the oil.

2. Check the engine oil level. After warming up the engine for five minutes, stop the engine and check the oil level. The level should be between the “L” and “F” marks on the dipstick. If low, check for oil leakage and add oil up to the “F” mark on the dipstick.

NOTE:
Do not fill with engine oil above the "F" mark.

CAUTION
Do not use non-detergent or straight mineral oil when adding or changing crankcase lubricant. Engine failure can result.

SELECTION OF ENGINE OIL

API SERVICE GRADE CERTIFIED

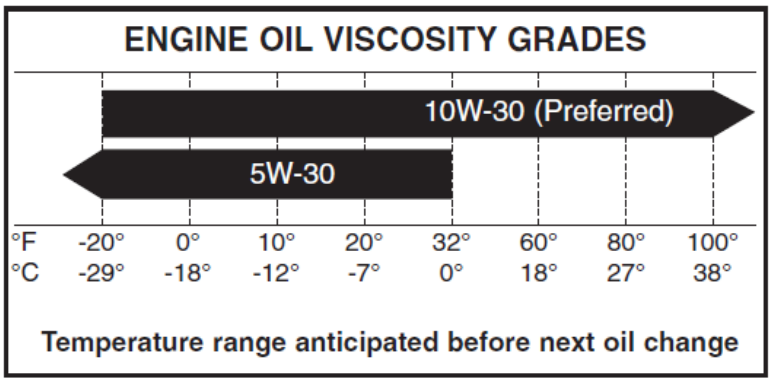
Use engine oil that is API Service Grade Certified. Standard engine oil identification notations have been adapted to aid in the proper selection of engine oil. The identifying notations are located on the label of engine oil plastic bottles and the top of engine oil cans.

API recommendation: SJ or above

NOTE: This applies to all automotive/industrial applications regardless of the fuel selection, i.e., gasoline, LPG or natural gas.

SAE VISCOSITY

An SAE viscosity grade is used to specify the viscosity of engine oil. **SAE 10W-30** specifies multiple viscosity engine oil. When choosing engine oil, consider the range of temperatures the vehicle will be operated in before the next oil change. Select engine oil that is best suited to your area's particular ambient temperature range and variation.



Temperature/Engine Oil Viscosity

CHECKING FOR FUEL LEAKS

LPG is a combustible gas and can be explosive if leaked and contained in a confined area. Keep cigarettes and all other flame sources away from these areas.

Inspection

1. If you see, smell, or 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 detectible leaks, start the engine.

3. For LPG fuel systems, check the entire fuel supply line from the source to the engine with a soapy water mixture. A stream of bubbles indicates leak sources.

4. Tighten fittings and clamps as needed to eliminate slow leaks.

5. If any fuel line components (hoses, pipe, fittings, etc.) need to 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.

NATURAL GAS & LPG FUEL LOCK-OFF VALVES

ZPP recommends the following fuel lock-offs for 416 liquid LPG (mobile) engines, and vapor propane and natural gas stationary engines.

Vapor Propane and NG: 201469
Liquid LPG: 200842

The fuel lock-off valve is located between the regulator/vaporizer and the fuel supply. The Engine Control Module (ECM) opens the fuel lock-off when the ECM detects engine speed from the CRANK sensor during cranking. The ECM turns off the fuel lock-off when the key switch is turned off or the ECM shuts down the engine for low oil pressure or engine overheat.

The fuel lock-off can sometimes "gum up" due to fuel deposits in the lock-off. The procedure below will verify if the lock-off is opening and closing correctly.

Inspection

1. Turn off the engine.

2. Disconnect the fuel lock-off positive and negative wires from the wiring harness.

3. Apply 12 VDC across the lock-off.

4. You should hear the valve open immediately when 12 V is applied and hear the valve close immediately when 12 V is removed. This indicates that the valve is moving freely.

If you cannot hear the valve open and close, replace the valve.

PRE-CAT AND POST-CAT OXYGEN SENSORS

ZPP Part Numbers:

Pre-Cat Sensor: 201280
Post-Cat Sensor: 201280

Sensor Locations:

The 416 pre-cat oxygen sensor is located at the outlet of the exhaust manifold.

The post-cat oxygen sensor is located in the outlet of the catalyst.

SPARK PLUGS & WIRES

Ignition System Part Specifications	
Spark plugs	Champion: RER8MC or NGK: LZKR6B-10E
Spark plug gap	0.030 ~ 0.040 inches .80 ~ 1.0 mm
Spark plug wires	N/A

Spark plug inspection

1. Remove one plug from each bank.
2. Inspect plugs for fouling and erosion.
3. Clean or replace plugs if needed.

Ignition wires inspection

1. Visually check ignition wires.
   - Look for spark arcing while the engine is running.
   - Check for cracks in the wire insulation.

2. If arcing and/or cracked insulation is evident, replace the complete set of ignition wires.

DIAGNOSTICS

How to manage and retrieve fault codes

The Engine Control Module (ECM) uses fault codes to identify and report control system faults. The ECM has three ways of reporting fault codes to the service technician. Each method uses a unique fault code format.

#	Device	Code Format
2	J1939 CAN (Controller Area Network) Link	SPN & FMI codes
3	PC Service Tool	DTC codes

Each fault has a unique set of codes and an associated diagnostic procedure. Each fault and its associated codes are listed in the "Fault Code List" following this section.

If the MIL is on while the engine is running, the operator is advised to have the engine serviced as soon as possible. Continuing to operate the engine with a fault condition may lead to engine and/or catalyst damage.

The ECM will automatically clear a fault code from its memory if the engine completes 20 consecutive start-run-stop cycles without the fault recurring.

Malfunction Indicator Lamp (MIL)

The MIL, or Check Engine lamp, is a light on the engine control panel. The MIL is usually yellow, amber, or orange.

As a bulb check, the ECM turns on the MIL when the ignition key is on, and the engine is not running. If the MIL is off during this condition, check for a burned-out bulb or wiring problem.

If the engine is running and the MIL is off, there are no current or recent faults to report.

DIAGNOSTICS - CONTINUED

If the MIL is on while the engine is running, the ECM has a fault to report. The MIL will stay on for 3 start-stop cycles after a fault is detected. The MIL will turn off on the 4th cycle if the fault has not recurred during the previous 3 cycles.

J1939 CAN Link

The ECM reports faults over the J1939 CAN link. If the engine is equipped with a CAN monitor or the technician has access to a handheld CAN reader, the technician can retrieve the fault codes from the CAN link.

The J1939 CAN standard uniquely defines each fault using a Suspect Parameter Number (SPN) and a Failure Mode Indicator (FMI).

PC Service Tool

The “4G Display” PC service tool reports a unique Diagnostic Trouble Code (DTC) and a text fault message for each fault.

The PC service tool also displays the values read from each sensor both in terms of the signal voltage/frequency and the engineering units (kPa, degrees C, etc.) which is helpful for diagnosing signal faults.

The PC service tool also allows the service technician to clear the fault codes.

Fault Code List

Diagnostic Trouble Code (DTC)	Fault Description	CAN SPN	CAN FMI	MIL Flash Code
	Leader/Trailer Code			111
0006	Lockoff open / ground short	632	4	6
0007	Lockoff short to power	632	3	7
0016	CRANK or CAM could not synchronize during start	636	8	216
0107	MAP signal low or shorted to ground	106	4	127
0108	MAP signal high	106	16	128
0112	IAT signal Low/Shorted to GND	105	4	112
0113	IAT signal High/Open	105	3	113
0116	ECT higher than warning threshold	110	15	116
0117	ECT Sensor Low/Shorted Input	110	4	117
0118	ECT Sensor High/Open Input	110	3	118
0120	TPS 1-2 voltage difference lower than expected	51	1	120
0121	TPS 1-2 voltage difference higher than expected	51	0	121
0122	Throttle Position Signal 1 low voltage	51	4	122
0123	Throttle Position Signal 1 high voltage	51	3	123
0134	Pre-Cat O2 Signal No Activity	724	10	134
0135	Front O2 sensor heater control fault	724	14	135
0151	Closed-loop LPG A/F correction exceeded lean limit	520206	0	151
0152	Closed-loop LPG A/F correction exceeded rich limit	520206	1	152
0153	Closed-loop NG A/F correction exceeded lean limit	520206	0	153
0154	Post-Cat O2 Signal No Activity	520208	10	154
0155	Closed-loop gasoline A/F correction exceeded lean limit	520204	0	155
0156	Closed-loop gasoline A/F correction exceeded rich limit	520204	1	156
0159	Closed-loop NG A/F correction exceeded rich limit	520206	1	159
0161	Adaptive LPG A/F correction exceeded lean limit	520202	0	161
0162	Adaptive LPG A/F correction exceeded rich limit	520202	1	162
0163	Adaptive NG A/F correction exceeded lean limit	520202	0	163
0164	Adaptive NG A/F correction exceeded rich limit	520202	1	164
0165	Catalyst inactive on LPG	520213	10	165
0166	Catalyst inactive on NG	520214	10	166
0171	Adaptive gasoline A/F correction exceeded lean limit	520200	0	171
0172	Adaptive gasoline A/F correction exceeded rich limit	520200	1	172
0182	Gasoline Fuel Temp Low Voltage	174	4	182
0183	Gasoline Fuel Temp High Voltage	174	3	183
0187	LPG Fuel Temp Low Voltage	520240	4	187
0188	LPG Fuel Temp High Voltage	520240	3	188
0211	Target TPS Lower than Actual			211
0212	Target TPS Higher than Actual			212
0217	ECT higher than engine shutdown threshold	110	0	217
0219	Engine Overspeed Condition	515	15	219

Fault Code List – Continued

Diagnostic Trouble Code (DTC)	Fault Description	CAN SPN	CAN FMI	MIL Flash Code
0221	TPS1 voltage higher than TPS2 voltage	51	0	221
0222	Throttle Position Signal 2 low voltage	520251	4	222
0223	Throttle Position Signal 2 high voltage	520251	3	223
0261	Injector 1 Low/Open	651	5	261
0262	Injector 1 High/Short	651	6	262
0264	Injector 2 Low/Open	652	5	264
0265	Injector 2 High/Short	652	6	265
0267	Injector 3 Low/Open	653	5	267
0268	Injector 3 High/Short	653	6	268
0270	Injector 4 Low/Open	654	5	269
0271	Injector 4 High/Short	654	6	271
0273	Injector 5 Low/Open	655	5	273
0274	Injector 5 High/Short	655	6	274
0276	Injector 6 Low/Open	656	5	276
0277	Injector 6 High/Short	656	6	277
0287	Gasoline Fuel Pressure too low	94	1	287
0288	Gasoline Fuel Pressure too high	94	0	288
0291	Gasoline Fuel Pressure low voltage	94	4	291
0292	Gasoline Fuel Pressure high voltage	94	3	292
0315	FPP1 higher than IVS limit			315
0325	Knock Retard at Limit	731	15	325
0326	Knock1/2 excessive signa	731	2	326
0327	Knock1/2 sensor open	731	4	327
0335	CRANK Sync Loss	636	4	335
0336	CRANK signal noise	636	2	336
0337	No CRANK signal	636	4	337
0339	FPP1 lower than IVS limit			339
0341	CAM signal noise	723	2	341
0342	No CAM signal	723	4	342
0359	Fuel (LPG or NG) run-out longer than expected	0	31	359
0411	Primary Loop Open or Low-Side Short to Ground	1268	5	411
0412	Primary Coil Shorted	1268	6	412
0421	Catalyst inactive on gasoline	520211	10	421
0524	Engine Oil Pressure Too Low	100	1	524
0562	Battery Voltage Low	168	17	562
0563	Battery Voltage High	168	15	563
0601	Microprocessor failure - FLASH	628	13	621
0604	Microprocessor failure - RAM	630	12	624
0606	Microprocessor failure - COP	629	31	626
0615	Starter relay coil open	1321	5	615

Fault Code List – Continued

Diagnostic Trouble Code (DTC)	Fault Description	CAN SPN	CAN FMI	MIL Flash Code
0616	Starter relay control short to GND	1321	4	616
0617	Starter relay coil short to 12V	1321	3	617
0627	Gasoline fuel pump relay control wire open	1348	5	627
0628	Gasoline fuel pump relay control wire short to ground	1348	4	628
0629	Gasoline fuel pump relay control wire short to 12 V	1348	3	629
0637	Pin 85 (AUX_PWM4) open/short to GND	700	5	637
0642	5V Reference #1 voltage low	1079	4	642
0643	5V reference #1 voltage high	1079	3	643
0644	MIL control ground short	1213	4	644
0645	MIL control short to power	1213	3	645
0650	Malfunction Indicator Lamp open	1213	5	651
0652	5V Reference #2 voltage low	1080	4	652
0653	5V Reference #2 voltage high	1080	3	653
0685	Power relay coil open	1485	5	685
0686	Power relay short to GND	1485	4	686
0687	Power relay short to 12V	1485	3	687
1087	Secondary fuel pressure low	94	1	1087
1088	Secondary fuel pressure high	94	0	1088
1153	NG Closed-loop: A/F is too lean	520207	0	153
1154	NG Closed-loop: A/F is too rich	520207	1	159
1161	LPG Adaptive-learn: A/F is too lean	520202	0	161
1162	LPG Adaptive-learn: A/F is too rich	520202	1	162
1163	NG Adaptive-learn: A/F is too lean	520203	0	163
1164	NG Adaptive-learn: A/F is too rich	520203	1	164
1171	EPR delivery pressure higher than expected	520260	0	371
1172	EPR delivery pressure lower than expected	520260	1	372
1173	EPR-ECU communications lost	520260	31	173
1174	EPR voltage supply high	520260	3	174
1175	EPR voltage supply low	520260	4	175
1176	EPR internal actuator fault detected	520260	12	176
1177	EPR internal circuitry fault detected	520260	12	177
1178	EPR internal communications fault detected	520260	12	178
1271	EPR secondary pressure higher than expected	520261	0	1271
1272	EPR secondary pressure lower than expected	520261	1	1272
1273	EPR secondary comm lost	520261	31	1273
1274	EPR secondary voltage supply high	520261	3	1274
1275	EPR secondary voltage supply low	520261	4	1275
1276	EPR secondary internal actuator fault	520261	12	1276
1277	EPR secondary internal circuitry fault	520261	12	1277
1278	EPR secondary internal comm fault	520261	12	1278

Fault Code List – Continued

Diagnostic Trouble Code (DTC)	Fault Description	CAN SPN	CAN FMI	MIL Flash Code
1351	Spark Plug or Coil Failure	1268	11	1351
1515	AUX 5V ANALOG INPUT 4 open or high	520215	3	515
1516	AUX 5V ANALOG INPUT 4 low	520215	4	516
1517	AUX 5V ANALOG INPUT 3 open or high	520218	3	517
1518	AUX 5V ANALOG INPUT 3 low	520218	3	518
1541	AUX 5V ANALOG INPUT 1 high / Low Coolant Shutdown (On units Equipped)	520219	3	541
1542	AUX 5V ANALOG INPUT 1 low or open	520219	4	542
1543	AUX 5V ANALOG INPUT 2 high or open	520220	3	543
1544	AUX 5V ANALOG INPUT 2 low	520220	4	544
1551	AUX DIGITAL INPUT 1 high	520222	4	551
1552	AUX DIGITAL INPUT 1 low	520222	3	552
1553	AUX DIGITAL INPUT 2 high	520223	3	553
1554	AUX DIGITAL INPUT 2 low	520223	4	554
1555	AUX DIGITAL INPUT 3 high	520224	3	555
1556	AUX DIGITAL INPUT 3 low	520224	4	556
1563	AUX 5V ANALOG INPUT 5 open or high	TBD	TBD	563
1564	AUX 5V ANALOG INPUT 5 low	TBD	TBD	564
1601	Envirotech receipt lost	4490	18	1601
1612	Watchdog processor blocked outputs (RTI 1)	629	31	712
1613	Microprocessor failure - RTI 2	629	31	713
1614	Microprocessor failure - RTI 3	629	31	714
1615	Microprocessor failure - A/D	629	31	715
1616	Microprocessor failure - Interrupt	629	31	716
1644	MIL control short to GND	1213	4	644
1645	MIL control short to 12V	1213	3	645
1673	Calibration Configuration Error	1634	13	1673
1674	Hardware ID Failure	1634	2	1674

SPECIFICATIONS

Component	Part Number or Specification
Air Filter:	202457
Drive belt:	25212 2B030 (Serpentine) 203600 (V-Belt, if equipped with cooling fan)
Battery:	12 V, 675 Cranking Amps, 550 Cold Cranking Amps 52 Amp Hours
Oil:	See “ENGINE OIL AND FILTER REPLACEMENT”
Oil Filter:	26300-35503
Pre-Cat Oxygen Sensor:	201280
Post-Cat Oxygen Sensor:	201280
Spark Plugs:	Champion: RER8MC NGK: LZKR6B-10E
Spark Plug Gap:	0.030 ~ 0.040 inches 0.80 ~ 1.0 mm
Valve Clearance: *(Engine coolant temperature: 20°C [68°F])*	Intake: 0.17 - 0.23mm (0.0067 - 0.0091in.) Exhaust: 0.22 - 0.28mm (0.0087 - 0.0110in.)
Recommended Liquid LPG Lock-Off Valve:	Vapor Propane and NG: 201469 Liquid LPG: 200842

* Check with ZPP for proper application

EMISSION CONTROL WARRANTY STATEMENT FOR ZPP ENGINES

YOUR WARRANTY RIGHTS AND OBLIGATIONS

Zenith Power Products LLC (ZPP) is pleased to explain the **emission control system warranty** on your **2024 model year emission certified ZPP** engine. This emissions warranty statement applies to all of ZPP's certified engines.

New off-road Large Spark-Ignition (LSI) engines must be designed, built and equipped to meet Federal stringent anti-smog standards. ZPP must warrant the emission control system on your engine for the periods of time listed below provided there has been no abuse, or improper maintenance of your engine.

Your emission control system may include parts such as the carburetor, regulator or fuel injection system, ignition system, engine computer unit (ECM), catalytic converter and air induction system. Also included may be sensors and other emission-related assemblies. See below the complete Emissions Warranty Parts List.

Where a warrantable condition exists, ZPP will repair your LSI engine at no cost to you including diagnosis, parts and labor.

MANUFACTURER'S WARRANTY COVERAGE

The warranty period begins on the date the engine or equipment is placed into service. Operating hours will be determined by the Engine Control Module's (ECM's) internal hour meter. If any emission-related part on your engine is defective, the part will be repaired or replaced by ZPP.

Base Warranty Period

Rating	***Months***	***Hours***
Stationary and Constant Speed Mobile	**12**	**2500**
Variable Speed Mobile	**24**	**2000**

- ***Stationary or Constant Speed Mobile-*** Means compressor applications, irrigation applications, or generator sets operating at a constant fixed speed.

- ***Variable Speed Mobile Applications-*** Means foot-pedal controlled equipment such as ground support vehicles.

EMISSION CONTROL WARRANTY STATEMENT (continued)

Standard Emissions-Related Components
3 (three) years or 2,500 hours, whichever comes first, for standard emissions-related components.
See “Standard Emissions Parts” list.

High-Cost Emissions-Related Components:
5 (five) years or 3,500 hours, whichever occurs first, for “high-cost” components.
See “High-Cost Emissions Parts” list.

OWNER’S WARRANTY RESPONSIBILITIES:

a) As the off-road LSI engine owner, you are responsible for the performance of the required maintenance listed in your Owner’s Manual. ZPP recommends that you retain all receipts covering maintenance of your off-road engine, but ZPP cannot deny warranty solely for the lack of receipts or for failure to ensure the performance of all scheduled maintenance.

b) As the off-road LSI engine owner, you should however be aware that ZPP may deny your warranty coverage if your off-road 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) Your engine is designed to operate on unleaded gasoline, LPG or pipeline-quality natural gas only. Use of other fuels may result in your engine package no longer operating in compliance with EPA and CARB emissions requirements.

d) You are responsible for initiating the warranty process. EPA and CARB suggest that you present your off-road LSI engine to ZPP or a ZPP-authorized agent as soon as any problem exists. The warranty repairs should be completed by ZPP or a ZPP-authorized agent as expeditiously as possible.

If you have any questions regarding your warranty rights or responsibilities, contact Zenith Power Products LLC at 715-453-9317 or at www.ZenithPP.com.

EMISSION CONTROL WARRANTY STATEMENT (continued)

ZPP's warranty on emissions-related parts is specified as follows:

1) Any part that is not scheduled for replacement as required maintenance in the Owner's Manual shall be warranted for the entire Emissions Control System (Emissions) Warranty Period. If any emissions-related part fails during the Emissions Warranty Period, it will be replaced by ZPP per subsection 4) below. Any emissions-related part repaired or replaced under the Emissions Warranty will be covered for the remainder of the Emissions Warranty Period.

2) Any warranted part that is scheduled only for inspection in the Owner's Manual during the Emissions Warranty Period is covered for the entire Emissions Warranty Period. Any inspected part that is repaired or replaced under this Emissions Warranty is covered until the end of the Emissions Warranty Period.

3) Any warranted part that is scheduled for replacement in the Owner's Manual is covered until the first replacement point for that part. If the emissions-related part fails prior to the first replacement point, it will be repaired or replaced per subsection 4) below. The repaired or replaced part will continue to be covered until the first replacement point.

4) Repair or replacement of any emissions-related part under this Emissions Warranty will be performed at a ZPP authorized service center at ZPP's expense.

5) The owner shall not make any modifications to the engine without ZPP's written consent. Unapproved changes shall void this Emissions Warranty and be sufficient basis for denying an Emissions Warranty claim.

6) Failure of unauthorized replacement parts shall not be covered by this Emissions Warranty.

7) Failure of authorized emission-related parts due to the use of unauthorized replacement parts shall not be covered by this Emissions Warranty.

8) Damage to or failure of emission-related parts caused by fire, flood, acts of God, or other accidents beyond ZPP's control shall not be covered by this Emissions Warranty.

EMISSION CONTROL WARRANTY STATEMENT (continued)

Standard Emissions Parts List Covered under the 2500 hour/3-year Warranty

(1) Fuel Metering System

- Gasoline fuel injection system
- Gasoline fuel pump
- Gasoline fuel pressure manifold assembly
- Mixer
- Electronic Pressure Regulator (DEPR)

(2) Air Induction System

- Intake manifold
- Electronic throttle
- Exhaust manifold

(3) Crankcase Ventilation Systems

- PCV Valve

(4) Ignition Control System

- Ignition coil or coil-pack
- Ignition wires
- Spark plugs (up to first Replace interval at 1500 hours)

(5) Miscellaneous Emissions Control System Components

- CAM sensor
- CRANK sensor
- Engine Control Module (ECM)
- Pre-cat and post-cat oxygen sensors
- Knock sensor
- TMAP sensor

High-Cost Emissions Parts List Covered under the 3500 hour/5-year Warranty

- Catalytic converter
- Cat-muffler

Engine Identification

Engine part number _____

Engine serial number _____

Engine application _____

Purchased from _____

In-service date _____

Engine hours at delivery _____

MAINTENANCE LOG

Service Interval: 250 Hours or 4 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 500 Hours or 8 Months

- ☐ Inspect air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 750 Hours or 13 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 1000 Hours or 17 Months

- ☐ Replace air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Replace engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Replace gasoline fuel filter
- ☐ Inspect spark plugs
- ☐ Inspect spark plug wires
- ☐ Inspect CCV system
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage
- ☐ Inspect fuel lock-off valve
- ☐ Inspect LPG filter, replace if needed
- ☐ Drain and inspect LPG regulator/vaporizer (If equipped)

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 1250 Hours or 21 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 1500 Hours or 25 Months

- ☐ Inspect air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect/Adjust Valve Clearance
- ☐ Replace engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 1750 Hours or 29 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 2000 Hours or 34 Months

- ☐ Replace air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Replace engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Replace gasoline fuel filter
- ☐ Inspect spark plugs
- ☐ Inspect spark plug wires
- ☐ Inspect CCV system
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage
- ☐ Inspect fuel lock-off valve
- ☐ Inspect LPG filter, replace if needed
- ☐ Drain and inspect LPG regulator/vaporizer (If equipped)

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 2250 Hours or 38 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 2500 Hours or 42 Months

- ☐ Inspect air filter
- ☐ Replace Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage
- ☐ Replace LPG fuel filter

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 2750 Hours or 46 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 3000 Hours or 50 Months

- ☐ Replace air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect/Adjust Valve Clearance
- ☐ Replace engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Replace gasoline fuel filter
- ☐ Inspect spark plugs
- ☐ Inspect spark plug wires
- ☐ Inspect CCV system
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage
- ☐ Inspect fuel lock-off valve
- ☐ Inspect LPG filter, replace if needed
- ☐ Drain and inspect LPG regulator/vaporizer (If equipped)

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 3250 Hours or 55 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 3500 Hours or 59 Months

- ☐ Inspect air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 3750 Hours or 63 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 4000 Hours or 67 Months

- ☐ Replace air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Replace engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Replace gasoline fuel filter
- ☐ Inspect spark plugs
- ☐ Inspect spark plug wires
- ☐ Inspect CCV system
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage
- ☐ Inspect fuel lock-off valve
- ☐ Inspect LPG filter, replace if needed
- ☐ Drain and inspect LPG regulator/vaporizer (If equipped)

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 4250 Hours or 71 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 4500 Hours or 76 Months

- ☐ Inspect air filter
- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect/Adjust Valve Clearance
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 4750 Hours or 80 Months

- ☐ Inspect Drive belt
- ☐ Inspect battery
- ☐ Inspect engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage

Date:	
Engine Hours:	
Mechanic:	

MAINTENANCE LOG

Service Interval: 5000 Hours or 84 Months

- ☐ Replace air filter
- ☐ Replace Drive belt
- ☐ Inspect battery
- ☐ Replace engine coolant
- ☐ Clean radiator outside
- ☐ Replace engine oil and filter
- ☐ Replace gasoline fuel filter
- ☐ Replace spark plugs
- ☐ Replace spark plug wires
- ☐ Replace pre-cat and post-cat oxygen sensors
- ☐ Inspect CCV system
- ☐ Inspect fuel lines, hoses, and fittings for leakage and damage
- ☐ Inspect fuel lock-off valve
- ☐ Replace LPG filter, replace
- ☐ Drain and inspect LPG regulator/vaporizer (If equipped)

Date:	
Engine Hours:	
Mechanic:	

Engine and Fuel System Installation Guide

NG and LP Vapor Fuel System Installation

- Vapor fuel line should be of sufficient size to prevent fuel pressure drop at full load operation. Vapor fuel pressure regulator should be set at **7-11 inWC**.
- All fuel lines must be a minimum of 12" from exhaust system components, with adequate airflow around pipes, and properly shielded from radiant heat.
- Fuel line used in stationary applications should be of ***Black Malleable Iron*** or ***Steel***. Galvanized steel pipe is not recommended or approved. A flexible line of suitable material, (***steel flex pipe*** or ***braided stainless*** is recommended) should be used between engine's fuel shutoff valve and supply line with a manual shutoff valve. Dual fuel systems must have shutoff valves on both supply lines.
- Fuel supply line fittings must be assembled with O2 sensor safe thread sealant. ***ZPP*** recommends the use of Loctite 592 Thread Sealant, or equivalent.
- All fuel lines should be properly supported and strapped to prevent vibration and undesired motion and free from kinks or bends with the least amount of elbows necessary. ***ZPP*** recommends a maximum of 1, 90° elbow per installation.
- Supply Line should be ¾" ID and free from sharp bends or kinks.

Electronic and Electrical Components

- All electronic components and controls should me mounted to control ***vibration*** to ***3g***s or less.
- Due to the sensitive nature of electronic components, all electrical emission sources should be considered during product installation. Electrical emissions can cause erratic operation of electronic control devices.
- Electrical and electronic components should be spaced at least 12", if practical from exhaust components and other external heat sources. Proper shielding and airflow should be provided to protect all sensitive components.
- Batteries and battery cables should be sized according to the specifications as outlined in the engines Owners and Operators Manuals.

Cooling and Airflow

Engines should be mounted as to maximize the amount of outside air across the engine and through the radiator while taking measures to prevent heated air from recirculating back through the cooling system. ***ZPP*** recommends the use of an air duct, no smaller than the radiator core, in buildings or enclosure installations, to prevent recirculation.
Radiator ***vibration*** should not exceed ***1.5g***s.

Engine Environment

Engines should be located and positioned to reduce the effects of wind, weather, temperature, and environmental conditions such as;

- Engine air intake temperature
- Airflow
- Air borne contaminants (Dirt, sawdust, fibers, insects, animal feathers or fur, etc.)
- Moisture
- Snow and Ice

Air inlet temperature should not exceed ambient temperature. Measurements between ambient and manifold temperature sensor should not exceed 130° F.
High air inlet temperatures can cause engine detonation and improper fueling which can lead to poor performance and severe engine damage. Electrical components and controls should be properly shielded from water. Damage from weather or moisture is not considered a warrantable condition.

Engine Mounting

Engines should be mounted level on a solid surface or frame while reducing vibration to the absolute minimum. Frames should include provisions for securing engine mounting legs to the extent of **all** mounting holes. Engine mounting legs should never be left unsupported.

Failure to follow engine mounting steps may result in severe damage to cooling system components and severe injury to bystanders.

Isolation mounting can be utilized provided that ***proper earth grounds*** are used to insure the reduction of electrical emissions as well as static electricity.

Exhaust System Installation

All fuel system components, wiring, and electronic components should be protected from exhaust heat sources. Catalysts should be mounted horizontally.

If application does not permit, ***ZPP*** will review and have the ultimate decision on the installation.

Catalysts should be mounted with flex pipe and provisions to reduce the ***vibration*** to less that ***3g***s.

Exhaust pipe size should be at least the same size as provided, or recommended by ***ZPP*** in the ***Emissions Related Installation Instructions***, as provided by ***ZPP***.

Exhaust pipe installations requiring additional length or bends will require increasing the I.D. off the pipe proportional to the length to reduce back pressure.

Back pressure should not exceed 1 psig for engines 6.5 liters and larger. Ultimately, back pressure readings with suitable gauge will be the determining factor for all exhaust installations.

Engine Misfire/Backfire Troubleshooting

- Improper air to fuel ratio
  - Failing oxygen sensor
  - Improper or insufficient fuel pressure
  - Poor fuel quality
- Incorrect spark plug or gap
- Cracked insulator on spark plug
- Damaged or leaking ignition cable
- High resistance in Ignition cable
- Oil in spark plug well
- Failing ignition coil
- Incorrect voltage to ignition coil
- Intermittent voltage loss (electrical connections or splices)
- Poor or improper engine ground
- Improper ignition timing or phasing
- Sync loss between cam and crank sensor
  - Air gap between tooth and sensor
  - Failing camshaft or crankshaft position sensor
  - Debris on tone ring or sensor
  - Electronic or magnetic noise or interference
- Valve not opening or closing
  - Insufficient valve clearance
  - Worn camshaft lobe
  - Broken or bent pushrod
  - Damaged tappet
- Unmetered air entering intake manifold
  - Leaking gasket
  - Missing cap or plug
  - Cracks
- Broken or damaged piston
- Excessive carbon buildup on piston
- Excessive back pressure
  - Plugged catalyst
  - Damaged exhaust pipe
  - Collapsed muffler
- Clogged air filter

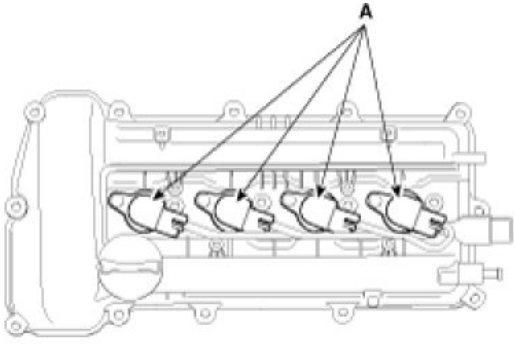
APPENDIX

Valve Clearance Inspection

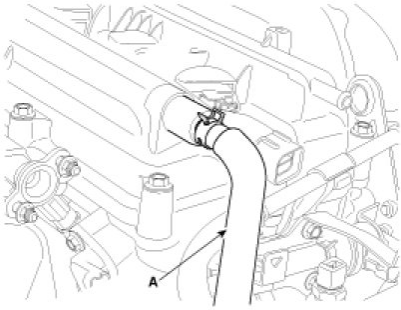
Inspect valve clearance when the engine is cold (Engine coolant temperature: 68°F [20°C]) and cylinder head is installed on the cylinder block.

1. Remove the engine center cover.
2. Remove the valve cover.

   a. Disconnect the ignition coil (A).

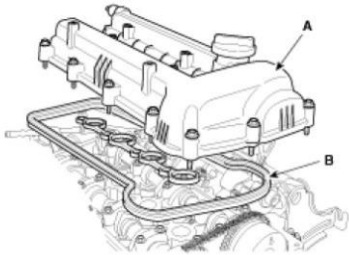


   b. *Disconnect the PCV hose(A).*



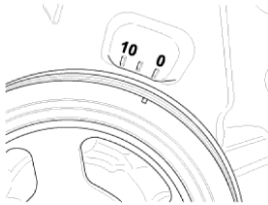
   c. Loosen the valve cover bolts and then remove the cover(A). (next page)

CAUTION: Do not reuse the valve cover gasket.

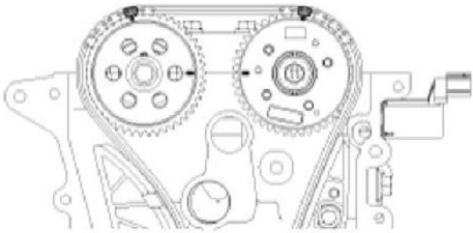


3. Set No.1 cylinder to TDC/compression.

   a) *Turn the crankshaft pulley and align its groove with the timing mark of the timing chain cover.*

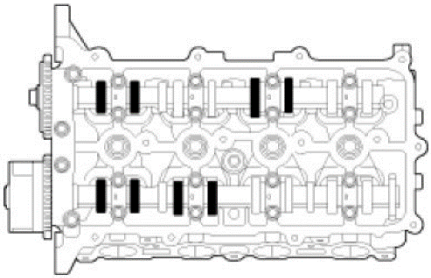


   b) *Check that the marks of the camshaft timing sprockets are in straight line on the cylinder head surface as shown in the illustration. If not, turn the crankshaft one revolution (360°).*



4. Inspect the valve clearance.

   a) *Check clearance on the intake valves on cylinders 1 and 2, and exhaust valves of cylinders 1 and 3*



NO.1 Cylinder TDC/Compression

1. Using a thickness gauge, measure the clearance between the tappet and the base circle of camshaft.

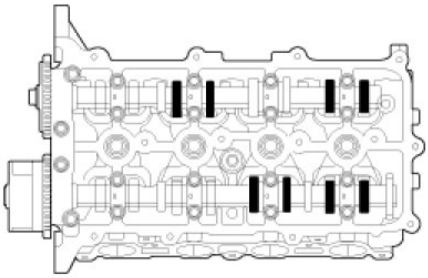
2. Record the out-of-specification valve clearance measurements. They will be used later to determine the required tappet for adjusting.

Valve clearance specification (Engine coolant temperature: 68°F [20°C])

Intake	**0.17~0.23mm**	**0.0067~0.0091in.**
Exhaust	**0.22~0.28mm**	**0.0087~0.0110in.**

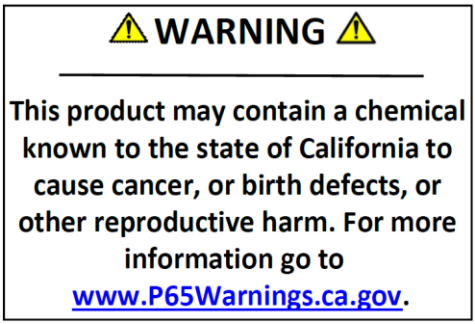
b) Turn the crankshaft pulley one revolution (clockwise 360°) and align its groove with timing mark of the timing chain cover.

c) Check the intake valves on cylinders 3 and 4 and exhaust valves on cylinders 2 and 4. (See diagram on following page)



NO.4 Cylinder TDC/Compression

NOTES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