



ZENITH
POWER PRODUCTS

NA424 / NA434

Operator Manual

and Maintenance Log

Constant-Speed 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.



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

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U.S. EPA Legal Requirements

ZPP's 424 and 434 engines have 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:

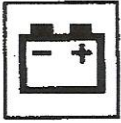
- Keep a maintenance plan and records of conducted maintenance.
- To the extent practicable, maintain and operate the engine in a manner consistent with good air pollution control practice for minimizing emissions.

Per section 113 of the U.S. Clean Air Act, failure to abide by these legal requirements can result in fines up to \$52,058 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



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.

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

Liquid LPG is drawn off of the bottom side of an LPG tank or cylinder and is a liquid until it has passed through the regulator/vaporizer, at which point it is vaporized to a gas. If you connect vapor 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 an 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 424 AND 434 ENGINES

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

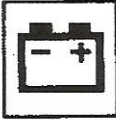
Periodic maintenance should be performed after specified intervals have elapsed in months or hours, whichever comes first	Months	4	8	12	16	20	24
	Hours	250	500	750	1000	1250	1500
Drive belt tension		I	I	I	I	I	I
Engine timing belt							
Intake and Exhaust manifold nuts		T					
Radiator outside	(A)			C			C
Engine oil	(A)		R		R		R
Oil Filter	(A)		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						

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.

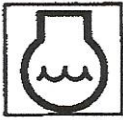
If the engine is still cranking slowly or not at all:

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.

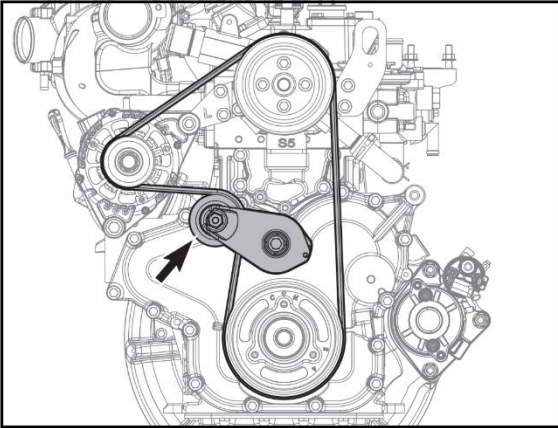
Check coolant level. If low, top off coolant with a premixed 50/50 mixture of antifreeze and water.

Engine Coolant Replacement

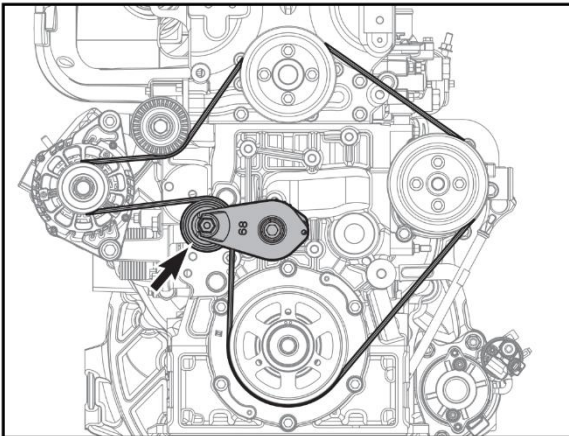
1. Open overflow bottle cap.
2. Drain old coolant.
3. Flush system with fresh, clean water.
4. Slowly refill system with premixed 50/50 antifreeze/water mixture.
5. Idle engine with radiator cap off to allow air to escape.
6. Top off coolant in overflow bottle if needed.
7. Stop engine.
8. Replace radiator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

DRIVE BELT

424 V-Belt P/N: 130205-01010



434 V-Belt P/N: 130205-01028



Inspection

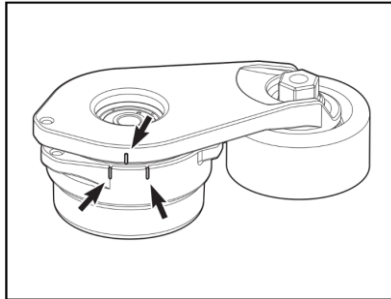
Check the belt for visible cracks, missing chunks, and fraying. Small cracks on the inside of the belt are OK. Replace the belt if cracks are visible on the outside of the belt, chunks are missing from the inside of the belt, or the belt is frayed.

Belt Tension

Measure the belt tension midway between the alternator and water pump pulley as specified by the arrow in the left figure above.

Deflection:

Each belt is equipped with an auto tensioner which automatically adjusts the belt tension. There is no need for extra adjustment of the tension. During daily inspections, be sure to inspect whether the pointer (upper bar) on the auto tensioner is within the minimum/maximum range (lower two bars) as shown below.



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:	424 & 434: 400508-00109	
Oil Grade:	See "SELECTION OF ENGINE OIL"	
API Certification:	SJ or later	
Oil Capacity (with filter):	424	Max: 8.6 L (9.1 qt) Min: 4.5 L (4.75 qt)
	434	Max: 12.6 L (13.3 qt) Min: 6.0 L (6.3 qt)

DRAIN THE ENGINE OIL

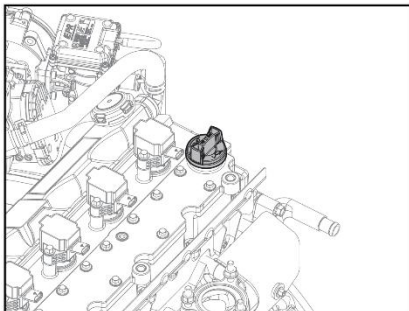
1. Remove the oil filler cap.
2. Remove the oil drain plug and drain the oil into a container.

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.

- 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.

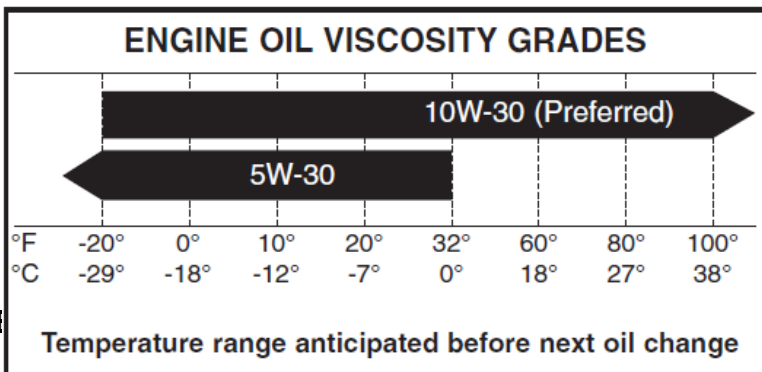
API recommendation: SJ or above



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.



CHI

Temperature/Engine Oil Viscosity



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 424 and 434 liquid LPG (mobile) engines, and vapor propane and natural gas stationary engines.

Vapor Propane and NG: 201469

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 424 & 434 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.

Add a diagram or picture?

SPARK PLUGS & WIRES

Ignition System Part Specifications	
Spark plugs	ZPP 204653 (NGK 91121 ILKAR7J7G)
Spark plug gap	0.5 - 0.7 mm 0.020 – 0.026 inches
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
1	1151	CL high LPG	4236	00
2	1152	CL low LPG	4236	01
3	1153	CL high NG	4236	0
4	1154	CL low NG	4236	1
5	16B	CL air/fuel ratio control at limit - too rich	0	1
6	16C	CL air/fuel ratio control at limit - too lean	0	1
7	1161	AL high LPG	4237	0
8	1162	AL low LPG	4237	1
9	1163	AL high NG	4237	0
10	1164	AL low NG	4237	1
11	118	ECT / CHT high voltage	110	3
12	117	ECT / CHT low voltage	110	4
13	116	ECT higher than expected 1	110	15
14	217	ECT higher than expected 2	110	0
15	1141	Post-catalyst delta-phi at min limit	520180	11
16	1142	Post-catalyst delta-phi at max limit	520181	11
17	134	EGO1 open / lazy	3217	5
18	154	EGO2 open / lazy	3227	5
19	31	EGOH1 open / ground short	3222	4
20	32	EGOH1 short to power	3222	3
21	51	EGOH2 open / ground short	3232	4
22	52	EGOH2 short to power	3232	3
23	116C	Pre-catalyst O2 sensor out of range	3221	31
24	563	Voltage high	168	15
25	562	Voltage low	168	17
26	2229	BP high pressure	108	0
27	2228	BP low pressure	108	1
28	342	Cam1 loss (intake)	723	4
29	337	Crank loss	636	4
30	341	Cam sync noise	723	2
31	336	Crank sync noise	636	2
32	16	Never crank synced at start	636	8
33	123	TPS1 high voltage	51	3
34	122	TPS1 low voltage	51	4
35	223	TPS2 high voltage	3673	3
36	222	TPS2 low voltage	3673	4
37	221	TPS1 higher than TPS2	51	0
38	121	TPS1 lower than TPS2	51	1
39	2112	Unable to reach higher TPS	51	7
40	2111	Unable to reach lower TPS	51	7
41	120E	DBW drive current high	5419	6
42	1113	RPM higher than expected	515	31
43	1111	Fuel rev limit	515	16
44	1112	Spark rev limit	515	0
45	1171	EPR / CFV regulation pressure higher than expected	520260	0
46	1172	EPR / CFV regulation pressure lower than expected	520260	1
47	1173	EPR / CFV comm lost	520260	31
48	1176	EPR / CFV internal actuator fault detection	520260	12
49	1177	EPR / CFV external Vrelay intermittent or internal circuitry fault detection	520260	12
50	188	FT gaseous fuel high	7722	3

Fault Code List – Continued

#	Diagnostic Trouble Code (DTC)	Fault Description	CAN SPN	CAN FMI
51	187	FT gaseous fuel low	7722	4
52	1016	FT gaseous fuel extremely low	7722	1
53	113	IAT high voltage	105	3
54	112	IAT low voltage	105	4
55	111	IAT higher than expected 1	105	15
56	127	IAT higher than expected 2	105	0
57	327	Knock sensor open	731	4
58	326	Knock excessive signal	731	02
59	1325	Knock retard at limit	731	00
60	1089	Fuel run-out longer than expected	632	31
61	6	Lockoff open / ground short	632	04
62	7	Lockoff short to power	632	03
63	108	MAP high pressure	106	16
64	107	MAP low voltage	106	4
65	1068	MAP higher than expected	3563	15
66	650	MIL open	1213	5
67	520	Oil pressure low stage 1 (sender or SENT)	100	18
68	524	Oil pressure low stage 2 (sender or SENT)	100	1
69	523	Oil pressure high voltage (switch or sender)	100	3
70	522	Oil pressure low voltage (switch or sender)	100	4
71	685	Relay coil open	1485	5
72	687	Relay coil short to power	1485	3
73	2300	Primary Loop Open or	1268	5
74	2301	Primary Coil Shorted	1268	6
75	616	Start relay control ground short	1321	4
76	617	Start relay coil short to power	1321	3
77	643	5VE1 high voltage	1079	3
78	642	5VE1 low voltage	1079	4
79	653	5VE2 high voltage	1080	3
80	652	5VE2 low voltage	1080	4
81	606	COP failure	629	31
82	1612	RTI 1 loss	629	31
83	1613	RTI 2 loss	629	31
84	1614	RTI 3 loss	629	31
85	1615	A/D loss	629	31
86	1616	Invalid interrupt	629	31
87	601	Flash checksum invalid	628	13
88	604	RAM failure	630	12
89	1674	Hardware ID Failure	1634	2
90	1673	Calibration Configuration Error	1634	13
91	1626	CAN1 Tx failure	639	12
92	1646	CAN2 Tx failure	1231	12
93	1627	CAN1 Rx failure	639	12
94	1648	CAN2 Rx failure	1231	12
95	1330	Intake backfire detected	520390	31

SPECIFICATIONS

Component	Part Number or Specification
Air Filter:	424 & 434: 200476
Drive belt:	424: 130205-01010 434: 130205-01028
Battery:	12 V, 675 Cranking Amps, 550 Cold Cranking Amps 52 Amp Hours
Oil:	See “ENGINE OIL AND FILTER REPLACEMENT”
Oil Filter:	424 & 434: 400508-00109
Pre-Cat Oxygen Sensor:	201280
Post-Cat Oxygen Sensor:	201280
Spark Plugs:	ZPP 204653 (NGK 91121 ILKAR7J7G)
Spark Plug Gap:	0.5 - 0.7 mm 0.020 – 0.026 inches
Recommended Liquid LPG Lock-Off Valve:	Vapor Propane and NG: 201469

* 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 **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

The ZPP 424 and 434 engines have a base engine warranty period of 24 months or 2500 hours, whichever comes first.

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.

EMISSION CONTROL WARRANTY STATEMENT **(continued)**

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 commercial LPG or pipeline-quality natural gas only. Use of other fuels may result in your engine package no longer operating in compliance with EPA 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.

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 - 2500 hour/3-year Warranty

(1) Fuel Metering System

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

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

- Catalytic converter

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
- 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 12 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 1000 Hours or 16 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 20 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 1500 Hours or 24 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 28 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 2000 Hours or 32 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 36 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 2500 Hours or 40 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 44 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 3000 Hours or 48 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 52 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 3500 Hours or 56 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 60 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 4000 Hours or 64 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 68 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 4500 Hours or 72 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 76 Months

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

Date:

Engine Hours:

Mechanic:

MAINTENANCE LOG

Service Interval: 5000 Hours or 80 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 be 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**.

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 than **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. of 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



 **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.