

NA416

Operator Manual *and Maintenance Log*

*Mobile, Stationary & Constant-Speed Mobile
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.

 **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:

1-276-525-4760

Hours:

Monday-Thursday: 8:00 – 5:00 Eastern Time

Friday: 8:00 – 12:00 Eastern 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.ZenithPowerProducts.com

TABLE OF CONTENTS	Page
U.S. EPA Legal Requirements	2
Safety Symbols & Precautions	3
Fuels	6
Starting, running, and stopping the engine	7
Engine maintenance	8
<ul style="list-style-type: none"> • Schedule • Air filter • Battery • CCV system • Engine coolant, radiator, and cooling system • Drive Belt • Engine oil & filter • Checking for fuel leaks • LPG fuel lock-off valve • Pre- & Post-cat oxygen sensors • Spark plugs & wires 	
Diagnostics	23
<ul style="list-style-type: none"> • How to retrieve fault codes • Fault Code List 	
Specifications	28
Engine Identification	29
Engine Warranty	30
<ul style="list-style-type: none"> • Warranty provisions • Base warranty period • Emissions-related warranty period • Owner's obligations • Component lists 	
Maintenance Log	32

U.S. EPA Legal Requirements

The ZPP 416 gasoline and liquid LPG engines have been certified by the U.S. Environmental Protection Agency (EPA) as mobile variable and constant speed engines. The 416 natural gas engines have been certified by the US EPA as stationary and mobile constant-speed engines. Please refer to your engine's emissions label to determine which type of engine it is.

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 stationary and mobile constant-speed engines in a variable-speed (foot pedal speed control) application.

To ensure emissions compliance of mobile variable and constant-speed engines, operate and maintain your engine as specified in this Operator's Manual.

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

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:

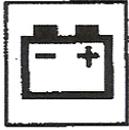
- Keep a maintenance plan and records of conducted maintenance.
- To the extent practicable, maintain and operate the engine in a manner consistent with good air pollution control practice for minimizing emissions.

Per section 113 of the U.S. Clean Air Act, failure to abide by these legal requirements can result in fines up to \$29,000 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

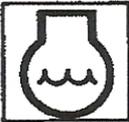
This section identifies the ISO 8999 symbols that may be used in this manual.



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

- 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. 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 the engine warranty, use commercial-grade HD-10 or better LPG.

Liquid LPG is drawn off of the bottom side of a 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 LPG to a liquid LPG fuel system, you may starve the engine for fuel, causing it to produce low power and excessive emissions.

Vapor LPG is drawn off of the top side of a LPG tank or cylinder and is a gas from the tank/cylinder 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.
3. 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-416 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		I	I	I	I	I	I
Engine timing belt							
Intake and Exhaust manifold nuts		T					
Radiator outside	(A)			C			C
Engine oil	(A)	R	R	R	R	R	R
Oil Filter	(A)	R	R	R	R	R	R
Engine coolant							
Fuel Filter gasoline					R		
Air cleaner element	(A)	I	I	I	I	I	I
Spark Plugs							
Spark Plug Wires						I	
PCV valve	(A)				I		
PCV hoses					I		
Check fuel supply & return lines for leaks				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.

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

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
					R								
	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/R								
			R										R
													R

REQUIREMENTS FOR LPG FUEL SYSTEM

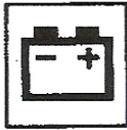
		R			I/R			I/R			R		
	I/D				I/D				I/D				
	I/D												

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.

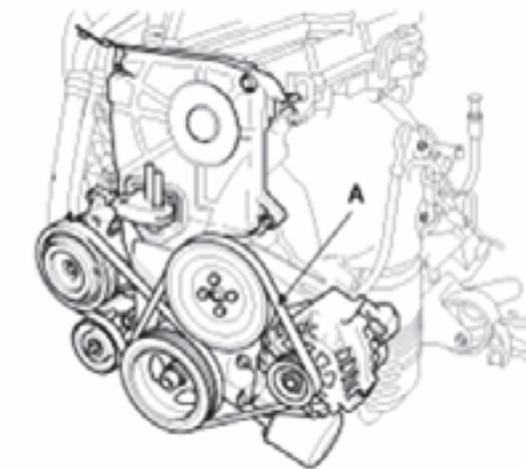
Check coolant level. If low, top off coolant with a premixed 50/50 mixture of antifreeze and water.

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

416 Belt P/N: 201978 (Standard)
201982 (When Equipped w/High Speed Fan Pulley*)



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. If the belt tension is not as specified, adjust it.

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

If the belt tension is not as specified, adjust it.

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

ENGINE OIL AND FILTER REPLACEMENT



Filter:	200449
Oil Grade:	See "SELECTION OF ENGINE OIL"
API Certification:	SJ or better
Oil Capacity (with filter):	3.49 qt/3.3 L

DRAIN THE ENGINE OIL

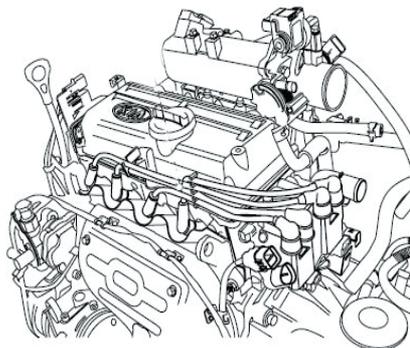
1. Remove the oil filler cap.
2. Remove the oil drain plug and drain the oil into a container.

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 $\frac{3}{4}$ 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.

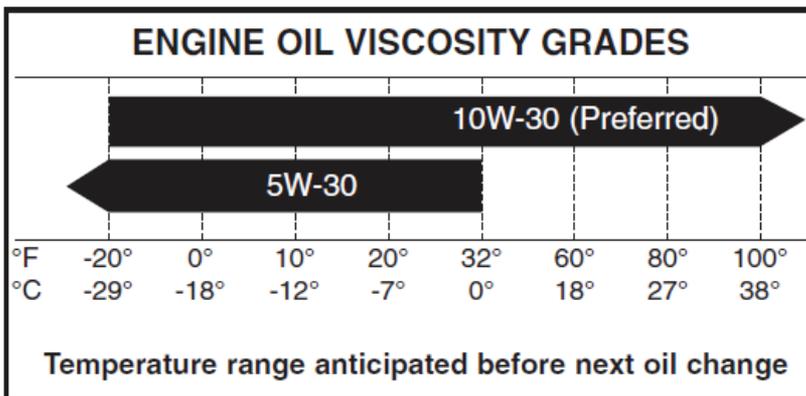
API recommendation: SJ or above



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.

FUEL LOCK-OFF VALVE

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 AND POST-CAT OXYGEN SENSORS

ZPP Part Numbers:

Pre-Cat Sensor: 200477
Post-Cat Sensor: 201280

Sensor Locations:

The 428 pre-catalyst oxygen sensor is located at the outlet of the exhaust manifold.

The 644 pre-cat oxygen sensor is located immediately downstream of the exhaust manifold Y-pipe junction.

The 428 & 644 oxygen sensors are located in the outlet of the catalyst.

SPARK PLUGS & WIRES

Ignition System Part Specifications	
Spark plugs	18814-11051
Spark plug gap	0.039 - 0.043 inches 1.00 - 1.010 mm
Spark plug wires	27501-26D00

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 entire 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
1	Malfunction Indicator Lamp (MIL)	Flash codes
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.

To retrieve flash codes from the ECM:

1. Install the 201985 shorting cap on the diagnostic test connector located at the front of the engine on the intake manifold, or, ground the Brown/White wire pin of the same connector.
2. Turn the ignition key on without starting the engine.
3. The ECM will flash the leader code (111), then the fault code(s), then trailer code. Each code is repeated 3 times.

J1939 CAN Link

The ECM also 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 “GCP 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 very helpful for diagnosing signal faults.

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

Fault Code List

DTC/ Pcode	Fault	CAN SPN	CAN FMI	MIL Flash Code
	Leader/Trailer Code			111
(P0) 016	CRANK or CAM could not synchronize during start	636	8	216
(P0) 107	MAP Signal open or shorted to ground	106	4	127
(P0) 108	MAP signal shorted high	106	16	128
(P0) 112	IAT Sensor Low/Shorted Input	105	4	112
(P0) 113	IAT Sensor High/Open Input	105	3	113
(P0) 116	ECT higher than warning threshold	110	15	116
(P0) 117	ECT Sensor Low/Shorted Input	110	4	117
(P0) 118	ECT Sensor High/Open Input	110	3	118
(P0) 121	TPS 1-2 voltage difference higher than expected	51	1	121
(P0) 122	Throttle Position Signal 1 low voltage	51	4	122
(P0) 123	Throttle Position Signal 1 high voltage	51	3	123
(P0) 134	O2 Bank 1 Sensor 1 No Activity	724	10	134
(P0) 135	Front O2 sensor heater control fault	724	14	135
(P0) 151	Closed-loop LPG A/F is too lean	520206	0	151
(P0) 152	Closed-loop LPG A/F is too rich	520206	1	152
(P0) 154	Post-Cat O2 Signal No Activity	520208	10	154
(P0) 155	Closed-loop gasoline bank 1 A/F is too lean	520204	0	155
(P0) 156	Closed-loop gasoline bank 1 A/F is too rich	520204	1	156
(P0) 165	Catalyst inactive on LPG	520213	10	165
(P0) 166	Catalyst inactive on NG	520214	10	166
(P0) 171	Pre-cat A/F is lean	520200	0	171
(P0) 172	Pre-cat A/F is rich	520200	1	172
(P0) 182	Gasoline Fuel Temp Sensor A Low Input	174	4	182
(P0) 183	Gasoline Fuel Temp Sensor A High Input	174	3	183
(P0) 187	LPG Fuel Temp Low Voltage	520240	4	187
(P0) 188	LPG Fuel Temp High Voltage	520240	3	188
(P0) 211	Target TPS Lower than Actual			211
(P0) 212	Target TPS Higher than Actual			212
(P0) 217	Engine Overheat Condition	110	0	217
(P0) 219	Engine Overspeed Condition	515	0	219
(P0) 221	TPS 1-2 voltage difference higher than expected	51	0	221
(P0) 222	Throttle Position Signal 2 low voltage	520251	4	222
(P0) 223	Throttle Position Signal 2 high voltage	520251	3	223
(P0) 261	Injector 1 Low/Open	651	5	261
(P0) 262	Injector 1 High/Short	651	6	262
(P0) 264	Injector 2 Low/Open	652	5	264
(P0) 265	Injector 2 High/Short	652	6	265
(P0) 267	Injector 3 Low/Open	653	5	267
(P0) 268	Injector 3 High/Short	653	6	268
(P0) 270	Injector 4 Low/Open	654	5	269
(P0) 271	Injector 4 High/Short	654	6	271
(P0) 273	Injector 5 Low/Open	655	5	273
(P0) 274	Injector 5 High/Short	655	6	274
(P0) 276	Injector 6 Low/Open	656	5	276
(P0) 277	Injector 6 High/Short	656	6	277

Fault Code List – Continued

DTC/ Pcode	Fault	CAN SPN	CAN FMI	MIL Flash Code
(P0) 287	Gasoline Fuel Pressure too low	94	1	287
(P0) 288	Gasoline Fuel Pressure too high	94	0	288
(P0) 291	Gasoline Fuel Pressure low voltage	94	4	291
(P0) 292	Gasoline Fuel Pressure high voltage	94	3	292
(P0) 315	FPP1 higher than IVS limit			315
(P0) 326	Knock signal excessive or erratic	731	2	326
(P0) 327	Knock signal open or not present	731	4	327
(P0) 335	Crank Sync Loss			335
(P0) 336	CRANK signal noise	636	2	336
(P0) 337	No CRANK signal	636	4	337
(P0) 339	FPP1 lower than IVS limit			339
(P0) 341	CAM signal noise	723	2	341
(P0) 342	Camshaft Position Sensor A (no signal)	723	4	342
(P0) 359	Fuel (LPG or NG) run-out longer than expected	0	31	359
(P0) 421	Catalyst inactive on gasoline	520211	10	421
(P0) 524	Engine Oil Pressure Too Low	100	1	524
(P0) 562	Battery Voltage Low	168	17	562
(P0) 563	Battery Voltage High	168	15	563
(P0) 601	Microprocessor failure - FLASH	628	13	621
(P0) 604	Microprocessor failure - RAM	630	12	624
(P0) 606	Microprocessor failure - COP	629	31	626
(P0) 615	Starter relay fault	1321	5	615
(P0) 616	Starter relay control short to GND	1321	4	616
(P0) 617	Starter relay coil short to 12V	1321	3	617
(P0) 627	Gasoline fuel pump relay control wire open	1348	5	627
(P0) 628	Gasoline fuel pump relay control wire short to ground	1348	4	628
(P0) 629	Gasoline fuel pump relay control wire short to 12 V	1348	3	629
(P0) 637	Pin 85 (AUX_PWM4) open/short to GND	700	5	637
(P0) 642	5V Reference #1 (pin 9) voltage low	1079	4	642
(P0) 643	5V reference #1 voltage high	1079	3	643
(P0) 650	Malfunction Indicator Lamp Control open	1213	5	651
(P0) 652	5V Reference #2 voltage low	1080	4	652
(P0) 653	5V Reference #2 voltage high	1080	3	653
(P0) 685	Power relay coil open	1485	5	685
(P0) 686	Power relay short to GND	1485	4	686
(P0) 687	Power relay short to 12V	1485	3	687
(P0) 1153	Closed-loop NG A/F is too lean	520207	0	153
(P0) 1154	Closed-loop NG A/F is too rich	520207	1	159
(P0) 1161	LPG Adaptive-learn A/F is too lean	520202	0	161
(P0) 1162	LPG Adaptive-learn A/F is too rich	520202	1	162
(P0) 1163	NG Adaptive-learn A/F is too lean	520203	0	163
(P0) 1164	NG Adaptive-learn A/F is too rich	520203	1	164
(P0) 1171	EPR delivery pressure higher than expected	520260	0	371
(P0) 1172	EPR delivery pressure lower than expected	520260	1	372
(P0) 1173	EPR-ECU communications lost	520260	31	173
(P0) 1174	EPR voltage supply high	520260	3	174
(P0) 1175	EPR voltage supply low	520260	4	175
(P0) 1176	EPR internal actuator fault detected	520260	12	176

Fault Code List – Continued

DTC/ Pcode	Fault	CAN SPN	CAN FMI	MIL Flash Code
(P0) 1177	EPR internal circuitry fault detected	520260	12	177
(P0) 1178	EPR internal communications fault detected	520260	12	178
(P0) 1515	AUX 5V ANALOG INPUT 4 open or high	520215	3	515
(P0) 1516	AUX 5V ANALOG INPUT 4 low	520215	4	516
(P0) 1517	AUX 5V ANALOG INPUT 3 open or high	520218	3	517
(P0) 1518	Throttle actuator zero cycle incomplete	520218	3	518
(P0) 1541	AUX 5V ANALOG INPUT 1 high / Low Coolant Shutdown (On units Equipped)	520219	3	541
(P0) 1542	AUX 5V ANALOG INPUT 1 low or open	520219	4	542
(P0) 1543	AUX 5V ANALOG INPUT 2 high or open	520220	3	543
(P0) 1544	AUX 5V ANALOG INPUT 2 low	520220	4	544
(P0) 1551	AUX DIGITAL INPUT 1 high	520222	3	551
(P0) 1552	AUX DIGITAL INPUT 1 low	520222	4	552
(P0) 1553	AUX DIGITAL INPUT 2 high	520223	3	553
(P0) 1554	AUX DIGITAL INPUT 2 low	520223	4	554
(P0) 1555	AUX DIGITAL INPUT 3 high	520224	3	555
(P0) 1556	AUX DIGITAL INPUT 3 low	520224	4	556
(P0) 1563	AUX 5V ANALOG INPUT 5 open or high	TBD	TBD	563
(P0) 1564	AUX 5V ANALOG INPUT 5 low	TBD	TBD	564
(P0) 1612	Watchdog processor blocked outputs (RTI 1)	629	31	712
(P0) 1613	Microprocessor failure - RTI 2	629	31	713
(P0) 1614	Microprocessor failure - RTI 3	629	31	714
(P0) 1615	Microprocessor failure - A/D	629	31	715
(P0) 1616	Microprocessor failure - Interrupt	629	31	716
(P0) 1644	MIL control short to GND	1213	4	644
(P0) 1645	MIL control short to 12V	1213	3	645
(P0) 1681	Customer Auxiliary Shutdown #1 / Low coolant level shutdown	970	31	681
(P0) 2115	APP1 indicates off-idle while IVS indicates idle	91	3	315
(P0) 2121	APP1/FPP1 lower than APP2/FPP2	91	18	321
(P0) 2122	APP1/FPP1 signal low voltage	91	4	322
(P0) 2123	APP1/FPP1 signal high voltage	91	3	323
(P0) 2126	APP1/FPP1 higher than APP2/FPP2	91	16	426
(P0) 2127	APP2/FPP2 signal low voltage	29	3	427
(P0) 2128	APP2/FPP2 signal high voltage	29	4	328
(P0) 2130	IVS stuck at idle, APP 1/2 mismatch	558	5	332
(P0) 2138	TPS D/E Performance (idle validation switch)			
(P0) 2131	IVS stuck at off-idle, APP 1/2 mismatch	558	6	331
(P0) 2139	APP1 indicates idle while IVS indicates off-idle	91	1	339

SPECIFICATIONS

Component	Part Number or Specification
Air Filter:	202457
Drive belt:	Standard 201978 High Speed Pulley 201982*
Battery:	12 V, 675 Cranking Amps, 550 Cold Cranking Amps 52 Ampere Hours
Oil:	See "ENGINE OIL AND FILTER REPLACEMENT"
Oil Filter:	26300-35503
Pre-Cat Oxygen Sensor:	200474
Post-Cat Oxygen Sensor:	201280
Spark Plugs:	18814-11051
Spark Plug Gap:	0.039 - 0.043 inches 1.00 – 1.010 mm
Spark Plug wires:	27501-26D00
Recommended Liquid LPG Lock-Off Valve:	Vapor Propane and NG: 201469 Liquid LPG: 200842

* Check with ZPP for proper application

Engine Identification

Engine part number _____

Engine serial number _____

Engine application _____

Purchased from _____

In-service date _____

Engine hours at delivery _____

Engine Warranty

Warranty Provisions

Zenith Power Products, LLC warrants that this engine was designed, built, and equipped so that it fully complies with the applicable emissions standards of U.S. EPA 40 CFR 60 and 1048 at the time of sale to you, the end customer, and that the engine is free of defects in materials and workmanship that may keep it from meeting the emissions standards.

Base Warranty Period

<i>Rating</i>	<i>Months</i>	<i>Hours</i>
Stationary and Constant Speed Mobile	12	2500
Variable Speed Mobile	24	2000
Emergency Standby	24	400

Emissions-Related Warranty Period

Your engine's emissions-related warranty period is 2500 operating hours or 3 years, whichever comes first.

“High-cost” emissions-related parts are warranted for 3500 hours or 5 years, whichever comes first.

The engine's operating hours are determined based on the Engine Control Module's (ECM's) hour meter. The warranty period begins when your engine is placed into service.

Owner Obligations

This warranty is valid only if you operate and maintain your engine as specified in this Operators Manual. You must maintain your engine as specified in the Maintenance Schedule and record your maintenance in the Maintenance Log.

You are responsible for initiating the warranty process. You should present your off-road LSI engine to ZPP or a ZPP-authorized agent as soon as any problem occurs. The warranty repairs will 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 **1-276-525-4760**

Engine Warranty

Components Covered under the 2500 hour/3 year Warranty

- Carburetor
- Catalyst
- CRANK sensor
- Engine Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Electronic throttle
- Engine wiring harness
- Exhaust manifold
- Final stage natural gas fuel pressure regulator
- Fuel supply pressure trim valve
- Gasoline Fuel Injectors
- Ignition coil pack
- CAM sensor
- Intake manifold
- Manifold Absolute Pressure (MAP)/Intake Air Temp (IAT) sensor
- Pre-catalyst oxygen sensor
- Post-catalyst oxygen sensor

Components Covered under the 3500 hour/5 year Warranty

None

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 (428 and mobile 644)
- 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
- 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 (428 and mobile 644)
- 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
- Replace engine coolant
- Clean radiator outside
- Replace engine oil and filter
- Replace gasoline fuel filter
- Inspect spark plugs
- Inspect spark plug wires (428 and mobile 644)
- 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 (428 and mobile 644)
- 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 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 (428 and mobile 644)
- Replace pre and post-cast 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:	

Notes

 **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.