

RAMJET 350 Engine 12499120 Specifications

Specifications Part Number 88962743

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This publication provides general information on components and procedures that may be useful when installing or servicing a RAMJET 350 engine. Please read this entire publication before starting work. Also, please verify that all of the components listed below are in fact included in the kit.

The information below is divided into the following sections: package contents, component information, RAMJET 350 engine specifications, installation instructions for the components included in this kit, additional parts that you may need to purchase, torque specifications, and a service parts list.

The RAMJET 350 engine is based on the GM electronic, port fuel injection marine engine. It incorporates modern technology in a package that can be installed in applications where 265-400ci small block Chevrolet V8s were originally used. The RAMJET 350 engine includes a fully assembled block and heads, oil pan, torsional damper, water pump, intake manifold, fully calibrated Engine Control Module (ECM), wiring harness, all the necessary sensors, and distributor. This engine is assembled using brand new, premium quality components.

The RAMJET operating system is a very advanced fuel injection control system that uses a minimum amount of inputs to the engine control module (ECM) for ease of installation. Because of this, there are certain operating conditions that should be understood to ensure proper operation.

For example, due to the variety of applications and uses, this system has no provisions for vehicle speed input, transmission range input (automatic) or clutch pedal input (manual transmission) to the ECM. If the Throttle Position Sensor (TPS) is reading a closed throttle with engine running, the engine controller has no way of determining if it is being driven down the road or idling in Park or Neutral. If the driver operates the engine in a way that pulls the engine speed below the desired idle, the normal reaction of the control module is try to keep the engine speed above the minimum RPM by adjusting the Idle Air Control (IAC) and ignition timing.

If the driver continues to operate the vehicle in this "forced low speed" manner, the IAC and spark may continue to climb until it is at maximum. If the load is suddenly taken away (clutch pedal depressed, shifter moved to neutral), the engine speed will be above desired idle. At that point the engine speed will begin to decrease until it gets back down to desired idle speed. To avoid driving under these conditions, shift the transmission to the next lower gear to prevent "lugging" the engine below the desired idle speed.

Operating the RAMJET engine at very low engine RPMs and low vacuum conditions is also not desirable from a fuel economy standpoint. The RAMJET electronic fuel injection system is a speed and air density system ("speed density" fuel management). Sensors provide the ECM with the basic information for the fuel management portion of its operation. Signals to the ECM establish the engine speed and air density factors. The engine speed signal comes from the Ignition Control (IC) module. The ECM uses this information to determine the "speed" or RPM factor for fuel and spark management.

The Manifold Absolute Pressure (MAP) sensor contributes the density factor. As intake manifold pressure increases, the vacuum decreases. The air density in the intake manifold also increases as additional fuel is needed. The MAP sensor sends this pressure information to the ECM, and the ECM increases the amount of fuel injected, by increasing the injector pulse width. As manifold pressure decreases, the vacuum increases, and the amount of fuel is decreased. These two inputs, MAP and RPM, are the major determinants of the air/fuel mixture delivered by the fuel injection system. The remaining sensors and switches provide electrical inputs to the ECM, which are used for modification of the air/fuel mixture, as well as other ECM control functions, such as idle control.

TITLE RAMJET 350 Engine 12499120 Specifications	REV 07DE09	PART NO. 88962743	PAGE 1 OF 48
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TO BE UNITIZED IN ACCORDANCE WITH GMSPO SPECIFICATIONS.

DATE	REVISION	AUTH
23JL03	Initial Release	
01AP08	Revised - Rusty Sampsel	

This package is designed to provide you a completely calibrated fuel injection engine. The engine you receive will provide a number of benefits over a carbureted engine. These benefits include improved driveability, better fuel economy, and increased performance throughout the entire RPM range. These benefits are the result of precise fuel and ignition control across the entire RPM range.

The ECM is the control center of the fuel injection system. It controls the fuel metering system, ignition timing, idle speed, and on-board diagnostics for engine functions. It constantly looks at the information from various sensors and controls the systems that affect engine performance. The ECM also performs the diagnostic function of the system. It can recognize operational problems and store diagnostic trouble codes, which identify the problem areas to aid the technician in making repairs. Refer to the small block RAMJET service manual, GM Part Number 88962723, included in this kit, for more information on using the diagnostic function of the ECM.

The ECM controls spark advance for all driving conditions. It monitors input signals from the following components as part of its ignition control function to determine the required ignition timing:

- Ignition Control (IC) module
- Engine Coolant Temperature (ECT) sensor
- Manifold Absolute Pressure (MAP) sensor
- Throttle Position (TP) sensor
- Knock Sensor (KS)

The function of the fuel metering system is to deliver the correct amount of fuel to the engine under all operating conditions. Fuel is delivered to the engine by individual fuel injectors mounted in the intake manifold, near each intake port. The ECM looks at inputs from several sensors to determine how much fuel to supply to the engine. The fuel is delivered under one of several conditions, called "modes". These modes include starting mode, clear flood mode, run mode, acceleration mode, fuel cutoff mode, and RPM reduction mode. Refer to the service manual for more information on the ECM and the characteristics of each mode.

The RAMJET 350 engine is manufactured on current production tooling; consequently you may encounter dissimilarities between the RAMJET 350 engine assembly and previous versions of the small block V8. In general, items such as motor mounts, accessory drives, exhaust manifolds, etc. can be transferred to a RAMJET 350 engine when installed in a vehicle originally equipped with a small block V8 engine. However, as noted in the following sections, there may be significant differences in the flywheel bolt pattern, water pump, torsional damper, etc., between a RAMJET 350 engine and an older small block V8 engine. These differences may require modifications or additional components not included with the RAMJET 350 engine. When installing a RAMJET 350 engine in a vehicle not originally equipped with a small block V8, it may be necessary to adapt or fabricate various components for the cooling, fuel, electrical, and exhaust systems. Due to the wide variety of vehicles in which a RAMJET 350 engine can be installed, some procedures and recommendations may not apply to specific applications.

These specifications are intended as a supplement to the 1998 Chevrolet C/K Truck service manuals, as servicing the 1998 C/K Truck engine is very similar to the RAMJET 350 engine. It is not the intent of these specifications to replace the comprehensive and detailed service practices explained in the GM service manuals.

Observe all safety precautions and warnings in the service manuals when installing a RAMJET 350 engine in any vehicle. Wear eye protection and appropriate protective clothing. Support the vehicle securely with jack stands when working under or around it. Use only the proper tools. Exercise extreme caution when working with flammable, corrosive, and hazardous liquids and materials. Some procedures require special equipment and skills. If you do not have the appropriate training, expertise, and tools to perform any part of this conversion safely, this work should be done by a professional.

TITLE **RAMJET 350 Engine 12499120 Specifications** REV07DE09 PART NO. **88962743** PAGE **2** OF **48**

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07DE09	Revised - Cassie Fenoseff	

Legal and Emissions Information

This publication is intended to provide information about the RAMJET 350 engine and related components. This manual also describes procedures and modifications that may be useful during the installation of a RAMJET 350 engine. It is not intended to replace the comprehensive service manuals and parts catalogs which cover General Motors engines and components. Rather, it is designed to provide supplemental information in areas of interest to "do-it-yourself" enthusiasts and mechanics.

This publication pertains to engines and vehicles which are used off the public highways except where specifically noted otherwise. Federal law restricts the removal of any part of a federally required emission control system on motor vehicles. Further, many states have enacted laws which prohibit tampering with or modifying any required emission or noise control system. Vehicles which are not operated on public highways are generally exempt from most regulations, as are some special interest and pre-emission vehicles. The reader is strongly urged to check all applicable local and state laws.

Many of the parts described or listed in this manual are merchandised for off-highway application only, and are tagged with the "Special Parts Notice" reproduced here:

Special Parts Notice

This part has been specifically designed for Off-Highway application only. Since the installation of this part may either impair your vehicle's emission control performance or be uncertified under current Motor Vehicle Safety Standards, it should not be installed in a vehicle used on any street or highway. Additionally, any such application could adversely affect the warranty coverage of such an on-street or highway vehicle.

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Package contents:

<u>Item</u>	<u>Description</u>	<u>Quantity</u>	<u>Part Number</u>
1	Engine Assembly	1	12499118
2	Specifications	1	88962743
3	Small block RAMJET service manual	1	88962723
4	Diagnostic trouble code tool (DTC tool)	1	12489400
5	Ignition coil assembly	1	12598697
6	Ignition coil wire	1	12097982
7	Spark plug wire kit	1	12361057
8	Wiring harness	1	88961967
9	Spark plug	8	5614210

Component Information:

350 RJ Intake Manifold:

This kit comes with a GM Performance Parts port fuel injection intake manifold designed especially for the RamJet 350 engine. This cast aluminum intake manifold comes with two holes in the rear of the plenum. The hole in the rear face of the plenum is tapped for a 3/8" NPT fitting and should be used for a vacuum port to operate the brake booster. It is in close proximity to the distributor so it may be beneficial to install this fitting after the engine oil is primed and the distributor is installed. The second hole is in the right side of the plenum and is tapped for 1/4" NPT. This hole is used for the vacuum port that supplies vacuum to the fuel pressure regulator. The fuel pressure regulator is mounted on the left rear fuel rail and uses a male -6 AN nipple on the bottom. This is the fuel return line that will be necessary to adapt to your application. The right fuel rail has a 3/8" NPT hole that is used for the fuel inlet. You will need to determine what will be needed to adapt the inlet fitting to your application.

Note: If your are installing this package in a vehicle that was originally equipped with a carburetor or TBI system, the fuel lines will need to be upgraded. The fuel lines must be able to handle the increased pressure required by the fuel injection system. Do not use any barbed fittings or worm clamps to secure the pressurized fuel lines in your fuel system. Also, ensure rubber lines are replaced with flexible hose of sufficient strength (i.e. stainless overbraid and AN style fittings for example). Finally, use caution in routing fuel lines to ensure that the lines are not located too close to the exhaust system and are protected from road debris or obstructions.

Water Pump:

The RAMJET 350 engine includes a standard rotation water pump. This is a cast iron, long leg water pump; the same pump that is installed on the GM Performance Parts ZZ4 crate engine.

Any small block engine, regardless of year, that uses Vortec heads, will require an external coolant bypass line from the intake manifold to the 5/8" hose nipple on the water pump (passenger's side). Suggested routing is from the 3/8 NPSF boss on intake manifold to the water pump.

Ignition System:

This kit includes a distributor ignition system that is connected to the ECM. The ECM monitors the inputs from various engine sensors, computes the desired spark timing, and signals the Ignition Control module in the distributor to adjust timing.

The spark plugs recommended for the RAMJET 350 engine are AC Delco Part Number MR43LTS.

DATE	REVISION	AUTH

RAMJET 350 Engine Specifications:

Displacement:	350 cubic inches
Bore x Stroke:	4.00 inch x 3.48 inch
Compression	9.4:1
Block:	Cast iron, two-bolt main caps
Cylinder Head:	Cast iron, Vortec
Valve Diameter(Intake/Exhaust):	1.94"/1.50"
Chamber Volume:	63cc
Crankshaft:	Cast iron, 1 piece rear seal
Connecting Rods:	Forged, powdered metal, 3/8" bolts
Pistons:	Cast aluminum
Rings	Top Moly, Second Iron
Camshaft:	Hydraulic roller tappet
Lift:	.460" intake, .481" exhaust
Duration:	196° intake, 205° exhaust @ .050" tappet lift
Centerline:	104° ATDC intake, 109° BTDC exhaust
Rocker Arm Ratio:	1.6:1, roller tip
Timing Chain:	Single roller design
Oil Pan:	5 quart excluding oil filter
Oil Pressure (Normal):	6 psig @ 1000 RPM 18 psig @ 2000 RPM 24 psig @ 4000 RPM
Recommended Oil:	5W30
Oil Filter:	AC Delco part # - PF1218
Valve Lash:	1/8 Turn Past 0 Lash
Fuel:	Premium unleaded - 92 (R+M/2)
Maximum Engine Speed:	5600 RPM
Spark Timing:	Initial: 10° Before Top Dead Center
Spark Plugs:	AC Delco part # MR43LTS
Spark Plug Gap:	0.040"
Firing Order:	1-8-4-3-6-5-7-2

Information may vary with application. All specifications listed are based on the latest production information available at the time of printing.

Caution: Before the engine is installed in a vehicle, it needs to be filled with oil and primed. You should add GM Goodwrench 10W30SG or equivalent motor oil to your new engine. Check the engine oil level on the dipstick and add accordingly. To prime the engine, first remove the distributor to allow access to the oil pump drive shaft. Note the position of the distributor before removal. Install an oil priming tool, GM Part Number 12368084, for example. Using a 1/2" drill motor, rotate the engine oil prime tool clockwise for two to three minutes. While you are priming the engine, have someone else rotate the crankshaft clockwise to supply oil throughout the engine and to all the bearing surfaces before the engine is initially fired. Reinstall the distributor in the same orientation as it was removed. After the engine has been installed in the vehicle, recheck the engine oil level and add oil as required.

Ignition Coil Installation:

The ignition coil will need to be installed. It can be attached to either the rear of the cylinder head, or the firewall of the vehicle, depending on the amount of clearance for your application. Torque the ignition coil bracket bolts to 22 Nm (16 ft.lbs.). Attach the ignition coil wire to the distributor.

DATE	REVISION	AUTH

ECM and Wiring Harness Installation:

The wiring harness included with the RAMJET 350, GM Part Number 88961967, will need to be installed. To ease the installation, all of the connectors have been labeled to identify which component each mates with. This harness installation requires a B+ connection and a fused ignition source. A tachometer output lead is also provided. This fuel injection harness is protected additionally by 3 mini fuses in a waterproof connector in the harness. Circuit protection of the B+ feed in the form of a fusible link is advised.

Among the items contained in this kit is an oxygen sensor. The oxygen sensor will monitor the exhaust gas and determine the level of richness or leanness of your engine. It will monitor the aggressive, performance oriented fuel tables in the ECM and trim them ever so slightly in order to optimize performance and driveability. This trimming allows you to operate at a maximum level of efficiency and thereby improve both driveability and fuel usage at the same time. In order to install the oxygen sensor in the exhaust, a weld-in exhaust bung has also been included in this kit. An oxygen sensor and exhaust bung are shown in Figure 1.

Another item in the kit is an intake air temperature sensor. This sensor acts much like a jet change that you might make on a race engine carburetor at the drag strip. Normally you might increase jet size when the temperature rises. This sensor takes the temperature of the inlet air and makes those "jet changes" electronically to the ECM fuel tables in order to optimize power output and get the best fuel mixture for improved performance and economy. An intake air temperature sensor is shown in Figure 2.

Installation of the exhaust bung requires welding. If you do not have the required equipment to install the exhaust bung, a qualified local muffler shop or service garage should be capable of completing this step for you.

Location of Exhaust Bung

Before you begin the installation of the exhaust bung, disconnect the negative battery cable to keep from damaging the ECM or sensors. Carefully inspect the engine and fuel system to ensure there are no fuel leaks in the fuel system. If a leak is found, repair before continuing with the installation.

The oxygen sensor that will be screwed into this bung will function best in the hottest part of the exhaust system. The closer the sensor is to the engine the better. If you have a cast exhaust manifold, locate the bung in the exhaust pipe downstream from the manifold flange — but as close to the flange as possible. If you have headers, install the bung into your collector adapter. For installation into a horizontal exhaust pipe, it is recommended that the sensor be installed with the tip facing downward, pointing to the center of the exhaust pipe. Figure 3 shows the recommended installation angles for a horizontal exhaust pipe. If the selected location for your sensor installation is vertical, there is no recommended installation angle; you will want to ensure the tip of the sensor is pointing to the center of the exhaust pipe. You will also need to be sure that your selected bung location will allow installation and removal of the oxygen sensor. Also, ensure that the sensor and associated wiring will not interfere with other components. Also, verify that the sensor wiring and connectors will not melt due to excessive exhaust heat. Drill a 7/8" hole in the exhaust pipe at your selected location using a hole saw.

The room must be well ventilated and you must ensure that there are no gasoline leaks or gasoline fumes anywhere near the room or area of welding.

Once the bung is installed, let the weld joint completely cool before installing the sensor. It is also recommended that you tap the bung with a 18mm x 1.50 metric tap to eliminate any distortion that may have occurred during the welding process.

FIGURE 1

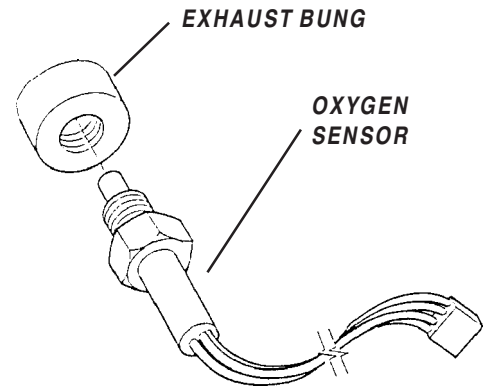


FIGURE 2

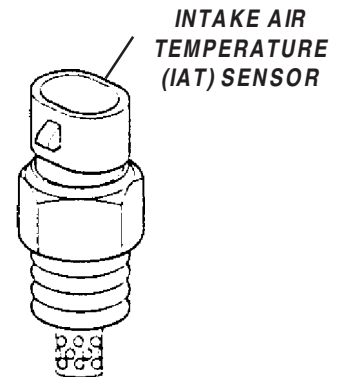
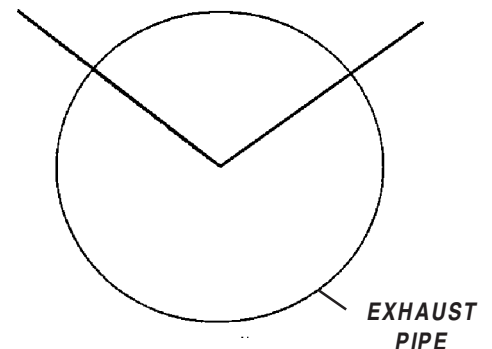


FIGURE 3

RECOMMENDED BUNG INSTALLATION RANGE



DATE	REVISION	AUTH

Installation of Sensors

Install the oxygen sensor into exhaust bung. A coat of anti-seize on the oxygen sensor's threads will ease removal of the sensor when replacement is necessary. The oxygen sensor should be torqued to 20 ft.lbs.

The intake air temperature (IAT) sensor should be located in the intake air stream. It is desirable to locate this sensor as far from the engine throttle body as possible. The thread on some of the available sensor is 1/4 NPT (National Pipe Thread). Determine where you will locate your IAT sensor. The sensor location will vary depending on your filter and intake duct configuration. If you are using a remote air filter with a duct from the filter to the throttle body, you should install the IAT sensor in the duct near the filter. If you are using a filter directly on the throttle body, you should install the IAT sensor in the filter. Installation of the IAT sensor in the intake manifold is not recommended. In the intake manifold the sensor may provide false readings due to the sensor absorbing heat from the engine/intake manifold. If you plan on welding in threads, a pipe nipple from your local hardware may facilitate the installation. Additionally, some "snap-in" intake sensor are available in a number of configurations.

Installation of Harness

You may need to lengthen or shorten the oxygen and IAT sensor wires on the harness. It is recommended that this be done by soldering and sealing your soldered connection with heat shrink. Standard butt connectors are not recommended. **NOTE: Do not make any repairs or modifications to the wires attached directly to the Oxygen Sensor.**

1. Lay the wiring harness along the left-hand side of the intake manifold with the idle air control valve, throttle position sensor, and engine coolant temperature sensor connectors at the front of the engine.
2. Connect the sensors mentioned above to their mating components.
3. Attach the eight fuel injector connectors.
4. Plug the MAP sensor connector into the MAP sensor, located on the left hand side of the intake manifold plenum.
5. Install the ECM connectors. Your ECM connectors on the harness can be identified by the clear or smoke colored alignment keys - J1 - smoke, J2-clear. The outside of each connector on the ECM is labeled J1 or J2.
6. Install the coil wire assembly, GM Part Number 12097982. One end attaches to the top of the coil, the other end to the rear of the distributor.
7. Attach the connectors from the harness to the distributor and the ignition coil.
8. Plug in the fuel pump and ignition relays.
9. Attach the knock sensor connector to the knock sensor. Use care in routing the wiring harness to the connector so that the harness will not be damaged by heat from the exhaust system.
10. Attach the B+ lead to the big terminal at the starter. A fusible link should be added at this connection for added protection.
11. Connect the fuel pump leads. The installer must provide a wiring harness from the fuel pump to the leads provided.
12. Connect the ignition lead to the ignition switch.
13. On your harness you will notice several different grounds. The grounds must be grounded on separate studs on the engine. Failure to use separate ground studs may result in improper engine performance or ECM failure.
14. You will also notice two tachometer outputs from the harness, tach1 is for a standard negative side of the coil driven tach. Tach2 is for digital tachometers; this is a 0-12 V square wave output. Select and connect the proper output for your application.
15. Reconnect your battery cable.

DATE	REVISION	AUTH

Setting Initial Timing:

In order to change base timing on the system, the ECM has to be entered into the "service mode" using the diagnostic trouble code (DTC) tool, GM Part Number 12489400. This can be accomplished by attaching the DTC tool to the data link connector on the wiring harness.

1. Turn the engine's ignition switch to the off position (Engine not running)
2. Place the DTC tool's test switch in the off position and plug the tool into the data link connector on the wiring harness.
3. Start the engine, and place the DTC tool test switch in the on position.

The IC module will then go to base ignition timing. At this time, the base timing can be adjusted by turning the distributor. Using a timing light, set base timing at 10° Before Top Dead Center (BTDC).

Initial Engine Break-in:

After the engine has been installed in your vehicle, the base timing has been set, and a sense check has been performed, i.e. good oil pressure, no fluid leaks, acceptable coolant temperature, etc.

1. The vehicle should then be driven under varying loads and conditions for the first 30 miles, without wide-open throttle or sustained, high RPM accelerations. NOTE: The ECM is programmed with a "Green Mode" that limits the maximum RPM during the break-in period. From start up to the end of the first hour the limit is 4000 RPM, for the second hour it is 4500 RPM, and for the third hour it is 5500 RPM.
2. Run five or six medium-throttle accelerations to about 4000 RPM, letting off in gear.
3. Run two or three hard accelerations to about 4000 RPM, letting off in gear.
4. Change the oil and the oil filter, and replace with 5W30 motor oil and a PF1218 ACDelco oil filter. Inspect both the used oil and filter to ensure that the engine is functioning properly.
5. Drive the next 500 miles under "normal" conditions. Do not run the engine at the maximum rated engine speed of 5500 RPM, and do not expose the engine to extended periods of high loads.
6. Change the oil and filter again.

Additional parts that may be needed:

Flywheel / Flexplate:

Like all GEN1 or GEN1E V8 engines produced since 1986, the RAMJET 350 engine has a 3.00" diameter flywheel flange bolt pattern. Small block V8 engines produced from 1958 through 1985 had a 3.58" diameter flywheel flange bolt pattern. This change in bolt circle diameter was made to accommodate a leak-resistant one-piece rear main seal. Due to revisions in the crankshaft design, a RAMJET 350 engine must have a counterweighted flywheel (or flexplate) for proper balance. The RAMJET 350 engine includes a 14" manual transmission flywheel, GM Part Number 14088648. If you are installing this engine with an automatic transmission or you want to use a 12 3/4" flywheel, select one of the flywheels or flexplates from the chart below. Use flywheel bolt GM Part Number 839756 (6 required) or flexplate bolt GM Part Number 3727207 (6 required).

NOTE: When installing this engine with an automatic transmission, the clutch pilot bearing should be removed. This will ensure that no interference exists when a torque converter is installed.

RAMJET 350 Engine Manual Transmission Flywheels

<u>GM Part Number</u>	<u>Outside Diameter</u>	<u>Clutch Diameter</u>	<u>Starter Ring Gear Teeth</u>	<u>Notes</u>
10105832	14"	11.0, 11.58"	168	For one-piece crank seal
14088646	12-3/4"	10.4, 11.0"	153	Lightweight nodular iron flywheel, weighs approximately 15 lbs.; for one-piece crank seal
14088650	12-3/4"	10.4"	153	Standard weight flywheel; for one-piece crank seal

DATE	REVISION	AUTH

RAMJET 350 Engine Automatic Transmission Flexplates

<u>GM Part Number</u>	<u>Outside Diameter</u>	<u>Converter Bolt Pattern</u>	<u>Starter Ring Gear Teeth</u>	<u>Notes</u>
14088765	12-3/4"	10.75"	153	For one-piece crank seal
12554824	14"	11.50"	168	Heavy-duty flexplate with increased thickness for one-piece crank seal
14088761	14"	10.75,11.50"	168	For one-piece crank seal

Starter:

The starter must be matched to flywheel (or flexplate) diameter when installing a RAMJET 350 engine assembly. Small diameter flywheels are 12-3/4" in diameter, and have starter ring gears with 153 teeth. Large diameter flywheels are 14" in diameter, and have 168 teeth on the starter ring gear. This difference in flywheel diameters requires two different starter housings. Starter noses used with 14" diameter flywheels have two offset bolt holes; starter used with 12-3/4" diameter flywheels have bolt holes that are straight across from each other. Note: Chevrolet starter motors use special shouldered mounting bolts that register the starter on the block.

The following starters can be used with the RAMJET 350 engine assemblies:

- 10496870 Heavy-duty, remanufactured starter for 12-3/4" diameter flywheel/flexplate
- 1876552 Heavy-duty, remanufactured starter for 14" diameter flywheel/flexplate
- 14097278 Bolt, starter mounting, long, for heavy duty starter
- 14097279 Bolt, starter mounting, short, for heavy duty starter
- 10455709 Remanufactured permanent magnet gear reduction (PMGR) starter for 12-3/4" diameter flywheel/flexplate (10 lb.)
- 12606096 Permanent magnet gear reduction (PMGR) starter for 14" diameter flywheel/flexplate (10 lb.)
- 14037733 Bolt, starter mounting, inner for 12-3/4" PMGR starter
- 12338064 Bolt, starter mounting, outer for 12-3/4" PMGR starter; also for 14" PMGR starter (2 required)

Oil Pan / Filter / Adapter / Dipstick:

The RAMJET 350 engine includes an oil pan, GM Part Number 10242245. This pan was originally design for marine and truck usage and may cause interference problems when installed in certain applications. Check for clearance before installation. The oil pan used on the ZZ4 engine, GM Part Number 12528916, is recommended as a replacement. This is a four-quart, right-hand dipstick oil pan and gasket.

An offset oil filter adapter can be installed to provide additional clearance for headers, clutch linkage, and suspension components. This offset oil filter adapter uses a small diameter, spin-on filter element.

- 12556204 Offset oil filter adapter
- 88893990 Gasket and seal, oil filter adapter
- 11610405 Washer, oil filter adapter (2 req.)
- 14092398 Bolt, oil filter adapter (2 req.)
- AC PF52 Filter, spin-on, small diameter

The oil dipstick for the RAMJET 350 engine is on the right-hand (passenger) side of the block. Check for clearance when replacing an early-model block with a left-hand dipstick configuration. The RAMJET 350 engine does not come with an oil dipstick. When using the oil pan supplied with the engine, the recommended oil dipstick and oil dipstick tube part numbers are 10190942 and 12552920 respectively. If the ZZ4 oil pan is installed on this engine, the recommended oil dipstick and tube part numbers are 12551144 and 12551154 respectively. This oil dipstick tube bolts to the engine block below the deck surface, and can be used with header-type exhaust systems.

DATE	REVISION	AUTH

Fuel Pump / Fuel Lines / Fuel Filter:

The RAMJET 350 engine does not include a fuel pump. The fuel system in your application must be capable of supplying a minimum of 35 gallons per hour of fuel. The operating pressure of the fuel pump must be within the range of 43 - 55 psi.

Proper fuel pressure is essential to the correct operation of the RamJet350. Below are the specifications for expected fuel pressure under various operating conditions.

Idle =	38-40 PSI (262-276 KPA)
Steady Cruise =	40-42 PSI (276-290 KPA)
Wide Open Throttle =	42-44 PSI (290-303 KPA)

An in-tank fuel delivery system from a GM vehicle is recommended for use with this system. The fuel system from any GM vehicle originally equipped with a port fuel injection system and a V-8 engine is a possible candidate. Production GM fuel pumps that would be good candidates include the Vortec truck fuel pump, or an LT1 Camaro/Firebird fuel pump. Carbureted and Throttle Body Injection fuel delivery systems will not meet the needs of a port fuel injection system. They do not provide enough pressure at the fuel rail.

An in-tank fuel system is recommended for a number of reasons. First, a GM production in-tank system will ensure that no vapor lock issues arise. Vapor lock is a common problem with in-line fuel pumps. In high ambient temperatures the fuel in the fuel line can vaporize. An in-line fuel pump cannot move this vapor at the levels required by the fuel injection system. As a result, the fuel pressure at the fuel rail drops, and a number of problems arise. These problems include a stumble or sag to a worst case of a stall and no start condition. Using a GM in-tank fuel system will ensure that this problem does not occur on your vehicle. Second, the in-tank fuel delivery system will have a return line plumbed into the fuel sender unit. This return line is required for proper operation of this system. The fuel regulator, mounted at the fuel rail, maintains the correct fuel pressure being fed to the injectors, based on intake manifold vacuum. In general, the fuel pump will supply fuel at a pressure greater than required at the rail. The regulator then bleeds off this extra fuel to maintain the correct pressure. The fuel that is bled off needs to be carried back to the fuel tank, via the fuel return line. Third, the fuel tanks used with in-tank fuel systems have baffles in them. These baffles ensure that the fuel pump will have fuel available as long as a sufficient amount of fuel is in the tank. The baffles keep all of the fuel from collecting at one side of the tank during hard cornering, or at the rear of the tank during hard accelerations.

If you are installing this package in a vehicle that was originally equipped with a carburetor, the fuel lines will need to be upgraded as well. The lines must be able to handle the increased pressure required by the fuel injection system. Do not use barbed fittings or worm clamps to secure the pressurized fuel lines. Also, ensure that the rubber lines are removed and replaced with fuel lines of sufficient strength, Aeroquip AQP fuel line hose with a stainless overbraid and AN style fittings for example. Finally, use caution in routing the fuel lines to ensure that the lines are not located too close to the exhaust system and are protected from road debris or obstructions.

The fuel filter recommended for use with this system is GM Part Number 25121792 (AC #GF626). This filter is a 10-micron filter with 3/8" fittings on each end. The fuel filter should be installed between the fuel tank and the fuel rail, typically located close to the fuel tank.

Headers:

A RAMJET 350 engine should be equipped with a header exhaust system for maximum performance in applications where a non-production exhaust system is legal. All of the calibration development work was done with a header exhaust system installed on our development engines. Installing production style exhaust manifold may increase backpressure and alter the performance of the system. The recommended header configuration is 1-3/4" diameter primary pipes, 32 to 36 inches long, with 3" diameter collectors. Use 2-1/2" diameter tailpipes with a balance tube ("H" pipe) and low restriction mufflers.

350 RAMJET Operating RPM Ranges

Thinking about the intended usage of the vehicle you will be installing your RAMJET engine into will allow you to make good decisions on your total vehicle package. To get the most effective usage from your crate engine, you should attempt to design the rest of the vehicle to complement the effective engine RPM range. Consider the weight, gearing (transmission and axle) of the vehicle, as well as the vehicle speeds and geography (hilly or flat) that you will most likely be driving in the majority of the time.

The RAMJET 350 engine makes peak horsepower at 5100 RPM. A good rule of thumb would be a highway cruising speed that places the engine at an RPM in the range of 60-70% lower than peak. Using this example would place optimal highway engine speed at 1500-2000 RPMs. Heavier vehicles (over 3500 lbs) would perform better using a combination at the higher end of this range and lighter vehicles (under 3000 lbs) would be better suited near the lower end of this range.

DATE	REVISION	AUTH

Things that impact final gear ratio are:

- Tire Size
- Axle Gear Ratio
- Transmission Gear Ratios (with or without overdrive)
- Torque Converters (stall speed selection and/or with or without lock up feature)

Some handy formulas are included below to help make informed decisions. Insert your numbers into these formulas to help you decide what will work best for your application.

Tire Diameter = Measured in inches

MPH = Typical highway cruising speed

Ratio = Final Gear Ratio (Transmission Gear Ratio multiplied by Axle Ratio)

Constant = 336

Final Gear Ratio = (RPM x Tire Diameter) divided by (MPH x 336)

RPM = (MPH x Final Gear Ratio x 336) divided by (Tire Diameter)

MPH = (RPM x Tire Diameter) divided by (Final Gear Ratio x 336)

Tire Diameter = (MPH x Final Gear Ratio x 336) divided by (RPM)

For example, using the first formula to estimate Final Gear Ratio:

$$\frac{2000 \text{ RPM} \times 30'' \text{ Tire Diameter}}{65 \text{ MPH} \times 336} = 2.74 \text{ Final Gear Ratio}$$

IMPORTANT: Remember to include overdrive transmission ratios in your final calculation.

For example, if using a 4L60E transmission, the overdrive ratio is 0.71. In order to get to 2.74 final gear ratio, you would calculate as follows:

$$\frac{2.74 \text{ (Final Gear Ratio)}}{0.7 \text{ (Trans O/D Ratio)}} = 3.91 \text{ (Estimated Axle Ratio)}$$

At this point, the estimated ratio you determine may not be a ratio that is readily available. You should then review ratio options higher or lower depending on other factors listed above (personal preference and driving habits, geography, overall average vehicle speed, vehicle final weight, ect...).

Remember that the examples given here are strictly for demonstration purposes and your results may vary. The consumer assumes all responsibility for determining actual usage conditions.

DATE	REVISION	AUTH

Spark Plugs / Spark Plug Wires / Wire Loom Kit:

The RAMJET 350 engine's cast iron, Vortec cylinder heads have straight spark plugs. Check for spark plug and wire clearance when using aftermarket headers designed for angled plugs.

The RAMJET 350 engine includes spark plug wires, GM Part Number 12361057. These heavy-duty wires come with 90° spark plug boots, and the GM Performance Parts logo stamped on the wires.

GM Performance Parts sells a spark plug wire loom kit, GM Part Number 12496806. The brackets in this kit are stainless steel, with the "Bow Tie" logo laser cut into them. This kit can be used with the RAMJET 350. The brackets bolt to the side of the cylinder heads.

Rocker Covers:

The RAMJET 350 engine comes equipped with chrome, center hold-down bolt rocker covers, GM Part Number 12355350. Black composite, center hold-down bolt rocker covers, GM Part Numbers 12552321 and 12552322, are also available from GM Performance Parts. If you want the appearance of an early-model engine, pre-'87 flange mount rocker covers can be installed on the RAMJET 350 engine using an adapter, GM Part Number 24502540. This adapter is machined from billet aluminum, and uses an O-ring seal between the adapter and cylinder head rocker cover rail. Ensure that enough clearance exists between the rocker cover and brake booster when using this adapter.

Diagnostic and Service Tools:

Included with the RAMJET 350 engine is a diagnostic trouble code tool. This simple device will allow you to read any diagnostic trouble codes stored in the ECM as well as set base ignition timing. If you would like more functionality than the DTC tool can provide, you can purchase a TechMate scan tool. Functionally, this scan tool is similar to a Tech 1 or Tech 1A used at GM dealerships. To purchase a TechMate scan tool, simply call or write to:

Rinda Technologies Inc.
4563 N. Elston Avenue
Chicago, IL 60630
(773) 736-6633

RAMJET 350 Engine Torque Specifications:

Camshaft retainer bolt/screw	106 in.lbs. / 12 Nm
Camshaft sprocket bolt/screw	21 ft.lbs. / 28 Nm
Connecting rod nut.....	006" bolt stretch preferred 20 ft.lbs. + additional 55° (45 ft.lbs. if no angle gauge is available) / 27 Nm + additional 55° (61 Nm if no angle gauge is available)
Crankshaft balancer bolt	74 ft.lbs. / 100 Nm
Crankshaft bearing cap bolt/screw and stud	67 ft.lbs. / 90 Nm
Crankshaft rear oil seal housing nut/bolt/screw	11 ft.lbs. / 15 Nm
Cylinder head bolt/screw	65 ft.lbs. / 88 Nm
Distributor bolt/screw	18 ft.lbs. / 25 Nm
Engine block oil gallery plug	15 ft.lbs. / 20 Nm
ECM mounting bolt/screw	106 in.lbs. / 12 Nm
Engine coolant temperature sensor	106 in.lbs. / 12 Nm
Engine front cover bolt screw	106 in.lbs. / 12 Nm
Flywheel bolt/screw	74 ft.lbs. / 100 Nm
Fuel pressure regulator bolt/screw	84 in.lbs. / 9.5 Nm
Fuel pressure regulator outlet line nut	13 ft.lbs. / 17.5 Nm
Fuel rail bolt/screw	88 in.lbs. / 10 Nm
Idle air control valve bolt/screw	28 in.lbs. / 3.2 Nm
Ignition oil bracket bolt/screw	16 ft.lbs. / 22 Nm

DATE	REVISION	AUTH

Intake manifold bolt/screw and stud

First pass	9 ft.lbs. / 12 Nm
Second pass	11 ft.lbs. / 15 Nm
Knock sensor	14 ft.lbs. / 19 Nm
MAP sensor bolt/screw	55 in.lbs. / 6 Nm
Oil filter adapter bolt/screw	18 ft.lbs. / 25 Nm
Oil level indicator tube bolt/screw	106 in.lbs. / 12 Nm
Oil pan assembly	
Corner nut/bolt/screw	15 ft.lbs. / 20 Nm
Side rail bolt/screw	106 in.lbs. / 12 Nm
Oil baffle nut	30 ft.lbs. / 40 Nm
Oil pan drain plug	15 ft.lbs. / 20 Nm
Oil pump bolt/screw to rear crankshaft bearing cap	66 ft.lbs. / 90 Nm
Oil pump cover bolt/screw	106 in.lbs. / 12 Nm
Sensor, oxygen	20 ft.lbs. / 27 Nm
Spark plug	15 ft.lbs. / 20 Nm (tapered seat)
Starter motor bolt/screw	35 ft.lbs. / 48 Nm
Throttle position sensor bolt/screw	18 in.lbs. / 2 Nm
Throttle body bolt/screw	11 ft.lbs. / 15 Nm
Valve lifterguide retainer bolt/screw	18 ft.lbs. / 25 Nm
Water pump bolt/screw	30 ft.lbs. / 40 Nm

Service Parts List:

Block Assembly, Engine -----	Not serviced separately
Engine Assembly, Service Partial -----	12556121
Plug, Engine Block Core Hole -----	3826504
Bearing, Camshaft#1 -----	12453170
Bearing, Camshaft#2,5 -----	12453171
Bearing, Camshaft#3,4 -----	12453172
Bolt/Screw, Crankshaft Brg Cap -----	12561388
Stud, Crankshaft Bearing Cap -----	12561389
Plug, Engine Block Cool Drain -----	14084945
Bearing Kit, Crankshaft #1,2,3,4 -----	12531215
Bearing Kit, Crankshaft #5 -----	12528826
Head Assembly, Cylinder (Complete) -----	12558060
Head Assembly, Cylinder With Studs -----	12528913
Valve, Intake -----	10241743
Valve, Exhaust -----	12550909
Spring, Valve -----	10212811
Key, Valve Stem -----	24503856

Seal, Intake Valve Stem Oil -----	10212810
Seal, Exhaust Valve Stem Oil -----	12558674
Cap, Valve Spring -----	10241744
Gasket, Cylinder Head -----	14096405
Bolt/Screw, Cylinder Head (Long) -----	10168525
Bolt/Screw, Cylinder Head (Medium) -----	10168526
Bolt/Screw, Cylinder Head (Short) -----	10168527
Plug Assembly, Cylinder Head Core -----	444662
Pin, Cylinder Head Locating -----	585927
Crankshaft -----	10243068
Pin, Crankshaft Rear Oil Seal -----	9441003
Housing Assembly, Crankshaft Rear Oil Seal -----	12554336
Stud, Crankshaft Rear Oil Seal -----	14080362
Seal Assembly, Crankshaft Rear Oil -----	12554337
Housing Assembly, Crankshaft Rear Oil -----	12554312
Stud, Crankshaft Rear Oil Seal -----	14080362
Seal Assembly, Crankshaft Rear Oil -----	12554314

DATE	REVISION	AUTH

Gasket, Crankshaft Rear Oil Seal ----- 12555771
 Bolt/Screw, Crankshaft Rear Oil ----- 14101030
 Bolt/Screw, Crankshaft Rear Oil ----- 14101032
 Stud, Crankshaft Rear Oil Seal ----- 14101058
 Nut, Crankshaft Rear Oil Seal ----- 9439915
 Deflector, Crankshaft Oil ----- 12557231
 Nut, Crankshaft Oil Deflector ----- 9442946
 Balancer Assembly, Crankshaft ----- 12555879
 Key, Crankshaft Balancer ----- 106751
 Flywheel Assembly ----- 10105832
 Gear, Flywheel Ring ----- 460583
 Bolt/Screw, Flywheel ----- 12337973
 Pin, Flywheel Locating ----- 3701679
 Rod Assembly, Connecting ----- 10108688
 Bolt/Screw, Connecting Rod ----- 461372
 Nut, Connecting Rod ----- 3866766
 Piston Assembly, With Pin(Standard) ----- 12522850
 Piston Assembly, With Pin(.127mm Oversize) ----- 12533560
 Piston Assembly, With Pin(.5mm Oversize) ----- 12524224
 Ring Kit, Piston(Standard) ----- 12522848
 Ring Kit, Piston(.127mm Oversize) ----- 12533559
 Ring Kit, Piston(.5mm Oversize) ----- 12524205
 Bearing, Connecting Rod ----- 12523925
 Pan Assembly, Oil With Gasket ----- 12529306
 Plug Assembly, Oil Pan Drain ----- 24100042
 Gasket, Oil Pan ----- 10108676
 Nut, Oil Pan ----- 1359887
 Bolt/Screw, Oil Pan ----- 9440033
 Stud, Oil Pan ----- 14080362
 Reinforcement, Oil Pan ----- 12553058
 Reinforcement, Oil Pan ----- 12553059
 Screen Assembly, Oil Pump ----- 12550042
 Pump Assembly, Oil ----- 12555283
 Cover Assembly, Oil Pump ----- 10168528
 Valve, Oil Press Relief ----- 3702366
 Plug, Oil Press Relief Valve ----- 3704871
 Spring, Oil Press Relief Valve ----- 10044435
 Pin, Oil Press Relief Valve S ----- 12551790
 Bolt/Screw, Oil Pump Cover ----- 11517518
 Shaft, Oil Pump Drive ----- 3998287
 Retainer, Oil Pump Drive Shaft ----- 3764554

Bolt/Screw, Oil Pump ----- 10046007
 Pin, Oil Pump Locating ----- 12554553
 Plug, Engine Block Oil Galley ----- 14091563
 Plug, Engine Block Oil Galley ----- 10110897
 Plug Assembly, Engine Block Oil Galley ----- 12338136
 Plug, Engine Block Oil Galley ----- 14091563
 Plug Assembly, Engine Block Oil Galley ----- 12338136
 Plug, Engine Block Oil Galley ----- 3738198
 Plug Assembly, Engine Block Oil Galley ----- 14084945
 Cap Assembly, Oil Fill ----- 10108650
 Cover Assembly, Engine Front ----- 12552557
 Seal Assembly, Crankshaft Front Oil ----- 10228655
 Bolt/Screw, Engine Front Cover ----- 10213293
 Bolt/Screw, Engine Front Cover ----- 12551135
 Grommet, Engine Front Cover ----- 10213294
 Pump Assembly, Water With Gasket ----- 12529305
 Plug, Engine Cool Thermostat Housing ----- 143936
 Hub, Fan & Water Pump Pulley ----- 354480
 Gasket, Water Pump Cover ----- 12555493
 Gasket, Water Pump ----- 3754587
 Bolt/Screw, Water Pump ----- 9439637
 Bolt/Screw, Water Pump ----- 9442250
 Stud, Water Pump ----- 3759755
 Camshaft Assembly ----- 14097395
 Pin, Camshaft Sprocket, Locating ----- 12554553
 Retainer, Camshaft ----- 10168501
 Bolt/Screw, Camshaft Retainer ----- 14093637
 Sprocket, Camshaft ----- 12552129
 Sprocket, Crankshaft ----- 14088784
 Bolt/Screw, Camshaft Sprocket ----- 9424877
 Chain Assembly, Timing ----- 14088783
 Plug, Camshaft Rear Bearing Hole ----- 10241154
 Rod Assembly, Valve Push ----- 10241740
 Lifter Assembly, Valve ----- 17120735
 Guide, Valve Lifter ----- 12550002
 Retainer, Valve Lifter Guide ----- 14101116
 Arm, Valve Rocker ----- 12367346
 Nut, Valve Rocker Arm ----- 12557390
 Ball, Valve Rocker Arm ----- 10144053
 Cover Assembly, Valve Rocker Arm ----- 12355350
 Bolt/Screw, Valve Rocker Arm Cover ----- 12356818

DATE	REVISION	AUTH

Gasket, Valve Rocker Arm Cover ----- 10046089
 Spark Plug Assembly ----- 5614210
 Pin, Transmission Locating ----- 12338119
 Engine Assembly, (Service Partial) ----- 12556121
 Valve Assembly, PCV ----- 25095452
 Grommet, PCV Valve ----- 10240678
 Hose Assembly, PCV Valve ----- 12556930
 Connector, PCV Valve Hose ----- 336018
 Manifold Assembly, Intake ----- 12489371
 Shield, Intake Manifold Oil Splash ----- 10128305
 Bolt/Screw, Intake Manifold ----- 11514149
 Gasket Assembly, Intake Manifold ----- 12529094
 Bolt/Screw, Intake Manifold ----- 12550027
 Fitting, Intake Manifold Vacuum ----- 14082470
 Body Assembly, Throttle ----- 17096144
 Sensor Assembly, Throttle Position ----- 17123852
 Valve Assembly, Idle Air Control ----- 17113209
 Seal, Idle Air Control Valve ----- 17082049
 Bolt/Screw Kit, Idle Air ----- 17113168
 Gasket, Throttle Body ----- 12551240
 Bolt/Screw, Throttle Body ----- 11516425
 Injector Kit, Multi-Port Fuel ----- 17124248
 Rail Assembly, Multi-Port Fuel Injection ----- 12553918
 Regulator, Fuel Pressure ----- 17123897
 Bolt, Fuel Pressure Regulator ----- 9439930
 Hose, Fuel Pressure Regulator ----- 12557247
 Connector, Fuel Line ----- 12489599
 Seal, Fuel Line Connector ----- 12489600
 Bolt/Screw, Fuel Injection ----- 11516061
 Housing Kit, Distributor ----- 10482981
 Pin, Distributor Ignition Pick Up ----- 454666
 Cap, Distributor ----- 10477841
 Bolt/Screw, Distributor Cap ----- 10469669
 Shaft, Distributor ----- 10491354
 Rotor, Distributor ----- 10477219
 Module Assembly, Distributor ----- 10482830
 Bolt/Screw, Distributor ----- 10469668
 Pole Piece, Distributor Pick Up ----- 10469667
 Coil, Distributor Pick Up ----- 10470794
 Retainer, Distributor Ignition Pick Up ----- 10493403
 Gear, Distributor Shaft ----- 10469459

Pin, Distributor Gear ----- 456652
 Washer, Distributor Shaft Thrust ----- 1977937
 Washer, Distributor Shaft ----- 1965864
 Shield, Distributor Ignition Pick Up ----- 10496783
 Gasket, Distributor ----- 10108445
 Clamp, Distributor ----- 10096197
 Bolt/Screw, Distributor ----- 14091544
 Sensor Assembly, Knock ----- 10456126
 Coil Assembly, Ignition ----- 1115498
 Bracket, Coil ----- 10470094
 Bracket, Coil ----- 10470624
 Screw/Bolt, Coil Bracket ----- 11507041
 Nut, Coil Bracket ----- 10180301
 Wire Assembly, Ignition Coil ----- 12097982
 Regulator Assembly, Fuel Pressure ----- 17123897
 Bolt/Screw, Fuel Pressure Regulator ----- 9439930
 Hose Assembly, Fuel Pressure Regulator ----- 12557247
 Module Assembly, Engine Control ----- 88962717
 Bracket, ECM Mounting ----- 12489584
 Bolt, ECM Bracket Mounting ----- 11509024
 Nut, ECM Bracket Mounting ----- 96068280
 Sensor Assembly, MAP ----- 16249939
 Seal, MAP Sensor ----- 16194007
 Bracket, MAP sensor ----- 12489583
 Bolt, MAP Sensor Bracket ----- 12489598
 Sensor Assembly, Engine Coolant Temperature ----- 12146312
 Bracket Assembly, Multiuse Fuse ----- 10029398
 Filter Assembly, Fuel ----- 25121792
 Harness Assembly, Throttle Body ----- 12181943
 Connector, Module-Engine Control ----- 12129228
 Retainer, ECM Wiring Harness ----- 12129231
 Retainer, ECM Wiring Harness ----- 12129234
 Retainer, ECM Wiring Harness ----- 12129232
 Retainer, ECM Wiring Harness ----- 12129233
 Connector, Fuse ----- 12102746
 Cover, Engine Wiring Harness Fuse ----- 12186406
 Fuse Assembly, Wiring Harness ----- 12092078
 Fuse Assembly, Wiring Harness ----- 12092079
 Connector, Relay-Fuel Pump ----- 15306045
 Relay Assembly, Fuel Pump ----- 12193601
 Connector, Relay-Ignition ----- 15306045

DATE	REVISION	AUTH

Relay Assembly, Ignition -----	12193601
Connector, Data Link -----	12125676
Connector, Data Link -----	12117372
Connector, Fuel Pump -----	12085491
Connector, Sensor-Map -----	12129946
Connector, Coil-Ignition -----	12101896
Wire Assembly, Ignition Coil -----	12097982
Connector, Sensor-Engine Coolant -----	12101899
Connector, Idle Air -----	12126487
Connector, Sensor-Throttle Position -----	12102748
Connector, Module-Distributor Ignition -----	12126487
Connector, Injector-Fuel -----	12085491
Connector, Inline-To Body Harness -----	12101855
Connector, Sensor-Knock -----	12102621
Harness, Engine Wiring -----	88961967
Wire Set, Spark Plug -----	12361057
Post, Transmission Cable -----	12489601
Nut, Transmission Cable Post -----	12489602
Washer, Transmission Cable Post (Lock) -----	12489603
Bracket, Transmission Cable -----	12489585
Bolt, Transmission Cable Bracket -----	11516061
Nut, Transmission Cable Bracket -----	11516075
Bracket, Transmission & Throttle Cable -----	12489586
Bolt, Transmission & Throttle Cable Bracket -----	11516061
Nut, Transmission & Throttle Cable Bracket -----	96068280
Bracket, Cable Bracket Mounting -----	12489587
Bolt, Cable Bracket Mounting Bracket -----	11516061
Pump, Water (with Gaskets) -----	12529305
Gasket, Water Pump -----	3754587
Bolt, Water Pump -----	9442012
Fitting, pipe oxygen sensor -----	15156588
Sensor Assembly, oxygen -----	25312200
Sensor, intake air temperature -----	25037651
Connector, oxygen sensor -----	12102741
Connector, mat sensor -----	12102620

DATE	REVISION	AUTH